NUDGING VACCINATION IN LATIN AMERICA: INSIGHTS FROM THREE FIELD EXPERIMENTS IN BEHAVIORAL ECONOMICS

by

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A Dissertation
Submitted to the
Graduate Faculty
of
George Mason University
in Partial Fulfillment of
The Requirements for the Degree
of
Doctor of Philosophy
Economics

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Date: ________________________________ Spring Semester 2023
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Fairfax, VA

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DEDICATION

I dedicate this work to my family, friends, and mentors, who supported and encouraged me to finish this program. Thank you for never ceasing to believe in me.

ACKNOWLEDGEMENTS

I thank my advisor, Dr. Thomas Stratmann, for his guidance, support, and patience. I am grateful to my committee members, Dr. Daniel Houser and Dr. Tyler Cowen, for their invaluable input and support. I am also grateful to Dr. Nathan Ashby for seeing the researcher in me early on and giving me a solid foundation to become one. Moreover, my work would not have been possible without Dr. Carlos Scartascini's trust in me to run the field experiments that became my dissertation and the collaboration of my colleagues Meenu Anand, Dr. Lina Diaz, and Dr. Stanislao Maldonado.

Finally, I would like to express my appreciation to my wife, Katherine Flaschen, who is a behavioral scientist herself. Her extensive knowledge about academia and social psychology has been a great source of guidance and inspiration for me throughout my academic journey. I am immensely grateful for her unwavering support, infinite patience, and the invaluable contribution of discussing with me the ideas that are central to this dissertation. Thank you, Katherine, for everything.

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ABSTRACT

NUDGING VACCINATION IN LATIN AMERICA: INSIGHTS FROM THREE FIELD EXPERIMENTS IN BEHAVIORAL ECONOMICS

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In this dissertation, I address the impact of various principles of behavioral economics on vaccination rates and attitudes toward vaccines in Latin America with an experimental economics methodology. Each experiment was implemented with government entities in the respective study locations. With the insights generated by these studies, I seek to provide evidence-based recommendations to aid governments in optimizing resource allocation toward effective health promotion.

In chapter one, I test the effect of norm nudges on increasing HPV vaccinations for parents of girls and adolescents in Bogota, Colombia, where only a minority of the population is vaccinated against HPV. Norm nudges provide social information describing the prevalence of a behavior and/or its degree of social approval. I use a text message campaign to target parents with daughters between 9 and 17 years old who need the first dose of the HPV vaccine. I compare five norm nudges, a control group, an experimental

control group, and a policy control group. Two norm nudges contain social information communicating how other people's behavior is changing over time, i.e., dynamic norm nudges. The results are based on actual HPV vaccinations from administrative data from the Secretariat of Health in Bogota. The results find that the trending norm, one of the two dynamic designs, increases average vaccination by 1.39 percent compared to the control group vaccination rate of 5.57 percent. It represents a difference in HPV vaccination rate equivalent to 25 percent compared to the control group. This study contributes to the growing literature on the applications of dynamic norm nudges on behavior change.

In chapter two, I examine the effectiveness of dynamic norm nudges on increasing second-dose HPV vaccinations for trendsetters. I follow the definition of trendsetters by Bicchieri and Funcke (2018). They define trendsetters as the initiators of norm abandonment. In this context, trendsetters are parents who vaccinated their daughters with the first-dose HPV vaccine between 2017-2020. The results are based on actual HPV vaccinations from administrative data from the Secretariat of Health in Bogota. The paper tests three variations of dynamic norm nudges that include trending norms, qualitative dynamic norms, and quantitative dynamic norms.

Contrary to chapter one, the results indicate that dynamic norms do not increase second-dose HPV vaccination rates of trendsetters. However, injunctive norms have a statistically significant marginal increase in second-dose HPV vaccinations of 5.22 percent compared to the control average of 15.2 percent. This difference is equivalent to a 34 percent difference. The study contributes to the literature on the effect of norm nudges on minority behaviors and identifies the elements that make dynamic norm nudges effective in this context. In addition, the study contributes to the literature on the specific conditions under which norm nudges are effective.

In chapter three, I test the hypothesis that online interventions grounded in the principles of behavioral economics, that is, nudges, impact COVID-19 vaccine attitudes. I test the hypothesis with a field experiment in cooperation with the government of Guanajuato, Mexico. Contrary to public health communications interventions, the behavioral economics approach assumes that individuals suffer from limited attention and cognitive resources that constrain information processing. This study's approach uses elements of gamification, heuristics, altruism, and framing to support the visual and message intervention to simplify the cognitive processing of information, thereby making information more salient. The results show that the online behavioral intervention has a positive effect on vaccine attitudes of 0.207 points on a 9-point scale from 1-9, where 1 is completely against, and 9 is completely in favor of the vaccine. Since recent studies show that vaccine attitudes have declined, low-cost interventions like the one studied in this chapter may hold the promise of containing a continued decline.

CHAPTER ONE. LEVERAGING THE TREND: DYNAMIC NORMS INCREASE VACCINATIONS

INTRODUCTION

Recent work uses nudges, which have gained wide notice since Thaler and Sunstein (2008), to study the effect of social norms on behavior change (Bicchieri and Dimant 2022). Norm nudges provide social information describing the prevalence of a behavior, i.e., descriptive norms, and its degree of social approval, i.e., injunctive norms (Cialdini et al. 1990). Scholars have studied how this information elicits or changes social expectations, ultimately resulting in an increase or decrease in the adoption of a behavior (Allcott 2011; Allcott and Rogers 2014; Alpizar et al. 2008; Belle and Cantarelli 2021; Bergquist and Nilsson, 2018; Bicchieri and Dimant 2022; Bicchieri and Xiao 2009; Bonan et al. 2020; Bursztyn et al. 2020; Cialdini et al. 1990; Constantino et al. 2022; Coleman 2007; Gerber and Rogers 2009; Hershey 1994; Moehring et al. 2023; Romley et al. 2016; Ryoo and Kim 2021; Smith et al. 2015; van Teunenbroek et al. 2020; Zhang et al. 2022). However, when a norm nudge informs that a behavior is only adopted by a minority, norm nudges can have the unintended outcome of entrenching the status quo (Bicchieri and Xiao 2009; Bicchieri and Dimant 2022; Kuang et al., 2020).

This paper contributes to previous research to address whether norm nudges can increase the adoption of a behavior that has not yet been adopted by a majority– a minority behavior. It also leverages an upward adoption trend to test the effect of dynamic norms.

Finally, it tests whether norms have differential effects based on various frames. To answer these questions, we run a field experiment through a text message campaign to increase the minority behavior of HPV vaccinations in Bogota, Colombia. The HPV vaccination rate for this age group in the city was 30 percent. The target population was parents with daughters between 9 and 17 yrs. who needed the first dose of the HPV vaccine. We test five norm nudges, an experimental control, a policy control, and a control group. Compared to previous studies that measure intention, the administrative data from the Secretariat of Health in Bogota has the advantage of testing the effect of norm nudges on actual HPV vaccinations.

Under minority behavior scenarios, there are several strategies to increase adoption with norm nudges. Cialdini's focus theory of normative conduct suggests making salient the injunctive norm to counter the descriptive norm of minority adoption (Cialdini et al. 1990; Schultz et al. 2007). Bicchieri and Dimant (2022) suggest highlighting small-scale examples of adoption. Furthermore, recent research suggests highlighting an upward trend in adoption (Aldoh et al. 2021; Cheng et al. 2022; Mortensen et al. 2017; Loschelder et al. 2019; Sparkman and Walton 2017; Milkman et al. 2022). This paper follows this literature to construct a variety of norm nudges.

Most closely related to this paper is the use of dynamic norms to increase the adoption of a minority behavior (Mortensen et al. 2017; Sparkman and Walton 2017). Based on Sparkman and Walton (2017), we refer to a norm nudge that communicates social information about one point in time as a static norm and one that uses more than one data point as a dynamic norm. Mortensen et al. (2017) and Sparkman and Walton (2017), the seminal papers on dynamic norms, found experimental subjects' behavior sensitive to information about the upward change in collective behavior. They found dynamic norms impactful despite informing subjects about the descriptive norm of minority adoption. Unlike our research on HPV vaccination, they use norm nudges to increase environmental behaviors.

This paper contributes to the growing literature on the applications of dynamic norm nudges to increase minority behaviors in different fields. In recent years, norms nudges have become a popular tool to increase sustainable behaviors (Aldoh et al. 2021; Mortensen et al. 2017; Sparkman and Walton 2017), education choices (Cheng et al. 2022; Loschelder et al. 2019), and vaccination (Milkman et al. 2022). Similar to our research, Aldoh et al. (2021) and Cheng et al. (2022) test static versus dynamic norms. However, those studies are survey experiments based on self-reported answers. Additionally, unlike our research, Loschelder et al. (2019) is a pre-post study of the effect of one dynamic norm. Closely related to our study, Milkman et al. (2022) evaluate the impact of dynamic norms on vaccinations with an RCT methodology. However, unlike our study focusing on norm nudges, Milkman et al. (2022) only tested two dynamic norms among many other non-norm nudges on influenza vaccinations.

Besides the previous research, this paper relates to the literature that tests the effect of gain and loss framing to change health behaviors. The applications of gain and loss framing have derived from prospect theory since Kahneman and Tversky (1979). However, research on the effect of these frames on the adoption of health behaviors has shown mixed results depending on whether the behavior one is trying to increase prevention or detection

(Rothman and Salovey 1997; Salovey and Williams-Piehota 2004). The design of our norm nudges is informed by this literature.

One of the caveats of our experimental design is the lack of elicitation of the target population's social expectations. Bicchieri (2017) deems it necessary to measure social expectations and conditional preferences before implementing social norms interventions. We do not conduct a representative survey of our target population to learn their perceptions of descriptive and injunctive norms. As in Schultz et al. (2007) and Allcott (2011), we risk reinforcing the lack of HPV vaccination in parents whose beliefs about HPV vaccination prevalence are higher than the descriptive norm communicated.

Our results indicate that the trending norm, one of the two dynamic designs, is the most impactful treatment. The trending norm increases average vaccination by 1.39 percent compared to the control group vaccination rate of 5.57 percent. This effect is statistically significant at the 95 percent confidence level and robust to different specifications. It represents a difference in HPV vaccination rate equivalent to 25 percent compared to the control group.

The injunctive and dynamic norm treatments show a marginal positive impact of 1.09 percent and 1.0 percent on HPV vaccinations compared to the control group. These represent a sizable increase of 19.5 percent and 18 percent on average HPV vaccination rates, respectively, compared to the control group average, and statistically significant at the 90 percent confidence level. The rest of the norm nudges and the experimental control are not statistically significant but show a positive sign in regression results. The policy control shows a negative sign, but the difference with the control group is not statistically significant.

THEORETICAL BACKGROUND

Norm nudges typically include either descriptive norms, injunctive norms, or both to elicit or change social expectations to impact the adoption of a behavior. Descriptive norms inform what individuals commonly do, and injunctive norms inform individuals of what is accepted or should be done. These can be communicated as a percentage of individuals who perform or accept a behavior. Sparkman and Walton (2017) refer to descriptive norms that inform about the current state of societal norms as static norms.

Frequently, norm nudges aim to increase the adoption of behavior that is not widely adopted. These behaviors are counternormative since these behaviors go against the established norms or expectations within a particular group (Sparkman and Walton 2017). For instance, COVID-19 vaccinations are counternormative in places where the minority believes that vaccination is the right thing to do or where only the minority is vaccinated. In those cases, a norm nudge that attempts to increase COVID-19 vaccination with a static norm that communicates minority adoption or acceptance will most likely entrench the status quo (Cialdini 1990; Bichhieri and Xiao 2009; Bicchieri and Dimant 2022; Kuang et al. 2020; Schultz et al. 2007).

This study tests the impact of a battery of norm nudges on a minority behavior, in this case, HPV vaccinations. Three norm nudges have a static design, including the descriptive norm of minority adoption. Based on previous literature's findings, our first hypothesis is that static norm nudges do not increase the adoption of the minority behavior.

H1: Static norms do not increase HPV vaccinations.

Moreover, according to Bicchieri and Xiao (2009), descriptive norms predict decisions significantly better than injunctive norms. Contrastingly, Cialdini (1990) postulates that the most salient aspect of a norm will dictate behavior. We test the impact of three different static norms, which vary in the descriptive and injunctive components, on adopting the minority behavior. Two of the norm nudges only contain descriptive norms. One of them includes descriptive and injunctive norms.

To construct the descriptive norms nudges, we vary the framing of the same static norm. Prospect theory by Kahneman and Tversky (1979) postulates that the expected negative utility is greater when losing a given amount than the positive expected utility from gaining the same amount. However, research has found mixed evidence on the impact of framing on health behaviors (Rothman and Salovey 1997; Salovey and Williams-Piehota 2004). Based on prospect theory, Rothman and Salovey (1997) propose that if the health behavior is illness-detecting, a loss frame message would be more impactful at increasing that behavior. On the contrary, a gain-frame message would be more impactful when the health behavior is illness-preventing.

We test one descriptive norm treatment with a loss frame and another with a gain frame. The former communicates to parents the loss of the opportunity of protecting their daughters from cancer. In contrast, the gain frame communicates the gain in protection against cancer derived from HPV vaccination. Additionally, the gain frame message is written in a positive frame, while the loss frame message is in a negative one. For instance, the positive/gain descriptive norm communicates a minority adoption in the positive, i.e., “3 of every 10 parents in your area vaccinated their daughters against HPV and protected them from cancer”. The negative/loss descriptive norm communicates that the majority had not adopted the behavior, i.e., “7 out of 10 parents in your area lost the opportunity to vaccinate their daughters and protect them from cancer”.

Following Rothman and Salovey (1997), one can expect a gain framing nudge to be a better tool to increase HPV vaccinations. However, this nudge also contains a descriptive norm of minority adoption. Given the evidence of the power of descriptive norms (Bicchieri and Xiao 2009), we hypothesize that the varying framing will not have a differential impact on adopting the minority behavior.

H2: Descriptive norms do not increase HPV vaccinations when framed in the negative/loss or the positive/gain framing.

The third static norm considers previous findings that injunctive norms can overcome the shortcomings of descriptive nudges on minority behaviors (Allcott 2011; Bonan et al. 2020; Jachimowicz et al. 2018; Ryo et al. 2021; Schultz et al. 2007). Jacobson et al. (2022) suggest that injunctive norms trigger self-reflection and effortful self-regulation that might compensate for the automatic perception of descriptive norms. A common way in the literature to insert injunctive norms into norm nudges is by adding an emoticon to transmit an accepted behavior.

Various studies have contributed to establishing emoticons as the tool to add injunctive norms to norm nudges. For instance, Schultz et al. (2007) and Allcott (2011) used emoticons to dissuade clients from consuming more energy when learning that their neighbors consume more energy than them. Bhanot (2021) experimentally finds that emoticons increase the impact of norm nudge in water conservation due to their injunctive norm message. Thus, we construct a third static norm that adds a sad face after the negative / loss frame nudge. We expect the combination of the descriptive and injunctive norms to increase the adoption of counternormative behavior more than a descriptive norm alone.

H3: Injunctive norms increase HPV vaccinations.

We turn to the recently coined dynamic norms to test our last two norm nudges. Instead of informing of the current state, dynamic norms highlight an increasing change in the adoption of a behavior over time (Sparkman and Walton 2017; Mortensen et al. 2017). Norm nudges that contain dynamic norms have shown promising results in increasing minority behaviors (Constantino et al. 2022; Milkman et al. 2022; Mortensen et al. 2017; Sparkman and Walton 2017).

According to Nyborg et al. (2016), communicating an increasing adoption of a minority behavior might lead people to infer that it will be the norm in the future, leading them to adopt that behavior in anticipation. The recent literature uses various terms to call the same type of changing social information. Mortensen et al. (2017) coined them trending norms, while Sparkman and Walton (2017) named them dynamic norms. More recently, Milkman et al. (2022) call it a growing norm. For this paper, we will refer to the umbrella of these norms as dynamic norms.

An example of dynamic norms from Milkman et al. (2022) communicates information about a positive change in COVID-19 vaccinations, i.e., “45% of Americans get the flu shot more than in the past”. The dynamic nudges in this paper follow Mortensen et al. (2017) and Sparkman and Walton (2017) and include the explicit level of minority adoption of HPV vaccination. Despite including the descriptive norm, we expect dynamic designs to increase the minority behavior compared to a control group.

H4: Dynamic norms increase HPV vaccinations.

Lastly, our experiment tests a variation between two dynamic norms. We call one of our norm nudges trending norm and the other dynamic norm. We add a temporal reference point in both treatments, i.e., 2016. The difference between the norm nudges resides in the inclusion of a percentage change in the adoption of the minority behavior since 2016. For example, the trending norm reads: "3 of every 10 parents in your town vaccinated their daughter to protect them from cancer, an increase of 128% since 2016." Moreover, the dynamic norm reads: "Since 2016, 3 of every 10 parents in your town began vaccinating their daughter against HPV, protecting them from cancer."

There is growing literature on field experiments testing dynamic design nudges. These fields include sustainability (Mortensen et al. 2017; Sparkman and Walton 2017), education (Loschelder et al. 2019; Cheng et al. 2022), and vaccinations (Milkman et al. 2022). Compared to the research by Loschelder et al. (2019), Cheng et al. (2022), and Milkman et al. (2022), our study tests variations in dynamic designs based on the inclusion of a temporal reference point and the percentage change. Our last hypothesis is that adding the percentage change of the minority behavior adoption to a dynamic norm nudge increases the adoption of the minority behavior as opposed to dynamic nudges that do not include this information.

H5: Informing subjects of population-wide increase in HPV vaccinations (trending norms) as a percentage change, increase first-dose HPV vaccination.

SITUATIONAL AND COUNTRY BACKGROUND

Cervical cancer (CC) is the fourth most common cancer in women worldwide, and it is one of the three most frequent cancers in women younger than 45 (D'Oria et al. 2022). In Colombia, new CC cases represented 7.9 percent of all cancer cases in 2020, equivalent to 4,742 cases in that year (Cordoba-Sanchez et al. 2022). According to the Ministry of Health in Colombia, CC is the leading cause of death from cancer in Colombia's women aged 30 to 59.

Almost all cervical cancers are caused by the human papillomavirus (HPV) (Walboomers et al. 1999). In addition to CC, HPV is associated with oropharyngeal, anus, genitals, head, and neck cancer. Estimates show that 75 percent of women and men who are sexually active will acquire HPV in their lifetime (Mavundza et al. 2021). Fortunately, the risk of HPV infection and the development of CC can be greatly reduced through an HPV vaccine (WHO 2017).

Colombia was among the first countries in South America to implement HPV vaccination. Since 2012, the Colombian government has administered the HPV vaccine through the Expanded Program on Immunization (PAI). This vaccine is targeted and free for girls between 9 and 17. Although individuals can be affiliated with a private insurer or covered under the subsidized regime, the country's health system allows citizens to be vaccinated at any vaccination point regardless of their health provider.

In 2012, Colombia was one of the leaders in HPV vaccination coverage in Latin America (Cordoba-Sanchez et al. 2022). However, the country's vaccination program's success came to a halt after an outbreak of unknown etiology in the municipality of Carmen de Bolivar. Similar incidents have occurred in Denmark, Japan and Australia (Simas et al. 2019). Although safety studies found no association between the HPV vaccine and Carmen de Bolivar's events, vaccine coverage rates began to decline steadily, reaching their lowest point in 2016 (Cordoba-Sanchez et al. 2022). Coverage levels of HPV vaccination have been recovering over the past years (Figure 1). However, they are still far from the pre-Carmen de Bolivar levels, representing a challenge for the vaccination policy in Colombia.

We partnered with the Health Secretariat of Bogota, Colombia, La Liga Colombiana Contra el Cancer, and the American Cancer Society to implement this experiment and offer solutions to the aforementioned challenges. As part of this research project, we conducted qualitative work to understand the drivers and barriers behind HPV vaccination in Bogota, Colombia. With those insights, we designed a large text message communications campaign that tested different tools from behavioral economics.

The selection of the text message campaign as our experiment delivery was informed by the technological structure of the Secretariat of Health (SH) and its vaccination efforts. The SH had in the past run text message campaigns to increase vaccinations, but not HPV vaccinations. Due to the current institutional framework in Colombia, health providers report data to the SH about all eligible individuals for vaccination. These include information about their progress in terms of recommended vaccinations. This centralized information system was instrumental in evaluating the effectiveness of our interventions.

This paper evaluates one of six large-scale experiments run during the text message campaign. The target population are parents with eligible girls and adolescents in Bogota, Colombia's largest city. The project was approved by the IRB of the University of Rosario in Colombia on October 06, 2020, under the name “Innovaciones conductuales para incrementar la tasa de vacunación contra el virus del papiloma humano en Bogotá, Colombia” (memorandum letter of approval available upon request from the authors). This study was pre-registered on January 21, 2022, at the American Economic Association’s registry for randomized controlled trials.[1]

EXPERIMENTAL DESIGN

This field experiment exploits alternative ways to communicate social norms through text messages to increase HPV vaccinations. We refer to text messages containing social norms for this experiment as norm nudges (Bicchieri and Dimant 2022). The challenging context of this social norms experiment is the minority adoption nature of HPV vaccinations in Bogota, i.e., only 30 percent of the population vaccinated their daughters against HPV in 2020. However, there had been a 128 percent increase in vaccination rates in Bogota since 2016. We leverage those statistics to design the norm nudges treatment’s content.

We test five norm nudges and three control groups (Figure 2). A control group does not receive any messages. A policy control group receives the "business as usual" message that the Secretariat of Health of Bogota had used in previous public health campaigns. An experimental control group receives placebo messages. All norm nudges and the placebo message include two fixed elements found effective in other settings: the name of the recipient and the sender’s information, in this case, “Secretariat of Health “(Constantino et

[1] A detailed description of our protocol can be accessed here: www.socialscienceregistry.org/trials/8543

al. 2021; Bursztyn et al., 2020; Tankard & Paluck, 2017). The policy message is not personalized nor signed by the SH.

The experiment consists of sending weekly norm nudges to the target population's parents over eight weeks through the online platform between October 21 – December 14, 2021. The content of the message remains constant throughout the weeks. Table 1 describes the messages delivered as part of this intervention. As an example, a subset of parents in this experiment receives a text message with a descriptive social norm (T3) of the following form: "Hello [Name of parent]. 3 of each 10 parents in your neighborhood vaccinated their daughters against HPV and protected them against cancer. Secretariat of Health". The administrative data from the Secretariat of Health in Bogota allow us to see the effect of norm nudges on actual HPV vaccinations.

The sample size by treatment arm is around 2,300 observations. The control has 4,600 observations. In our power calculations, we assume an effect size of 3 percentage points change in the vaccination rate for an individual randomized design. This considers a test for differences in proportions (Chi2 test), assuming 90 percent power, and accounts for multiple comparisons using a Bonferroni correction (allowing up to 17 comparisons in each experiment). A minimum sample size of 13,578 per experiment is estimated using the above parameters. The sample analyzed in this experiment is 20,704. Participants

The target population for this intervention consists of parents with unvaccinated daughters ages 9-17 registered with a cellphone number in the administrative records of the Health Secretariat in Bogota. The administrative records are pulled based on girls between 9-17 years who were pending the first HPV vaccine. Our inclusion criteria are

Bogota residency, the record of at least one parent, and a valid cellphone number of the parent. Since this is an intervention based on text messages, we drop those girls whose parent's phone do not appear on the database. Moreover, because the experiments are block-randomized based on locality and girls' age, we drop all the observations from neighbor localities outside Bogota or records without information regarding their locality. We also drop records from Sumapaz, a very small locality in Bogota, with only 41 observations. The final sample size for this experiment with unvaccinated girls is 20,704.

This intervention is implemented within the regular communication policy of the Secretariat of Health. Participants are not informed that they are part of these experiments. This is standard practice for government interventions, and it was approved by IRB. A weekly message is sent to the treatment sample for eight weeks. The timeline and exact day of text message delivery during the intervention are reported in Figure 3.

Descriptive Statistics

Table 2 shows the descriptive statistics of available variables in the database, and Table 3 shows that treatments are balanced on the observable characteristics of the sample. The columns of Table 4 show the T-test value of each treatment compared to the control. Out of 84 comparisons, only 2 differences are statistically significant at the 95 percent confidence level. However, the differences are less than 2 percent and come from insurance company affiliation. EPS (name of an insurance provider), contributory insurance, uninsured, subsidized insurance, ethnic group, displaced by the armed conflict, Colombian nationality, and stratum low are binary. Stratum low is also binary and is constructed by grouping the two lowest neighborhood levels that the government of Bogota uses to characterize low socioeconomic status.

REGRESSION MODEL

The impact analysis is based on a standard intention-to-treat analysis (ITT). The main outcome variable is a binary measure of whether a parent's daughter is vaccinated against HPV during the text message campaign window or within 3 months after the campaign ended. The software we use to send the text messages does not allow us to identify who receives or reads the messages. Thus, a treatment-on-the-treated (TOT) analysis is not possible.

We estimate models of the following form:

Equation 1

$$y_i = \alpha + \beta_1 T_1 + \beta_2 T_2 + \beta_3 T_{3-5} + \beta_4 T_{6-7} + \gamma X_i + \theta_s + \mu_i$$

y_i is the value of a dependent variable that indicates if the parent i vaccinated their daughter against HPV (0 = daughter does not get vaccinated, 1 = daughter gets vaccinated). T_{3-5} is an indicator variable taking the value of 1 when i was assigned to a static nudge and T_{6-7} is an indicator variable taking the value of 1 when i was assigned to a dynamic nudge. Therefore, the coefficient β_3 is relevant for H1 and β_4 for H4. The reference group for this estimation is the control group. X is a vector of controls that includes all observable characteristics available in the administrative database: insurance company, type of insurance, ethnic group, displaced by the armed conflict, Colombian nationality, and a variable that identifies whether the family lives in a low-income area (stratum low). θ_s is a vector of randomization strata dummy variables (locality*age), and μ_i is the error term.

Equation 2

$$y_i = \alpha + \beta_j T_j + \gamma X_i + \theta_s + v_i$$

Similarly to estimation 1, y_i is the value of a dependent variable that indicates if the parent i vaccinates their daughter against HPV (0 = daughter does not get vaccinated, 1 = daughter gets vaccinated), and T_j are indicator variables for i's treatment assignments j=1-7. In this case, the coefficients β_j estimate the average treatment effects of treatment j compared to the reference control group. X is the same vector of controls in equation 1 that includes all observable characteristics available in the administrative database, θ_s is a vector of randomization strata dummy variables (locality*age), and v_i is the error term.

RESULTS

Table 5 presents the results of estimation 1. Column 1 displays the OLS estimates without controls, and column 2 shows the OLS estimates controlling for relevant covariates. As a robustness test, columns 3 and 4 show the Probit estimation results without and with controls, respectively. The control variables include insurance provider, type of insurance, ethnic group, displaced by armed forces, Colombian nationality, and stratum low. All the controls are dummy variables. The results remain largely consistent across specifications. The average vaccination rate in the control group during the experimental period is 5.57 percent.

Contrary to H1, column 1 shows that the average HPV vaccination rate of girls whose parents received the static norm treatment is 0.75 percent higher than the control group. This result is statistically significant at a 90 percent confidence level. Column 2 shows that this result is robust when we control for covariates. These estimates show that the static norm coefficient is equivalent to a 13.5 percent difference between the static norm and the control group.

The findings do not support H1, which states that static norms do not increase HPV vaccination rates. Instead, the evidence shows a positive and sizable effect of static norms on HPV vaccinations, albeit not significant beyond a 90 percent confidence level. Since the coefficient of static norms is an average of negative descriptive, positive, and injunctive norms, subsequent analysis will disentangle the impact of each static norm on HPV vaccination.

Additionally, Table 5 shows the impact of dynamic norms on HPV vaccinations. Column 1 displays the OLS estimates without controls, and column 2 shows the OLS estimates controlling for relevant covariates. Column 1 shows that the average HPV vaccination rate of girls whose parents received the dynamic norm treatment is 1.2 percent higher than the control group's average. This result is statistically significant at the 95 percent confidence level. This result is robust to the inclusion of covariates. This is a large effect equivalent to 21.5 percent compared to the control group. This result supports H4, which states that dynamic norms increase HPV vaccination rates. It also supports recent evidence of the impact of dynamic norms on increasing adoption of minority behaviors (Cheng et al. 2022; Loschelder et al. 2019; Milkman et al. 2022; Mortensen et al. 2017; Sparkman and Walton 2017).

Results from estimation 2 disentangle the effect of each separate norm nudge on HPV vaccinations. Column 1 of Table 6 shows the results without controls, and column 2 shows the estimates controlling for relevant covariates. All the norm nudges' coefficients are positive. However, only two are statistically significant at the 95 percent confidence level and robust when controlling for covariates.

The results show that norm nudges that only contain a descriptive norm, irrespective of their framing, do not increase HPV vaccinations compared to the control. The OLS coefficient estimation without controls for the positive descriptive norm is 0.913 percent, and the negative descriptive is 0.261 percent. The coefficients are similar when controlling for covariates. However, the coefficient on the negative norm is approximately 3.5 times smaller than the positive descriptive norm.

This finding supports H2. However, the variation between positive and negative framing foes do not change the result. Thus, the results preclude us from inferring conclusions related to the effect of framing on health behaviors. As expected from Bicchieri and Xiao (2009), these treatment results might be driven by the salience of information about minority adoption that the descriptive norm provides in isolation.

The estimation results for descriptive norms do not show evidence of the expected "boomerang effect" (Cialdini 1990; Bicchieri and Xiao 2009; Bicchieri and Dimant 2022; Kuang et al. 2020; Schultz et al. 2007). The backfire effect might still be present in the population that corrected overstated beliefs of the descriptive norm, as in Schultz et al. (2007). However, our setting limits the strength of our conclusion since beliefs on current vaccination rates held by the participants are not elicited, impeding analysis of heterogenous effects of descriptive norms on HPV vaccinations.

Supporting the focus theory of normative conduct by Cialdini (1990), we find evidence that adding an injunctive norm to an otherwise descriptive norm nudge increases the impact on HPV vaccinations. Table 6 shows a positive and statistically significant coefficient for the injunctive norm of 1.09 percent at the 90 percent confidence level from an OLS estimation. When controlled for covariates, the resulting coefficient is 1.13 percent statistically significant at the 95 percent confidence level. This is equivalent to a 20 percent difference compared to the control group's average vaccination rate of 5.57 percent. These findings support H3 and the literature that states that injunctive norms can overcome the boomerang effect of descriptive nudges on minority behaviors (Allcott 2011; Bonan et al. 2020; Jachimowicz et al. 2018; Jacobson et al. 2022; Ryo at al. 2021; Schultz et al. 2007).

Furthermore, Table 6 shows the results of the OLS estimation effect of trending and dynamic norms. The OLS estimation in Column 1 shows that the average HPV vaccination rate of girls whose parents received the dynamic norm treatment is 1.00 percent higher than the control group at the 90 percent confidence level. The coefficient estimate decreases to .94 percent when controlling for covariates and remains statistically significant at the 90 percent confidence level.

Lastly, the trending norm results in the most impactful treatment for increasing HPV vaccination rates in this experiment. The findings support H5, which states that trending norms increase vaccinations. The OLS estimation in column 1 of Table 6 shows that the average HPV vaccination rate of girls whose parents received the trending norm treatment is 1.39 percent higher than the control group at the 95 percent confidence level. The result remains consistent when controlling for covariates in column 2. This result represents a 25 percent difference compared to the control group HPV vaccination average.

To correct for multiple comparisons of the second model, I use a Bonferroni correction to adjust the significance level for each test. The findings show that trending and injunctive norms, ceased to be significant after the correction. However, the uncorrected results for trending norms (t=2.44, p=0.015) and injunctive norms (t=1.98, p=0.047) provide some evidence that the program may have had a positive effect on these outcomes. These results support recent work that finds dynamic nudges impactful at increasing behaviors that have not yet been adopted by a majority (Aldoh et al. 2021; Cheng et al. 2022; Mortensen et al. 2017; Loschelder et al. 2019; Sparkman and Walton 2017; Milkman et al. 2022).

CONCLUSION

We run a field experiment through a text message campaign to increase HPV vaccinations in Bogota, Colombia. The target population are parents with daughters between 9 and 17 who need the first dose of the HPV vaccine. We test five norm nudges, an experimental control, a policy control, and a control group. Compared to previous studies that measure intention, the administrative data from the Secretariat of Health in Bogota has the advantage of testing the effect of norm nudges on actual HPV vaccinations.

Our main finding provides robust evidence of the impact of dynamic norms on increasing HPV vaccinations in our setting. The trending norm, one of the two dynamic designs, increases average vaccination by 1.39 percent compared to the control group vaccination rate of 5.57 percent. This effect is statistically significant at the 95 percent confidence level and robust to different specifications. It represents a difference of 25 percent compared to the control group. Our results support recent evidence on the impact of dynamic norms on increasing adoption of minority behaviors (Cheng et al. 2022; Loschelder et al. 2019; Milkman et al. 2022; Mortensen et al. 2017; Sparkman and Walton 2017).

Our second contribution is that from static norm nudges, injunctive norms show a sizable positive effect on HPV vaccinations. This supports the literature on the injunctive norms as an element to overcome the shortcomings of descriptive nudges on minority behaviors (Allcott 2011; Bonan et al. 2020; Jachimowicz et al. 2018; Jacobson et al. 2022; Ryo at al. 2021; Schultz et al. 2007). Third, supporting Bicchieri and Xiao (2009), we find that descriptive norms with social information about minority adoption in isolation do not increase HPV vaccination rates compared to the control group. We find this result despite varying the frames of descriptive norms between a gain and a loss frame.

Finally, our research contributes to the general research on the relationship between social norms and behavior change. Our results are relevant for the design of nudge strategies that aim to increase HPV vaccinations. Highlighting that others are increasingly adopting a minority behavior, in this case, HPV vaccinations, is likely to increase that behavior. Including a component of injunctive norms that communicates what others approve of, e.g., an emoticon, is likely to increase the impact of a norm nudge.

The implications of this study's findings are relevant for developing cost-effective public health nudge interventions. This study's estimated cost per marginal vaccinated girl was approximately USD 2.84. However, had the trending norm nudge been implemented across all groups, the cost per marginal vaccinated girl would have decreased to USD 1.29. These results highlight the importance of experiments that find effective nudges for the target population, as they can help keep the costs low when implemented at scale. Furthermore, given the link between HPV vaccination and reduced risk of cervical cancer, norm nudge interventions and reminders may ultimately lower public resources allocated to cancer-related medical care.

TABLES AND FIGURES FOR CHAPTER ONE

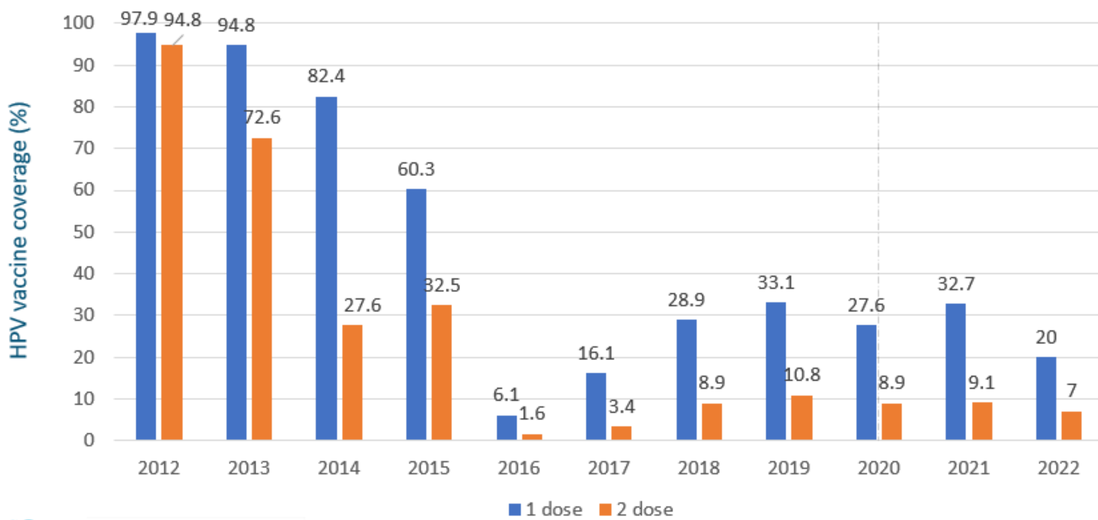

Figure 1. HPV vaccination rates in Colombia since the introduction of the vaccine in 2012

Source: Author's elaboration based on data from the Information System of the Expanded Immunization Program (PAI) of the Ministry of Health and Social Protection of Colombia.

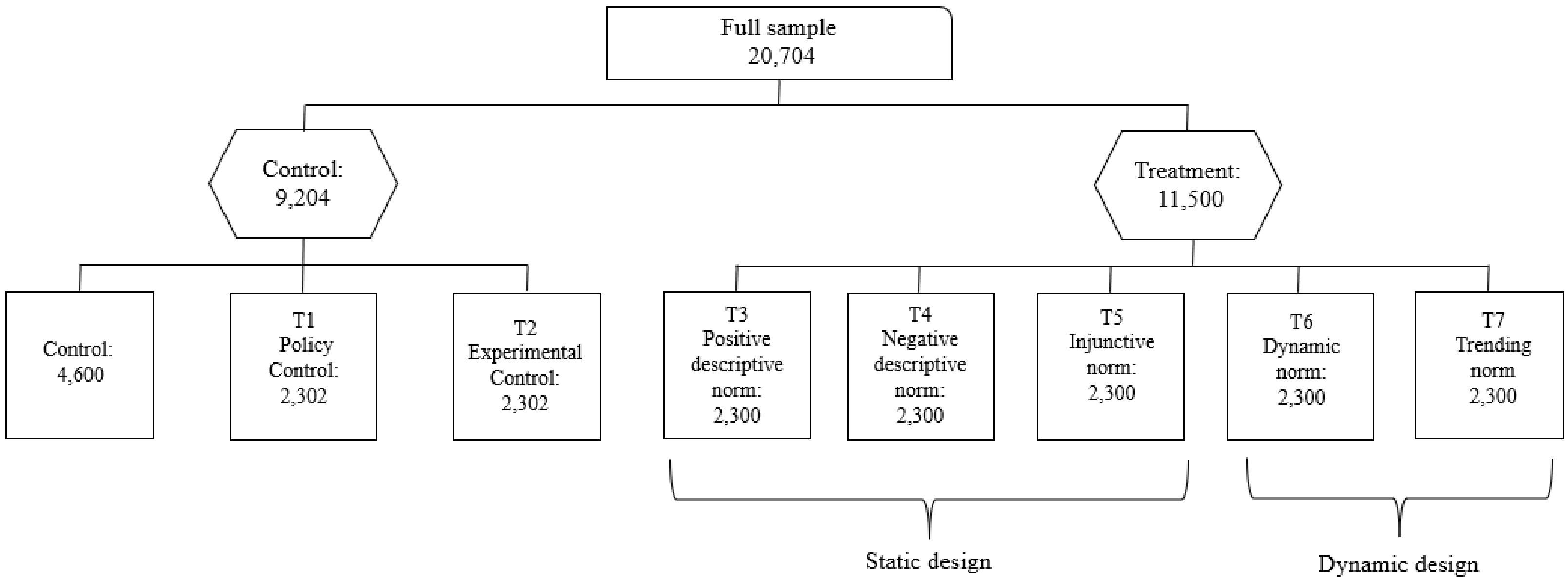

Figure 2. Graphic representation of experimental groups

Table 1. Text message content by norm nudge treatment and social norms element

Treatment	Norm nudge text message content	Social norm element
Control	*No message*	None
Policy control	*Vaccinate them: Give your son or daughter all the protection. Look up http://aldm.co/Eq2vT9s for the nearest location. Secretariat of Health*	None
Experimental Control	*Hi [Name of the parent]. Vaccinate her against HPV: give her all the protection. Secretariat of Health*	None
Positive descriptive norm	*Hi [Name of the parent]. 3 of every 10 parents in your locality vaccinated their daughter against HPV and protected them from cancer. Secretariat of Health.*	Descriptive norm
Negative descriptive norm	*Hi [Name of the parent]. 7 of every 10 parents in your locality lost the opportunity to vaccinate their daughter against HPV and protect them from cancer. Secretariat of Health*	Descriptive norm
Injunctive norm	*Hi [Name of the parent]. 7 of every 10 parents in your locality lost the opportunity to vaccinate their daughter against HPV and protect them from cancer :(. Secretariat of Health*	Descriptive and Injunctive norm (emoticon)
Dynamic norm	*Hi [Name of the parent]. Since 2016, 3 of every 10 parents in Bogota began vaccinating their daughters against HPV to protect them from cancer. Secretariat of Health*	Dynamic norm
Trending norm	*Hi [Name of the parent]. 3 of every 10 parents in Bogota vaccinated their daughter to protect them from cancer, an increase of 128% since 2016. Secretariat of Health*	Dynamic norm

Table 2. Descriptive statistics of the sample

VARIABLE	N	Mean	SD	min	max
EPS Sanitas	20,704	0.13	0.34	0	1
EPS Salud Total	20,704	0.11	0.32	0	1
EPS Famisanar	20,704	0.19	0.39	0	1
EPS Compensar	20,704	0.15	0.36	0	1
EPS Capital Salud	20,704	0.11	0.31	0	1
Contributory Insurance	20,704	0.77	0.42	0	1
Uninsured	20,704	0.038	0.19	0	1
Subsidized insurance	20,704	0.14	0.35	0	1
Ethnic group	20,704	0.0076	0.087	0	1
Displaced by the armed conflict	20,704	0.016	0.13	0	1
Colombian nationality	20,704	0.99	0.10	0	1
Stratum low	20,704	0.60	0.49	0	1

Note: All observable characteristics of the sample are coded as dummy variables and get a value of 1 if it applies to the girl’s record. Variables containing “EPS” refer to the insurance provider's name. Contributory insurance refers to insurance plans in which the employee contributes a portion of the premium, and the employer pays the rest. Uninsured, subsidized insurance, ethnic group, displaced by the armed conflict, Colombian nationality, and contributory insurance are binary. Stratum low is also binary and was constructed by grouping the two lowest neighborhood levels used by Bogota to characterize low socioeconomic status.

Table 3. Balance table of covariates per treatment arm

VARIABLE	(1) Control	(2) Policy	(3) Experimental	(4) Positive descriptive	(5) Negative descriptive	(6) Injunctive	(7) Dynamic	(8) Trending
EPS Sanitas	0.131	0.128	0.126	0.131	0.132	0.119	0.137	0.132
	(0.005)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0007)	(0.007)
EPS Salud Total	0.108	0.113	0.107	0.109	0.117	0.125	0.111	0.125
	(0.005)	(0.007)	(0.006)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
EPS Famisanar	0.193	0.192	0.189	0.200	0.183	0.207	0.192	0.191
	(0.006)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
EPS Compensar	0.150	0.153	0.152	0.149	0.166	0.133	0.147	0.147
	(0.005)	(0.008)	(0.007)	(0.007)	(0.008)	(0.007)	(0.007)	(0.007)
EPS Capital S.	0.109	0.119	0.107	0.115	0.105	0.103	0.116	0.110
	(0.005)	(0.007)	(0.006)	(0.007)	(0.006)	(0.006)	(0.007)	(0.007)
Contributory	0.770	0.765	0.767	0.777	0.773	0.784	0.775	0.775
	(0.006)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Uninsured	0.038	0.038	0.043	0.035	0.038	0.043	0.032	0.038
	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Subsidized	0.143	0.154	0.145	0.144	0.143	0.131	0.144	0.150
	(0.005)	(0.008)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Ethnic	0.009	0.005	0.007	0.005	0.009	0.007	0.009	0.009
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Displaced	0.016	0.013	0.019	0.014	0.013	0.020	0.019	0.018
	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)
Colombian	0.990	0.986	0.990	0.992	0.987	0.988	0.990	0.993
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Stratum low	0.598	0.603	0.589	0.592	0.605	0.594	0.605	0.593
	(0.007)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
N	4600	2302	2302	2300	2300	2300	2300	2300

Note: All observable characteristics of the sample are coded as dummy variables with a value of 1 if it applies to the girl's record. The values represent the mean value of each observable variable across treatment arms. Standard errors are in parentheses. Contributory and subsidized refer to insurance plans.

Table 4. Testing the balance of covariates between treatments and the control group

	T-test						
VARIABLES	(1)-(2)	(1)-(3)	(1)-(4)	(1)-(5)	(1)-(6)	(1)-(7)	(1)-(8)
EPS Sanitas	0.003	0.005	0.000	-0.000	0.013	-0.006	-0.001
EPS Salud Total	-0.004	0.001	-0.001	-0.009	-0.017**	-0.003	-0.017**
EPS Famisanar	0.002	0.005	-0.006	0.010	-0.014	0.001	0.002
EPS Compensar	-0.003	-0.002	0.000	-0.016*	-0.017*	0.002	0.003
EPS Capital salud	-0.009	0.002	-0.006	0.004	0.006	-0.006	-0.001
Contributory insurance	0.005	0.003	-0.007	-0.003	-0.014	-0.005	-0.005
Uninsured	0.000	-0.004	0.003	0.000	-0.005	0.006	0.000
Subsidized insurance	-0.011	-0.002	-0.001	-0.000	0.012	-0.001	-0.007
Ethnic	0.003	0.002	0.003	0.000	0.002	-0.000	-0.000
Displaced by the armed conflict	0.003	-0.003	0.002	0.002	-0.004	-0.003	-0.002
Colombian	0.004	-0.001	-0.002	0.003	0.001	-0.000	-0.003
Stratum low	-0.005	0.009	0.007	-0.007	0.004	-0.006	0.005

Note: The value displayed for T-test is the difference in the means of the control group and a given treatment group. The numbers inside the parenthesis on the column headers correspond to the following treatments: control (1); policy control (2); experimental control (3); positive descriptive norm (4); negative descriptive norm (5); injunctive norm (6); dynamic norm (7); trending norm (8). The standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 5. Do static and dynamic norm nudges increase HPV vaccination?

VARIABLES	(1) OLS **Applied vaccine**	(2) OLS **Applied vaccine**	(5) Probit **Applied vaccine**	(6) Probit **Applied Vaccine**
Policy control	-0.0079	-0.0079	-0.00885	-0.00868
	(0.0060)	(0.0060)	(0.0064)	(0.0063)
Experimental control	0.0004	0.000618	0.00041	-0.00001
	(0.0060)	(0.0060)	(0.0061)	(0.0061)
Static norm	0.0075*	0.0076*	0.0076*	0.0077*
	(0.0045)	(0.0045)	(0.0045)	(0.0045)
Dynamic norm	0.0120**	0.0118**	0.0117**	0.0119**
	(0.0049)	(0.0049)	(0.0049)	(0.0048)
Constant	0.0557***	0.0355		
	(0.0035)	(0.0292)		
Observations	20,704	20,704	20,704	20,704
R-squared	0.001	0.015		
Control	NO	YES	NO	YES

Note: The reported coefficient values for the Probit model represent the difference in the mean value of HPV vaccinations between those assigned to a norm nudge and those assigned to the control group. The control variables include insurance provider, type of insurance, ethnic group, displaced by armed forces, Colombian nationality, and stratum low. All the controls are dummy variables. Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 6. Disentangling the effect of static and dynamic norm nudges on HPV vaccination

VARIABLES	(1) OLS **Applied vaccine**	(2) OLS **Applied vaccine**	(5) Probit **Applied vaccine**	(6) Probit **Applied Vaccine**
Policy control	-0.0078	-0.00811	-0.00884	-0.00868
	(0.0060)	(0.0057)	(0.00641)	(0.00634)
Experimental control	0.0004	0.00062	0.00041	-0.00001
	(0.0060)	(0.0060)	(0.0062)	(0.0061)
Positive descriptive norm	0.0091	0.00865	0.00910	0.00834
	(0.0060)	(0.0057)	(0.0060)	(0.0059)
Negative descriptive norm	0.0026	0.00227	0.00271	0.00276
	(0.0060)	(0.0057)	(0.0061)	(0.0061)
Injunctive norm	0.0109*	0.0113**	0.0107*	0.0117**
	(0.0060)	(0.0057)	(0.0059)	(0.0059)
Dynamic norm	0.0100*	0.0094*	0.0099*	0.0098*
	(0.0060)	(0.0057)	(0.0059)	(0.0059)
Trending norm	0.0139**	0.0139**	0.0134**	0.01387**
	(0.0060)	(0.0057)	(0.0059)	(0.0058)
Constant	0.0557***	0.0359		
	(0.0035)	(0.0291)		
Observations	20,704	20,704	20,704	20,704
R-squared	0.001	0.016		
Controls	NO	YES	NO	YES

Note: The reported coefficient values for the Probit model represent the difference in the mean value of HPV vaccinations between those assigned to a norm nudge and those assigned to the control group. The control variables include insurance provider, type of insurance, ethnic group, displaced by armed forces, Colombian nationality, and stratum low. All the controls are dummy variables. Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 7. No heterogeneous effects of the treatments

VARIABLES	(1) Colombian **Applied vaccine**	(2) Displaced **Applied vaccine**	(3) Ethnic **Applied vaccine**	(4) Contributory **Applied vaccine**	(5) Subsidized **Applied vaccine**	(6) Stratum Low **Applied vaccine**	(7) Uninsured **Applied vaccine**
Policy control	0.0010	-0.0012	-0.0397	0.0183	-0.0303*	-0.0092	0.0059
	(0.0538)	(0.0516)	(0.0780)	(0.0142)	(0.0168)	(0.0123)	(0.0314)
Experimental control	0.0317	-0.0766*	-0.0552	-0.0060	-0.0052	-0.0023	-0.0145
	(0.0611)	(0.0458)	(0.0701)	(0.0142)	(0.0171)	(0.0122)	(0.0304)
Positive descriptive norm	-0.0513	-0.0266	0.0322	0.0105	-0.0101	0.0112	-0.0107
	(0.0643)	(0.0504)	(0.0780)	(0.0144)	(0.0171)	(0.0123)	(0.0324)
Negative descriptive norm	0.0556	-0.0475	-0.0493	0.0129	-0.0125	-0.0035	0.0035
	(0.0548)	(0.0510)	(0.0649)	(0.0144)	(0.0172)	(0.0123)	(0.0315)
Injunctive norm	0.0505	-0.0618	-0.0506	-0.0047	0.0185	-0.0081	-0.0193
	(0.0571)	(0.0448)	(0.0718)	(0.0145)	(0.0176)	(0.0123)	(0.0302)
Dynamic norm	0.0198	0.0545	-0.0014	-0.0185	-0.0037	-0.0109	-0.0125
	(0.0602)	(0.0455)	(0.0639)	(0.0144)	(0.0171)	(0.0123)	(0.0333)
Trending norm	0.0631	-0.0464	-0.0186	0.0224	-0.0252	-0.0043	-0.0056
	(0.0669)	(0.0461)	(0.0640)	(0.0144)	(0.0170)	(0.0123)	(0.0315)
Constant	0.0555	0.0359	0.0354	0.0383	0.0351	0.0341	0.0357
	(0.0419)	(0.0291)	(0.0291)	(0.0297)	(0.0292)	(0.0294)	(0.0292)
Observations	20,704	20,704	20,704	20,704	20,704	20,704	20,704
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control mean	0.0557	0.0557	0.0557	0.0557	0.0557	0.0557	0.0557

Note: Contributory and subsidized refer to insurance plans. Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.

CHAPTER TWO. NUDGING THE TRENDSETTERS: DO DYNAMIC NORMS INCREASE VACCINATION?

INTRODUCTION

In my first chapter, findings indicate that dynamic norm nudges increase first-dose HPV vaccinations for parents of girls and adolescents in Bogota, Colombia, where only a minority of the population is vaccinated against HPV. In the context of my first chapter, I refer to first-dose HPV vaccinations as a minority behavior. Since 2016, the World Health Organization health guidelines has recommended two doses of the HPV vaccine for coverage against cervical cancer (WHO 2022).[2] First-dose and second-dose HPV vaccination have been a minority behavior in Bogota since 2016. In this chapter, I test the hypothesis that dynamic norm nudges increase second-dose HPV vaccinations for trendsetters. I employ Bicchieri and Funcke's (2018) definition of trendsetters, i.e., as the initiators of norm abandonment. Norm abandonment occurs when societies replace one social norm for another (Andreoni et al. 2021; Bicchieri 2017). In this context, trendsetters are the group of parents who vaccinated their daughters with the first-dose HPV vaccine between 2017-2020.

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[2] Recent studies demonstrate that a single dose of the HPV vaccine is sufficient to provide the same protection as a multidose regimen against HPV (WHO 2022). However, the two-dose vaccine schedule is still the public health recommendation in Bogota, where this study takes place. Therefore, financial resources continue to be allocated to vaccination campaigns to increase second-dose HPV vaccinations.

This is the first study that tests dynamic norm nudges' effect on trendsetters' behavior. To test my hypothesis, I conduct a field experiment in Bogota, Colombia. The experiment consists of text messages to parents of daughters 9-12 years old who have received the first-dose HPV vaccine but not the second. As in chapter one, the experiment studies the effect of five norm nudge treatments. Three treatments are dynamic norms, one treatment is a descriptive norm, and another treatment is an injunctive norm. This experiment has one control group, one experimental control, and one policy control. Administrative records on vaccination from Bogota's Secretary of Health allow me to measure the effect of norm nudges on actual HPV vaccinations.

The literature most closely related to this chapter are studies of the effect of dynamic norm nudges on minority behaviors (Aldoh et al. 2021; Cheng et al. 2022; Mortensen et al. 2017; Loschelder et al. 2019; Sparkman and Walton 2017; Milkman et al. 2022). In these studies, dynamic norm nudges inform experimental participants how other people's behavior has changed, or is changing, over time (Sparkman and Walton, 2017). The literature also tests different variations of dynamic norms, such as framings that either include or exclude elements like the percentage change in the adoption of the minority behavior. For example, Mortensen et al. (2017) and Sparkman and Walton (2017) study the framings of dynamic norm nudges, which is also a focus of this study. This approach helps to determine which dynamic norm nudge has the largest effect on changing minority behaviors.

I test the effect of three framings based on the seminal work by Mortensen et al. (2017) and Sparkman and Walton (2017). In the first treatment, the trending norm contains information about the percentage change in the adoption of the minority behavior by the reference population: “Since 2016, the number of parents in your town who got the second dose of the HPV vaccine for their daughters increased by 83 percent.” In the second treatment, the qualitative dynamic norm communicates the trend in HPV vaccinations, without alluding to the percentage change: "More and more parents in your area are giving their daughters their second dose of the HPV vaccine.” And in the third treatment, the quantitative dynamic norm adds the descriptive norm, which communicates the prevalence of the minority behavior, to the qualitative dynamic norm message: “eight percent of parents in your area have already gotten the second dose of the HPV vaccine for their daughters, and more and more are doing it.” The messages in each of the treatments refer to an increase in the trend of second-dose HPV vaccinations.

In addition to the research on the effects of dynamic norms on increasing minority behaviors, this paper draws on several other literatures. One of these literatures is the research on trendsetters’ behaviors (Bicchieri 2017; Bicchieri and Funcke 2018). Trendsetters have also been called positive deviants in the health literature (Herington and van de Fliert 2018). Spreitzer and Sonenshein (2003) define positive deviants as individuals or groups that depart from the norms of a referece group in honorable ways. The research on positive deviants informs the design of interventions for behavioral change (Herington and van de Fliert 2018; Bicchieri 2017). For example, Pascale and Sternin (2010) decreased children's malnutrition in Vietnam by applying the strategies of mothers who belonged to the minority and did not have malnourished children in the community.[3] Pascale and Sternin (2010) refer to mothers who belong to the minority as positive deviants. Unlike studies such as Pascale and Sternin's (2010), my study focuses on an intervention directed at trendsetters.

Contrary to chapter one, the results indicate that dynamic norms do not increase second-dose HPV vaccination rates of trendsetters. Only the quantitative dynamic norm has a marginal statistically significant effect compared to the control group at the 90 percent confidence level. This is a surprising result since dynamic norms effectively increase minority behaviors in other contexts (Aldoh et al. 2021; Cheng et al. 2022; Mortensen et al. 2017; Loschelder et al. 2019; Sparkman and Walton 2017; Milkman et al. 2022). As in chapter one, the injunctive norm has a statistically significant marginal increase on second-dose HPV vaccinations of 5.22 percent compared to the control average of 15.2 percent. This difference is equivalent to a 34 percent difference at a 99 percent confidence level. Consistent to the results in chapter one, the coefficient of the descriptive norm is not statistically significant compared to the control group.

The most effective message for increasing second-dose HPV vaccination is the experimental control. The experimental control is a personalized reminder signed by the Secretariat of Health of the following form: "Hi [Name of the parent]. Get your daughter the second dose of the HPV vaccine: give her all the protection. Secretariat of Health." Its

[3] The strategies applied by these mothers go against locally accepted wisdom. Some of these strategies are feeding children even when they have diarrhea; feeding children several smaller meals rather than one or two large ones; adding what is considered low-class food to children's rice (Pascale and Sternin 2010).

effect represents a statistically significant increase of 50 percent compared to the control group.

THEORETICAL BACKGROUND

Bicchieri and Dimant (2022) suggest that the effect of norm nudges depends on the target population's underlying beliefs. Frequently, heterogeneous analysis on the effect of norm nudges find unintended consequences on specific populations (Allcott 2011; Beshears et al. 2015; Bicchieri and Dimant 2022; Castro and Scartascini 2015; Fellner et al. 2013; Ferraro et al. 2011; Kantorowicz-Reznichenko 2021; Peth 2018; Richter et al. 2018; Schultz et al. 2007). This is what Schultz et al. (2007) coined the boomerang effect.

Boomerang effects occur when the sub-population that already exhibits a behavior receives a descriptive norm nudge designed to affect that behavior. For example, Schultz et al. (2007) and Allcott (2011) find that households that consume less energy than their neighbors increase their consumption after receiving a descriptive norm nudge that makes this difference in energy consumption salient. Beshears et al. (2015) find that providing information about average savings decreases savings disproportionally among lower-income workers, as compared to other income brackets, in a work setting. Castro and Scartascini (2015) find that descriptive norms that communicate current levels of tax evasion increase tax compliance among previous non-compliers but decrease compliance among previously compliant taxpayers.

Moreover, norm nudge interventions frequently show null effects on behaviors (Dimant et al. 2020; Dur et al. 2021; Gravert et al. 2021; Silva et al. 2017; Venema et al. 2020). For example, Dur et al. (2021) test the effect of norm nudges on savings behavior and find no effects in the general target population or subsamples. Biccheri and Dimant (2022) suggest that such null effects can occur when populations have preferences that are independent of social. As Bicchieri and Mercier (2014) explain, behaviors like brushing one's teeth are independent of social norms since an individual's decision to brush their teeth is not conditional on the perception of the popularity of this behavior. Therefore, nudging such a behavior with social information would likely be ineffective (Bicchieri and Dimant, 2022).

The target population of this study, the trendsetters, allows me to test the effect of the social norms nudges I tested in chapter one on a population with underlying characteristics where boomerang effects or null effects are expected. The trendsetters already engaged in the minority behavior by getting their daughters their first-dose HPV vaccine. This behavior might indicate that trendsetters have HPV vaccination preferences independent of social norms. My first hypothesis tests the effect of norm nudges on second-dose HPV vaccination for trendsetters.

H1: Norm nudges do not increase second-dose vaccinations for trendsetters.

Norm nudges typically include either descriptive norms, injunctive norms, or both to elicit or change social expectations to impact the adoption of a behavior. Bicchieri and Xiao (2009) find that descriptive norms are the primary driving force behind social norm conformity. In this scenario in which the norm is a minority behavior, the descriptive norms treatment reads, "8 percent of parents in your area have already gotten the second dose of the HPV vaccine for their daughters."

My second hypothesis tests whether descriptive norms increase second-dose HPV vaccination for trendsetters. A nudge containing only a descriptive message with the minority behavior will likely entrench the status quo (Bicchieri and Xiao 2009; Bicchieri and Dimant, 2022; Kuang et al., 2020). However, it is not clear if this finding applies to trendsetters.

H2: Descriptive norms do not increase second-dose vaccinations for trendsetters.

Research finds that including injunctive norms prevents adverse outcomes of descriptive norms (Allcott 2011; Bonan et al. 2020; Jachimowicz et al. 2018; Ryo et al. 2021; Schultz et al. 2007). Jacobson et al. (2022) suggest that injunctive norms trigger self-reflection and effortful self-regulation that might compensate for the automatic perception of descriptive norms. For example, in Schultz et al. (2007) and Allcott (2011), injunctive norms dissuade clients from consuming more energy when learning that their neighbors consume more energy than them. It is common to use a smiley face to communicate the injunctive norm (Allcott 2011; Bhanot 2021; Schultz 2007). The injunctive norm in this paper adds a smiley face to the descriptive norm in the following way, "8 percent of parents in your area have already gotten the second dose of the HPV vaccine for their daughters. You still have not :(."

The assumption is that trendsetters' vaccination behavior falls under what Bicchieri and Dimant (2022) call independent behaviors. Independent behaviors are preferred either because it meets someone's needs or because of moral convictions (Bicchieri and Dimant, 2022). If that is the case, then injunctive norms would address the underlying motivations of this population and are likely to increase second-dose HPV vaccinations.

H3: Injunctive norms increase second-dose HPV vaccinations for trendsetters.

As mentioned in my previous chapter, many studies find that norm nudges based on dynamic norms increase the adoption of minority behaviors (Aldon et al. 2021; Cheng et al. 2022; Mortensen et al. 2017; Loschelder et al. 2019; Sparkman and Walton 2017; Milkman et al. 2022). Dynamic norms are mainly effective in environmental minority behaviors (Constantino et al. 2022). Nyborg et al. (2016) suggest that the adoption mechanism relies on individuals' anticipation of the behavior becoming a social norm in the future.

The literature loosely defines dynamic norms as social information communicating how other people's behavior changes over time (Sparkman and Walton 2017). Studies that test dynamic norms refer to them by various names, such as trending (Mortensen et al. 2017) or growing norms (Milkman et al. 2022). The application of dynamic norms in the literature is not consistent across studies. Therefore, I first test the effect of dynamic norms, loosely defined, on the increase of the minority behavior of second-dose HPV vaccinations for trendsetters.

H4: Dynamic norms increase second-dose HPV vaccinations for trendsetters.

To identify the elements that make dynamic norms effective, I test the effect of three dynamic norm treatments on second-dose HPV vaccinations for trendsetters based on the seminal work by Mortensen et al. (2017) and Sparkman and Walton (2017). The first treatment, the trending norm follows the structure of Mortensen et al. (2017). In that study, Mortensen et al. (2017) define trending norms as the increasing number of people engaging in a behavior. For example, the trending norm treatment in that study reads as "In

July, [previous year], 48 percent of the MTurk workers who took our surveys donated funds to the SEAA. This increased from 17 percent in July (2 years previous)”. Unlike Mortensen et al. (2017), I do not communicate the descriptive minority behavior in this study. As seen in Table 8, the trending norm in the present study reads, "Since 2016, the number of parents in your town who got the second dose of the HPV vaccine for their daughters increased by 83 percent.

H5: Trending norms, informing subjects of population-wide increase in HPV vaccinations as a percentage change increase second-dose HPV vaccinations for trendsetters.

In the second treatment, the qualitative dynamic norm communicates the trend in HPV vaccinations without alluding to the percentage change based on Sparkman and Walton (2017). Sparkman and Walton (2017) find that experimental subjects’ behavior is sensitive to social information of an upward change in collective behavior without communicating the number of people who have engaged in this behavior. For example, Sparkman and Walton (2017) test the following dynamic norm treatment: “Stanford Residents Are Changing: Now Most Use Full Loads! Help Stanford Conserve Water!” This study communicates the qualitative dynamic norm to trendsetters: “More and more parents in your area are giving their daughters their second dose of the HPV vaccine.” As the trending norm, this version of the dynamic norm does not communicate the descriptive norms of the minority behavior. I test the hypothesis that qualitative dynamic norms increase second-dose HPV vaccinations for trendsetters.

H6: Qualitative dynamic norms, informing the trend in HPV vaccinations without alluding to the percentage change, increase second-dose HPV vaccinations for trendsetters.

Lastly, I test a dynamic norm that includes the minority behavior of an eight percent second-dose HPV vaccination rate, additionally to qualitatively communicating an increase in the popularity of the behavior. I call this treatment the quantitative dynamic norm and it reads the following way: “Eight percent of parents in your area have already gotten the second dose of the HPV vaccine for their daughters, and more and more are doing it.” This treatment is influenced by the mix of elements seen in the dynamic norm nudge literature, such as Milkmann et al. (2022). In that study, the Milkman et al. (2022) refer to the dynamic norm as growing norm. The growing norm reads the following way: "More Americans are getting the flu shot than ever in the last decade. Last year, 45 percent of American adults got one”. Previous studies find dynamic norms to be effective at increasing minority behavior despite informing subjects about the minority behavior (Mortensen et al. 2017; Sparkman and Walton 2017; Milkman et al. 2022).

H7: Quantitative dynamic norms, including the minority behavior of an eight percent second-dose HPV vaccination rate, increase second-dose HPV vaccinations for trendsetters.

SITUATIONAL AND COUNTRY BACKGROUND

Cervical cancer (CC) is the fourth most common cancer in women worldwide, and it is one of the three most frequent cancers in women younger than 45 (D’Oria et al., 2022). Almost all cervical cancers are caused by the human papillomavirus (HPV) (Walboomers et al. 1999). In addition to CC, HPV is associated with oropharyngeal, anus, genitals, head, and neck cancer. Estimates show that 75 percent of women and men who are sexually active will acquire HPV in their lifetime (Mavundza et al. 2021). Fortunately, the risk of HPV infection and the development of CC can be significantly reduced through a set of HPV vaccines (WHO 2017).

According to the Colombian Ministry of Health, CC is the leading cause of death from cancer in Colombia's women aged 30 to 59. In 2020, new CC cases represented 7.9 percent of all cancer cases, equivalent to 4,742 cases in that year (Cordoba-Sanchez et al., 2022). In this country, the risk of HPV infection can be reduced with two HPV vaccines administered through the Expanded Program on Immunization (PAI). The country's health system allows citizens to be vaccinated at any vaccination point regardless of their health provider. These vaccines are free for girls between 9 and 17. The Expanded Immunization Program of Colombia's Ministry of Health and Social Protection prioritizes 9-year-old girls' HPV vaccinations.

In 2012, Colombia was one of the leaders in HPV vaccination coverage in Latin America (Cordoba-Sanchez et al., 2022). After the initial introduction of the vaccine in 2012, it became recommended by the health authority, and it was administered in schools. However, the country's vaccination program's success stopped after an outbreak of unknown etiology in the municipality of Carmen de Bolivar. Although safety studies found no association between the HPV vaccine and Carmen de Bolivar's events, vaccine coverage rates began to decline steadily, reaching their lowest point in 2016 (Cordoba-Sanchez et al., 2022).

Coverage levels of HPV vaccination have been recovering over the past years but are still far from the pre-Carmen de Bolivar levels. Figure 3 shows the vaccination rate of the first and second doses of the HPV vaccine for 9-year-old girls in Colombia. The second-dose vaccination rate is substantially lower than the first dose.

Through a large text message communications campaign, I tested the impact of several behavioral economics principles on first and second-dose HPV vaccinations. To provide recommendations to increase HPV vaccination rates, I partnered with the Health Secretariat of Bogota, Colombia, La Liga Colombiana Contra el Cancer, and the American Cancer Society to run six experiments.

This centralized information system of the Secretariat of Health was instrumental in evaluating the effectiveness of our interventions. Due to the current institutional framework in Colombia, health providers report data to the SH about all eligible individuals for vaccination. These include information about the administration of recommended vaccines by the country's health authorities. Moreover, the Secretariat of Health's (SH) technological capacities and vaccination efforts informed the selection of the text message campaign as the channel for this experiment. The SH had run text message campaigns to increase the administration of some vaccines, but not HPV vaccinations.

This study was pre-registered on January 21, 2022, at the American Economic Association's registry for randomized controlled trials.[4] The project was approved by the IRB of the University of Rosario in Colombia on October 06, 2020, under the name "Innovaciones conductuales para incrementar la tasa de vacunación contra el virus del

[4] A detailed description of our protocol can be accessed here: www.socialscienceregistry.org/trials/8543

papiloma humano en Bogotá, Colombia" (memorandum letter of approval available upon request from the authors).

EXPERIMENTAL DESIGN

This field experiment exploits alternative ways to communicate social norms through text messages to increase second-dose HPV vaccinations in parents with daughters 9-12 yrs. In this experiment, I test five norm nudge treatments, three containing dynamic norms, one experimental control, a policy control, and a control group. The remaining two norm nudges include descriptive and injunctive norms, like chapter one (Figure 4). The administrative data from the Secretariat of Health in Bogota allows me to see the effect of norm nudges on actual HPV vaccinations.

The experiment consists of sending weekly norm nudges to the target population's parents over eight weeks through the online platform between October 21 – December 14, 2021. This intervention is implemented within the regular communication policy of the Secretariat of Health. The content of the message remains constant throughout the weeks. Table 8 describes the messages delivered as part of this intervention. As an example, a subset of parents in this experiment receives a text message with a descriptive social norm (T3) of the following form: "Hello [Name of parent]. 8 percent of parents in your area have already gotten the second dose of the HPV vaccine for their daughters. Secretariat of Health".

A control group does not receive any messages. A policy control group receives the "business as usual" message that the Secretariat of Health of Bogota had used in previous public health campaigns. An experimental control group receives a placebo message. All norm nudges and the placebo message include two fixed elements found effective in other settings: the name of the recipient and the sender's information, in this case, "Secretariat of Health" (Constantino et al. 2021; Bursztyn et al. 2020). The policy message is not personalized nor signed by the SH.

The target population for this intervention consists of parents with daughters ages 9-12 pending the second vaccine against HPV. The parents' administrative records are pulled based on records of girls between 9-12 years who had the first-dose HPV vaccine but were pending the second. The inclusion criteria are Bogota residency, the record of at least one parent, and a valid cellphone number of the parent. Moreover, because the experiments are block-randomized based on locality and girls' age, I do not include observations from neighbor localities outside Bogota or records without information regarding their locality. I also drop records from Sumapaz, a small locality in Bogota, with only 41 observations.

The sample size for this experiment with unvaccinated girls is 4,956. The sample size by treatment arm is around 552 observations, and the control has 1,099 observations. The power calculations indicate a 4.14 percent minimum detectable effect based on the sample size and a 7 percent base rate. The base rate was an average of the past seven years' second-dose HPV vaccination rate. The power calculation is based on differences in proportions (Chi2 test), assuming 80 percent power and a 5 percent significance level.

Descriptive Statistics

Table 9 shows the descriptive statistics of available variables in the database, and Table 10 shows that treatments are balanced on the observable characteristics of the sample. Table 11 shows the t-test value of each treatment compared to the control. Out of 84 comparisons, only three differences are statistically significant at the 95 percent confidence level. The differences are equivalent to less than 2 percent of the comparisons. EPS (name of an insurance provider), contributory insurance, uninsured, subsidized insurance, ethnic group, displaced by the armed conflict, Colombian nationality, and stratum low are binary. Stratum low is also binary and is constructed by grouping the two lowest neighborhood levels that the government of Bogota uses to characterize low socioeconomic status.

Regression Model

The impact analysis is based on a standard intention-to-treat analysis (ITT). The main outcome variable is a binary measure of whether a parent's daughter gets vaccinated with a second-dose HPV vaccine during the text message campaign window or within three months after the campaign ends. The software I use to send text messages does not allow me to identify who receives or reads the messages. Thus, a treatment-on-the-treated (TOT) analysis is not possible.

I estimate models of the following form:

Equation 3

$$y_i = \alpha + \beta_1 T_1 + \beta_2 T_2 + \beta_3 T_{3-7} + \gamma X_i + \theta_s + \mu_i$$

y_i is the value of a dependent variable that indicates if the daughter of parent *i* gets vaccinated with the second-dose HPV vaccine (0 = daughter does not get vaccinated, 1 = daughter gets vaccinated). T_1 is an indicator variable taking the value of 1 when i is assigned to the policy control, and T_2 is an indicator variable taking the value of 1 when *i* is assigned to the experimental control. T_{3-7} is an indicator variable taking the value of 1 when *i* is assigned to a norm nudge. The reference group for this estimation is the control group. X is a vector of controls that includes all observable characteristics available in the administrative database: insurance company, type of insurance, ethnic group displaced by the armed conflict, Colombian nationality, and a variable identifying whether the family lives in a low-income area (stratum low). θ_s is a vector of randomization strata dummy variables (locality*age), and μ_i is the error term.

Equation 4

$$y_i = \alpha + \beta_1 T_1 + \beta_2 T_2 + \beta_3 T_3 + \beta_4 T_4 + \beta_5 T_{5-7} + \gamma X_i + \theta_s + \mu_i$$

y_i is the value of a dependent variable that indicates if the daughter of parent *i* gets vaccinated with the second-dose HPV vaccine (0 = daughter does not get vaccinated, 1 = daughter gets vaccinated). T_1 is an indicator variable taking the value of 1 when *i* is assigned to the policy control. T_2, T_3, and T_4 take the value of 1 when *i* is assigned to the experimental control, descriptive norm, and injunctive norm treatments, respectively. T_{5-7} is an indicator variable taking the value of 1 when *i* is assigned to a norm nudge. The reference group for this estimation is the control group. X is a vector of controls that includes all observable characteristics available in the administrative database: insurance company, type of insurance, ethnic group displaced by the armed conflict, Colombian nationality, and a variable identifying whether the family lives in a low-income area (stratum low). θ_s is a vector of randomization strata dummy variables (locality*age), and μ_i is the error term. error term.

Equation 5

$$y_i = \alpha + \beta_j T_j + \gamma X_i + \theta_s + v_i$$

Similarly to the previous equations, y_i is the value of a dependent variable that indicates if the daughter of parent *i* gets vaccinated with the second-dose HPV vaccine (0 = daughter does not get vaccinated, 1 = daughter gets vaccinated), and T_j are indicator variables for *i*'s treatment assignments *j*=1-7. In this case, the coefficients β_j estimate the average treatment effects of treatment *j* compared to the reference control group. X is the same vector of controls in equation 1 that includes all observable characteristics available in the administrative database, θ_s is a vector of randomization strata dummy variables (locality*age), and v_i is the error term.

RESULTS

Table 12 presents the results of estimation one that show the effect of norm nudges on increasing the second-dose HPV vaccinations for trendsetters. Column one displays the OLS estimates without controls, and column two shows the OLS estimates controlling for relevant covariates. The control variables include insurance provider, type of insurance, ethnic group, displaced by armed forces, Colombian nationality, and stratum low. All the controls are dummy variables. The average vaccination rate in the control group during the experimental period is 15.2 percent.

Column one of Table 12 shows that the average second-dose HPV vaccination rate of girls whose parents received a norm nudge treatment is 2.8 percent higher than the control group's average. This result is statistically significant at a 95 percent confidence level. Column two shows that this result is robust when we control for covariates. This estimate is equivalent to an 18.4 percent difference between norm nudges and the control group.

This result does not support H1, which states that norm nudges do not increase second-dose HPV vaccination rates for trendsetters. However, norm nudges include descriptive, injunctive, and dynamic norms. The subsequent analysis will allow me to identify what elements of norm nudges impact this population.

Table 13 shows the impact of descriptive and injunctive norms on second-dose HPV vaccinations for trendsetters. Column one shows that the average second-dose HPV vaccination rate of girls whose parents received the descriptive norms treatment is 2.38 percent higher than the control group's average. This result is not statistically significant and remains the same after controlling for covariates. Thus, the result does not support H2, which states that descriptive norms do not increase second-dose HPV vaccination rates for trendsetters.

Similarly to the estimation results for descriptive norms in chapter one, this result does not show evidence of the expected "boomerang effect" of descriptive norms (Cialdini 1990; Bicchieri and Xiao 2009; Bicchieri and Dimant 2022; Kuang et al. 2020; Schultz et al. 2007). The backfire effect might still be present in the population that corrected overstated beliefs of the descriptive norm, as in Schultz et al. (2007). However, our setting limits the strength of our conclusion since beliefs on current vaccination rates held by the participants are not elicited, impeding analysis of heterogenous effects of descriptive norms on HPV vaccinations.

Regarding the effect of injunctive norms, the average second-dose HPV vaccination rate of trendsetters in the injunctive norm treatment is 5.1 percent higher than the control group's average. The result is robust to the inclusion of covariates and statistically significant at the 99 percent confidence level. This is a 33.55 percent difference from the control group, and the result reaches statistical significance after the Bonferroni correction for multiple comparisons.

This finding supports H3, which states that injunctive norms increase trendsetters' second-dose HPV vaccinations. Moreover, the result supports the literature that finds injunctive norms effective at increasing a minority behavior (Allcott 2011; Bonan et al. 2020; Jachimowicz et al. 2018; Ryo et al. 2021; Schultz et al. 2007). A potential mechanism, as suggested by Bicchieri and Dimant (2022) and Hauser (2018), is that injunctive norms address the underlying motivations of trendsetters.

Table 13 also shows the effects of dynamic norms loosely defined. The estimation shows a marginal coefficient of 2.2 percent not statistically significant compared to the control group. Albeit positive, this result does not support H4, which states that dynamic norms increase second-dose HPV vaccinations. Furthermore, this goes against recent studies which find that dynamic norms effectively increase minority behaviors (Aldon et al. 2021; Cheng et al. 2022; Mortensen et al. 2017; Loschelder et al. 2019; Sparkman and Walton 2017; Milkman et al. 2022).

The results from estimation three in Table 14 disentangle the effect of each separate dynamic norm treatment on second-dose HPV vaccinations for trendsetters. Column 1 of Table 14 shows the results without controls. Column two shows the estimates controlling for relevant covariates. The marginal coefficients for the trending, qualitative, and quantitative dynamic norms show a positive sign. However, none are statistically significant at a 95 percent confidence level. These results are relevant for H5 and H6, which state that trending and qualitative norms increase second-dose HPV vaccinations. With the caveat that this effect might be due to the lack of power, these results do not the hypotheses.

The quantitative dynamic norm shows a marginal effect of 3.8 percent statistically significant at the 90 percent confidence level compared to the control group. The coefficient remains the same when I control for covariates. Although being a large effect equivalent to a 25 percent difference in second-dose HPV vaccinations compared to the control group, the result does not show significant effects with a significant level Bonferroni correction for multiple comparisons.

A heterogeneous effects estimation shows that quantitative dynamic norms have a negative effect on the population with subsidized insurance. The marginal coefficient is -11.4 percent, statistically significant at the 95 percent confidence level. This result is consistent with studies that find boomerang effects of norm nudges in sub-populations (Cialdini 1990; Bicchieri and Xiao 2009; Bicchieri and Dimant 2022; Kuang et al. 2020; Schultz et al. 2007). The result does not show significant effects with a significant level Bonferroni correction for multiple comparisons.

Lastly, the results show that the most effective nudge of the intervention to increase second-dose HPV vaccination for trendsetters is the experimental control for increasing second-dose HPV vaccination. This treatment shows a marginal increase of 7.5 percent compared to the control group. The result is robust to including covariates and statistically significant at a 99 percent confidence level. This difference is equivalent to an approximately 50 percent increase compared to the control group's average and reach statistical significance after the Bonferroni correction for multiple comparisons.

The experimental control is a non-norm nudge that contains two elements like norm nudges, the recipient's name, and the sender's information, in this case, the Secretariat of Health. The content of the experimental control is the following, "Get your daughter the second dose of the HPV vaccine: give her all the protection." Thus, it can be considered a reminder. This result supports vast literature on reminders' role in increasing vaccinations (Briss et al., 2000; Jacobson Vann and Szilagyi 2005; Busso 2015; Busso 2017; Stockwell, 2012; Szilagyi 2013).

This intervention based on SMS norm nudges is highly cost-effective in increasing second-dose HPV vaccinations of trendsetters. The cost per additional girl vaccinated is estimated at USD $0.61. This cost considers the cost of all messages bought for the intervention and the marginal vaccination rate per treatment. However, a simple reminder to the same population would cost of USD $0.24. This is a cost reduction of 61 percent.

CONCLUSION

In this study, I run a field experiment through a text message campaign to increase the minority behavior of second-dose HPV vaccinations for trendsetters in Bogota, Colombia. The target population is parents with daughters between 9 and 12 who already have the first dose of the HPV vaccine. Because this population of parents has acted against social norms in the past, I refer to them as the HPV vaccination trendsetters. The vaccination rate of the first-dose HPV vaccine at the time of the experiment is approximately 30 percent, and the second-dose HPV vaccination rate is 9 percent.

Like chapter one, I test the effect of five norm nudges, one experimental control, one policy control, and one control group on second-dose HPV vaccinations. The main findings are the following. First, I find a lack of statistically significant evidence of the effect of dynamic norms in increasing second-dose HPV vaccinations for trendsetters. Second, the results show a positive statistically significant effect of injunctive norms on second-dose HPV vaccinations for trendsetters. The difference in the mean of vaccinations for the injunctive norm treatment group and the control group was sizable at 33 percent. Third, the most effective nudge at increasing second-dose HPV vaccination is the experimental control, i.e., a personalized reminder signed by the Secretariat of Health. The experimental control shows a statistically significant increase of 7.5 percent, equivalent to an approximately 50 percent increase compared to the control group's second-dose HPV vaccination average.

The results in this chapter do not support chapter one and other studies that find dynamic norms effective at increasing minority behaviors. However, the results support the literature that finds the effect of norm nudges depends on the underlying preferences of the target population.[5] The differences in the effect of norm nudges containing the same

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[5] For example, Castro and Scartascini (2015) find that a descriptive nudge does not affect the average population's behavior; however, it increases tax compliance on previously non-compliers but decreases compliance on previously compliant taxpayers. Unlike this study, norm nudge experiments typically find differential effects of norm nudges by analyzing heterogeneous effects (Allcott 2011; Beshears et al. 2015; Bicchieri and Dimant 2022; Castro and Scartascini 2015; Fellner et al. 2013; Ferraro et al. 2011; Kantorowicz-Reznichenko 2021; Peth 2018; Richter et al. 2018; Schultz et al. 2007).

social norm components on first dose and second-dose HPV vaccinations illustrate the importance of understanding the underlying characteristics of the population to develop effective nudge interventions. This study's results, a posteriori, allow me to reflect on trendsetters underlying preferences.

Trendsetters who have gone against social norms may have preferences less influenced by others' behaviors, resulting in the ineffectiveness of dynamic norm nudges. Additionally, these individuals may adhere to a moral rule for behavior that favors their daughters' health, explaining the significant impact of injunctive norms on second-dose HPV vaccination. Furthermore, a simple reminder, i.e., the experimental control, is highly effective for trendsetters who may have forgotten to administer the second HPV vaccine six months after the first dose.

The implications of this study's findings are relevant for developing cost-effective public health nudge interventions. The estimated cost per additional vaccinated girl in this study was approximately USD 0.61. However, had the simple reminder been implemented across all groups, the cost would have decreased to USD 0.24 per additional vaccinated girl. This estimation highlights the importance of experiments that find effective nudges for the target population, as they can help keep the costs low when implemented at scale.

Finally, coupled with the results of chapter one, the result of this study provides the following insight. Compared to the cost estimations for the marginal vaccinated girl in chapter one, which was USD 2.84, the cost of nudging the trendsetters is about one-fifth of that cost. Thus, when vaccination completion is the problem, important public health goals can be achieved by norm nudges or reminders. Furthermore, given the link between

HPV vaccination and reduced risk of cervical cancer, norm nudge interventions and reminders may ultimately lower public resources allocated to cancer-related medical care.

TABLES AND FIGURES FOR CHAPTER TWO

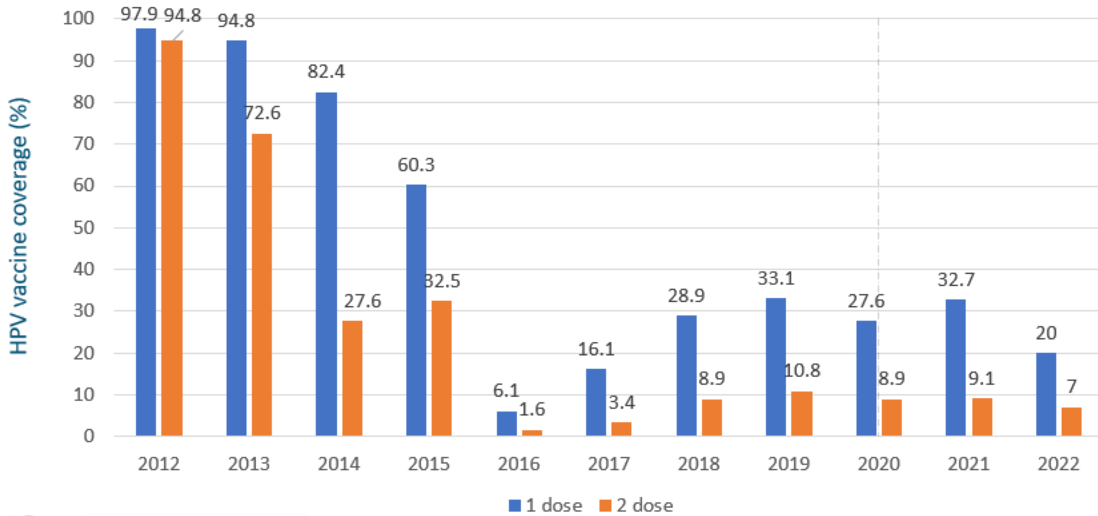

Figure 3. HPV vaccination rates in Colombia since the introduction of the vaccine in 2012

Source: Author's elaboration based on data from the Information System of the Expanded Immunization Program (PAI) of the Ministry of Health and Social Protection of Colombia.

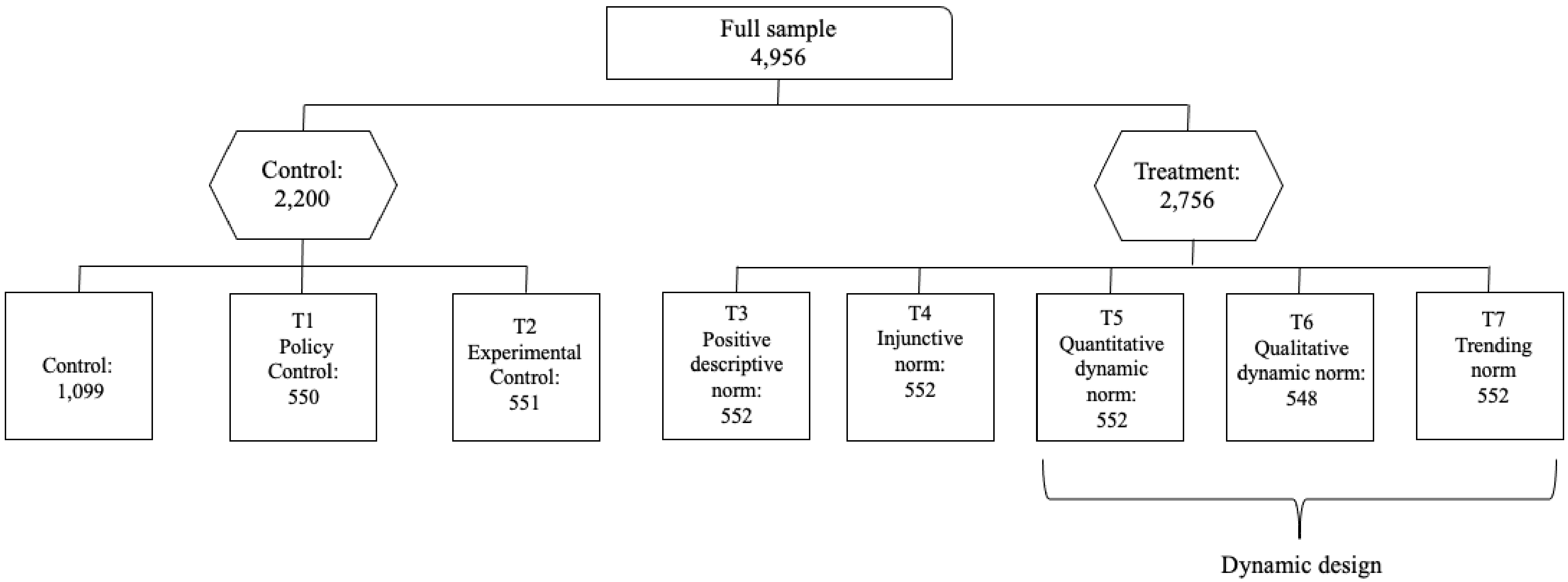

Figure 4. Graphic representation of experimental group

Table 8. Text message content by norm nudge treatment and social norms element

Treatment	Norm nudge text message content	Social norm element
Control	*No message*	None
Policy control	*Vaccinate them: give your son or daughter all the protection. Consult http://aldm.co/Eq2vT9s for the nearest location. Secretariat of Health*	None
Experimental Control	*Hi [Name of the parent]. Get your daughter the second dose of the HPV vaccine: give her all the protection. Secretariat of Health*	None
Positive descriptive norm	*Hi [Name of the parent]. 8% of parents in your area have already gotten the second dose of the HPV vaccine for their daughters. Secretariat of Health*	Descriptive norm
Injunctive norm	*Hi [Name of the parent]. 8% of parents in your area have already gotten the second dose of the HPV vaccine for their daughters. You still have not :(. Secretariat of Health*	Descriptive and Injunctive norm (emoticon)
Quantitative dynamic norm	*Hi [Name of the parent]. 8% of parents in your area have already gotten the second dose of the HPV vaccine for their daughters, and more and more are doing it. Secretariat of Health*	Dynamic norm
Qualitative dynamic norm	*Hi [Name of the parent]. More and more parents in your area are giving their daughters their second dose of the HPV vaccine. Secretariat of Health*	Dynamic norm
Trending norm	*Hi [Name of the parent]. Since 2016, the number of parents in your town who got the second dose of the HPV vaccine for their daughters increased by 83%. Secretariat of Health*	Dynamic norm

Table 9. Descriptive statistics of the sample

VARIABLES	N	Mean	SD	Min	Max
EPS Sanitas	4956	0.16	0.37	0	1
EPS Salud Total	4956	0.13	0.34	0	1
EPS Famisanar	4956	0.18	0.39	0	1
EPS Compensar	4956	0.16	0.36	0	1
EPS Capital Salud	4956	0.14	0.35	0	1
Contributory Insurance	4956	0.77	0.42	0	1
Uninsured	4956	0.03	0.18	0	1
Subsidized insurance	4956	0.16	0.37	0	1
Ethnic group	4956	0.00	0.07	0	1
Displaced by the armed conflict	4956	0.01	0.11	0	1
Colombian nationality	4956	0.97	0.17	0	1
Stratum low	4956	0.70	0.46	0	1

Note: All observable characteristics of the sample are codded as dummy variables and get a value of 1 if it applies to the girl's record. Variables containing "EPS" refer to the insurance provider's name. Contributory insurance refers to insurance plans in which the employee contributes a portion of the premium, and the employer pays the rest. Uninsured, subsidized insurance, ethnic group, displaced by the armed conflict, Colombian nationality, and contributory insurance are binary. Stratum low is also binary and was constructed by grouping the two lowest neighborhood levels used by Bogota to characterize low socioeconomic status.

Table 10. Balance table of covariates per treatment arm

VARIABLES	(1) Control	(2) Policy control	(3) Experimental control	(4) Positive descriptive	(5) Injunctive	(6) Quantitative dynamic	(7) Qualitative dynamic	(8) Trending
EPS Sanitas	0.182	0.178	0.162	0.141	0.159	0.154	0.133	0.152
	(0.012)	(0.016)	(0.016)	(0.015)	(0.016)	(0.015)	(0.015)	(0.015)
EPS Salud Total	0.122	0.129	0.160	0.147	0.116	0.118	0.148	0.132
	(0.010)	(0.014)	(0.016)	(0.015)	(0.014)	(0.014)	(0.015)	(0.014)
EPS Famisanar	0.181	0.204	0.160	0.185	0.194	0.190	0.190	0.178
	(0.012)	(0.017)	(0.016)	(0.017)	(0.017)	(0.017)	(0.017)	(0.016)
EPS Compensar	0.156	0.142	0.143	0.163	0.154	0.167	0.155	0.174
	(0.011)	(0.015)	(0.015)	(0.016)	(0.015)	(0.016)	(0.015)	(0.016)
EPS Capital Salud	0.143	0.136	0.156	0.149	0.143	0.134	0.141	0.147
	(0.011)	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)
Contributory	0.770	0.765	0.740	0.759	0.754	0.799	0.759	0.775
	(0.013)	(0.018)	(0.019)	(0.018)	(0.018)	(0.017)	(0.018)	(0.018)
Uninsured	0.029	0.035	0.038	0.034	0.034	0.024	0.036	0.029
	(0.005)	(0.008)	(0.008)	(0.008)	(0.008)	(0.006)	(0.008)	(0.007)
Subsidized	0.159	0.156	0.189	0.163	0.170	0.149	0.175	0.161
	(0.011)	(0.016)	(0.017)	(0.016)	(0.016)	(0.015)	(0.016)	(0.016)
Ethnic group	0.006	0.004	0.005	0.007	0.004	0.002	0.005	0.004
	(0.002)	(0.003)	(0.003)	(0.004)	(0.003)	(0.002)	(0.003)	(0.003)
Displaced	0.014	0.018	0.016	0.009	0.014	0.004	0.013	0.014
	(0.004)	(0.006)	(0.005)	(0.004)	(0.005)	(0.003)	(0.005)	(0.005)
Colombian	0.975	0.962	0.966	0.976	0.966	0.973	0.971	0.971
	(0.005)	(0.008)	(0.008)	(0.006)	(0.008)	(0.007)	(0.007)	(0.007)
Stratum low	0.710	0.680	0.721	0.694	0.712	0.688	0.690	0.681
	(0.014)	(0.020)	(0.019)	(0.020)	(0.019)	(0.020)	(0.020)	(0.020)
N	1099	550	551	552	552	552	548	552

Note: All observable characteristics of the sample are codded as dummy variables and get a value of 1 if it applies to the girl's record. The values above represent the mean value of each observable variable across treatment arms. Standard errors are in parentheses.

Table 11. Testing the balance of covariates between treatments and the control group

			T-test				
VARIABLES	(1)-(2)	(1)-(3)	(1)-(4)	(1)-(5)	(1)-(6)	(1)-(7)	(1)-(8)
EPS Sanitas	-0.004	-0.020	-0.041**	-0.023	-0.028	-0.049**	-0.030
EPS Salud total	0.007	0.038**	0.025	-0.006	-0.004	0.026	0.010
EPS Famisanar	0.023	-0.021	0.004	0.013	0.009	0.009	-0.004
EPS Compensar	-0.014	-0.012	0.007	-0.002	0.011	-0.000	0.018
EPS Capital salud	-0.006	0.013	0.006	0.000	-0.009	-0.002	0.004
Contributory	-0.004	-0.029	-0.011	-0.016	0.029	-0.011	0.006
Uninsured	0.005	0.009	0.005	0.005	-0.006	0.007	-0.000
Subsidized	-0.003	0.030	0.004	0.011	-0.011	0.016	0.002
Ethnic group	-0.003	-0.001	0.001	-0.003	-0.005	-0.001	-0.003
Displaced	0.005	0.003	-0.005	0.001	-0.010*	-0.001	0.001
Colombian	-0.013	-0.009	0.002	-0.009	-0.002	-0.004	-0.004
Stratum low	-0.030	0.011	-0.016	0.002	-0.021	-0.020	-0.029
N	1649	1650	1651	1651	1651	1647	1651

Note: The value displayed for T-test is the difference in the means of the control group and a given treatment group. The numbers inside the parenthesis on the column headers correspond to the following treatments: control (1); policy control (2); experimental control (3); positive descriptive norm (4); negative descriptive norm (5); injunctive norm (6); dynamic norm (7); trending norm (8). The standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 12. Social norms increase second-dose HPV vaccinations for trendsetters

VARIABLES	(1) OLS **Applied vaccine**	(2) OLS **Applied vaccine**
Policy control	-0.0120	-0.0109
	(0.0198)	(0.0198)
Experimental control	0.0749***	0.0760***
	(0.0198)	(0.0198)
Norm nudge	0.0280**	0.0283**
	(0.0135)	(0.0135)
Constant	0.152***	0.111
	(0.0114)	(0.0769)
Observations	4,956	4,956
R-squared	0.004	0.014
Control	NO	YES

Note: The control variables include insurance provider, type of insurance, ethnic group, displaced by armed forces, Colombian nationality, and stratum low. All the controls are dummy variables. The unreported coefficient values for the Probit model show the same coefficients as the OLS estimation. Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 13. There is no evidence that dynamic norms broadly defined effectively increase second-dose HPV vaccinations for trendsetters

VARIABLES	(1) OLS **Applied vaccine**	(2) OLS **Applied vaccine**
Policy control	-0.0120	-0.0109
	(0.0198)	(0.0198)
Experimental control	0.0749***	0.0760***
	(0.0198)	(0.0198)
Positive descriptive norm	0.0238	0.0244
	(0.0198)	(0.0197)
Injunctive norm	0.0509***	0.0522***
	(0.0198)	(0.0197)
Dynamic norms	0.0218	0.0217
	(0.0148)	(0.0147)
	0.152***	0.110
Constant	(0.0114)	(0.0769)
Observations	4,956	4,956
R-squared	0.004	0.015
Controls	NO	YES

Note: The control variables include insurance provider, type of insurance, ethnic group, displaced by armed forces, Colombian nationality, and stratum low. All the controls are dummy variables. The unreported coefficient values for the Probit model show the same coefficients as the OLS estimation. Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 14. A closer look into different elements of dynamic norms does not show statistically significant effects

VARIABLES	(1) OLS **Applied vaccine**	(2) OLS **Applied vaccine**
Policy control	-0.0120	-0.0109
	(0.0198)	(0.0198)
Experimental control	0.0749***	0.0760***
	(0.0198)	(0.0198)
Positive descriptive norm	0.0238	0.0244
	(0.0198)	(0.0197)
Injunctive norm	0.0509***	0.0522***
	(0.0198)	(0.0197)
Quantitative dynamic norm	0.0383*	0.0373*
	(0.0198)	(0.0198)
Qualitative dynamic norm	0.0105	0.0120
	(0.0198)	(0.0198)
Trending norm	0.0165	0.0157
	(0.0198)	(0.0197)
Constant	0.152***	0.110
	(0.0114)	(0.0769)
Observations	4,956	4,956
R-squared	0.005	0.015
Controls	NO	YES

Note: The control variables include insurance provider, type of insurance, ethnic group, displaced by armed forces, Colombian nationality, and stratum low. All the controls are dummy variables. The unreported coefficient values for the Probit model show the same coefficients as the OLS estimation. Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 15. Dynamic norms have a heterogeneous effect on the subsidized population

VARIABLES	(1) Colombian **Applied vaccine**	(2) Displaced **Applied vaccine**	(3) Ethnic **Applied vaccine**	(4) Contributory **Applied vaccine**	(5) Subsidized **Applied vaccine**	(6) Stratum low **Applied vaccine**	(7) Uninsured **Applied vaccine**
Policy control	-0.0264	-0.163	-0.154	-0.0530	0.0609	0.0638	-0.0036
	(0.111)	(0.156)	(0.304)	(0.0468)	(0.0544)	(0.0429)	(0.112)
Experimental control	-0.0209	0.0138	-0.248	-0.0425	0.0490	-0.0082	-0.0419
	(0.115)	(0.161)	(0.262)	(0.0459)	(0.0518)	(0.0439)	(0.108)
Positive descriptive	-0.0410	-0.293	0.114	-0.0099	0.0146	0.0141	0.0007
	(0.129)	(0.197)	(0.239)	(0.0465)	(0.0537)	(0.0432)	(0.113)
Injunctive norm	0.0706	-0.189	-0.142	-0.0619	0.0631	0.0393	0.0519
	(0.115)	(0.168)	(0.305)	(0.0463)	(0.0531)	(0.0436)	(0.112)
Quantitative dynamic norm	-0.175	0.145	-0.194	0.0433	-0.114**	-0.0368	0.152
	(0.123)	(0.286)	(0.407)	(0.0486)	(0.0551)	(0.0430)	(0.127)
Qualitative dynamic norm	0.0803	-0.148	0.191	-0.0132	0.0176	0.0009	-0.0263
	(0.121)	(0.175)	(0.262)	(0.0466)	(0.0528)	(0.0431)	(0.110)
Trending norm	0.0275	-0.158	-0.153	-0.0357	0.0481	0.0433	-0.0128
	(0.121)	(0.167)	(0.306)	(0.0473)	(0.0539)	(0.0428)	(0.118)
Observations	4,956	4,956	4,956	4,956	4,956	4,956	4,956
Controls	YES	YES	YES	YES	YES	YES	YES

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

CHAPTER THREE. THE EFFECTS OF ONLINE BEHAVIORAL INTERVENTIONS ON ATTITUDES: VACCINATION ATTITUDES

INTRODUCTION

The Theory of Planned Behavior (TPB) by Ajzen (1985) in the field of psychology is frequently used to predict health behaviors, such as alcohol consumption, dieting, and vaccination (Hagger et al. 2016; Berg and Lin 2021; Khayyam 2022; Wolff 2021). The TPB identifies attitudes as a determinant of intentions and, in turn, behavior. The model defines attitudes as the degree to which a person has a favorable or unfavorable evaluation or appraisal of the behavior in question (Ajzen 1985).

Two public health factors have recently sparked an interest in vaccine attitudes. One factor is the seemingly increasing negative appraisal of vaccination in general across the globe, which affects vaccination behavior and puts at risk the previously eradicated vaccine-preventable diseases (Azarpanah et al. 2021, Dubé et al. 2014; Dubé et al. 2015). Another factor is the importance of vaccine attitudes for COVID-19 vaccination behavior specifically (Fridman et al. 2021).

Public health communications interventions frequently aim to positively impact vaccine attitudes by disseminating educational and promotional messages (Albarracin et al. 2003, Reñosa 2021). There is a perception in the public health field that public health communications are essential as a continuing response to prevent COVID-19 infections (Stolow et al. 2020). However, two systematic reviews by Batteaux et al. (2022) and

Reñosa (2021) find a limited effect of public health communications interventions. In contrast, Reñosa's (2021) literature review finds that nudge interventions, can increase vaccination attitudes, intentions, and behavior.

This study tests the hypothesis that online interventions grounded in the principles of behavioral economics, that is, nudges, impact COVID-19 vaccine attitudes. Contrary to public health communications interventions, the behavioral economics approach assumes that individuals suffer from limited attention and cognitive resources that constrain information processing (Dellavigna and Pollet 2009). This study's approach uses elements of gamification, heuristics, altruism, and framing to support the visual and message intervention to simplify the cognitive processing of information, thereby making information more salient.[6] The next section of this paper describes each of the intervention's behavioral economics components.

I test the hypothesis that the online behavioral intervention positively affects COVID-19 vaccine attitudes with a field experiment in cooperation with the government of Guanajuato, Mexico. The government operates an online communications campaign aimed at citizens of the state through its social media, email, and text message contacts. The communications campaign features the intervention as a quiz called "¿Realmente eres

[6] Hauser (2018) defines interventions that use a set of previous impactful nudges to impact several beliefs as kitchen sink interventions. While kitchen sink interventions increase the probability of having an impact, the effect of each component cannot be determined (Hauser 2018). Given the current pandemic, I choose a kitchen sink approach to maximize the likelihood of achieving impact, despite the potential sacrifice of a more detailed analysis of individual elements.

el coronaheroe que crees?".[7] The quiz is advertised as a tool for measuring personal knowledge about COVID-19 and assigning a hero character based on the result.

The quiz takers are unaware of their participation in an experiment. The online platform that hosts the quiz allows the assignment of experimental participants to a control and a treatment group. The control group answers the outcome question "What is your attitude towards the COVID-19 vaccine?" on a 9- point Likert scale before exposure to the behavioral economics content of the intervention (Figure 5). Given this experimental design, the control group's answers are unaffected by the intervention. The treated group answers the outcome question after intervention exposure. The difference in vaccine attitude average between the control and treatment groups measures the effect of the intervention.

This study contributes to two different literatures. First, it contributes to the study of the effect of behavioral economics-based interventions on vaccination behavior, intention, and attitudes, i.e., vaccine hesitancy.[8] Second, it contributes to the study of the impact of online interventions on health-related behaviors, intentions, and attitudes (Davis Kirsch and Lewis 2004; Dumit et al. 2018; Guse et al. 2012; Horvath et al. 2015; Johnson et al. (2016); Little et al. 2015; O'Leary et al. 2019; Pull 2006; Van den Berg et al. 2007). The majority of work in both literatures was done in developed countries like the UK, the US, and other European countries. This study is the first field experiment that measures the

[7] The translation of the quiz's name in English is "Are you really the coronahero you think you are? A demo of the quiz is available at the following link: https://survey.typeform.com/to/x37OycDJ.
[8] See Batteaux et al. (2022) and Reñosa (2021) for two systematic reviews of this literature.

effect of an online behavioral intervention on COVID-19 vaccine attitudes in Latin America.

The results show that the online behavioral intervention has a small and statistically significant positive effect on vaccine attitudes of 0.207 points on a 9-point Likert scale from 1-9, where 1 is completely against, and 9 is completely in favor of the vaccine. The baseline of COVID-19 vaccine attitudes is 7.82, implying that the intervention results in a 2.65 percentage point increase in positive attitudes toward the COVID-19 vaccine. Following TPB predictions, those with more positive vaccine attitudes are more likely to get vaccinated (Ajzen 1985). Since recent studies show that vaccine attitudes have declined, low-cost interventions like the one studied in this chapter may hold the promise to containing a continued decline (Azarpanah et al. 2021, Dubé et al. 2014; Dubé et al. 2015).

THEORETICAL BACKGROUND

The Theory of Planned Behavior (TPB) suggests that the most important determinant of behavior is the intention to act (Ajzen 1985). In turn, intentions depend on attitude toward a behavior, subjective norms, and perceived behavioral control. Attitudes are defined by Ajzen (1985) as the degree to which a person has a favorable or unfavorable evaluation or appraisal of a given behavior (Ajzen 1985). In this study, I focus on vaccination attitudes toward the COVID-19 vaccine.

Vaccination attitudes toward COVID-19 is the variable of interest in this study due to three factors. First, unlike the previous two chapters of this dissertation, I cannot access vaccination records to measure vaccination behavior. Second, I cannot create hypothetical scenarios that elicit vaccination intention because the partner government cannot ensure a consistent supply of COVID-19 vaccine and does not want to create expectations regarding COVID-19 availability. Third, vaccine attitude is an important predictor of behavior, and it falls under the recently popular studied concept of vaccine hesitancy, its determinants, and effective strategies to mitigate it (Galasso et al. 2022; Guzman-Holst et al. 2020; Lazarus et al. 2021; Lindley et al. 2006; Opel et al. 2013; Urrunga-Pastor et al. 2021; Sarasty et al. 2020; Skjefte et al. 2021).[9]

A vast amount of literature on the effect of behavioral economics-based interventions on COVID-19 vaccine attitudes, intentions, and uptake has surged in the recent past (Argote 2021; Altay 2023; Galasso et al. 2022; Kerr et al. 2023; Kachurka et al. 2021; Milkman et al. 2022; Reñosa 2021; Vivion et al. 2022). In contrast to education-based interventions, nudge interventions rely on changing the context in which a decision is made or enacted (Reñosa 2021, Thaler and Sunstein 2009). Systematic reviews of this literature suggest that they are a reliable strategy to increase vaccinations (Batteux 2022; Brewer 2017; Kerr 2021; Reñosa 2021). For example, a nudge that reminds individuals of pending vaccination through an SMS increases vaccinations by 2 percentage points (Milkman et al. 2022).

[9] Vaccine hesitancy is defined by the World Health Organization (WHO) Strategic Advisory Group (SAGE) group as the delay in acceptance or refusal of vaccination despite the availability of services (WHO 2014). The SAGE suggests that vaccine hesitancy derives from three factors: lack of confidence in vaccines, complacency towards the disease that the vaccine is supposed to cure, and lack of convenience in terms of cost and appeal of immunization services (Galasso 2022; Khubchandani 2021; Matos 2021). These are called by the SAGE the 3C's (WHO 2014). In a review of 470 studies on barriers to vaccination, Schmid (2017) finds that confidence and complacency are major reasons for influenza vaccine uptake.

This study's intervention design relies on the behavioral economics finding that individuals suffer from limited attention, and cognitive resources limit information processing (Dellavigna and Pollet 2009). For example, Persson's (2018) experiment finds that adding information is not always better for leading customers with limited attention to make better choices. To simplify the cognitive process of information, I apply the nudge components of gamification, heuristics, altruism, and framing to simplify the cognitive process of information. I integrate the nudge components into an online intervention to increase positive attitudes toward COVID-19 vaccines (see Figure 6). This is what Hauser (2018) defines as a kitchen sink intervention. The paragraphs below will present the theoretical foundation for each intervention component.

Online channel: This study is delivered through an online communications campaign. Recent studies find the Internet increasingly influential in immunization decisions (Cox et al. 2010; Zimmerman et al. 2005). The low cost of delivering an online intervention allows it to reach a wide audience (Strecher 2007). Moreover, online interfaces allow the use of engaging graphics and interactive tools.[10] The graphics are central to the intervention since graphic representations are easier to understand and increase the intention to adopt risk-reduction behaviors like vaccination (Cox et al. 2010).

Gamification: The intervention uses feedback, a game element, to deliver the nudges (Johnson et al. 2016; Liu et al. 2017; van Gaalen et al. 2021). Gamification is studied through various disciplinary theory-driven principles, ranging from neoclassical economics to social psychology (Liu et al., 2017). I use the general definition of

[10] I used the online platform Typeform to implement this study.

gamification to describe the use of game attributes in a non-gaming context (van Gaalen et al. 2021). Some of the more utilized gamification elements are challenges, points, levels, leader boards, and the provision of feedback (Liu et al., 2017; van Gaalen et al., 2021; Johnson et al., 2016). Health-related outcomes, including mental health, physical exercise, nutrition, and the reduction of substance abuse, are positively impacted by gamified interventions (Johnson et al., 2016).

Heuristics: Heuristics are simple rules of thumb that can simplify the problem domain to make our decisions more manageable, especially under complex and uncertain environments (Kahneman, 2011). For instance, Drexler et al. (2014) find that simplified rule-of-thumb training on financial heuristics is effective at increasing the financial outcomes of micro-entrepreneurs compared to standard accounting training. In this study, I use acronyms and analogies to create rules-of-thumb from COVID-19 public health recommendations, instead of educating the experiment population with technical information about the disease.

Altruism: Messages concerning vaccination appeal to altruistic motives. I define altruism as messages appealing to the benefit of protecting others when an individual vaccinates against COVID-19. The election of altruism as an element of the intervention follows the findings of two experiments during COVID-19 by Galasso et al. (2021) and Argote et al. (2021). Galasso et al. (2021) suggest that altruistic appeals effectively increase vaccination intentions and behaviors. Argote et al. (2021), from an experiment in six Latin American countries, find that enforcing the belief that vaccination is part of a collective effort to overcome COVID-19 can reduce vaccine hesitancy.

Framing: Finally, the intervention applies different framings to group public health information. The integration of framing is based on studies showing that the organization of information affects how individuals relate to that information (Mertens et al., 2022). Mertens et al. (2022) call these interventions decision information assistance interventions. For instance, one of these assistance interventions is a traffic light symbol, which provides a quick and easy guide to help with a decision (Sinclair 2014). Specifically, Sinclair (2014), in a systematic review and meta-analysis on the effect of menu labeling on calories selected, finds that including interpretative nutrition intervention (e.g., traffic light symbols) leads consumers to eat fewer calories. In this study, I use a traffic light rating system to communicate the levels of risk of different activities during COVID-19.

This study tests the hypothesis that an online intervention grounded in the principles of behavioral economics, commonly used as nudges, impacts COVID-19 vaccine attitudes.

Ho: Relative to the control group, exposure to the content of the online behavioral intervention increases positive attitudes toward the COVID-19 vaccine.

EXPERIMENTAL DESIGN

To test the hypothesis that the online behavioral intervention positively affects COVID-19 vaccine attitudes, I implement a field experiment with the government of the state of Guanajuato, Mexico. The government runs an online communications campaign featuring a quiz called "¿Realmente eres el coronaheroe que crees?, and the experiment is embedded in the quiz (see Figure 7).

The quiz takers are unaware of their participation in an experiment. Both groups start with a series of demographic questions. After the demographic questions, the control and treatment groups are assigned based on one of two picture choices. The pictures are almost identical, and they appear in random order. I use this assignment system because the online platform hosting the quiz does not provide a built-in randomizing mechanism.

Immediately after the assignment to control and treatment groups, the control group answers the outcome question about COVID-19 vaccine attitudes toward the COVID-19 vaccine before exposure to the behavioral economics content of the intervention. The treated group answers the outcome question after exposure to the behavioral economics content of the intervention. Given this experimental design, the control group's answers are unaffected by the intervention.

The outcome variable is: What is your attitude towards the COVID-19 vaccine? The answers are based on a 9-point Likert scale where 1 is completely against, and 9 is completely in favor. The 9-point Likert scale design follows Taherdoost (2019). On a 9-point Likert scale, option 6 represents "slightly in favor" (Taherdoost 2019).

Participants

The experiment in this study is in collaboration with the government of Guanajuato, Mexico. The Guanajuato's government social communications department recruited respondents through their social media accounts, WhatsApp messages, official websites, and an email campaign to the state university and high schools. The first wave of recruitment lasted three weeks, starting on May 7, 2021, and it recruited 4,679 people. The second wave of the recruitment process lasted around four weeks, from July 27 to September 2021, and recruited 807 additional people. In total, 5,486 people from

Guanajuato participated in the study. Given the recruitment process, the sample was more educated and younger than the average Mexican.

Descriptive Statistics

Table 16 shows the descriptive statistics of available variables in the database. Table 17 shows that treatments are balanced on the observable characteristics of the sample. “Female” takes value 1 if the respondent is female and 0 otherwise. “Adults” is a binary variable that takes the value 1 if the individual is 64 or younger and 0 otherwise, and “Senior” is a binary variable that takes the value 1 if the individual is 65 or older and 0 otherwise. “High school or less” takes the value 1 if the respondent has a basic education and 0 otherwise. “Intervention Score” represents the score obtained during the intervention based on the answers to the quiz questions.

The population in the experimental sample is younger, more educated, and shows a greater proportion of females than the average Mexican person as per the latest available Mexican Population Census (INEGI). As such, the recruitment method is under-sampling older and less educated individuals. However, there are no strong reasons to believe that it affects the external validity of the results. The literature on internet-based health interventions shows that more females than males seek web-based health information (Strecher 2007). Moreover, compared to non-seekers, seekers are better educated, wealthier, and younger (Strecher 2007).

REGRESSION MODEL

The impact analysis is a standard treatment-on-the-treated analysis (TOT) since the online quiz does not record the answers of those who do not finish the experiment. Therefore, in this analysis, I can only use completed quiz answers.

I estimate models of the following form:

Equation 6

$$y_i = \propto + \beta T + \gamma X_i + u_i$$

The outcome variable in the regression model is a categorical variable that measures attitudes toward the COVID-19 vaccine on a scale of 1 to 9. A value of 1 indicates a strong negative attitude (completely against), and 9 indicates a strong positive attitude (completely in favor). T is an indicator variable taking the value of 1 for the treatment group, with T=0 as the reference category. The coefficient β represents the difference in the mean value of the dependent variable between those assigned to the control and treatment. X is a vector of controls that include characteristics collected at the beginning of the quiz: gender, education, age, and knowledge about health recommendations (game score).

RESULTS

Table 18 presents the results of estimation 1. Column 1 displays the OLS estimates without controls; subsequent columns add controls gradually. The outcome variable I estimate in Table 18 is a categorical variable ranging from 1 to 9. The results show that, on average, subjects who go through the behavioral intervention reported a COVID-19 vaccine attitude score of 0.207 points higher than those in the control group ($p<.001$). This is a small but statistically significant improvement from the mean COVID-19 vaccine attitude of 7.82 out of 9 points. The difference is equivalent to a 2.69 percent improvement over the control mean.

Table 19 shows the results from an estimation model to a binary variable that takes the value 1 when the reported attitude score exceeds three different cut-offs and 0 otherwise. The cut-offs are 6 or more, 7 or more, or 8 or more. The first cut-off was decided based on Taherdoost (2019), which identifies 6 as "slightly in agree," 7 as "agree," and 8 as "strongly agree" on a scale from 1-9. Odd-numbered columns show regression results without controlling for covariates. Even-numbered columns report the results controlling for the covariates.

The results of the OLS estimation are consistent with the marginal effects results from the Probit estimation. Thus, I interpret the coefficients of the table as marginal probabilities. I show that compared to the control group, there is a 2.84 percent higher probability that a subject will answer the attitude question with a 6 or greater if they were part of the treatment group. Moreover, these results show that the intervention increases the probability of having a COVID-19 vaccine attitude of more than 7 and more than 8 by 3.5 percent and 5.1 percent, respectively. All estimations show statistically significant results at the 99 percent confidence level.

The results of different cut-offs show that, as I code answers on vaccine attitudes closer to the positive extreme as 1, the β coefficient increases. Thus, changes in the extreme values of the scale seem to be driving the results. To investigate this further, a two-way histogram and a density function of vaccine attitudes are shown and compared in Figure 8 and Figure 9. Table 20 shows the Kolmogorov-Smirnov test for equality of distributions. The result shows that the treatment group had a higher concentration of respondents that scored their attitude as completely in favor (Score = 9) of the vaccine.

Other studies show that attitudes toward vaccines are different among different population groups, specifically females, the youth, and people with different levels of education (Paul et al., 2020; Malik et al., 2020). Thus, possible heterogeneous effects were tested with the original model. The results show that the treatment had a marginally positive effect on adults with high school as their highest level of education at a 90 percent confidence level of 0.171 points on a scale from 1 to 9. The results do not show other heterogeneous effects. Table 21 includes the regression results.

CONCLUSION

The results from this field experiment show that the online behavioral intervention has a small and statistically significant positive effect on vaccine attitudes of 0.207 points on a scale from 1-9. The baseline of COVID-19 vaccine attitudes is 7.82. Thus, the change is equivalent to a 2.65 percentage point increase. The heterogeneous analysis shows that the online behavioral intervention is marginally more effective for individuals with low levels of education in a statistically significant way. Finally, the improvement in vaccine attitudes comes from the positive extreme of the distribution, i.e., positive vaccine attitudes improve by experiencing the online intervention.

This study may provide valuable insights to governmental entities seeking low-cost methods for positively impacting COVID-19 vaccine attitudes and other vaccines. However, to provide policymakers with more robust recommendations, future research could focus on three different fronts. First, researchers could endeavor to disentangle the effects of each behavioral economics element that the online intervention incorporates. Second, an additional study could explore the impact of this online intervention on populations with more negative vaccine attitudes. Lastly, a similar study to this chapter can test the effect of a kitchen sink behavioral intervention on attitudes toward other vaccines.

TABLES AND FIGURES FOR CHAPTER THREE

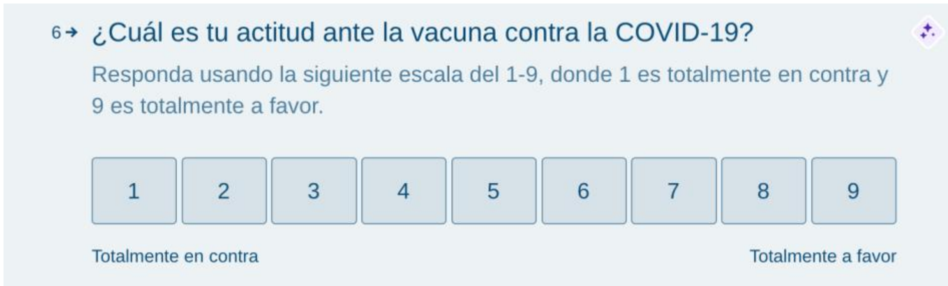

Figure 5. Outcome question as seen by experiment participants

Note: The English translation of the question is: What is your attitude toward the COVID-19 vaccine? Respond using the following scale from 1-9, where 1 is completely against, and 9 is completely in favor. Labels: Completely against. Completely in favor.

Figure 6. Examples of the feedback given during the quiz based on the behavioral economics elements of heuristics, altruism, and framing

Note: The English translation is the following. Top left: Do it for OTHERS. Physical distancing, open spaces, mask on. Top right: Wearing your mask like this... is like wearing your glasses like this. Cover your nose and mouth with your mask. Bottom right: Get vaccinated. Be part of the solution, get vaccinated against COVID-19 [The illustration shows elderly people in the background]. Bottom left: High risk (red), moderate risk (yellow), low risk (green).

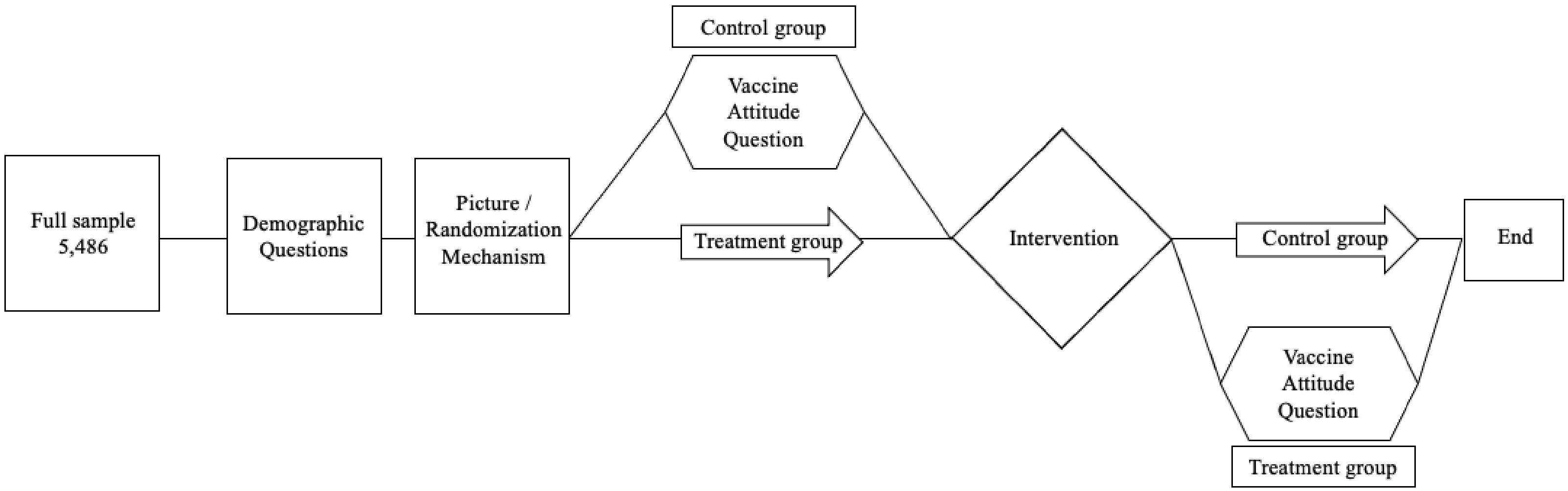

Figure 7. Graphic representation of the experimental design

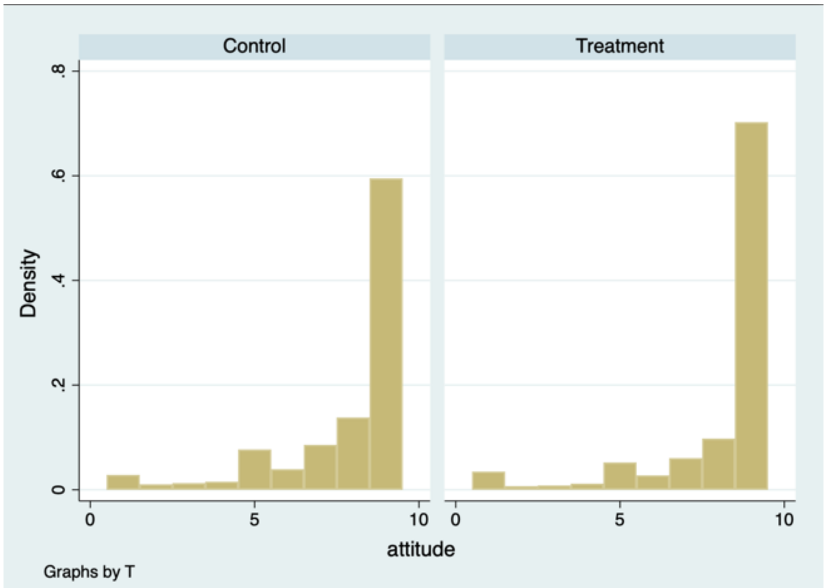

Figure 8. Two-way histogram of vaccine attitude answers from a scale of 1 to 9

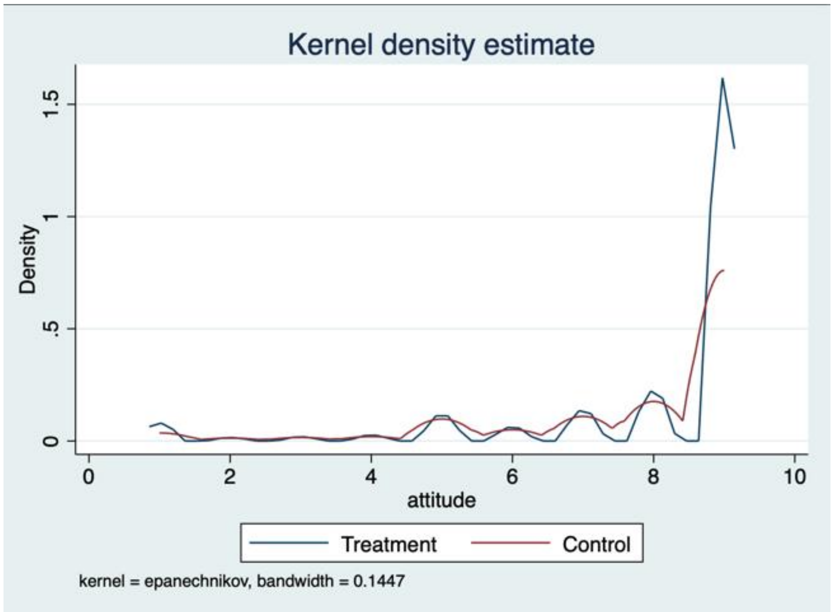

Figure 9. The density function of COVID-19 vaccine attitudes of the sample by the experimental group

Note: The blue line in this graph represents the kernel density function for the attitude score for the treatment group, and the red line represents the control group attitude score kernel density distribution. The X-axis represents the attitude score of the vaccine, which ranges from 1 to 9. The Y-axis represents the kernel density distribution.

Table 16. Descriptive statistics

		N	Mean	SD	Min	Max
	Female	5486	0.62	0.48	0	1
	Adult	5486	0.99	0.08	0	1
Demographics	*Senior*	5486	0.01	0.08	0	1
	High school or less	5486	0.45	0.50	0	1
	College or more	5486	0.55	0.50	0	1
	May	5486	0.85	0.35	0	1
	June	5486	0.02	0.14	0	1
Months	*July*	5486	0.04	0.20	0	1
	August	5486	0.08	0.27	0	1
	September	5486	0.002	0.04	0	1
Intervention score	*Quiz score*	5486	59.16	10.87	0	71
Outcome variable	*Vaccine attitude*	5486	7.91	1.94	0	1

Note: "Female" takes value 1 if the respondent is female and 0 otherwise. "Adults" is a binary variable that takes the value 1 if the individual is 64 or younger and 0 otherwise, and "Senior" is a binary variable that takes the value 1 if the individual is 65 or older and 0 otherwise. "High school or less" takes the value 1 if the respondent counts only with basic education and 0 otherwise. "Intervention Score" represents the score obtained during the intervention based on the answers to the quiz questions.

Table 17. Balance table

VARIABLES	(1) Control Mean (SE)	(2) Treatment Mean (SE)	(3) Pairwise t-test Mean difference
Female	0.630	0.614	-0.015
	(0.008)	(0.011)	
Adult	0.995	0.991	-0.003
	(0.001)	(0.002)	
Senior	0.005	0.009	0.003
	(0.001)	(0.002)	
High school or less	0.452	0.459	0.007
	(0.009)	(0.011)	
College or more	0.548	0.541	-0.007
	(0.009)	(0.011)	
Quiz score	59.266	58.982	-0.284
	(0.178)	(0.255)	
N	2082	3404	5486

Note: "Female" takes value 1 if the respondent is female and 0 otherwise. "Adults" is a binary variable that takes the value 1 if the individual is 64 or younger and 0 otherwise, and "Senior" is a binary variable that takes the value 1 if the individual is 65 or older and 0 otherwise. "High school or less" takes the value 1 if the respondent counts only with basic education and 0 otherwise. "Intervention Score" represents the score obtained during the intervention based on the answers to the quiz questions. The value displayed for T-test is the difference in the means of the control and treatment groups for each variable. The standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 18. Does the online intervention increase positive vaccine attitudes?

VARIABLES	(1) OLS **Vaccine attitudes**	(2) OLS **Vaccine attitudes**	(3) OLS **Vaccine attitudes**	(4) OLS **Vaccine attitudes**	(5) OLS **Vaccine attitudes**	(6) OLS **Vaccine attitudes**
Treatment	0.242***	0.239***	0.240***	0.246***	0.256***	0.207***
	(0.0538)	(0.0538)	(0.0538)	(0.0528)	(0.0511)	(0.0534)
Female		-0.147***	-0.149***	-0.0987*	-0.186***	-0.183***
		(0.0539)	(0.0540)	(0.0531)	(0.0515)	(0.0515)
Senior			-0.296	-0.310	-0.0636	-0.124
			(0.324)	(0.318)	(0.308)	(0.308)
High school or less				-0.749***	-0.542***	-0.525***
				(0.0516)	(0.0510)	(0.0513)
Quiz score					0.0454***	0.0444***
					(0.00234)	(0.00236)
June						0.125
						(0.177)
July						0.332***
						(0.125)
August						0.204**
						(0.0943)
September						-0.182
						(0.612)
Constant	7.821***	7.913***	7.916***	8.223***	5.494***	5.525***
	(0.0332)	(0.0474)	(0.0476)	(0.0512)	(0.149)	(0.149)
Observations	5,486	5,486	5,486	5,486	5,486	5,486
R-squared	0.004	0.005	0.005	0.042	0.104	0.105
Controls	NO	YES	YES	YES	YES	YES

Note: *** p<0.01, ** p<0.05, * p<0.1. The variable "Treatment" takes value 1 if the individual was assigned to the treatment group and 0 otherwise. "Female" takes value 1 if the respondent is female and 0 otherwise. "Senior" is a binary variable that takes the value 1 if the individual is 65 or older and 0 otherwise. "High school or less" takes the value 1 if the respondent counts only with basic education and 0 otherwise. "Intervention Score" represents the score based on the answers to the quiz questions. The month variables control for the time in 2021 a subject takes the quiz.

Table 19. Regression results if the attitude score is greater than six, seven or eight

VARIABLES	(1) OLS **Slightly agree 6+**	(2) OLS **Slightly agree 6+**	(3) OLS **Agree 7+**	(4) OLS **Agree 7+**	(5) OLS **Strongly Agree 8+**	(6) OLS **Strongly Agree 8+**
Treatment	0.0296***	0.0279***	0.0413***	0.0346***	0.0670***	0.0510***
	(0.0094)	(0.0095)	(0.0103)	(0.0104)	(0.0119)	(0.0119)
Female		-0.0276***		-0.0409***		-0.0403***
		(0.0092)		(0.0100)		(0.0115)
Senior		-0.0198		0.0102		0.0814
		(0.0548)		(0.0599)		(0.0685)
High school or less		-0.0802***		-0.0978***		-0.120***
		(0.0091)		(0.0099)		(0.0114)
Quiz score		0.0062***		0.0073***		0.0084***
		(0.0004)		(0.0005)		(0.0005)
Constant	0.858***	0.546***	0.818***	0.456***	0.733***	0.310***
	(0.0058)	(0.0266)	(0.00637)	(0.0290)	(0.00732)	(0.0332)
Observations	5,486	5,486	5,486	5,486	5,486	5,486
R-squared	0.002	0.068	0.003	0.084	0.006	0.095
Control	NO	YES	NO	YES	NO	YES

Note: *** p<0.01, ** p<0.05, * p<0.1. Columns 1 and 2 code the outcome variable as 1 if the subject answered the vaccine attitude question as "slightly agree," i.e., with 6 or more. Columns 3 and 4 code the outcome variable as 1 if the subject answered the vaccine attitude question as "agree," i.e., 7 or more. Columns 5 and 6 code the outcome variable as 1 if the subject answered the vaccine attitude question as "strongly agree," i.e., 8 or more. Even numbered columns do not control for covariates, and odd-numbered columns do. Odd-numbered columns include month controls. A Probit estimation shows virtually the same results as the OLS estimation.

Table 20. Kolmogorov-Smirnov test for equality of distribution functions

Smaller group	D	P-value
Control	0.1073	0.000
Treatment	-0.0064	0.900
Combined K-S	0.1073	0.000

Note: The table above presents the Kolmogorov-Smirnov test for equality of distribution functions for the attitude scores looking at the difference between Treatment and Control.

Table 21. Heterogeneous effects analysis

VARIABLES	(1) OLS **Vaccine attitudes**	(2) OLS **Vaccine attitudes**	(3) OLS **Vaccine attitudes**
Treatment	0.139*	0.213***	0.126*
	(0.0842)	(0.0536)	(0.0726)
Female	-0.225***	-0.184***	-0.184***
	(0.0653)	(0.0515)	(0.0515)
Senior	-0.109	0.299	-0.115
	(0.308)	(0.434)	(0.308)
High school or less	-0.527***	-0.527***	-0.589***
	(0.0513)	(0.0513)	(0.0641)
Quiz score	0.0444***	0.0443***	0.0444***
	(0.00236)	(0.00236)	(0.00236)
T x Female	0.111		
	(0.105)		
T x Senior		-0.848	
		(0.615)	
T x High school or less			0.171*
			(0.103)
Constant	5.556***	5.536***	5.558***
	(0.152)	(0.150)	(0.151)
Observations	5,486	5,486	5,486
R-squared	0.106	0.106	0.106
Month FE	YES	YES	YES

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. The table above provides the OLS regression results of equation 6. The outcome variable is a categorical variable that measures vaccine attitudes on a 9-point scale. The covariates are Female, Senior, and Highschool or less, and T represents the treatment allocation.

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