

**Encouraging completion of HPV vaccine schedule using decision aids**

**Author**

*Julian Peña Duarte*

**Advisor**

*Stanislao Maldonado*

Submitted as a requirement to opt for the degree of  
Master in Economics



**Universidad del  
Rosario**

Department of Economics

Universidad del Rosario

Bogotá D.C., Colombia

2023

# Encouraging completion of HPV vaccine schedule using decision aids \*

Julian Peña Duarte<sup>†</sup>

June 16, 2023

## Abstract

This paper presents a randomized controlled trial involving parents in Bogotá, D.C., and nearby cities to encourage the completion of their daughters' HPV vaccine schedule. The experiment employed decision aids through a text message campaign with two behavioral components: ownership reminders, soft-default options, or both. The results showed the soft-default option had a similar effect to the treatments that combined the message with the ownership reminder. Particularly the impacts of these messages go from 7.96 percentage points to 9.13 percentage points compared to 8.63% of the vaccination rate in the control group. However, there is evidence that soft-default options have different impacts than the treatment that only sent the ownership reminder because the effect of this last treatment is 4.62 percentage points. These results suggest that behavioral-based SMS interventions effectively increase the uptake of the second dose of the HPV vaccine and can be adopted as a tool by the Health Secretariat for boosting vaccination rates.

---

\*I am thankful to Stanislao Maldonado for his invaluable guidance. I also would like to express my sincere gratitude to the American Cancer Society for funding this project. Additionally, I extend heartfelt thanks to the Inter-American Development Bank, the Colombian League Against Cancer, Bogota Health Secretariat, and the Behavioral Government Lab (Universidad del Rosario) for supporting and contributing to my research. I also want to thank my parents, girlfriend, and brothers for their unconditional support. IRB approval was obtained through Universidad del Rosario under study number DVO005 1663-CV1287. The experiment was registered with the AEA RCT registry under ID AEARCTR-0009705.

<sup>†</sup>Universidad del Rosario. Email: julian.penad@urosario.edu.co

# 1 Introduction

Vaccination is a critical health investment that protects individuals and communities from diseases. For instance, Li et al. (2021) estimate that from 2000 to 2019, vaccination programs against ten pathogens<sup>1</sup> in 98 low-income and middle-income countries prevented 37 million deaths and could avert 32 million more by 2030. Given these benefits, the standard economic theory would suggest that agents assess risk perceptions using the expected utility theory, determining that vaccination lowers disease contraction likelihood against minimal adverse event probabilities, making vaccination the rational choice. However, many people fail to take advantage of these health innovations provoking suboptimal uptake rates on two fronts: unvaccinated individuals and those with incomplete vaccination schedules. Although the literature extensively examines reasons for non-vaccination<sup>2</sup>, fewer studies analyze the reasons behind unfinished vaccination schedules. Exploring vaccination schedule completion is also crucial since it increases protection against diseases.<sup>3</sup> This paper focuses on this population that has already expressed an interest in vaccination. Nevertheless, several factors contribute to this population’s failure to fulfill their vaccine schedules.

Among these factors is procrastination, a behavioral aspect often observed in individuals who intend to accomplish vaccination but tend to delay the process as the vaccination date approaches (Nuscheler & Roeder, 2016). Another critical factor is the time lapse between the first and other doses. This lengthy interval between doses creates a challenge, as McDaniel and Einstein (2007) demonstrates that people have limited prospective memory, which implies

---

<sup>1</sup>Specifically, hepatitis B virus, Haemophilus influenzae type B, human papillomavirus, Japanese encephalitis, measles, Neisseria meningitidis serogroup A, Streptococcus pneumoniae, rotavirus, rubella, and yellow fever.

<sup>2</sup>One possible explanation is the beliefs about safety and adverse events (Gust et al., 2005; Azarpanah et al., 2021). These risk perceptions derive from different behavioral biases, such as the availability heuristic (Tversky & Kahneman, 1973), omission bias (Ritov & Baron, 1990), loss aversion (Tversky & Kahneman, 1991), and confirmation bias (Nickerson, 1998). Another reason for non-vaccination is the beliefs about the disease’s perceived likelihood and severity (Brewer et al., 2007).

<sup>3</sup>In the covid-19 context, Mukherjee et al. (2022) discovered that patients with one dose of the anti-SARS CoV-2 vaccine had a 50% lower risk of in-hospital death, whereas those with two doses had a 60% lower probability of dying.

that they may face difficulties in remembering and executing tasks in the future. Furthermore, overconfidence in memory capacities (Ericson, 2011; Tasoff & Letzler, 2014) can further complicate compliance with vaccination schedules. As a result of these factors, individuals may intend to take action regarding vaccination but fail to follow through, a concept known in the literature as the intention-action gap.

Understanding the above factors is essential for designing effective public health policies to improve vaccination rates and health outcomes. Similarly, it is crucial to understand the context in which an intervention aimed to boost vaccination rates. For instance, low and middle-income countries often lack sufficient information or resources to design targeted or personalized interventions for each population group. Monetary incentives (Banerjee et al., 2010; Basinga et al., 2011; Robertson et al., 2013; Caskey et al., 2017), educational campaigns (Owais et al., 2011; Andersson et al., 2009), and home visits (Brugha & Kevany, 1996; Kendrick et al., 2000) may be effective, but they can be expensive or challenging to implement on a large scale.

This paper employs a behavioral sciences-based procedure since its solutions, in many cases, are low-cost and easy to implement. Specifically, I implemented a short messaging service (SMS) campaign targeting parents of girls (typically the mother) who still need to complete their HPV vaccination schedules in Colombia, concretely Bogota, D.C., and surrounding cities. I focused on parents because they are mainly responsible for making health-related decisions for their daughters. Moreover, Yagi et al. (2016) found that the decision to accept or reject the vaccine was primarily driven by mothers' vaccine beliefs rather than the daughters' beliefs. Additionally, the campaign featured decision aids to overcome the intention-action gap among parents, ultimately facilitating the vaccination of their daughters. Parents were randomized to receive a series of SMS from the Health Secretariat (HS) for six weeks in one of the four treatment groups described below, a pure or placebo control group.

The most basic treatment arm is similar to a strategy used in recent literature by Milkman

et al. (2021): an ownership reminder, which implies sending a message indicating that a vaccine is “reserved for you”. This reminder is highly effective because it employs threefold strategies. The approach frames getting the vaccine as the default and leverages a sense of reciprocity and ownership. Furthermore, the second primary intervention uses a variant of default options, pre-selected choices applied to individuals in the absence of action. In this setting, the message suggested the time and the day for vaccinating their daughters with the dose of the HPV vaccine. Thus, this treatment encourages parents to follow a recommended path by the government. The other two interventions are combinations of the two previous, differing only in the timing of the ownership reminders being sent.

Once explained the treatments, it is crucial to examine the situation in Colombia, a country that has faced significant challenges in maintaining HPV vaccination rates. From nearly 100% coverage for the first dose in 2012, the national rate in 2019 for first doses descended to 34.1% and 11.1% for second doses (Ministerio de Salud y Protección Social de Colombia, 2020). This dramatic drop is explained by an outbreak of unknown origin in Carmen de Bolívar (a Colombian city), which was associated with the HPV vaccine by media, turning the HPV vaccine into a controversial topic. Hence, this event distorted families’ beliefs about the safety of HPV vaccination, making Colombia an engaging setting to explore these concerns.

Regarding the experiment’s results on this population, my estimates indicate that the SMS campaign improves compliance with the second dose of the VPH vaccine. The general intervention (without distinguishing between treatments) increases the probability of taking the vaccine by 7.6 percentage points compared to 8.63% percent of the vaccination rate in the control group, resulting in an 88% boost in vaccine uptake. Regarding the specific effects, the most impactful messages are the ones related to soft-default options. In addition, I find no evidence for the complementary effects of sending two SMS; even in some results, it seems the opposite exists. Finally, there are heterogeneous impacts concerning whether the girl is younger contrasted with older girls or if they live inside Bogotá versus outside Bogotá.

This paper relates to a body of studies using behavioral science to increase vaccination uptake. For instance, Stockwell et al. (2014) found that reminders in a low-income obstetric population effectively improve influenza vaccine rates. Closely related to my study, Milkman et al. (2021) conducted an extensive field study examining the effect of 19 SMS prompts on increasing influenza vaccine uptake. I used their approach of ownership reminder but with some differences. First, the intervention is at the parent level, but the vaccine is for their daughters, so the content of the message changes to a vaccine is “reserved for your daughter”. I also included default options as they effectively improve vaccination rates in different settings (Chapman et al., 2010; Lehmann et al., 2016). This paper is also connected with emerging literature that deploys insights from behavioral sciences to encourage vaccination against Covid-19 and mitigate the effects of the pandemic<sup>4</sup>.

Regarding the HPV vaccine, there is also a growing literature that uses behavioral sciences to promote the vaccine. Notably, Kharbanda et al. (2011); Matheson et al. (2014); Tull et al. (2019) deploys text message reminders, proving effective in enhancing vaccination uptake. Rand et al. (2017) utilize SMS and phone calls, finding that SMS is more efficacious in boosting HPV vaccine uptake. In addition, Chao et al. (2015) discovered that reminder letters effectively motivate completing the HPV series. My messages are similar, for example, in reminding the second dose of the vaccine, but also different since it is a soft default indicating the date of an appointment to vaccinate the daughters of the parents but without telling a place because the vaccine is generally available and free at any vaccination station.

Finally, this paper is related to the literature that uses technological solutions to encourage vaccination. In the existing literature, various strategies have been employed, including not only SMS interventions but also the use of mobile applications (Atkinson et al., 2016; Fadda et al., 2017), interactive web-based tools (Betsch et al., 2012) or social media interventions

---

<sup>4</sup>Specifically, Dai et al. (2021) designed text message reminders. The most effective message provided a sense of ownership of the vaccine. Thus this supports the idea that the ownership message from Milkman et al. (2021) worked well in another context different from influenza. Similarly, in the covid-19 scenario, (Tentori et al., 2022) shows that changing the default option of opt-in to opt-out increased the vaccination uptake.

(Nowak et al., 2015; Glanz et al., 2017). Furthermore, this experiment is beyond a laboratory setting since it is part of a large-scale, city-wide effort in partnership with the government. Therefore, this study is also associated with both the growing literature on wide-scale experimentation (Muralidharan & Niehaus, 2017; Duflo, 2020) and research that cooperates with the government to nudge people toward a desired action (Halpern & Sanders, 2016; Benartzi et al., 2017).

The rest of the paper is organized as follows. The next section describes the background. Section 3 presents the research design, which includes the behavioral biases, the description of the intervention, the data, the ethical issues, and the randomization. Section 4 shows the estimation strategy. Section 5 examines the main results, the dynamics of the effects, the complete model, and the global effect of the campaign. Section 6 presents the heterogeneous treatment effects and robustness checks by multiple comparisons. Section 7 presents a brief Cost-effectiveness analysis. Section 8 concludes.

## 2 Background

In 2020 approximately 342,000 women died from cervical cancer (CC), and around 90 percent of the deaths occurred in low- and middle-income countries (Sung et al., 2021). The primary cause of CC is the Human Papillomavirus (HPV) since more than 95% of CC is due to HPV (WHO, 2022), preventable by a cost-effective solution such as vaccination. However, in Latin America, a significant reduction in HPV vaccination coverage has occurred in the years following its inclusion in the vaccination plans (Nogueira-Rodrigues, 2019). Consequently, there is a severe public health problem in the region. Since many women are still unimmunized, the long-term consequences are devastating. For instance, CC causes severe impact on women and families, resulting in psychological distress, physical suffering, and loss of life (Distefano et al., 2008). Additionally, CC can result in significant financial impacts on those affected, including income loss and raised healthcare expenses. Similarly, CC can lead to decreased

productivity and increased healthcare costs for the countries. Remarkably, Shah et al. (2020) suggest that the cost of CC in the United States is substantially higher for those affected. Specifically, the study found that the average health expenditure for a woman with CC was \$10,031, compared to only \$4,913 for those without the condition. Therefore, governments must implement effective HPV vaccination programs to mitigate costs associated with CC.

Colombia is a particular case regarding HPV vaccination, as according to Nogueira-Rodrigues (2019) in 2013, the vaccination coverage of first doses was 97.5%, the second-best rate worldwide after Australia. A significant part of its success is attributable to the campaign implemented in 2012 in schools across the country, where girls over nine years of age were vaccinated on a mandatory basis. Nevertheless, in 2014 an outbreak of unknown etiology occurred in the municipality of Carmen de Bolivar; around 500 girls who had been immunized against HPV presented headaches, fainting, and numbness of extremities. Some families in the municipality and anti-vaccine movements claimed that the HPV vaccination was the cause of the outbreak. This case led to a huge controversy surrounding the vaccine and bad publicity in the media. So vaccination rates dropped precipitously, to the point that by 2016 coverage for first doses was 14% and 9% for second doses (Simas et al., 2019). However, the Colombian Ministry of Health and Social Protection, in conjunction with the National Institute of Health, conducted an epidemiological study in which they demonstrated that it was not plausible to associate HPV vaccination with the events in Carmen de Bolivar (Martínez et al., 2015). Similarly, several international studies have confirmed the safety of the vaccine. In particular, Phillips et al. (2018) identified 109 studies demonstrating that all HPV vaccines have an acceptable safety profile.

Following the Carmen de Bolivar incident, much political instability was generated around the vaccine. Therefore, the Colombian state preferred to withdraw its support for HPV vaccination and adopt a more indifferent stance. The school campaign was interrupted, and

the government decided to incorporate informed consent so that the parents would have the autonomy to decide whether to vaccinate their daughters. Provoking an additional barrier since other vaccines in the vaccination plan do not require informed consent.

Despite little government support, institutions such as the Liga Colombiana Contra el Cáncer and the American Cancer Society have made several efforts to improve HPV vaccination coverage in the country. In Arauca (a city in Colombia), for example, an educational campaign was developed targeting the different members of the HPV vaccination process. After the campaign, vaccination rates in Arauca went from 5% in 2017 to 41% in 2018, and 83 % in 2019 (Castro et al., 2020). Hence the Liga made significant progress in Aracua. However, there is still massive room for improvement in the rest of the country because the national coverage for 2019 for first doses was 34.1% nationally and only 11.1% for second doses. While the situation is more alarming in Bogota, the coverage of first doses was 25.7% for first doses and only 6% for second doses in 2019 (Ministerio de Salud y Protección Social de Colombia, 2020). These statistics reflect the severe problem that Bogota is facing regarding HPV vaccination, especially in the coverage of second doses.

### **3 Research design**

This section discusses the intervention's structure and the cognitive biases that it addresses. Additionally, it describes the ethical issues, the data and its descriptive statistics, the outcome of interest, the randomization process, and the balance tests.

#### **3.1 Behavioral biases**

The target population is the parents of girls between 9 and 17 years old with incomplete HPV vaccination schedules because the vaccine is free for this age range. These parents already exhibit their interest in the vaccine by vaccinating their daughters against HPV with the first dose. Therefore, it is not necessary to change their beliefs about the vaccine. The fact that

parents have not completed the vaccination schedule is not due to incorrect beliefs about HPV vaccination or the HPV disease itself. Contrarily, it is plausible to assume that they know the importance of vaccinating their daughters against HPV. Moreover, novel literature underlines the existence of altruistic behavior among parents regarding vaccination. Goss et al. (2020) found that one of the primary motivations for vaccinating their children is the desire to protect and keep them healthy. Given that parents have already demonstrated interest in the HPV vaccine and could have altruistic tendencies toward their daughters' well-being, it can be presumed that they intend to complete the vaccination schedule.

However, parents constantly postpone this duty due to different possible reasons. One possible explanation is cognitive overload. Parents frequently have multiple tasks and responsibilities, leading to much information to process. This behavioral bias may result in forgetting crucial tasks, such as completing their daughters' vaccination schedules. Likewise, Lobel and Amir (2011) identified that cognitive overload could lead to suboptimal medical decisions. Another behavioral bias, present bias, can result in parents procrastinating on the day of vaccinating their daughters (Nuscheler & Roeder, 2016). These parents may think that the second additional dose can wait because they have already given their children the first dose of the vaccine, continuously delaying the duty. Moreover, McDaniel and Einstein (2007) shows that individuals' prospective memory is limited, implying that they could face challenges when remembering and performing future tasks. Furthermore, overconfidence in their memory capacity (Ericson, 2011; Tasoff & Letzler, 2014) can also restrain compliance with vaccination schedules. Thus, I implemented interventions that addressed these behavioral biases and incorporated behavioral insights in the text messages to bridge the intention-action gap.

## **3.2 Intervention**

Elaborating on this approach, in 2021, I partnered with several organizations to design and implement behavioral interventions via text messages targeting HPV vaccination compliance. The organizations include the American Cancer Society, the Behavioral Government Lab

(Universidad del Rosario), the Inter-American Development Bank, the Liga Colombiana Contra el Cáncer, and the Health Secretariat (HS) of the City of Bogota. I collaborated in the design and implementation of all the experiments. Indeed, this experiment constitutes a component of this alliance <sup>5</sup>.

The messages of my experiment have different behavioral elements. Each treatment arm included two fixed components: the mother’s first name and the message’s sender. The first fixed component personalized the SMS, as other settings have shown effective (Karlan et al., 2012). In the context of the HPV vaccine Wynn et al. (2021) shows that personalized reminders effectively promote the completion of the HPV series. The second fixed component concludes the message with the name of the sender since some parents believe that the government does not strongly support the vaccine. Therefore, placing this authority gives institutional backing and provides monitoring. In addition, the messages have the principal behavioral component that, depending on the treatment, uses soft-default options or ownership reminders as in (Milkman et al., 2021) or both.

Default options are effective because they take advantage of several behavioral biases influencing decision-making. For instance, people tend to stick with the current option and are hesitant to change. This bias is known in the literature as the status quo bias (Samuelson & Zeckhauser, 1988). Additionally, the default options deal with cognitive overload because providing a recommended choice can facilitate the decision-making process.

Regarding vaccination, default options are proven to be successful. Specifically, Chapman et al. (2010) and Lehmann et al. (2016) found that an opt-out condition increased the probability of a flu shot appointment. I used a similar strategy by suggesting a time and a day for parents to go and vaccinate their daughters. The only difference is that the message doesn’t provide a location because mothers can go to any vaccination center and ask for the HPV vaccine.

---

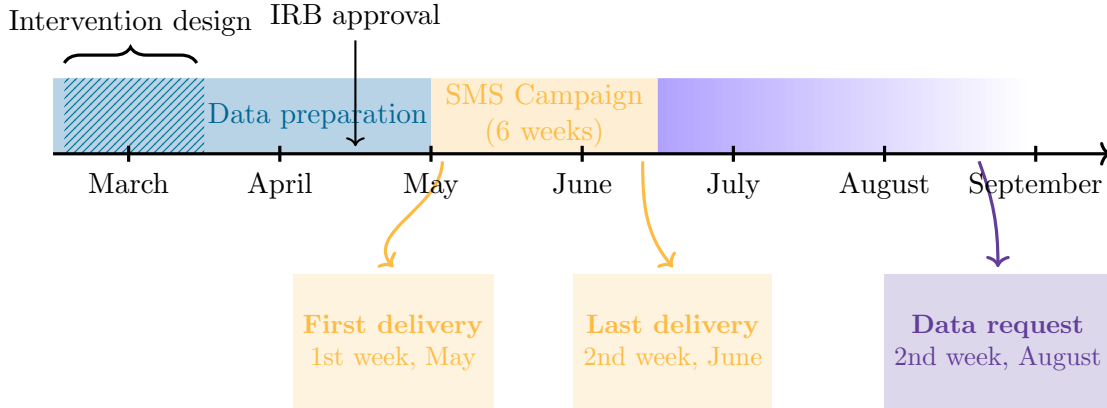
<sup>5</sup>My treatments differ from the big experiment, which utilized planning tools, reminders and social norms. In the case of this paper, I implemented ownership reminders and soft-default options. Additionally, two control groups (pure and placebo) are used, compared to three in the other experiment.

The treatment is named the soft-default option since, in the end, it is a recommendation. There is nothing concrete because the message is not mentioning the location. In addition, this can facilitate the work of the HS since they do not need to think about the best place for each mother to take her daughter to be vaccinated.

Concerning the methodology of ownership reminders proposed by Milkman et al. (2021), they used the following message in their treatments: “a flu shot has been reserved for you”. According to the authors, the behavioral strategies used in this kind of message are threefold. First, the message frames the vaccination as the default and the expected behavior. Second, there is a loss aversion component because the language makes parents feel the vaccine belongs to their daughters, and therefore they do not want to miss “their” dose. Lastly, there is reciprocity since the health provider took the time to set aside the vaccine dose. Thus, it would be disrespectful not to correspond to the action of the HS by taking the dose. Additionally, the ownership reminder works as a traditional reminder because it addresses procrastination by nudging people to take action and complete the task. Similarly, it confronts the limited prospective memory and overconfidence in their memory capacities by refreshing that it is the time to vaccinate their daughters and encouraging compliance.

In this context, I used the ownership reminder with the wording “an HPV vaccine reserved for your daughter.” This study tested four treatments sent for six weeks from May 4 to June 11. Once a daughter of a treated parent was vaccinated, the messages stopped being sent. The timeline of the experiment is presented in figure (1). The first treatment is the ownership reminder only. The second treatment is only one SMS using soft-default options. The assigned appointments were Saturday at 10 am because vaccination posts continue to operate on that day, and parents can have more time to vaccinate their daughters. These two treatments were sent alone to test the individual effects of each message. The last two treatments are a combination of the two previous interventions. First, the Soft-default option message was sent with the appointment for vaccination on Wednesday at 7:00 pm,

Figure 1: Experiment Timeline



Notes: The figure presents the timeline of the experiment in the year 2022. It shows how long each process took, from the intervention design to the data request. The first round of messages sent was on Wednesday, May 4, 2022, and the last round was on Saturday, June 11, 2022.

when parents had already left work hours. Then, the parents received a message with the Ownership reminder. I carried out two versions of the reminder timing: one 24 hours before the appointment and one 2 hours before. These versions allow us to identify whether the timing of the reminder matters. Figure (A1) in the appendix presents the content of the text messages based on these dimensions.

### 3.3 Ethical issues

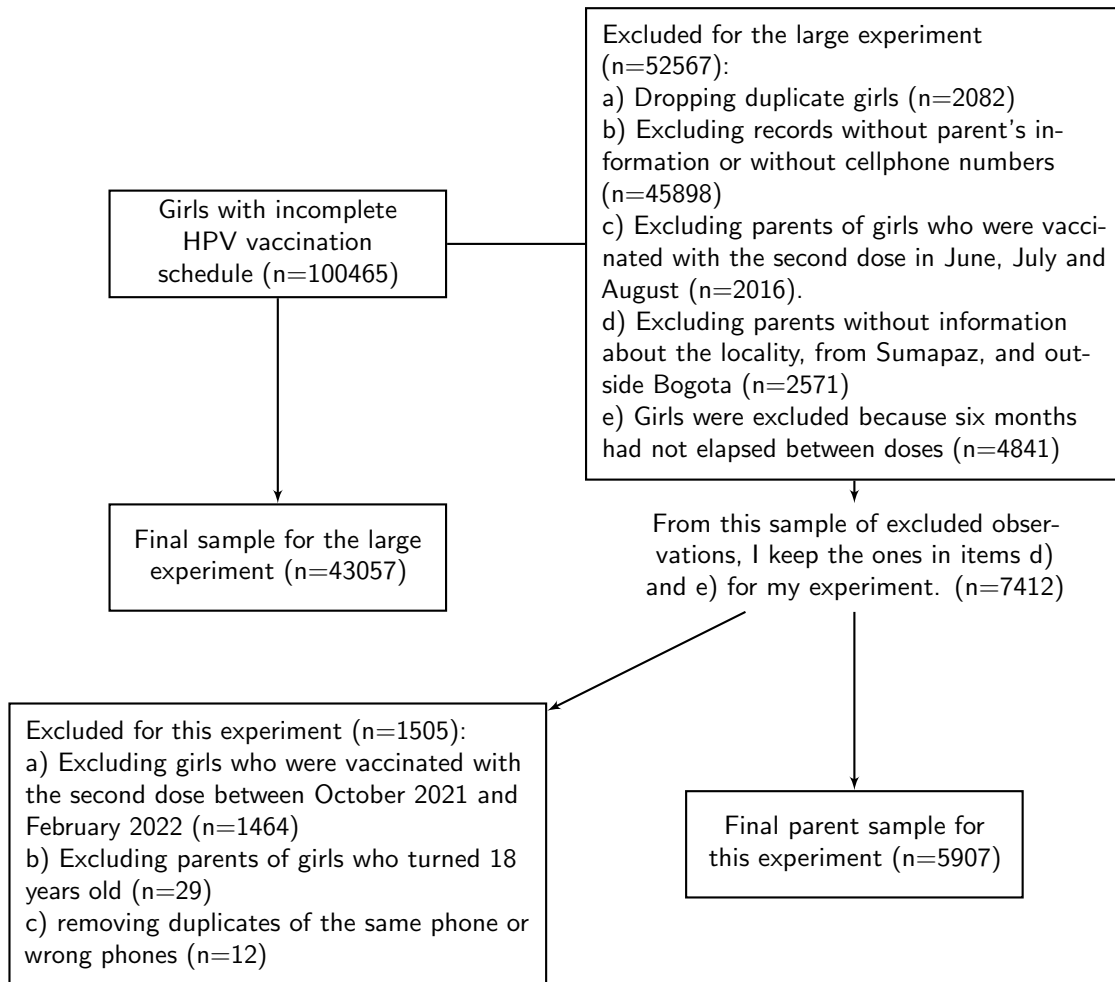
Informed consent was not necessary for this project as it was implemented within the framework of the public policy of vaccination against HPV implemented by the health authorities of the District of Bogotá. In this scenario, the HS of the District of Bogotá already uses a communication campaign through text messages to encourage vaccination. The research team's contribution was to design a communication strategy based on behavioral sciences to improve the strategy already implemented by the city's health authorities. The IRB of the Universidad del Rosario approved this intervention. In addition, the data were managed with the greatest care, ensuring the protection of sensitive information of the parents. Rigorous measures were taken to maintain the confidentiality and privacy of the data, attaching to best practices and guidelines in handling personal information.

## 3.4 Data

### 3.4.1 Data sources

The implementation of the SMS campaign was possible due to the administrative data of HS. Colombia has an excellent immunization program (PAI) that covers the entire population, and it does not matter whether the person is insured in the health system. Regarding the information on the vaccines, this is uploaded to the application (PAIWEB) by the health providers constantly. Therefore, I can observe whether the girls have been vaccinated and the immunization dates.

Figure 2: Sample construction for this experiment



Notes: The figure shows how the base of the experiment was constructed, basically using part of the sample excluded in the large project.

### **3.4.2 Sample composition**

As previously mentioned, this experiment is a subset of a larger group of experiments. Figure (2) illustrates in detail the origin of the specific sample used in this study, derived from the excluded subset of records from the large experiment. Specifically, I used the records outside Bogota, the observations without the locality information, or if the parent belonged to the locality of Sumapaz. In this experiment, this information is not required. In contrast, the other research does need the data since it includes social norms at the locality level, and Sumapaz was excluded due to its limited number of observations.

Similarly, I used the sample of girls who still needed to complete the time for the second dose (6 months) in that experiment. However, by the date of this experiment's implementation, they would be eligible for the second dose. The final sample for this experiment is composed of 5907 parents who have daughters with an incomplete HPV schedule.

### **3.4.3 Variables**

There are limited pre-treatment covariates. Among these covariates are the health care provider (EPS), the entities in charge of organizing and guaranteeing the mandatory health plan. Likewise, there is information about whether the mother belongs to the contributory regimen, that is, has payment capacity, or belongs to the subsidized regime. Although the Colombian health system intends to cover the population, some people are uninsured, and others belong to special regimes. Moreover, the administrative records provide the person's nationality, location, ethnicity, if was displacement by civil war, and the daughter's age. Regarding the primary outcome, it is a categorical variable that indicates whether a parent's daughter is vaccinated against HPV during the SMS campaign window (six weeks) or two months after the end of the intervention.

### 3.4.4 Summary statistics

The table (1) provides descriptive statistics of the covariates mentioned above for the final sample of parents. Approximately 62.8% of the parents are within Bogota, and the average girl’s age is 11.25 years. Concerning the enrollment in health insurance, the EPS Famisanar has the majority of the affiliates in this sample, followed by the Compensar (18.4%) and the EPS Sanitas (14.7%). Additionally, the table presents the principal health regimes. Around 81.3% of the parents belong to the contributory scheme, 12.3% belong to the subsidized scheme, and 5.08% are part of other schemes or special regimes. Only 1.3% of the parents are uninsured. Finally, the table includes whether the parent has Colombian nationality (96.3%), belongs to an ethnic group (0.508%), or has been displaced by the armed conflict (1.24%).

Table 1: Descriptive Statistics

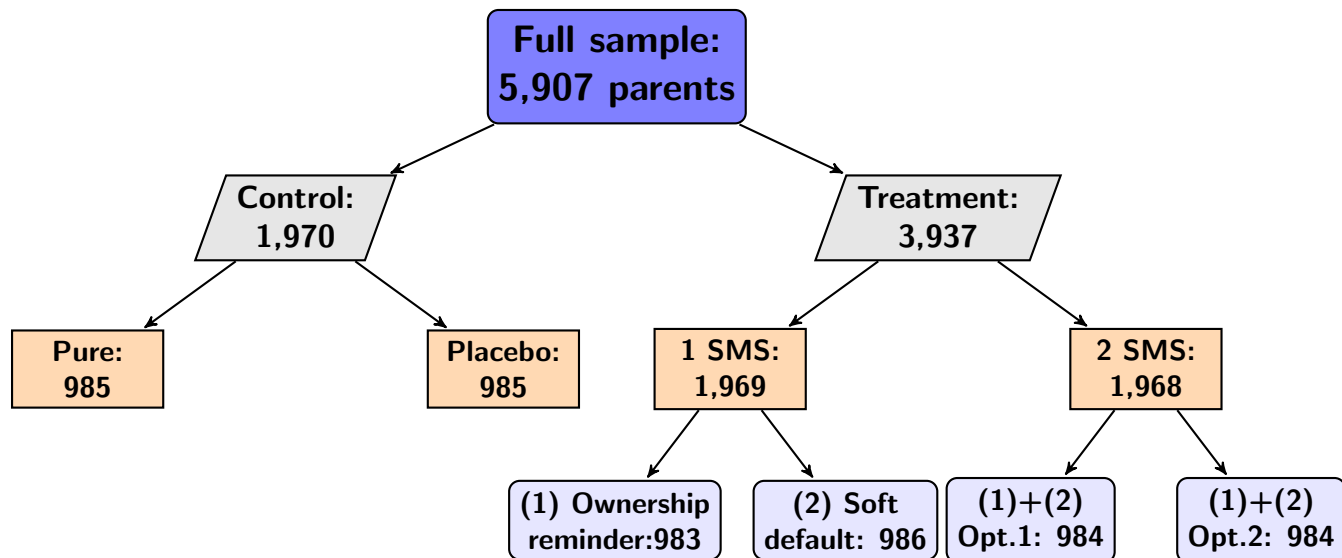
Variables	mean	sd	min	max	N
Girl’s age in years	11.25	2.013	9	17	5,907
Parent is within Bogota	0.628	0.483	0	1	5,907
EPS Sanitas	0.147	0.354	0	1	5,907
EPS Salud Total	0.101	0.301	0	1	5,907
EPS Famisanar	0.204	0.403	0	1	5,907
EPS Compensar	0.184	0.387	0	1	5,907
EPS Capital Salud	0.0963	0.295	0	1	5,907
Other EPS	0.268	0.443	0	1	5,907
Contributory Scheme	0.813	0.390	0	1	5,907
Uninsured	0.0130	0.113	0	1	5,907
Subsidized Scheme	0.123	0.328	0	1	5,907
Other scheme	0.0508	0.220	0	1	5,907
Belongs to some ethnic group	0.00508	0.0711	0	1	5,907
Displaced by the armed conflict	0.0124	0.110	0	1	5,907
Colombian nationality	0.963	0.189	0	1	5,907

Notes: The table presents summary statistics for the final sample of parents in the experiment based on the Health Secretariat of Bogotá administrative records. The reported statistics include means, standard deviations, minimum and maximum values, and the sample size for each variable.

### 3.5 Randomization

The experiment employed a randomized block design. Specifically, participants were divided into blocks according to their location (Bogotá or outside Bogotá) and the girl’s age. Since I used age as a block variable, I constructed a binary variable to avoid the “curse of dimensionality .” This dummy variable equals 1 for girls aged 9 and 10 and 0 for the other cases. Participants were subsequently assigned to only one of the above behavioral experiments using the re-randomization algorithm suggested by Morgan and Rubin (2012). Table (A1) reports the analysis of the balance of randomization on the limited set of pre-treatment covariates for the experiment. The tables suggest that the randomization of the experiment ensured no difference between treatment arms in terms of observables.

Figure 3: Experimental Design for the experiment



Notes: The figure shows the number of observations in each group after the randomization, encompassing the control and treatment types.

The experiment incorporates two control groups besides the behavioral treatment groups: the pure control group does not receive any message, and the placebo control receives a message about mental health care and contains the fixed elements. I intend to distinguish between the effect of sending a message and sending a behavioral-based text message with this placebo message. Figure A2 in the appendix shows the content of the placebo control message.

## 4 Estimation Strategy

This section discusses the methods that will be employed to evaluate the impact of the SMS campaign on vaccination adherence. Utilizing an RCT design allows for robust causal inference since it controls for both observable and unknown confounders. The principal method used for the estimations is Ordinary Least Squares (OLS). Below there is a complete description of each equation.

### 4.1 Estimation of Treatments impacts

I will estimate the impacts of interventions using an intention-to-treat (ITT) approach. This approach is appropriate since the messages can be sent, but confirming if the parent read the message is infeasible. Therefore, the ITT approach maintains the benefits of randomization and tackles non-compliance issues by studying all parents according to their allocated treatment groups. I will estimate models as follows:

$$Y_{ij} = \alpha + \sum_{\kappa=1}^K \tau_{\kappa} T_j + \theta_s + X'_{ij} \gamma + \epsilon_{ij} \quad (1)$$

Where  $Y_{ij}$  is the outcome of interest for girl  $i$  from parent  $j$  measured two months after the end of the SMS campaign.  $T_j$  denotes the treatment status of the parent  $j$ .  $\theta_s$  is the vector of categorical variables of the stratification (location\*age).  $X'_{ij}$  is a vector of pretreatment covariates at the girl and parent level, and  $\epsilon_{ij}$  is the error term.  $\tau_{\kappa}$  is our parameter of interest that will capture the ITT effect for each treatment arm.

### 4.2 Heterogeneous Treatment Impacts

I will examine the differential impact of the treatments by including interaction terms between the pre-treatment variables of interest  $W_j$  for parent  $j$  and the treatment variables. Thus, models with the following structure will be estimated:

$$Y_{ij} = \alpha + \sum_{\kappa=1}^K \beta_{\kappa} Z_j + \gamma W_j + \sum_{\kappa=1}^K \varphi_{\kappa} (Z_j \cdot W_j) + \theta_s + X'_{ij} \delta + \varepsilon_{ij} \quad (2)$$

Where the coefficients  $\varphi_{\kappa}$  recover the heterogeneous treatment effects. The pre-treatment covariates of interest are the variables used for the stratification location and the girl's age. In addition, I employ a series of categorical variables for heterogeneous effects, including the parent's affiliation with the subsidized regime or absence of health insurance, Colombian nationality, and whether they have been displaced due to the armed conflict.

### 4.3 Estimation of Complementary Impacts

In this section, I will investigate the possibility of positive complementary effects deriving from the two types of messages: ownership reminders and soft-default options. This examination can provide valuable insights into the advantages of combining different messaging methods to enhance vaccination. Precisely, the following equation will estimate the complementary effects of the treatments:

$$Y_{ij} = \alpha + \psi O_j + \omega S_j + \pi (O_j \cdot S_j) + \theta_s + X'_{ij} \gamma + \epsilon_{ij} \quad (3)$$

Where  $O_j$  is a categorical variable equal to 1 if the parent receives a message with the behavioral component of ownership reminder.  $S_j$  is a dummy equal to 1 if the parent receives a message with soft-default options. The coefficient  $\pi$  captures whether there are positive complementary effects.

### 4.4 Addressing issues with RCTs

In this study, several issues may arise. For instance, multiple hypothesis testing could arise from multiple treatment arms. Therefore, the Bonferroni correction will be implemented to account for multiple inferences. Additionally, given the nature of the study, parents cannot

change their treatment status. However, exceptions might occur, such as parents changing their phone numbers, no longer being in use, or messages not being read. An intention-to-treat (ITT) analysis will be implemented to account for all the possible deviations. As a final point, attrition will not be a problem since I work with administrative records. However, I could implement Lee (2009) if required.

## 5 Results

First, I estimated the individual effects using the equation (1). Then, I present the results by week because it is crucial to analyze the dynamics of the impacts<sup>6</sup>. Subsequently, I show the complete model to look for complementary effects in the SMS. Finally, I present the results of the global effect of the intervention.

### 5.1 Individual effects

The first four rows of table (2) present the impacts of the individual treatments. Each column uses different comparison groups. For instance, column(1) uses pure control (no message), column(2) the placebo control, and column(3) uses both comparison groups, the pure and the placebo. The comparison between the mean of the dependent variable of the pure control group and the placebo group suggests no difference between the two groups. All interventions increased the vaccination uptake of the HPV vaccine and are statistically significant at the standard level of significance under all specifications. Furthermore, table (A2) in the appendix shows the estimates without controls, and it is evident that the coefficients are practically identical.

The best-performing intervention is the treatment that includes soft-default options and an ownership reminder two hours before the appointment since this message increases the

---

<sup>6</sup>For a comprehensive view of the cumulative effects over time, figures (A9) and (A10) in the appendix illustrate the Kaplan-Meier estimates, representing the percentage of girls in the control groups and the treatment groups who received the second dose of the HPV vaccine by a specific day.

probability of vaccination by 9.13 percentage points compared to a vaccination rate of 8.63% in the pure control group. This effect is comparable to the findings of other contexts. In particular, the magnitude of the impact of reminder letters found by Chao et al. (2015) is 9.8 percentage points. However, my result is more prominent than what was observed by Tull et al. (2019) 3.29 percentage points. In general, this result is remarkable, representing a 105.8% relative increase in the uptake of HPV immunization compared to the pure control group. The effectiveness of this treatment holds changing the reference group by the placebo control.

Table 2: Effect of the SMS campaign on HPV vaccination schedule completion

Variables	HPV vaccine schedule adherence		
	(1)	(2)	(3)
Ownership reminder	0.0462*** (0.0139)	0.0310** (0.0143)	0.0386*** (0.0125)
Soft-default	0.0867*** (0.0147)	0.0723*** (0.0150)	0.0795*** (0.0133)
Soft-default+Ownership reminder (2 SMS: 62 h+24 h pre-appt)	0.0796*** (0.0146)	0.0651*** (0.0149)	0.0723*** (0.0133)
Soft-default+Ownership reminder (2 SMS: 62 h+2 h pre-appt)	0.0913*** (0.0149)	0.0764*** (0.0152)	0.0839*** (0.0135)
Observations	4,922	4,922	5,907
Controls	Yes	Yes	Yes
Control type	Pure control	Placebo control	All controls
Control mean	0.0863	0.0995	0.0929
P-value, Ownership reminder only=other treatments	0.016	0.014	0.015
P-value, Soft-default only=other soft-default treatments	0.775	0.786	0.778

Notes: The dependent variable is a dummy equal to 1 whether the girl is vaccinated with the second dose of the HPV vaccine during the SMS campaign window (six weeks) or two months after the end of the intervention. Each column compares the effects of interventions against a different type of control. Column (1) uses the pure control group, column (2) utilizes the placebo control group, and column (3) incorporates a combined group of both control types. All columns include control variables such as the parent's EPS, the associated regime, the individual's nationality, displacement status, the girl's age, ethnicity, and the variables employed for the stratification. P-value, Ownership reminder only=other treatments tests whether the ownership reminder's effect equals the other treatments' effects on the given outcome. P-value, Soft-default only=other soft-default treatments assesses whether Soft-default only and other soft-default treatments have equal impacts on the dependent variable. Robust standard errors are in parentheses. Additionally, I employed a specification adjusting standard errors for parent clusters, and the results remained consistent, confirming the robustness of the results. \*\*\*, \*\* and \* indicate statistical significance at the 1%, 5% and 10% respectively.

Nevertheless, the other two treatments that include default options are also highly effective since the magnitude of the effects is very similar to the best-performing message. Indeed, I performed a Wald test between the coefficients of soft default only (8.67 percentage points) and the other soft-default treatments. The p-value of 0.775 suggests that the coefficients are equal. This finding also suggests that the message's timing did not differ significantly. This result aligns with conclusions from other settings, as the meta-analysis conducted by

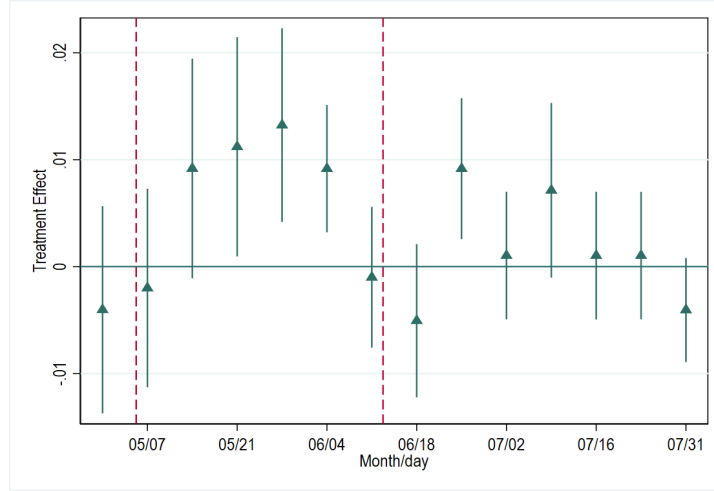
Boksmati et al. (2016) indicated that the timing of SMS reminders does not significantly influence their effectiveness in boosting appointment attendance.

Besides, there is evidence that messages that include soft-default options have different and larger impacts than just an ownership reminder. Given that if the coefficient of the ownership reminder is compared against the other coefficients, I find that the p-value (0.016) is less than 0.05. Therefore, the lowest-performing intervention was the message that only applied the Milkman et al. (2021) methodology. However, the effect is close to what they found because their top-performing intervention led to a 4.6 percentage points boost in influenza vaccination. In contrast, in this paper, I found that the single ownership reminder increases the HPV vaccination by 4.62 percentage points.

## 5.2 Dynamics of effects

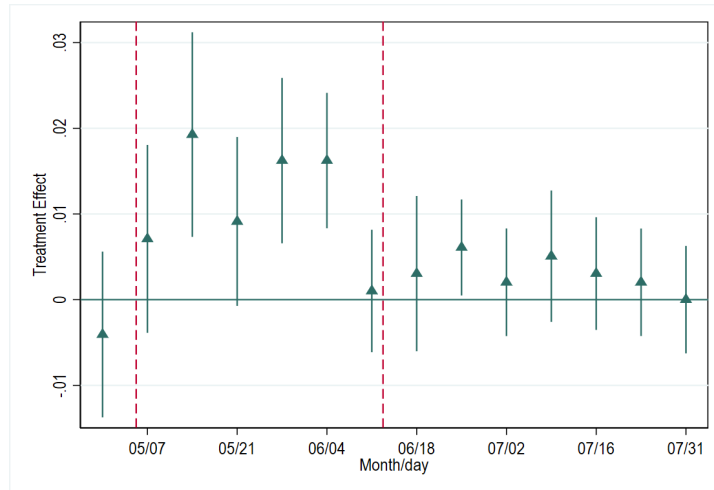
Figure (4) shows the dynamic of the effects of the message “A vaccine reserved for your daughter.” Interestingly, the first week shows no effect, possibly because receiving a message indicating that there is a vaccine available for their daughter is surprising or unexpected for the parents. They may initially perceive the message as insignificant or unrelated to their circumstances, leading to a lack of attention during the first week. However, figure (4) indicates that the persistence of the messages leads to an increase in vaccination uptake, with almost a percentage point effect observed in the second week compared to the control group at a level significance of 10%. This trend continues to strengthen until the fourth week. Additionally, there is a medium-term effect, as the impacts of the messages continue to be present in the second week since the last SMS (at a 1% significance level) and extend to the fourth week after the last SMS, but with a 10% level of significance.

Figure 4: The dynamic effects of Ownership reminder by week



Notes: The X-axis represents the week in which the outcome was evaluated. The Y-axis illustrates the treatment effect of the ownership reminder, calculated by combining the data from all periods, estimating equation (1) with week dummies and one treatment dummy per period, and using pure control for comparison. In the appendix, see the graph with the placebo control. The vertical bars signify 95% confidence intervals, with robust standard errors. Dashed vertical lines indicate the start and end dates of the SMS campaign.

Figure 5: The dynamic effects of Soft-default by week

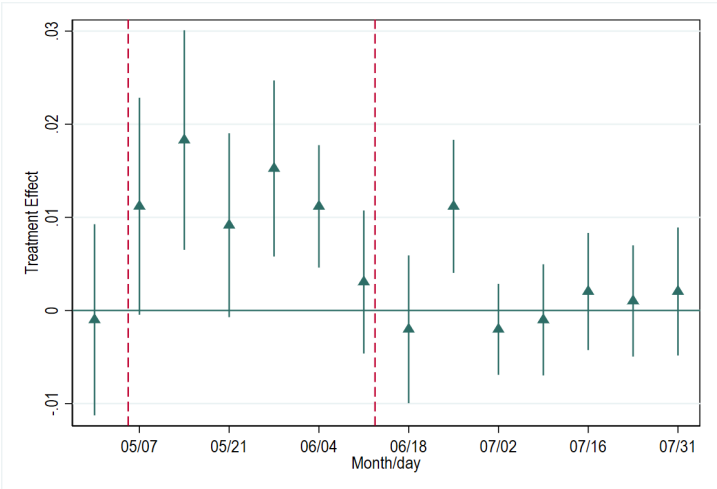


Notes: The X-axis represents the week in which the outcome was evaluated. The Y-axis illustrates the treatment effect of the only soft-default options, calculated by combining the data from all periods, estimating equation (1) with week dummies and one treatment dummy per period, and using pure control for comparison. In the appendix, see the graph with the placebo control. The vertical bars signify 95% confidence intervals, with robust standard errors. Dashed vertical lines indicate the start and end dates of the SMS campaign.

Figure (5) reveals the dynamics of treatment effects for the message that includes only

soft-default options. This message differs from the previous treatment in two elements. First, In the second week, the impact of the message is almost two percentage points. This impact is plausible, as the treatment motivates the action by specifying a vaccination date and time. The second element is that in the weeks following the SMS campaign, the effect seems less pronounced than the ownership reminder. This low impact is likely because the message scheduled an appointment. Therefore, If parents miss their daughters’ appointments, they might feel they have missed their chance and are no longer motivated to act.

Figure 6: The dynamic effects of Soft-default+ Ownership reminder (2 SMS: 62 h+24 h pre-appt) by week

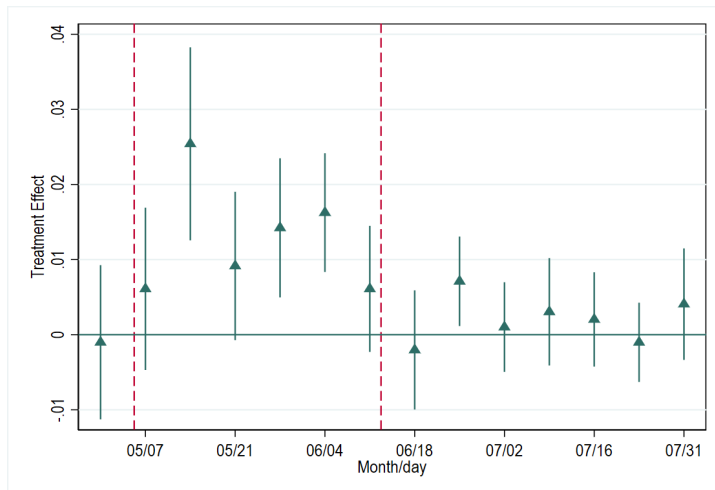


Notes: The X-axis represents the week in which the outcome was evaluated. The Y-axis illustrates the treatment effect of the message that combines soft-default options (62h prior the appointment) and ownership reminders (24h prior the appointment), calculated by combining the data from all periods, estimating equation (1) with week dummies and one treatment dummy per period, and using pure control for comparison. In the appendix, see the graph with the placebo control. The vertical bars signify 95% confidence intervals, with robust standard errors. Dashed vertical lines indicate the start and end dates of the SMS campaign.

Figures (6) and (7) present the effects of combining both messages. The dynamics of the impacts are different between the two versions. For instance, the message on the version reminding the parents 24 hours before the appointment impacted the first week at 10% of significance. In contrast, the second version has a positive effect, but the coefficient is not statistically significant. This difference may be because the first version allows parents to plan appointments more effectively. After all, the first version reminds parents a day in

advance, while the second version reminds them only two hours in advance.

Figure 7: The dynamic effects of Soft-default+Ownership reminder (2 SMS: 62 h+2 h pre-appt) by week



Notes: The X-axis represents the week in which the outcome was evaluated. The Y-axis illustrates the treatment effect of the message that combines soft-default options (62h prior the appointment) and ownership reminders (2h prior the appointment), calculated by combining the data from all periods, estimating equation (1) with week dummies and one treatment dummy per period, and using pure control for comparison. In the appendix, see the graph with the placebo control. The vertical bars signify 95% confidence intervals, with robust standard errors. Dashed vertical lines indicate the start and end dates of the SMS campaign.

In addition, the second version had a similar effect to the message with only soft-default options during the first week since the reminder was received close to the appointment. However, those parents who missed their assigned vaccination appointments and were informed that the vaccine was reserved for their daughters may have felt guilty. Therefore, they wanted to respond to this effort from HS by reciprocating by taking their daughters on vaccination the following week. This behavior can be observed because, in week two, the treatment effect was around 2.5 percentage points. The rest of the weeks have similar impacts between the two versions. In fact, the second week post-SMS campaign has an effect in both versions.

### 5.3 Complete model and global effect

Table (3) presents the results for the full model. With this complete model, I am interested in observing if sending a text message based on default options and one ownership reminder

has a greater positive impact on HPV vaccination take-up than the individual effects of these treatments. The interaction between the ownership reminder and the default option indicates whether this is factual. Nevertheless, it appears that there is no complementary effect because the interaction between the soft default option and the remainder is negative and significant at 5% if the pure control group is taken as the reference group. Therefore, instead of contributing, it has a negative effect, so there is evidence that sending more messages is not necessarily better. One possible explanation is that parents could see it as repetitive or spammy. However, this negative result is not robust because it is not statistically significant under specification (2), which changes the placebo control’s reference group. This finding is crucial since it is unnecessary to send two messages to have a relevant impact. Thus, the HS can only send the soft default option and obtain a comparable effect to the treatments that send two messages.

Table 3: Complete model

Variables	HPV vaccine schedule adherence		
	(1)	(2)	(3)
Ownership reminder	0.0462*** (0.0139)	0.0310** (0.0143)	0.0386*** (0.0125)
Soft default	0.0867*** (0.0147)	0.0723*** (0.0150)	0.0795*** (0.0133)
Ownership reminderXSoft default	-0.0475** (0.0200)	-0.0326 (0.0202)	-0.0401** (0.0190)
Observations	4,922	4,922	5,907
Controls	Yes	Yes	Yes
Control type	Pure control	Placebo control	All controls
Control mean	0.0863	0.0995	0.0929

Notes: The dependent variable is a dummy equal to 1 whether the girl is vaccinated with the second dose of the HPV vaccine during the SMS campaign window (six weeks) or two months after the end of the intervention. The variable “Ownership reminderXSoft default” captures whether there are positive complementary effects. Each column compares the complementary effects with a different type of control. Column (1) uses the pure control group, column (2) utilizes the placebo control group, and column (3) incorporates a combined group of both control types. All columns include control variables such as the parent’s EPS, the associated regime, the individual’s nationality, displacement status, the girl’s age, ethnicity, and the variables employed for the stratification. Robust standard errors are in parentheses. \*\*\*, \*\* and \* indicate statistical significance at the 1%, 5% and 10% respectively.

Table (4) presents the global impact of the behavioral intervention by comparing the parents

who received one of the four behavioral treatments to those in the different control groups. This comparison aims to assess the campaign’s effectiveness without distinguishing between treatments. In this analysis, the “Decision aids” variable is a categorical indicator, taking one if the parent receives any behavioral intervention and zero otherwise. The results suggest that the global effect of the treatments in boosting the vaccination rates against HPV is 7.6% percentage points compared to 8.63% of the vaccination rate in the control group. This finding demonstrates the campaign’s success because it increased the HPV completion of the vaccination schedule by 88.06%. This result is robust as it is maintained when the placebo group is used as the comparison group.

Table 4: Global Effect of the SMS campaign on HPV vaccination schedule completion

Variables	HPV vaccine schedule adherence		
	(1)	(2)	(3)
Decision aids	0.0760*** (0.0106)	0.0612*** (0.0111)	0.0686*** (0.0087)
Observations	4,922	4,922	5,907
Controls	Yes	Yes	Yes
Control type	Pure control	Placebo control	All controls
Control mean	0.0863	0.0995	0.0929

Notes: The dependent variable is a dummy equal to 1 whether the girl is vaccinated with the second dose of the HPV vaccine during the SMS campaign window (six weeks) or two months after the end of the intervention. Each column compares the effect of the overall intervention (i.e., “Decision aids” pools all treatment arms.) with a different type of control. Column (1) uses the pure control group, column (2) utilizes the placebo control group, and column (3) incorporates a combined group of both control types. All columns include control variables such as the parent’s EPS, the associated regime, the individual’s nationality, displacement status, the girl’s age, ethnicity, and the variables employed for the stratification. Robust standard errors are in parentheses. \*\*\*, \*\* and \* indicate statistical significance at the 1%, 5% and 10% respectively.

## 6 Heterogeneous effects and robustness checks

In this section, I present additional results regarding heterogeneous impacts and show if the main results are robust to multiple comparisons.

## 6.1 Heterogeneous effects

This section examines whether the decision aids have differential impacts by estimating the equation (2). The results of the heterogeneous effects are presented in table (A3) of the appendix for the overall intervention (i.e., pooling all the treatments in one variable named “Decision aids”) using the pure control group as the comparison group. Since the stratification was done at the location level and the girl’s age level, it was expected that there might be heterogeneous effects in these two dimensions. Therefore, columns (2) and (3) present whether there are heterogeneous effects in these aspects. I also focused on the heterogeneous effects of whether the parent belongs to the subsidized regime or does not have health insurance (column 4), if the person is a Colombian national (column 5), and lastly, if they are displaced by the armed conflict (column 6). Regarding the individual heterogeneous effect of each treatment, graphs from (A3) to (A7) show if the interactions between treatments and the variables of interest are statistically significant.

As expected, table (A3) shows differential effects in the variables used for the block randomization. For instance, I found that the interaction between the intervention and the categorical variable age is positive and significant. What is surprising is that the magnitude of the effect is not small. The coefficient is 9.0 percentage points, suggesting that the treatment effect is more than three times larger in the group of 9 and 10 years old girls than the girls between 11 and 17 years old. This result indicates that parents respond more to interventions when their daughters are younger than when they are older. Similarly, I encountered heterogeneous effects for each treatment in figure (A3). This impact is consistent with what was found by Chao et al. (2015) because they found that the treatments work better in the population of girls between 9 and 17 years of age than in the population of young women between 18 and 26 years of age.

Similarly, the interaction between the intervention and if the parent is in Bogotá is highly significant and positive. Figure (A4) shows that the same applies to individual treatments,

except for the ownership reminder. This impact can be possible because we are working with data from the HE from Bogotá. Therefore, the quality of the information may not be the best for people outside of Bogota. In any case, if this is the primary reason, the baseline impact of the intervention or the lower bound in cities outside of Bogota is estimated at 3.3 percentage points. This finding could also result from the added time and monetary expenses parents outside Bogota must incur to access health centers. Finally, there is no evidence of heterogeneous effects regarding the other variables like subsidized or uninsured schemes, if the person is a Colombian citizen, and whether the parent faced displacement from armed conflict.

## 6.2 Multiple comparisons tests

Tables (A4), (A5) and (A6) of the appendix present the results of the Bonferroni correction for the different control groups. Specifically, Table (A4) compares interventions and the pure control group. Table (A5) contrasts interventions with the placebo control group. Table (A6) examines treatments and all control groups.

The ownership reminder intervention demonstrated a robust, statistically significant positive effect compared to the pure control group (Bonferroni-corrected p-value of 0.009). However, this significance decreased when evaluated against the placebo control. Despite this, the intervention indicated a positive impact compared to a combined group of all controls (pure and placebo) with a Bonferroni-corrected p-value of 0.020, suggesting it influences HPV vaccination uptake. A larger sample size would have been necessary to establish robustness against the placebo control. In contrast, the soft-default and soft-default with ownership reminder interventions (administered 24 or 2 hours before) consistently showed highly robust, statistically significant positive effects across all control types, with Bonferroni-corrected p-values of 0.000.

## 7 Cost-effectiveness analysis

The following section presents a simple cost-effectiveness examination of the intervention. The analysis aims to determine the economic viability and efficiency of implementing this experiment by comparing its costs and benefits. The costs associated with implementing the interventions are mainly the text message sent. Each text message costs 8 COP (0.0017 USD). In this experiment, a cumulative total of 41,340 text messages were sent. This results in an overall cost of 330,720 COP (73.49 USD). Furthermore, the labor expense associated with programming and delivering the messages over six weeks, which consists of 10 work hours, should be considered. At a rate of 40,000 COP per hour, this adds 400,000 COP (88.88 USD) to the total cost of the experiment. Therefore, the total cost of the intervention is over 730,720 COP (162.38 USD). Regarding the benefits of the SMS campaign, The overall effect of the treatments is an increase of 7.6 percentage points compared to the control group's vaccination rate of 8.63%. Hence, out of the 3,937 parents with daughters in our treatment groups, the interventions led to the completion of the vaccination schedule of 296 girls, the other 340 girls would have been vaccinated anyway, as the control group suggests.

From these girls not all of them would suffer from cervical cancer if the second dose had not been applied. To determine the potential impact of the second dose on cervical cancer incidence, I set out to calculate a straightforward probability. First, In Colombia, there were 4,742 new cases of cervical cancer in 2020 out of 25,898,320 females (Globocan, 2021). Thus, for simplicity, it is plausible to assume that the global probability of getting the disease in one year is  $4,742/25,898,320$ . However, this probability takes into account both unvaccinated and vaccinated girls. Therefore to obtain the probabilities for each group, I estimated the following equation:

$$P_0(1 - X - Y) + P_0P_xX + P_0P_yY = \frac{4742}{25898320} \quad (4)$$

In equation (4),  $P_0$  denotes the probability of cervical cancer among unvaccinated women, while  $X$  and  $Y$  denote the proportion of women receiving one and two doses of the vaccine, respectively.  $P_x$  signifies the complement of the reduction in cervical cancer probability for women administered one dose of the vaccine.  $P_y$  indicates the complement of reducing cervical cancer probability for women who have received two vaccine doses.

Regarding  $X$  and  $Y$ , the information is available from (Ministerio de Salud y Protección Social de Colombia, 2020). The national coverage for the first doses in 2019 was 34.1%, while it was 11.1% for the second doses. Regarding  $P_x$  and  $P_y$ , completing the HPV vaccination schedule provides protection ranging from 70% to 90% against cervical cancer (Joura et al., 2014; Serrano et al., 2012; De Sanjose et al., 2010). Similarly, Kavanagh et al. (2014) demonstrated that two doses are more effective than a single dose in preventing HPV infection. In particular, they reported that two doses could offer 27% p.p. greater prevention against infection compared to a single dose. In terms of preventing high-grade histological lesions, another study found that two doses demonstrated statistically significant effects, whereas one dose did not (Crowe et al., 2014).

For simplicity, I will assume that the reduced probability of contracting cervical cancer is 80% for girls with complete vaccination schemes and 45% for those with incomplete schemes. Consequently,  $P_x$  equals 0.55 and  $P_y$  equals 0.2. Then, the probability of unvaccinated women contracting cervical cancer is 0.000239, while it is 0.000131 for those with one dose and 0.000047 for those with two doses. Thus, among the 296 girls who completed the HPV vaccination schedule, 0.038 would have developed cervical cancer if they had not received the second vaccine. Now, this number is reduced to 0.013, yielding a difference of 0.025 girls saved from cervical cancer.

The costs associated with cervical cancer can be significant. In 2004, Tapiero García et al. (2008) estimated that the combined direct and indirect costs for a case of cervical cancer amounted to 78,391,031 COP per woman. However, adjusting this number to a current value

due to inflation for 2022, these costs would be 176,453,324 COP per woman ( 39,211.85 USD). Consequently, the benefits of this intervention can be calculated as  $176,453,324 * 0.025$ , which equals 4,411,333.1 COP ( 980.3 USD). Dividing this amount by the total expenditure on the intervention yields a cost-effectiveness ratio of 6.03 COP (i.e., 6.03 COP per 1 COP spent). As a result, the intervention is cost-effective, and the cost-effectiveness ratio could be higher as the treated population expands because the labor cost remains relatively constant, irrespective of the sample size. Hence, as more parents receive the intervention, the cost per parent would decrease, leading to a higher cost-effectiveness ratio.

## 8 Conclusion

In this paper, I present the lessons from a field experiment that employs text messages using decision aids to encourage parents from Colombia to vaccinate their daughters with the second dose of the HPV vaccine. The results suggest that the SMS campaign is a cost-effective strategy to increase vaccination rates against HPV in a large-scale implementation. In particular, the effects are outstanding since the impacts of the individual messages go from 53% to 105% in the vaccination rates compared to the pure control group. Additionally, the dynamics of the effects indicate that being persistent works, at least in the short term. Similarly, it is interesting to note that sending more messages is not necessarily better, as sending a single soft-default message has a comparable effect to its peers that also have an ownership reminder. Thus, the HS can save funds by only sending one message and obtaining similar results. At the same time, it increases the cost-effectiveness ratio of the intervention.

Moreover, there are some heterogeneous effects regarding age and people inside Bogotá. One possible line of research would be to discover effective ways to incentivize the older population of girls. In the same way, we could expand the data set to see if there are indeed heterogeneous effects from being in Bogota or if it is simply because the information is not fully available. It

is also necessary to expand the set of covariates to see if there are more heterogeneous effects. An additional line for exploration may also analyze the spillover effects of these messages on the uptake of other vaccines within the experimental sample. Similarly, there are also areas for improvement and further research. One possibility is to explore additional behavioral interventions that leverage parental altruism toward their daughters. Furthermore, exploring the potential benefits of employing different strategies, like applications, websites, or online marketing, could be beneficial. Finally, studying the long-term effects of these messages on vaccination rates can provide valuable insights for future policy implementation.

From a policy perspective, this study improves an existing strategy employed by the HS by incorporating behavioral insights. These messages could be a practical strategy for developing countries to motivate vaccination since they are easy to implement and low-cost. Hence, this strategy can improve vaccination coverage and overall public health outcomes. However, more research is needed to determine the best practices for text message campaigns to promote vaccination.

## 9 References

- Andersson, N., Cockcroft, A., Ansari, N. M., Omer, K., Baloch, M., Ho Foster, A., ... Soberanis, J. L. (2009). Evidence-based discussion increases childhood vaccination uptake: a randomised cluster controlled trial of knowledge translation in pakistan. *BMC International Health and Human Rights*, *9*, 1–9.
- Atkinson, K. M., Westeinde, J., Ducharme, R., Wilson, S. E., Deeks, S. L., Crowcroft, N., ... Wilson, K. (2016). Can mobile technologies improve on-time vaccination? a study piloting maternal use of immunizeca, a pan-canadian immunization app. *Human vaccines & immunotherapeutics*, *12*(10), 2654–2661.
- Azarpanah, H., Farhadloo, M., Vahidov, R., & Pilote, L. (2021). Vaccine hesitancy: evidence from an adverse events following immunization database, and the role of cognitive biases. *BMC Public Health*, *21*(1), 1–13.
- Banerjee, A. V., Duflo, E., Glennerster, R., & Kothari, D. (2010). Improving immunisation coverage in rural india: clustered randomised controlled evaluation of immunisation campaigns with and without incentives. *Bmj*, *340*.
- Basinga, P., Gertler, P. J., Binagwaho, A., Soucat, A. L., Sturdy, J., & Vermeersch, C. M. (2011). Effect on maternal and child health services in rwanda of payment to primary

health-care providers for performance: an impact evaluation. *The Lancet*, 377(9775), 1421–1428.

Benartzi, S., Beshears, J., Milkman, K. L., Sunstein, C. R., Thaler, R. H., Shankar, M., . . . Galing, S. (2017). Should governments invest more in nudging? *Psychological science*, 28(8), 1041–1055.

Betsch, C., Brewer, N. T., Brocard, P., Davies, P., Gaissmaier, W., Haase, N., . . . others (2012). Opportunities and challenges of web 2.0 for vaccination decisions. *Vaccine*, 30(25), 3727–3733.

Boksmati, N., Butler-Henderson, K., Anderson, K., & Sahama, T. (2016). The effectiveness of sms reminders on appointment attendance: a meta-analysis. *Journal of medical systems*, 40, 1–10.

Brewer, N. T., Chapman, G. B., Gibbons, F. X., Gerrard, M., McCaul, K. D., & Weinstein, N. D. (2007). Meta-analysis of the relationship between risk perception and health behavior: the example of vaccination. *Health psychology*, 26(2), 136.

Brugha, R., & Kevany, J. (1996). Maximizing immunization coverage through home visits: a controlled trial in an urban area of ghana. *Bulletin of the World Health Organization*, 74(5), 517.

Caskey, R., Sherman, E. G., Beskin, K., Rapport, R., Xia, Y., & Schwartz, A. (2017). A behavioral economic approach to improving human papillomavirus vaccination. *Journal of Adolescent Health*, 61(6), 755–760.

Castro, C., Marín, M., & Muñoz, N. (2020). Hpv vaccination in colombia. from a nightmare to a bright and promising dawn. *www.HPVWorld.com*, 105.

Chao, C., Preciado, M., Slezak, J., & Xu, L. (2015). A randomized intervention of reminder letter for human papillomavirus vaccine series completion. *Journal of Adolescent Health*, 56(1), 85–90.

Chapman, G. B., Li, M., Colby, H., & Yoon, H. (2010). Opting in vs opting out of influenza vaccination. *Jama*, 304(1), 43–44.

Crowe, E., Pandeya, N., Brotherton, J. M., Dobson, A. J., Kisely, S., Lambert, S. B., & Whiteman, D. C. (2014). Effectiveness of quadrivalent human papillomavirus vaccine for the prevention of cervical abnormalities: case-control study nested within a population based screening programme in australia. *Bmj*, 348.

Dai, H., Saccardo, S., Han, M. A., Roh, L., Raja, N., Vangala, S., . . . Croymans, D. M. (2021). Behavioural nudges increase covid-19 vaccinations. *Nature*, 597(7876), 404–409.

De Sanjose, S., Quint, W. G., Alemany, L., Geraets, D. T., Klaustermeier, J. E., Lloveras, B., . . . others (2010). Human papillomavirus genotype attribution in invasive cervical cancer: a retrospective cross-sectional worldwide study. *The lancet oncology*, 11(11), 1048–1056.

Distefano, M., Riccardi, S., Capelli, G., Costantini, B., Petrillo, M., Ricci, C., . . . Ferrandina, G. (2008). Quality of life and psychological distress in locally advanced cervical cancer

patients administered pre-operative chemoradiotherapy. *Gynecologic oncology*, *111*(1), 144–150.

Duflo, E. (2020). Field experiments and the practice of policy. *American Economic Review*, *110*(7), 1952–73.

Ericson, K. M. M. (2011). Forgetting we forget: Overconfidence and memory. *Journal of the European Economic Association*, *9*(1), 43–60.

Fadda, M., Galimberti, E., Fiordelli, M., Romanò, L., Zanetti, A., & Schulz, P. J. (2017). Effectiveness of a smartphone app to increase parents' knowledge and empowerment in the mmr vaccination decision: A randomized controlled trial. *Human vaccines & immunotherapeutics*, *13*(11), 2512–2521.

Glanz, J. M., Wagner, N. M., Narwaney, K. J., Kraus, C. R., Shoup, J. A., Xu, S., ... Daley, M. F. (2017). Web-based social media intervention to increase vaccine acceptance: a randomized controlled trial. *Pediatrics*, *140*(6).

Globocan. (2021). *Colombia*. <https://gco.iarc.fr/today/data/factsheets/populations/170-colombia-fact-sheets.pdf>.

Goss, M. D., Temte, J. L., Barlow, S., Temte, E., Bell, C., Birstler, J., & Chen, G. (2020). An assessment of parental knowledge, attitudes, and beliefs regarding influenza vaccination. *Vaccine*, *38*(6), 1565–1571.

Gust, D., Brown, C., Sheedy, K., Hibbs, B., Weaver, D., & Nowak, G. (2005). Immunization attitudes and beliefs among parents: beyond a dichotomous perspective. *American journal of health behavior*, *29*(1), 81–92.

Halpern, D., & Sanders, M. (2016). Nudging by government: Progress, impact, & lessons learned. *Behavioral Science & Policy*, *2*(2), 52–65.

Joura, E. A., Ault, K. A., Bosch, F. X., Brown, D., Cuzick, J., Ferris, D., ... others (2014). Attribution of 12 high-risk human papillomavirus genotypes to infection and cervical disease. *Cancer Epidemiology, Biomarkers & Prevention*, *23*(10), 1997–2008.

Karlan, D., Morten, M., & Zinman, J. (2012). *A personal touch: Text messaging for loan repayment* (Tech. Rep.). National Bureau of Economic Research.

Kavanagh, K., Pollock, K., Potts, A., Love, J., Cuschieri, K., Cubie, H., ... Donaghy, M. (2014). Introduction and sustained high coverage of the hpv bivalent vaccine leads to a reduction in prevalence of hpv 16/18 and closely related hpv types. *British journal of cancer*, *110*(11), 2804–2811.

Kendrick, D., Hewitt, M., Dewey, M., Elkan, R., Blair, M., Robinson, J., ... Brummell, K. (2000). The effect of home visiting programmes on uptake of childhood immunization: a systematic review and meta-analysis. *Journal of Public Health*, *22*(1), 90–98.

Kharbanda, E. O., Stockwell, M. S., Fox, H. W., Andres, R., Lara, M., & Rickert, V. I. (2011). Text message reminders to promote human papillomavirus vaccination. *Vaccine*, *29*(14), 2537–2541.

- Lee, D. S. (2009). Training, wages, and sample selection: Estimating sharp bounds on treatment effects. *The Review of Economic Studies*, 76(3), 1071–1102.
- Lehmann, B. A., Chapman, G. B., Franssen, F. M., Kok, G., & Ruiter, R. A. (2016). Changing the default to promote influenza vaccination among health care workers. *Vaccine*, 34(11), 1389–1392.
- Li, X., Mukandavire, C., Cucunuba, Z. M., Londono, S. E., Abbas, K., Clapham, H. E., . . . others (2021). Estimating the health impact of vaccination against ten pathogens in 98 low-income and middle-income countries from 2000 to 2030: a modelling study. *The Lancet*, 397(10272), 398–408.
- Lobel, O., & Amir, O. (2011). Healthy choices: Regulatory design and processing modes of health decisions. *Available at SSRN 1876734*.
- Martínez, M., Estévez, A., Quijada, H., Walteros, D., Tolosa, N., Paredes, A., . . . others (2015). Brote de evento de etiología desconocida en el municipio de el carmen de bolívar, bolívar, 2014. *Informe Quincenal Epidemiológico Nacional*, 20(3-4), 41–77.
- Matheson, E. C., Derouin, A., Gagliano, M., Thompson, J. A., & Blood-Siegfried, J. (2014). Increasing hpv vaccination series completion rates via text message reminders. *Journal of Pediatric Health Care*, 28(4), e35–e39.
- McDaniel, M. A., & Einstein, G. O. (2007). Prospective memory: An overview and synthesis of an emerging field.
- Milkman, K. L., Patel, M. S., Gandhi, L., Graci, H. N., Gromet, D. M., Ho, H., . . . others (2021). A megastudy of text-based nudges encouraging patients to get vaccinated at an upcoming doctor’s appointment. *Proceedings of the National Academy of Sciences*, 118(20).
- Ministerio de Salud y Protección Social de Colombia. (2020). *Plantillas de reporte mensual - sistemas de información - mps*.
- Morgan, K. L., & Rubin, D. B. (2012). Rerandomization to improve covariate balance in experiments. *The Annals of Statistics*, 40(2), 1263–1282.
- Mukherjee, A., Kumar, G., Turuk, A., Bhalla, A., Bingi, T. C., Bhardwaj, P., . . . others (2022). Vaccination saves lives: a real-time study of patients with chronic diseases and severe covid-19 infection. *QJM: An International Journal of Medicine*.
- Muralidharan, K., & Niehaus, P. (2017). Experimentation at scale. *Journal of Economic Perspectives*, 31(4), 103–124.
- Nickerson, R. S. (1998). Confirmation bias: A ubiquitous phenomenon in many guises. *Review of general psychology*, 2(2), 175–220.
- Nogueira-Rodrigues, A. (2019). Hpv vaccination in latin america: global challenges and feasible solutions. *American Society of Clinical Oncology Educational Book*, 39, e45–e52.
- Nowak, G. J., Gellin, B. G., MacDonald, N. E., Butler, R., et al. (2015). Addressing vaccine hesitancy: The potential value of commercial and social marketing principles and practices. *Vaccine*, 33(34), 4204–4211.

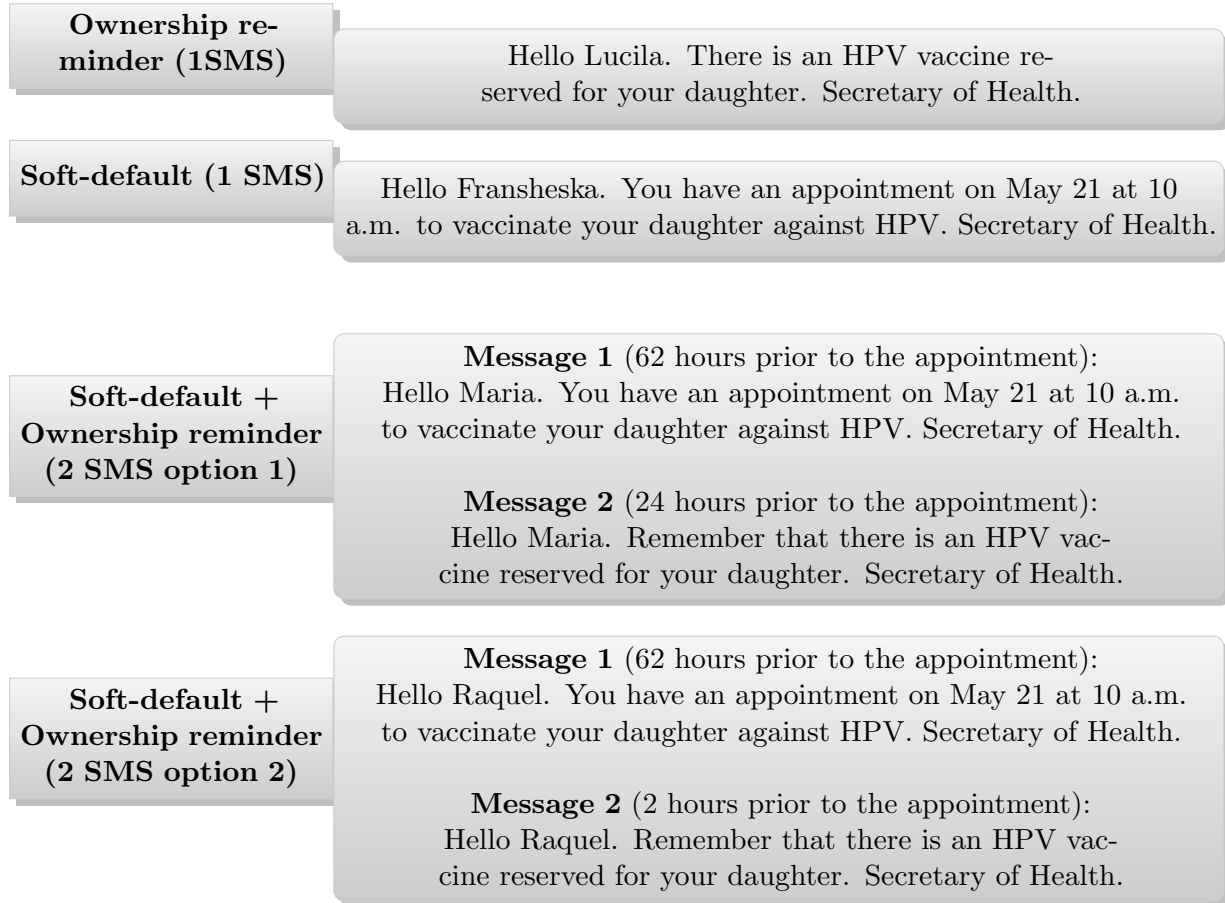
- Nuscheler, R., & Roeder, K. (2016). To vaccinate or to procrastinate? that is the prevention question. *Health economics*, *25*(12), 1560–1581.
- Owais, A., Hanif, B., Siddiqui, A. R., Agha, A., & Zaidi, A. K. (2011). Does improving maternal knowledge of vaccines impact infant immunization rates? a community-based randomized-controlled trial in karachi, pakistan. *BMC public health*, *11*(1), 1–8.
- Phillips, A., Patel, C., Pillsbury, A., Brotherton, J., & Macartney, K. (2018). Safety of human papillomavirus vaccines: an updated review. *Drug safety*, *41*(4), 329–346.
- Rand, C. M., Vincelli, P., Goldstein, N. P., Blumkin, A., & Szilagyi, P. G. (2017). Effects of phone and text message reminders on completion of the human papillomavirus vaccine series. *Journal of Adolescent Health*, *60*(1), 113–119.
- Ritov, I., & Baron, J. (1990). Reluctance to vaccinate: Omission bias and ambiguity. *Journal of behavioral decision making*, *3*(4), 263–277.
- Robertson, L., Mushati, P., Eaton, J. W., Dumba, L., Mavise, G., Makoni, J., ... others (2013). Effects of unconditional and conditional cash transfers on child health and development in zimbabwe: a cluster-randomised trial. *The Lancet*, *381*(9874), 1283–1292.
- Samuelson, W., & Zeckhauser, R. (1988). Status quo bias in decision making. *Journal of risk and uncertainty*, *1*, 7–59.
- Serrano, B., Alemany, L., Tous, S., Bruni, L., Clifford, G. M., Weiss, T., ... de Sanjosé, S. (2012). Potential impact of a nine-valent vaccine in human papillomavirus related cervical disease. *Infectious agents and cancer*, *7*(1), 1–13.
- Shah, R., Nwankwo, C., Kwon, Y., & Corman, S. L. (2020). Economic and humanistic burden of cervical cancer in the united states: results from a nationally representative survey. *Journal of Women's Health*, *29*(6), 799–805.
- Simas, C., Munoz, N., Arregoces, L., & Larson, H. J. (2019). Hpv vaccine confidence and cases of mass psychogenic illness following immunization in carmen de bolivar, colombia. *Human vaccines & immunotherapeutics*, *15*(1), 163–166.
- Stockwell, M. S., Westhoff, C., Kharbanda, E. O., Vargas, C. Y., Camargo, S., Vawdrey, D. K., & Castaño, P. M. (2014). Influenza vaccine text message reminders for urban, low-income pregnant women: a randomized controlled trial. *American journal of public health*, *104*(S1), e7–e12.
- Sung, H., Ferlay, J., Siegel, R. L., Laversanne, M., Soerjomataram, I., Jemal, A., & Bray, F. (2021). Global cancer statistics 2020: Globocan estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA: a cancer journal for clinicians*, *71*(3), 209–249.
- Tapiero García, N., et al. (2008). Costos socioeconómicos del cáncer de estómago, cervix y seno en colombia durante el año de 2004.
- Tasoff, J., & Letzler, R. (2014). Everyone believes in redemption: Nudges and overoptimism in costly task completion. *Journal of Economic Behavior & Organization*, *107*, 107–122.

- Tentori, K., Pighin, S., Giovanazzi, G., Grignolio, A., Timberlake, B., & Ferro, A. (2022). Nudging covid-19 vaccine uptake by changing the default: A randomized controlled trial. *Medical Decision Making*, 42(6), 837–841.
- Tull, F., Borg, K., Knott, C., Beasley, M., Halliday, J., Faulkner, N., . . . Bragge, P. (2019). Short message service reminders to parents for increasing adolescent human papillomavirus vaccination rates in a secondary school vaccine program: a randomized control trial. *Journal of Adolescent Health*, 65(1), 116–123.
- Tversky, A., & Kahneman, D. (1973). Availability: A heuristic for judging frequency and probability. *Cognitive psychology*, 5(2), 207–232.
- Tversky, A., & Kahneman, D. (1991). Loss aversion in riskless choice: A reference-dependent model. *The quarterly journal of economics*, 106(4), 1039–1061.
- WHO. (2022). *Cervical cancer*. Retrieved 2023-01-15, from <https://www.who.int/news-room/fact-sheets/detail/cervical-cancer#:~:text=A%20large%20majority%20of%20cervical,some%20may%20be%20repeatedly%20infected.>
- Wynn, C. S., Catalozzi, M., Kolff, C. A., Holleran, S., Meyer, D., Ramakrishnan, R., & Stockwell, M. S. (2021). Personalized reminders for immunization using short messaging systems to improve human papillomavirus vaccination series completion: parallel-group randomized trial. *JMIR mHealth and uHealth*, 9(12), e26356.
- Yagi, A., Ueda, Y., Egawa-Takata, T., Tanaka, Y., Morimoto, A., Terai, Y., . . . others (2016). Development of an efficient strategy to improve hpv immunization coverage in japan. *BMC Public Health*, 16(1), 1–11.

# Appendix

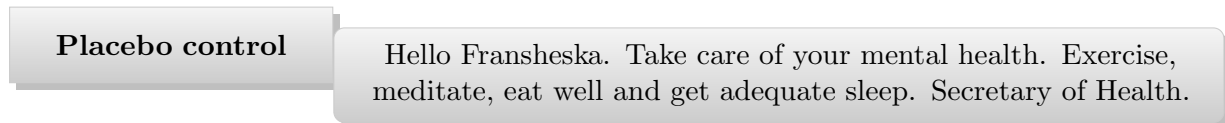
## Figures

Figure A1: SMS Content for each treatment



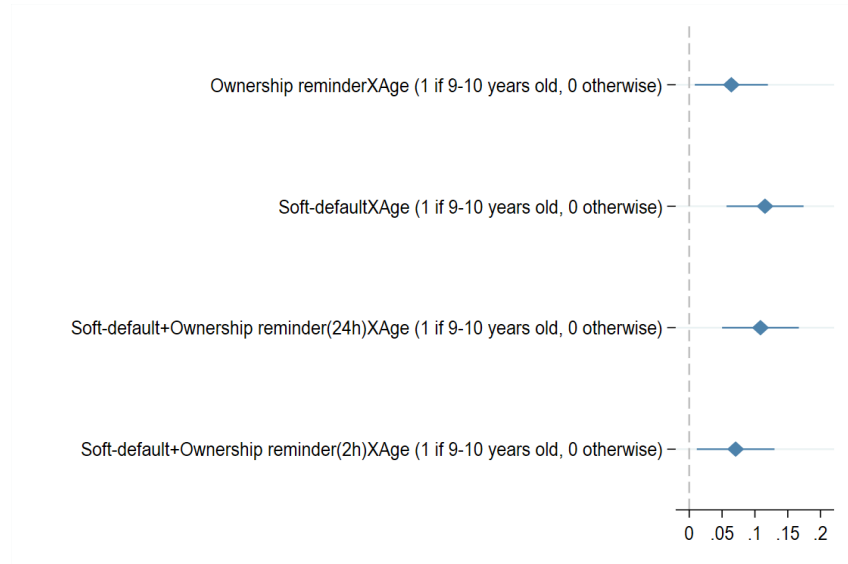
Notes: The figure presents the text messages sent for each treatment. Each message has the name of the mother and the information of the sender. The first two treatments only send one message, while the other two send two messages.

Figure A2: SMS Content for placebo control



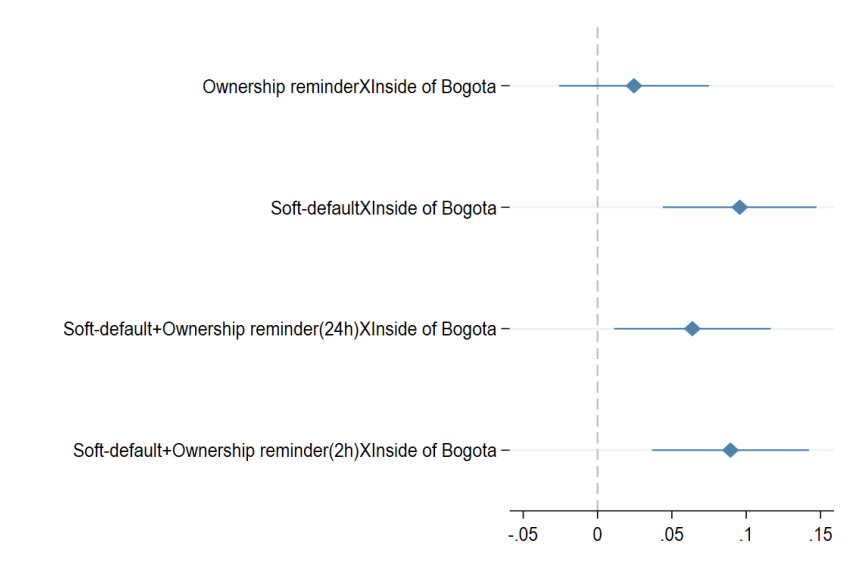
Notes: The figure shows the message used as a placebo control. It has nothing to do with HPV vaccination, but it is a message that the Health Secretariat could send for the welfare of the people.

Figure A3: Heterogeneous treatment effects for variable Age (1 if 9-10 years old, 0 otherwise)



Notes: The X-axis represents the heterogeneous effect of the individual treatments and the variable Age (1 if 9-10 years old, 0 otherwise), calculated by estimating equation (2), and using pure control for comparison. The horizontal bars signify 95% confidence intervals, with robust standard errors.

Figure A4: Heterogeneous treatment effects for variable Inside of Bogota



Notes: The X-axis represents the heterogeneous effect of the individual treatments and the variable Inside of Bogota, calculated by estimating equation (2), and using pure control for comparison. The horizontal bars signify 95% confidence intervals, with robust standard errors.

Figure A5: Heterogeneous treatment effects for variable Subsidized or uninsured scheme



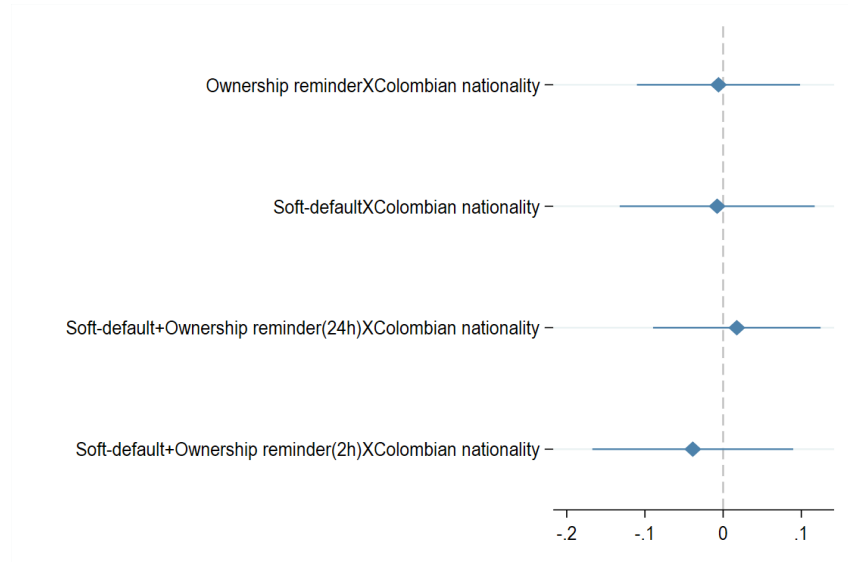
Notes: The X-axis represents the heterogeneous effect of the individual treatments and the variable Subsidized or uninsured scheme, calculated by estimating equation (2), and using pure control for comparison. The horizontal bars signify 95% confidence intervals, with robust standard errors.

Figure A6: Heterogeneous treatment effects for variable Displaced by the armed conflict



Notes: The X-axis represents the heterogeneous effect of the individual treatments and the variable Displaced by the armed conflict, calculated by estimating equation (2), and using pure control for comparison. The horizontal bars signify 95% confidence intervals, with robust standard errors.

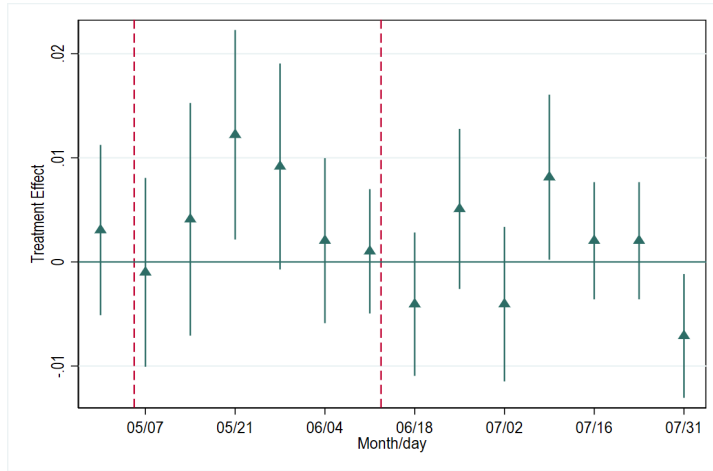
Figure A7: Heterogeneous treatment effects for variable Colombian nationality



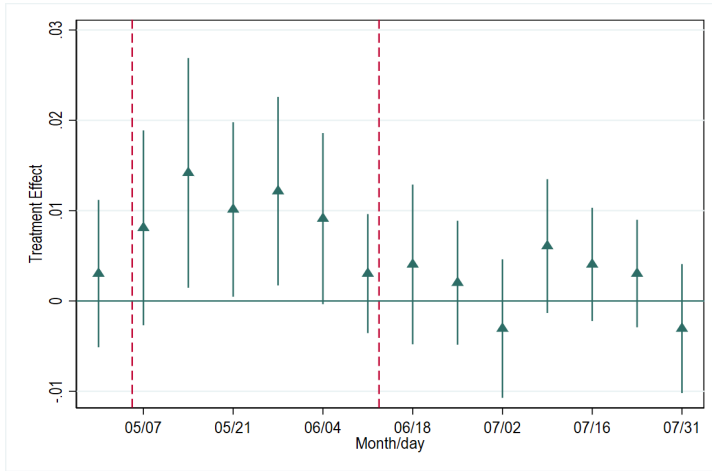
Notes: The X-axis represents the heterogeneous effect of the individual treatments and the variable Colombian nationality, calculated by estimating equation (2), and using pure control for comparison. The horizontal bars signify 95% confidence intervals, with robust standard errors.

Figure A8: The dynamic effects by week using the placebo control

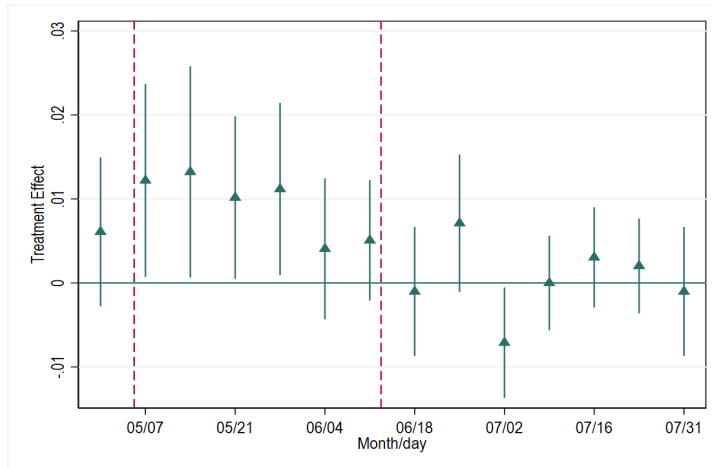
(a) Ownership reminder



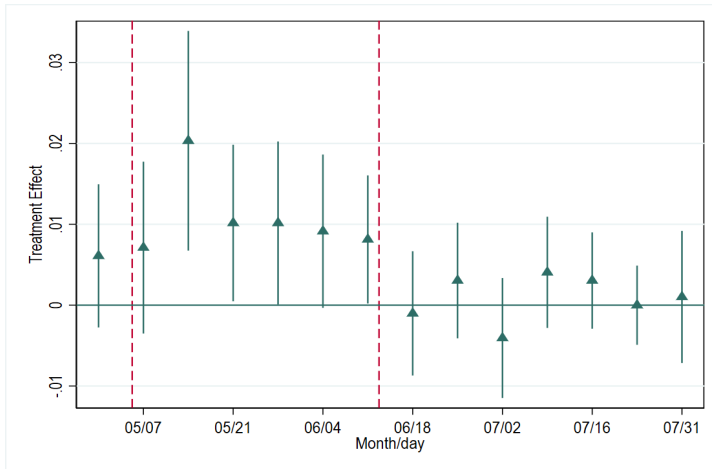
(b) Soft-default only



(c) Soft-default+Ownership reminder(62 h+24 h pre-appt)



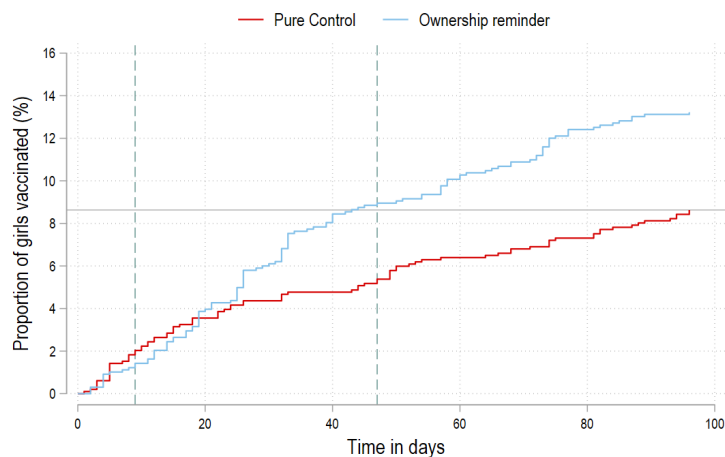
(d) Soft-default+Ownership reminder(62 h+2 h pre-appt)



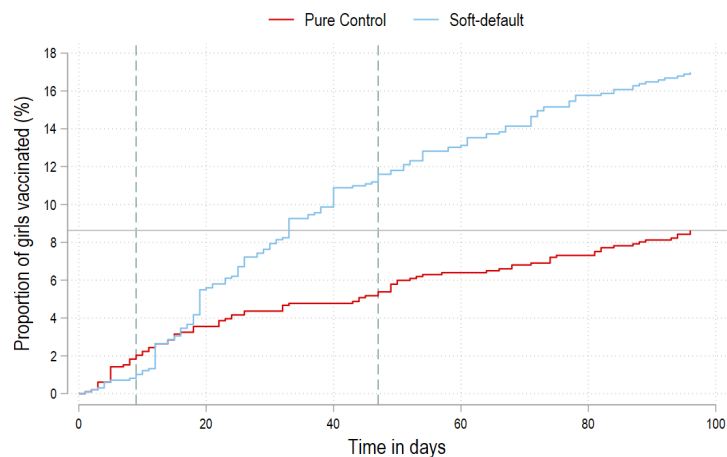
Notes: The X-axis represents the week in which the outcome was evaluated. The Y-axis illustrates the treatment effects, calculated by combining the data from all periods, estimating equation (1) with week dummies and one treatment dummy per period, and using the placebo control for comparison. The vertical bars signify 95% confidence intervals, with robust standard errors. Dashed vertical lines indicate the start and end dates of the campaign.

Figure A9: Kaplan-Meier curves illustrating the proportion of girls who received the second dose -Pure control

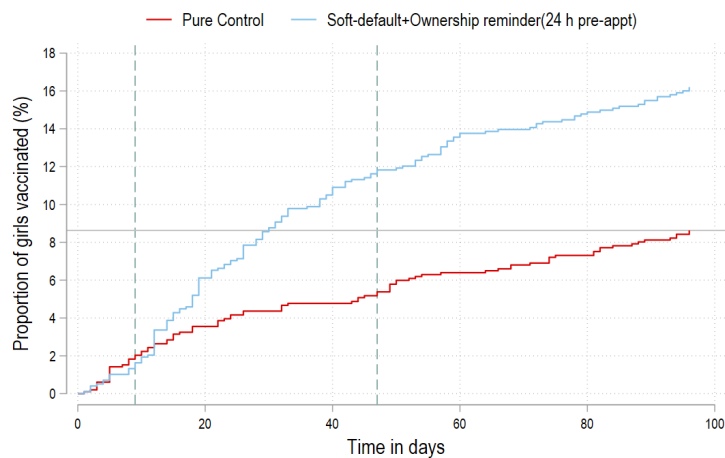
(a) Ownership reminder



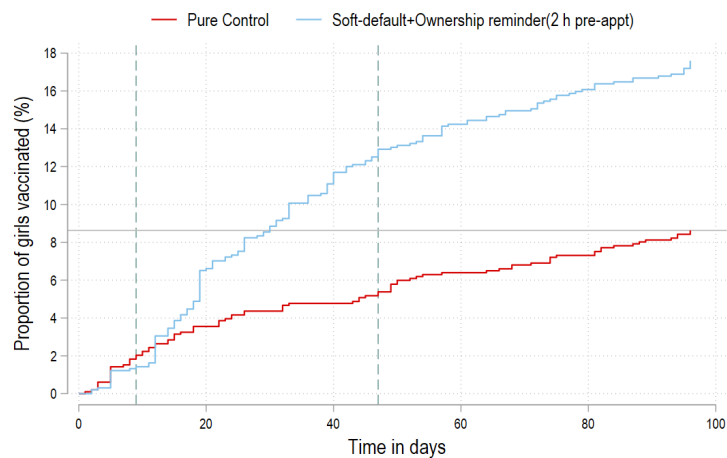
(b) Soft-default only



(c) Soft-default+Ownership reminder(62 h+24 h pre-appt)

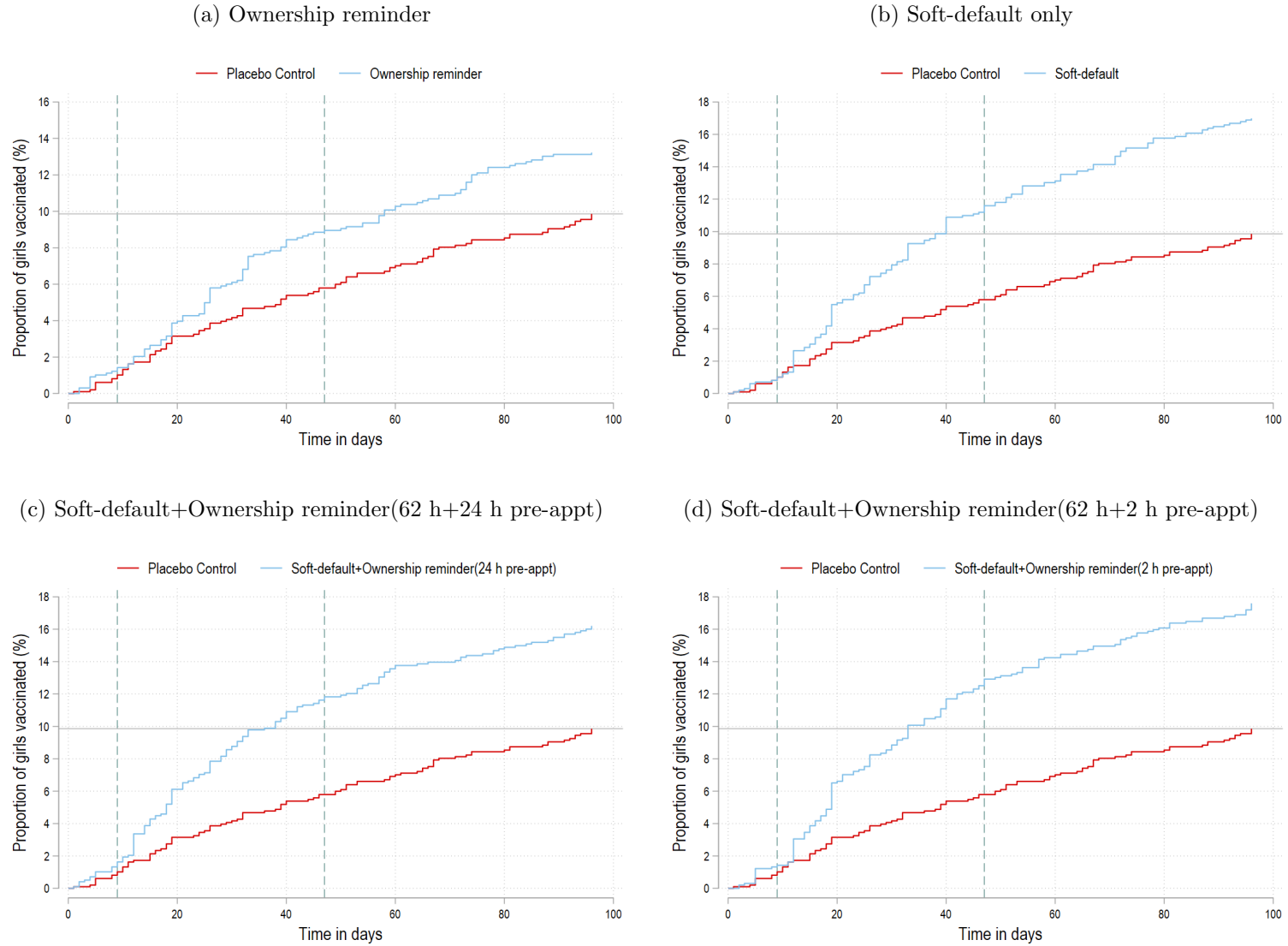


(d) Soft-default+Ownership reminder(62 h+2 h pre-appt)



Notes: Kaplan-Meier curves illustrate the percentage of girls in the pure control group (red curve) and the treatments (blue curve) who received the second dose of the HPV vaccine by a specific day. Dashed vertical lines indicate the beginning and end dates of the SMS campaign, while the solid horizontal line indicates that 8.62% of girls in the pure control group had obtained the second dose by the conclusion of the analysis period.

Figure A10: Kaplan-Meier curves illustrating the proportion of girls who received the second dose -Placebo control



Notes: Kaplan-Meier curves illustrate the percentage of girls in the placebo control group (red curve) and the treatments (blue curve) who received the second dose of the HPV vaccine by a specific day. Dashed vertical lines indicate the beginning and end dates of the SMS campaign, while the solid horizontal line indicates that 9.85% of girls in the placebo control group had obtained the second dose by the conclusion of the analysis period.

# Tables

Table A1: Randomization Balance Analysis

Variable	(1)	(2)	(3)	(4)	(5)	(6)	T-test				
	Pure Control Mean/SE	Placebo Control Mean/SE	Ownership Reminder Mean/SE	Soft-default Mean/SE	(3)+(4) (24 h pre-appt) Mean/SE	(3)+(4) (2 h pre-appt) Mean/SE	(1)-(2)	(1)-(3)	(1)-(4)	(1)-(5)	(1)-(6)
EPS Sanitas	0.144 (0.011)	0.131 (0.011)	0.145 (0.011)	0.152 (0.011)	0.153 (0.011)	0.158 (0.012)	0.013	-0.001	-0.008	-0.009	-0.013
EPS Salud Total	0.092 (0.009)	0.105 (0.010)	0.100 (0.010)	0.098 (0.009)	0.108 (0.010)	0.104 (0.010)	-0.012	-0.007	-0.006	-0.015	-0.011
EPS Famisanar	0.216 (0.013)	0.202 (0.013)	0.215 (0.013)	0.194 (0.013)	0.203 (0.013)	0.193 (0.013)	0.014	0.002	0.023	0.013	0.023
EPS Compensar	0.180 (0.012)	0.183 (0.012)	0.195 (0.013)	0.185 (0.012)	0.172 (0.012)	0.188 (0.012)	-0.003	-0.016	-0.005	0.008	-0.008
EPS Capital Salud	0.095 (0.009)	0.101 (0.010)	0.083 (0.009)	0.102 (0.010)	0.102 (0.010)	0.095 (0.009)	-0.005	0.012	-0.007	-0.006	0.001
Other EPS	0.272 (0.014)	0.279 (0.014)	0.261 (0.014)	0.269 (0.014)	0.262 (0.014)	0.263 (0.014)	-0.007	0.011	0.003	0.010	0.009
Contributory Scheme	0.827 (0.012)	0.801 (0.013)	0.815 (0.012)	0.810 (0.012)	0.814 (0.012)	0.812 (0.012)	0.026	0.013	0.017	0.013	0.015
Uninsured	0.012 (0.003)	0.012 (0.003)	0.015 (0.004)	0.015 (0.004)	0.011 (0.003)	0.012 (0.004)	0.000	-0.003	-0.003	0.001	-0.000
Subsidized Scheme	0.112 (0.010)	0.131 (0.011)	0.115 (0.010)	0.129 (0.011)	0.126 (0.011)	0.125 (0.011)	-0.019	-0.003	-0.017	-0.014	-0.013
Other scheme	0.049 (0.007)	0.056 (0.007)	0.055 (0.007)	0.046 (0.007)	0.049 (0.007)	0.051 (0.007)	-0.007	-0.006	0.003	-0.000	-0.002
Belongs to some ethnic group	0.002 (0.001)	0.005 (0.002)	0.006 (0.002)	0.007 (0.003)	0.003 (0.002)	0.007 (0.003)	-0.003	-0.004	-0.005*	-0.001	-0.005*
Displaced by the armed conflict	0.012 (0.003)	0.010 (0.003)	0.015 (0.004)	0.010 (0.003)	0.008 (0.003)	0.018 (0.004)	0.002	-0.003	0.002	0.004	-0.006
Colombian nationality	0.969 (0.006)	0.959 (0.006)	0.957 (0.006)	0.963 (0.006)	0.966 (0.006)	0.961 (0.006)	0.009	0.011	0.005	0.002	0.007
Girl's age in years	11.237 (0.064)	11.278 (0.065)	11.243 (0.063)	11.217 (0.063)	11.275 (0.065)	11.264 (0.065)	-0.042	-0.007	0.020	-0.039	-0.028
N	985	985	983	986	984	984					

Notes: The table presents the randomization balance analysis of the experiment. For each type of control or treatment, means and standard errors are reported for each pre-treatment variable. Column 5 is the combination of soft-default options (62h prior to the appointment) and ownership reminders (24h prior to the appointment), while column 6 is the version that uses the ownership reminder 2 hours before the appointment. The values displayed for t-tests are the differences in the means across the groups versus the pure control group.\*\*\*, \*\*, and \* indicate significance at the 1, 5, and 10 percent critical levels.

Table A2: Effect of the SMS campaign on HPV vaccination schedule completion-without controls

Variables	HPV vaccine schedule adherence		
	(1)	(2)	(3)
Ownership reminder	0.0460*** (0.0140)	0.0328** (0.0144)	0.0394*** (0.0126)
Soft-default	0.0861*** (0.0150)	0.0729*** (0.0154)	0.0795*** (0.0137)
Soft-default+Ownership reminder (2 SMS: 62 h+24 h pre-appt)	0.0783*** (0.0148)	0.0651*** (0.0152)	0.0717*** (0.0135)
Soft-default+Ownership reminder (2 SMS: 62 h+2 h pre-appt)	0.0905*** (0.0151)	0.0773*** (0.0155)	0.0839*** (0.0138)
Observations	4,922	4,922	5,907
Controls	No	No	No
Control type	Pure control	Placebo control	All controls
Control mean	0.0863	0.0995	0.0929
P-value, Ownership reminder only=other treatments	0.021	0.021	0.021
P-value, Soft-default only=other soft-default treatments	0.766	0.766	0.766

Notes: The dependent variable is a dummy equal to 1 whether the girl is vaccinated with the second dose of the HPV vaccine during the SMS campaign window (six weeks) or two months after the end of the intervention. Each column compares the effects of interventions against a different type of control. Column (1) uses the pure control group, column (2) utilizes the placebo control group, and column (3) incorporates a combined group of both control types. Specifications do not include controls. P-value, Ownership reminder only=other treatments tests whether the ownership reminder's effect equals the other treatments' effects on the given outcome. P-value, Soft-default only=other soft-default treatments assesses whether Soft-default only and other soft-default treatments have equal impacts on the dependent variable. Robust standard errors are in parentheses. \*\*\*, \*\* and \* indicate statistical significance at the 1%, 5% and 10% respectively.

Table A3: Heterogeneous treatment effects

Variables	(1)	(2)	(3)	(4)	(5)	(6)
Decision aids	0.076*** (0.012)	0.035*** (0.013)	0.033*** (0.012)	0.073*** (0.012)	0.084** (0.041)	0.075*** (0.011)
Decision aidsXAge (1 if 9-10 years old, 0 otherwise)		0.090*** (0.021)				
Decision aidsXInside of Bogota			0.068*** (0.019)			
Decision aidsXSubsidized or uninsured scheme				0.027 (0.028)		
Decision aidsXColombian nationality					-0.008 (0.043)	
Decision aidsXDisplaced by the armed conflict						0.105* (0.056)
Observations	4,922	4,922	4,922	4,922	4,922	4,922
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Control type	Pure control	Pure control	Pure control	Pure control	Pure control	Pure control
Control mean	0.0863	0.0863	0.0863	0.0863	0.0863	0.0863

Notes: The dependent variable is a dummy equal to 1 whether the girl is vaccinated with the second dose of the HPV vaccine during the SMS campaign window (six weeks) or two months after the end of the intervention. The interaction between the overall intervention (i.e., “Decision aids” pools all treatment arms.) and the variables represents the heterogeneous effects of the intervention, calculated by estimating equation (2), and using pure control for comparison. Robust standard errors are in parentheses. \*\*\*, \*\* and \* indicate statistical significance at the 1%, 5% and 10% respectively.

Table A4: Treatment Effects vs Pure Control Group-Bonferroni correction

Comparison	Contrast	Std. err.	T-test (Bonferroni)	P>  t  (Bonferroni)
Ownership reminder vs Pure control	0.046	0.014	3.32	0.009
Soft-default vs Pure control	0.087	0.015	5.91	0.000
Soft-default+Ownership reminder(24h) vs Pure control	0.08	0.015	5.45	0.000
Soft-default+Ownership reminder(2h) vs Pure control	0.091	0.015	6.14	0.000

Notes: After estimating the equation (1), the individual treatment effects and the pure control group are compared using the Bonferroni correction. The values in the table indicate the contrast between the treatments and control group, the standard error of the contrast, the T-test with Bonferroni correction, and the p-value with Bonferroni correction.

Table A5: Treatment Effects vs Placebo Control Group-Bonferroni correction

Comparison	Contrast	Std. err.	T-test (Bonferroni)	P>  t  (Bonferroni)
Ownership reminder vs Placebo control	0.031	0.014	2.17	0.304
Soft-default vs Placebo control	0.072	0.015	4.82	0.000
Soft-default+Ownership reminder(24h) vs Placebo control	0.065	0.015	4.36	0.000
Soft-default+Ownership reminder(2h) vs Placebo control	0.076	0.015	5.03	0.000

Notes: After estimating the equation (1), the individual treatment effects and the placebo control group are compared using the Bonferroni correction. The values in the table indicate the contrast between the treatments and control group, the standard error of the contrast, the T-test with Bonferroni correction, and the p-value with Bonferroni correction.

Table A6: Treatment Effects vs All Control Groups-Bonferroni correction

Comparison	Contrast	Std. err.	T-test (Bonferroni)	P>  t  (Bonferroni)
Ownership reminder vs All controls	0.039	0.013	3.08	0.020
Soft-default vs All controls	0.08	0.013	5.97	0.000
Soft-default+Ownership reminder(24h) vs All controls	0.072	0.013	5.46	0.000
Soft-default+Ownership reminder(2h) vs All controls	0.084	0.014	6.2	0.000

Notes: After estimating the equation (1), the individual treatment effects and all control groups are compared using the Bonferroni correction. The values in the table indicate the contrast between the treatments and control group, the standard error of the contrast, the T-test with Bonferroni correction, and the p-value with Bonferroni correction.