Targeting vaccine information framing to recipients' education: a randomized trial*

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Abstract

Can we target information framing to the background of its recipients to increase vaccination uptake? We randomize framing in an informational intervention on 7616 mothers of girls and boys due to receive the HPV vaccine in Sweden in 2021. Mothers are stratified by education level. We send a written leaflet covering vaccine safety and the consequences of catching HPV-induced cancers. It emphasizes sterility and invasive medical procedures, which are concerns leveraged by disinformation. The leaflet is framed emotionally, through the testimonies of local cancer survivors, or scientifically, using medical and statistical terminology. We add a control group that receives a reminder of the same length. Only mothers with compulsory schooling respond to scientific framing by increasing their vaccination uptake (+5.7 p.p. or +7.25%), but they understate their willingness to vaccinate. The effect is driven by mothers who read our leaflet attentively and had little previous knowledge of HPV. Emotional framing reduces the uptake of mothers with high school education who are more hesitant at baseline and read superficially (-4.8 p.p. or -5.41%).

JEL: I12, I18, D83, J13

Keywords: information framing, vaccinations, education

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1 Introduction

Vaccine hesitancy was already a concern for public health in 2019 (Dubé et al., 2021),[1] and the Covid-19 pandemic has only increased the urgency to address it. However, designing and targeting effective vaccine informational campaigns is challenging, one reason being that the role of recipients' education in absorbing information on vaccines is unclear. Some studies from health economics showed that college-educated mothers reacted more to waves of pseudo-scientific disinformation following the Measles-Mumps-Rubella (MMR) scare (Anderberg et al., 2011; Chang, 2018). On the other hand, correlational epidemiological studies suggest that parents with low education are more susceptible to emotionally-framed vaccine disinformation on social media (Yiannakoulias et al., 2019; Puri et al., 2019; Kearney et al., 2019; Hoffman et al., 2019). Framing, therefore, could be the key to resolving the apparent inconsistencies in how education interacts with the absorption of vaccine information. Nevertheless, existing studies do not focus on the interaction of framing and education, nor do they consider possible non-linearities in the effect of education.[2]

This paper uses a stratified randomised controlled trial in Sweden to study the effect of framing true vaccine information by recipients' education. Specifically, we investigate whether scientific and emotional framing raise vaccination uptake differently by mothers' educational background. To uncover potential non-linearities, we include four educational strata: compulsory schooling, high school degree, undergraduate university and postgraduate university education. We also include a fifth stratum comprised only of immigrants from the most representative immigrant communities in Sweden and Europe. Non-European immigrants consistently appear among the least vaccinated and more vulnerable populations to preventable diseases, due to higher vaccine hesitancy and lower access and utilization of health services (Dahlström et al., 2010; Wang et al., 2019; Azerkan et al., 2012; Møen et al., 2017). In other words, we investigate whether the framing techniques adopted by disinformation can be leveraged in the context of informational campaigns and whether the relationship between framing and recipients' education and background can be exploited in the same way.

We focus on the Human Papillomavirus (HPV) vaccine. It is recommended at age 12 and it has the potential to eradicate cervical cancer, a common cause of death for 15-44 years old

[1] It was listed among the World Health Organization's *Ten threats to global health*.

[2] Indeed, they either consider education as a covariate and not as their main focus, or they define education as a binary variable (college-educated or not) due to data constraints.

women in both developed and developing countries. Nevertheless, between 2019 and 2021 the HPV vaccine uptake experienced a 25% decrease, more than any other vaccine (The Economist, 2023). Counteracting the disinformation behind this uptake decline with effective informational campaigns thus constitutes a policy challenge in many countries.

Our treatment consists of a 650-word leaflet covering the vaccine's safety and the consequences of catching cancer induced by HPV, similar to those handed out by Swedish government authorities. The emotional framing conveys these contents through the testimonies of local cancer survivors, whereas the scientific framing uses medical and statistical jargon. A third group (the control) receives a leaflet which reminds of the upcoming vaccination possibility and contains some uninformative text of the same length which covers the history of the Swedish vaccination program.

With a different framing, our treated mothers receive the same informal content. The leaflets aim at shifting the focus from the adverse effects of the vaccine to the consequences of HPV-induced cancers, which are far more likely: cervical cancer alone, which is caused by HPV, is the fourth most common cause of women's deaths in the world,[3] and in recent years HPV has been found to cause an increasing number of head-neck cancers that also affect men (Chaturvedi et al., 2013). Our leaflets report that HPV-induced cancers are transmitted sexually and are a serious threat at any age. We emphasize that treatment for gynaecological HPV-induced cancers is invasive, that it often causes temporary or even permanent sterility, and significantly increases the risk of miscarriages. Vaccine disinformation often claims that vaccines negatively affect both women's and men's fertility – also recently, relative to Covid-19 vaccines[4] –, and this type of disinformation is particularly effective and widespread among some immigrant communities that attach high value to their children's fertility.

Written leaflets are a low-cost policy intervention that, unlike other strategies such as SMS, e-mails and social media campaigns, facilitates the identification of the sender as a trustworthy public authority and has a nearly universal reach. In Scandinavian countries, it is the norm for government agencies to send written materials to the recipients' home addresses. Indeed, our leaflets are built upon the status quo leaflet on the HPV vaccine from the Swedish Public Health Agency.[5] Written leaflets also avoid competing for attention on social media, which are used by for-profit firms in the

[3] As of January 2019, according to the World Health Organization fact sheet.

[4] Fake news even claim that vaccinated people might affect women's fertility by standing close to them, and have now spread to also consider men.

[5] The governmental leaflet can be found at this link, whereas our leaflets are included in Section A of the Appendix.

context of advertising and do not ensure that the entire target population is reached. Leaflets, on the other hand, can be delivered in schools and hospitals to ensure near-universal coverage of the target population. Indeed, Hirani (2021) finds that reminder letters are effective for parents who lag behind with their children's vaccinations in Denmark.

We conduct our experiment in collaboration with *Statistics Sweden* in Stockholm County, Sweden, on a sample of 7616 mothers whose children were offered the HPV vaccine in the autumn of 2021.[6] Sweden is the ideal setting for two reasons. First, we relied on population registers to measure vaccination uptake from administrative, objective records, and to build our sample: as a result, our main analysis does not suffer from participation bias. Since we also include a short survey to measure self-reported intention to vaccinate, we provide a secondary contribution by comparing results using as outcomes the actual uptake ($N = 7616$) and self-reported intention to vaccinate ($N = 2204$), a common solution for field experiments in the absence of vaccination registries (e.g. Alsan and Eichmeyer (2023)). Moreover, the rich information contained in population registers allows us to characterize survey respondents relative to the full, non-selected sample, and those who react to our treatment. Second, all childhood vaccinations are fully voluntary in Sweden, and they are offered for free directly in schools and administered by school-resident nurses: parents only need to sign an authorization and do not need to be present at the moment of inoculation. This greatly reduces both the monetary and non-monetary costs faced by parents when choosing to vaccinate their children. Moreover, kids who are absent on the day of vaccination can still be vaccinated by the school nurse when they come back to school: school absences do not constitute a problem in our setting.

We restrict our attention to Stockholm County to ensure homogeneous exposition to previous informational campaigns at baseline- typically organized at the county level- and to ensure a sufficient presence of mothers with a postgraduate education or an immigration background. Finally, HPV vaccine uptake in Sweden remains sub-optimal (below 90%), and it is particularly low for boys (82.9% for the first dose in 2020). Furthermore, these figures hide a substantial heterogeneity by parents' educational level: even after receiving an extra reminder, the uptake in our control group ranges from 78.6% when mothers stopped at compulsory education to 93% when they pursued graduate studies.[7]

[6] We also observe fathers' characteristics and consider them in our heterogeneity analysis. The literature highlights that mothers are more often responsible for decisions on children's health and for managing doctor appointments (Case and Paxson, 2001; Daly and Groes, 2017).

[7] More statistics on HPV vaccination uptakes can be found on the Swedish Public Health Agency's website.

We find that scientific framing increases uptake by 5.7 percentage points (+7.25%) among mothers with compulsory education. However, emotional framing is counterproductive, as it lowers the uptake of mothers with a high school degree by 4.8 percentage points (-5.41%). Framing is not a solution to the low uptake among immigrant mothers, as their reactions are mostly driven by baseline socioeconomic characteristics. Moreover, our heterogeneity analysis reveals significant differences by country of origin: for immigrants, research should investigate framing in more narrowly targeted dimensions. Relative to pre-existing studies, our results confirm the negative educational gradient in the absorption of vaccine information (Hirani, 2021; Anderberg et al., 2011; Chang, 2018; Qian et al., 2020) and provide new insights on the relationship between education and the effectiveness of information framing.

The positive effect of scientific framing is driven by mothers who respond to our first survey, whereas the negative effect of emotional framing is found exclusively among mothers who did not respond. To investigate mechanisms, we characterize respondents and non-respondents: we find that respondents have a more positive attitude towards vaccines at baseline and are more attentive in reading our leaflet. While Hirani (2021) finds that people who do not respond to written reminders are reluctant rather than inattentive, we find that when information is provided on top of the reminder, attentiveness also drives the behavioural response to the campaign (i.e. vaccination uptake). These results are complemented by a heterogeneity analysis using causal forests (Athey and Imbens, 2016). For both positive and negative effects, estimates are larger for mothers who had no knowledge of HPV prior to our intervention. As a policy recommendation, we highlight the importance of planning only a few, highly effective campaigns: being exposed to ineffective information can exhaust attention for future interventions and lead to null or potentially counterproductive effects. To this end, emotional framing should be avoided regardless of the recipients' background.

In terms of measurement, the positive effect of scientific framing is also found when the outcome is the self-reported intention to vaccinate. However, the effect is understated with respect to actual vaccination uptake: this suggests that studies relying on self-reported intention to vaccinate provide a lower-bound estimate of the effect on actual vaccination uptake.

This paper broadly contributes to a large and growing literature on the use of behavioural messaging and nudges in several fields of economics. Two recent examples are Delfino (2021), in labour economics, which uses pictures and information about the degree of competitiveness to

increase male applications to female-dominated jobs, while in finance Barboni et al. (2022) test several written nudges to encourage repayment from debt holders. Our contribution is to show that different types of behavioural messages affect different people. Within a health setting, our experimental design is built around this contribution with a specific focus on recipients' education. We show that different reactions can be rationalized by reluctance and attentiveness in absorbing the information. Moreover, contrary to evidence from other fields (e.g. Antinyan and Asatryan (2019) who review the effect of nudges on tax payments), we show that informational interventions can produce a behavioural response in low-income recipients even after months from the initial intervention.

This study also adds to a growing economic literature on the theme of vaccinations. Qian et al. (2020) shows that the negative educational gradient in disinformation absorption (Anderberg et al., 2011; Chang, 2018) can be rationalized by confirmatory bias during parents' information search. More recent randomized trials in health economics have been testing the effect of informational interventions on vaccination uptakes. Alsan and Eichmeyer (2023) focused on the under-vaccinated population of black males in the US and randomize an informational video on the flu vaccine where the treatment consists of varying race concordance and perceived expertise of the speaker, as well as their acknowledgement of past injustice towards racial minorities. In this context, where receivers are typically lowly educated, they find that non-experts are more effective in increasing the uptake by reducing the perceived social distance between the informant and the information receiver. We test whether the emotionally framed testimonies of local cancer survivors and the scientifically framed information impact receivers differently across the entire spectrum of education and by their immigration background. Banerjee et al. (2021) instead test the effectiveness of several nudges used to remind people in India about the measles vaccination, both for themselves and their children. Galasso et al. (2022) test a series of messages on Covid-19 vaccines in 9 countries to identify which informational contents are most effective in raising intentions to vaccinate. Randomized informational interventions are also present in the field of epidemiology (Tiro et al., 2015; Nyhan et al., 2014; Nyhan and Reifler, 2015; Horne et al., 2015). Rather than changing the informational content, we contribute by focusing on its framing and its interaction with recipients' educational and cultural backgrounds.

Cox et al. (2010) also investigate the effect of framing of HPV vaccine information on 471 mothers of 11-16 years old girls in the US. Treatments vary in whether statistical information is

presented at all, and if so, whether in a graphical or written form. However, the authors do not focus on mothers' educational backgrounds. Moreover, their experiment was carried out in the US, where the vaccine is not free and the results might be confounded by income effects. Another key difference is the type of framing we consider: we consider two techniques that are successfully exploited by disinformation.

In the context of the Danish childhood vaccination program, Hirani (2021) argues that parents who do not vaccinate even after receiving a written reminder are not inattentive but rather reluctant. We show that attentiveness also plays a role across different educational backgrounds when information is provided on top of reminders.

The rest of the paper proceeds as follows: Section 2 introduces the institutional context and the data; Section 3 describes our informational intervention; Section 4 details our experimental design and outcome variables; Section 5 presents our main results, and Section 6 investigates heterogeneity by child's gender and using causal forests; Section 7 discusses the mechanisms of action of our intervention. Finally, Section 8 concludes the paper.

2 Background and data

2.1 The HPV virus and the HPV vaccine in Sweden

There are approximately 100 types of HPV, 14 of which pose a high risk to develop cancer. HPV is responsible for up to 90% cases of cervical cancer, the second most common cause of death for women in Europe, and for the majority of vulvar, vaginal, anal and penile cancers.[8] It is now thought to also cause approximately 70% of oropharyngeal cancers, the prevalent HPV-associated cancer in men. It is estimated that nearly every sexually active adult enters into contact with HPV during their life (European Centre for Disease Prevention and Control, 2020; Viens et al., 2016; Chaturvedi et al., 2013). The HPV vaccine GARDASIL 9©offered by the Swedish vaccination program protects against 9 HPV types responsible for the most part of cancer cases.

The diffusion of HPV and HPV-induced cancers in Sweden is in line with the rest of Europe, with some cancers exhibiting higher incidence peaks (International Agency for Research on Cancer,

[8]In Europe, there are 33000 annual cases and 15000 deaths caused by cervical cancer (European Centre for Disease prevention and Control, 2018).

2019).[9] In terms of vaccination uptake, the Swedish figure remains below the recommended value (90%), although the figure for girls is high relative to other European countries (Bruni et al., 2021). However, the 80% uptake of the two doses hides considerable heterogeneity by parents' education: this is evident in Table 2, where, however, the uptake figures for the control group are higher than in the population since it is measured after one extra reminder and, potentially, having answered a survey on the HPV vaccine. In particular, our field area (Stockholm County) reports an average uptake of 78% for both doses, lower than other areas in the country (The Public Health Agency of Sweden, 2018).

Sweden also constitutes an exceptional setting to randomize an informational intervention on vaccines. Children in fifth grade (11-12 years old) are offered the HPV vaccine free of charge directly in schools, between September and October.[10] All vaccinations in Sweden are fully voluntary, and parents only need to express consent for the vaccination through a paper consent form. The vaccine is then administered by the resident school nurse during normal school time.[11] This ensures that the choice to vaccinate is the result of personal beliefs about the vaccine and is not confounded by monetary and non-monetary costs.

2.2 Population and administrative data

Our population of interest is children (and their mothers) who were due to receive the HPV vaccine in the fall of 2021 in Stockholm County. We sample 7616 children-mothers pairs out of a population of 21952.[12] We restrict to Stockholm county to ensure uniformity of available information at baseline, since informational campaigns administered by schools are organized at the county level. Moreover, the city of Stockholm ensures a sufficient representation of both immigrant and highly educated parents. As detailed in Section 4, we stratify by mothers' country of origin and education level. For mothers born outside of Sweden, we restrict to those born in Eritrea, Iraq, Iran, Afghanistan, Somalia and Syria, as they are the most common non-European immigrants

[9] Bruni et al. (2023) report the age-standardized incidence per 100.000 inhabitants of all HPV-induced cancers in Sweden compared to the world figure: it has a higher incidence of anal (0.61, versus 0.49), vulvar (1.34 vs 0.85), penile (0.91 versus 0.80), oropharyngeal (3.85 versus 1.79 for men, 1.31 versus 0.40 for women), whereas cervical (10.4 versus 13.3) and vaginal cancer (0.26 versus 0.36) incidences are close to the global incidence rate.

[10] While this has been true for girls since 2010, boys have been included under the same conditions in 2020, in line with several other countries.

[11] Children who are absent on the day of inoculation can receive it with the same modalities once they are back in school, and every child's parents are asked about their consent.

[12] Mothers are more often responsible for decisions on children's health and for managing doctor appointments (Case and Paxson, 2001; Daly and Groes, 2017). We discuss this point again in Section 4 and in the Appendix.

in Sweden, and they are representative of numerous immigrant communities in other European countries.

For all 7616 children-mothers in the sample, we observe HPV vaccination records (the primary outcome) so that our results are not affected by voluntary participation in the study. Our secondary outcomes, namely self-reported intention to vaccinate and beliefs on vaccines, are instead measured with a survey administered right after being exposed to the leaflet and are observed only among survey respondents. We also run an endline survey in November, after the HPV vaccination: it asks mothers whether they have authorized the vaccination and investigates possible mechanisms. The evidence from this second survey remains only suggestive due to the reduced sample size and high self-selection ($N = 694$). The main purpose of this second survey is to study the determinants of self-selecting into replying, which we discuss for our mechanisms' analysis (Section 7).

The administrative data also include detailed information on parents/guardians' income, capital gains and losses, occupation, education and demographic characteristics and children's most recent vaccination record before treatment (how many doses of the MMR vaccine they received three years before treatment). The full list of variables is presented in Section C of the Appendix. The first survey (Section D of the Appendix) asks about pre-treatment reception of information on the vaccine, sources of information, intention to vaccinate, beliefs on vaccines, questions about personal networks and percentage of the informational leaflet read. The Appendix also contains the second survey.

Population registers are held by Statistics Sweden, and combining different registers and survey data implies using sensitive information, including subjects' identity and residence address. For this reason, the sampling, implementation and data collection are carried out in collaboration with Statistics Sweden, the Swedish Statistics Bureau, and the Public Health Agency of Sweden, which holds vaccination registers.

3 The informational intervention

Our intervention consists of a written information leaflet of approximately 650 words, printed on an A4 coloured paper sheet, divided into 3 text boxes. They are included in Section A of the

Appendix. The structure mimics actual leaflets from the Swedish Public Health Agency.[13] Leaflets have been compiled by the authors,[14] drawing information from several sources that are summarized in Table J.9 in the Appendix. The content, which is kept fixed across both treated arms, addresses common concerns and misconceptions in our populations of interest which are leveraged by vaccine disinformation. For each topic that causes concern, we shift the focus away from the adverse effects of the vaccine by underlining the possibility and consequences of catching HPV-induced cancer. In particular, we cover the following topics:

Topic 1 Reminder of the upcoming vaccination possibility;

Topic 2 **Information on HPV:** there are many types of HPV, which can cause a number of cancers, affecting both men and women of all ages. The most common HPV-induced cancer is cervical cancer, which imposes a non-negligible death toll on women in Sweden. It is estimated that almost every adult enters in contact with HPV in their life and often it remains asymptomatic: this makes infected people potential virus spreaders, and vulnerable to discovering cancer when it is already at an advantaged stage, and treatment can be invasive;

Topic 3 **Efficacy and safety of the vaccine:** the HPV vaccine is almost 100% effective in preventing infection and its safety has been extensively tested as part of its approval by the European Medical Agency (EMA);

Topic 4 **Mildness and rarity of adverse effects:** the vaccine's adverse effect are closely monitored in Sweden, and are typically very rare and mild in nature;

Topic 5 **Cervical cancer is an actual threat for women of all ages**: cervical cancer, and its treatment, affect women of all ages, and it can be deadly also for young women;

Topic 6 **Cancer treatment is very invasive and has very serious side effects**: the treatment of HPV-induced can be very invasive and distressful. Cervical cancer is typically treated with combinations of surgery (if it is caught before it spreads excessively), chemo and radiotherapy. These therapies can have serious adverse effects: we pose particular emphasis on the loss of fertility (both temporary and permanent), and we also mention that they can facilitate the emergence of other infections, which can require further invasive treatment.

[13] the governmental leaflet of reference can be found at this link.

[14] Author Lisen A. Dahlström is an epidemiologist with extensive research experience on HPV, HPV-induced cancers, and optimal vaccination strategies in Sweden.

In particular, qualitative studies highlight that policy interventions aimed at non-European immigrants should be targeted to their concerns which, in the specific case of HPV, also relate to the stigma associated with sexually transmissible diseases. Indeed, while cultural factors, religious in particular, increase overall vaccine hesitancy due to vaccine components of porcine origin and concerns about vaccines causing sterility (WHO Africa, 2014; WHO EMRO, 2014; Ahmed et al., 2018; Martinez-Bravo and Stegmann, 2021), vaccinating girls and boys as young as 12 against a sexually transmitted disease (STD) is often interpreted by parents as signalling acceptance of pre-marital active sexual life, which entails high reputational costs in some immigrants' cultures (Wong, 2009; European Centre for Disease Prevention and Control, 2017). [15]

We randomize the framing of the leaflet based on three treatment groups:

- C (Control): this leaflet contains a reminder of the upcoming possibility of vaccination, plus text on the history of the Swedish vaccination program, taken from the Public Health Agency of Sweden's website;
- T1 (Emotional framing);
- T2 (Scientific framing).

The first important framing difference between treatment groups concerns the use of statistical figures. Within emotional framing (T1), we only report the ratio of adults who enter into contact with HPV and the absolute number of cervical cancer cases (and deaths) in Sweden from 2018: we explicitly avoid the use of percentages, incidence and mortality rates. Both are, instead, included in the scientific framing (T2). In addition, T2 explicitly mentions three concepts from inferential statistics: one-sided tests, statistical significance, and power of the test. These are all mentioned relative to Phase-3 clinical trials conducted on the HPV vaccine (Gardasil 9©) and are taken from its 2015 Public Assessment Report of the European Medical Agency (European Medical Agency, 2015). The second difference concerns the framing of topics (5) and (6) – cervical cancer is a threat at all ages, and cancer treatment is highly invasive and has very serious side effects. In emotional framing (T1) this information is reported in terms of testimonies of local cervical cancer survivors

[15] This might imply that reminding parents HPV is transmitted sexually might as well decrease their uptake: in the absence of previous quantitative literature, we had no prior on the effect for immigrant mothers. Similar moral hazard phenomena, known as the Peltzman effect (Peltzman, 1975) have been documented following increased access to condoms, emergency contraception, and HIV tests (e.g. Girma and Paton (2011); Durrance (2013); Buckles and Hungerman (2018); Philipson and Posner (1995)).

who describe in non-technical but emotionally charged language their experience with cervical cancer treatment, and how it affected their fertility.[16] In scientific framing (T2), the language is emotionally neutral and includes medical terminology: where possible, medical procedures have been mentioned using their technical name. The notion that cancer affects women of all ages is reported in terms of incidence and death rates in Sweden.

Both individual testimonies and scientific jargon – even when it cannot be easily understood by the audience – are used by disinformation on vaccines. Individual recounts are used more often in the context of social and traditional media disinformation (Hoffman et al., 2019; Yiannakoulias et al., 2019; Kearney et al., 2019). A famous example of scientifically framed disinformation is the MMR scare, which originated by Wakefield et al. (1998)'s then-retracted study on the supposed link between the MMR vaccine and autism, and spurred a long-lasting pseudo-scientific debate in the media. Indeed, reminder campaigns are already in use in Sweden and elsewhere: our policy question is whether providing framed information can raise uptakes beyond reminders.

The status quo in Sweden is also the reason we focused on written information, by far the most used type of campaign chosen by public health authorities.[17] Compared to videos and other social media content, its diffusion can be more easily controlled by policymakers. For instance, authorities can exploit schools as informational hubs to reach parents, or residence addresses from administrative records. By comparing different leaflets, we investigate whether framing affects how much attention people pay to written information, and how the interaction of framing and attention impacts the effectiveness of informational campaigns. Our leaflets are 650 words long: the average adult reads 238 English words per minute (Brysbaert, 2019), implying an average reading time of 2.73 minutes for our leaflets.

4 Evaluation design and outcomes

Our goal is to evaluate the effect of information framing across educational levels, and with an extra focus on immigrants. Therefore, we stratify mothers by education level and immigration background, for a total of five strata. One stratum is dedicated to all immigrant mothers from

[16] These have been extracted with the consent of their authors from the stories published by Nätverket mot gynekologisk cancer, a Swedish association of gynaecological cancer patients, survivors and their relatives.

[17] All educational materials on vaccinations aimed at both parents and health professionals can be found on thethe Swedish Public Health Agency's website.

the selected origin countries (Eritrea, Somalia, Iran, Iraq, Syria, Afghanistan) regardless of their education level, though their education is observed and controlled for in our analyses. The remaining four strata are Swedish-born mothers, categorized by their highest educational attainment. Table 1 describes the definition of strata, the number of subjects and their allocation to treatment arms. It also reports the number of survey respondents in brackets: these constitute the available sample for secondary outcomes. Section Q in the Appendix shows the subsample of respondents to the second survey, administered after vaccinations have taken place. In Section L in the Appendix, we include tables that show the balance of pre-treatment covariates across treatment arms. The differences between survey respondents and non-respondents are discussed in our mechanisms' analysis in Section 7.

Within each stratum, randomization to treatment arms is at the individual level. Children in our sample attend 611 schools located in 49 municipalities. Section H in the Appendix shows the distribution of the number of sampled children within the same school and presents a robustness check to exclude the presence of spillover effects.

Table 1: Stratified design and sample sizes for the primary and secondary outcomes

Stratum	Stratum definition	N	C units Control	T1 units Emotional	T2 units Scientific
1. Immigrants	Selected origin countries	2548	611	961	976
		(416)	(106)	(148)	(162)
Swedish-born mothers					
2. Educ-level-1	$\leq$ 3 yrs high school	1627	393	616	617
	End of compulsory schooling	(353)	(94)	(138)	(121)
3. Educ-level-2	(3 yrs high school, high school degree]	1413	337	535	541
		(484)	(112)	(203)	(169)
4. Educ-level-3	(High school degree, Undergrad]	1009	243	385	381
		(417)	(101)	(168)	(148)
5. Educ-level-4	> Undegrad degree	1019	242	387	390
		(534)	(122)	(213)	(199)
Total		7616	1826	2884	2905
		(2204)	(535)	(870)	(799)

Notes: immigrants are mothers born in Iraq, Iran, Syria, Afghanistan, Eritrea or Somalia. Stratum 2 comprises mothers with at most 3 years of high school: this corresponds to Swedish *högstadiet* (grades 7-9), the last compulsory grades under Swedish law. Mothers in stratum 3 completed high school (*gymnasium*, grades 10-12), which is not compulsory and comprises different tracks, including vocational ones. Numbers in brackets indicate survey respondents, i.e. subjects for whom we can estimate results on the secondary outcome (intention to vaccinate).

The timeline of the study was the following: at baseline (May 2021), our implementing partner *Statistics Sweden* identified the population of eligible mothers within each stratum and randomly selected subjects. The baseline information on mothers, their partners and the child was made available from registers held by *Statistics Sweden* and the *Public Health Agency of Sweden*. Invited mothers were contacted by ordinary post at their home addresses in mid-June 2021. The letter contained the informational leaflet, a short description of the study, the informed consent to take part in the first survey (with instructions to access it after reading the leaflet) and the survey. Mothers who did not answer the survey in June received up to three reminders, until August 2021.[18] All the materials were written in Swedish. However, the invitation letter states (in English)

[18]The choice of mid-June for the first contact is meant to maximize the number of mothers found at home before vacations. The most important summer holiday in Sweden, *midsommar*, marks the beginning of summer: from

that it's possible to access the leaflet and survey in English by logging in to the online version. Immigrant mothers received all printed materials in Swedish, plus a printed copy in either Arabic or Farsi depending on their country of birth. Section B in the Appendix shows the original invitation letter. Table J.10 in the Appendix summarizes the content of each envelope along the entire timeline. Finally, in November 2021, mothers who replied to the first survey received an invitation to compile an endline survey.

We do not have direct control over who replies to the survey. However, we find that on average, respondents and non-respondents differ along maternal and not along paternal baseline characteristics, suggesting that mothers are those answering (Table M.13 in the Appendix). This is in line with previous literature showing that mothers are often in charge of decisions on children's health and managing doctor appointments (Case and Paxson, 2001; Daly and Groes, 2017).

The trial was registered at the AEA Registry and at *ClinicalTrials.gov*.

4.1 Outcome variables: definition and measurement

Our main interest lies in understanding the effect of framing written messaging on vaccination uptake, which we measure in two ways:

1. **Actual vaccination (primary outcome)**. These are administrative records from population vaccination registers, measured as a binary indicator of whether the child has received the first dose of the HPV vaccine, and observed for all sampled children ($N = 7616$);

2. **Intention to vaccinate (secondary outcome)**. Subjects are instructed to answer a short survey after reading the leaflet. We ask "As of now, how likely is it that you will authorize the HPV vaccination for your child in the autumn?" and collect answers on a 7-point Likert scale. We code a binary variable equal to 1 if the parent chose one between "Slightly likely", "Likely" or "For sure", and 0 otherwise. We observe this outcome only for survey respondents ($N = 2204$);

The rationale for multiple measures is to contribute to the understanding of measurement issues

then until August, there is no customary period when the majority of the population goes on vacation. Scattering reminders over the entire period maximizes the probability that all sampled mothers receive an invitation while at home.

studies about vaccinations: they often resort to both self-reported intentions to vaccinate and ex-post indicators, given the rarity of vaccination registers (e.g. Alsan and Eichmeyer (2023)).[19]

5 Results

Within each stratum, we estimate the following logit model:

$$log\left(\frac{P(Y_i = 1)}{P(Y_i = 0)}\right) = \alpha + \tau T_i + \boldsymbol{X_i'}\boldsymbol{\beta} + \eta_m + \varepsilon_i \tag{1}$$

where $P(Y_i = 1)$ is the probability that the child receives the vaccine according to our two measures, namely:

$$Y_i = \begin{cases} \mathbb{1}\{\text{Vaccinated in vaccination registry}_i\}, \\ \mathbb{1}\{\text{Mother intends to vaccinate}_i\} \end{cases}$$

T_i is a binary treatment status indicator. We assess the effectiveness of each treatment against the control group (T1 *vs* C and T2 *vs* C). Our significant results are robust to a Bonferroni correction for 2 hypotheses. However, this correction is too conservative since both treatments involve the reception of vaccine information with the same modalities and only vary in terms of framing: they are likely to be correlated.[20]

We complement the analysis by testing the two treatments against each other (T2 *vs* T1). η_m are municipality fixed effects (our children attend 611 schools located in 49 municipalities). We follow Abadie et al. (2017) and do not cluster standard errors, since randomization is at the individual level.

$\boldsymbol{X}$ is a vector of pre-treatment covariates aimed at increasing statistical power and efficiency.

[19] In Section Q of the Appendix, we complement with a third measure collected in the second survey: after vaccination took place, mothers who replied to the first survey are contacted again to answer a second survey (in November). We ask them "Did you authorize HPV vaccination for your child in the past months?". Due to the reduced sample size ($N = 694$), we only consider this measurement as qualitative evidence.

[20] In any case, the number of hypotheses should not be multiplied by the number of strata. In fact, sampling variance drives the probability of obtaining at least one spurious significant result as the number of hypotheses increases, but in this study, each stratum has been sampled independently of the others as per the pre-analysis plan. In terms of outcomes, we effectively have one outcome measured in two ways, and among survey respondents, the two measures are almost perfectly correlated (see Section N in the Appendix).

It includes:

- Outcome before treatment: number of MMR vaccine doses received by the child;[21]
- Child characteristics: gender, birth order (relative to the mother's children);
- Parents' characteristics: total number of children, income and net capital gains in the last 12 months, reception of government transfers, age, a dummy for the mother being married, three dummies indicating whether the highest educational attainment is focused on numerical, scientific or medical subjects, grade at the national high school exam, a dummy for whether the father is a Swedish citizen;
- For immigrant mothers in stratum 1: country of origin dummies, education level. Relative to Swedish parents, we remove the high school final grade, as the percentage of immigrant mothers who graduated in Sweden is very low (less than 11%). For the restricted sample on secondary outcomes (only survey respondents), we include a dummy indicating whether they compiled the survey in Swedish.

In Section E of the Appendix we replicate the results estimating equation (1) with a linear probability model. Moreover, we also add the following "structural" linear specification:

$$Y_i = \alpha + \tau_1 T1_i + \tau_2 T2_i + \boldsymbol{X_i'}\boldsymbol{\beta} + \eta_m + \varepsilon_i \tag{2}$$

The structural interpretation of Equation (2) follows from the fact that by design, $T1$ and $T2$ are never simultaneously equal to 1. The results are quantitatively comparable.[22]

To account for the sporadic missingness in registry data and preserve power, we use multiple imputation (with 5 datasets) on the pre-treatment covariates, following Little and Rubin (2019). Section K in the Appendix describes in detail the missingness in the data and the imputation. The results are consistent when estimated on complete data.[23] Power calculations that take this into

[21] The second dose of the MMR vaccine is offered approximately three years before the intervention, under the national vaccination program, and thus under the same conditions. It constitutes a conservative measure of vaccine hesitancy, since the most recent coverage data indicate an uptake consistently above 95% across all cohorts for the second dose of MMR (whereas the most recent figure for the second dose of the HPV vaccine is only 82.9%).

[22] While this specification exploits the covariates on the entire sample in every comparison, we still consider Equation (1) our main specification for comparability reasons, since it is the model used for causal forest estimation in our heterogeneity analysis (Section 6) and to discuss some of our mechanism analysis (Section 7).

[23] They are available upon request.

account are reported in Section G of the Appendix.

Results are presented in terms of average marginal effects (AME): Table 2 refers to vaccination status measured from registers, whereas Table 3 shows result for the intention to vaccinate. For actual vaccination records, our primary outcome measure, the estimates identify an Intention-To-Treat (ITT) effect for the overall population from which each stratum is randomly sampled. For the intention to vaccinate (our secondary measure) we can only estimate the models on the subsample of subjects who replied to the first survey: the estimates identify the Average Treatment Effect (ATE) within the population of survey respondents, provided that all survey respondents have read the information leaflet. Indeed, we ask mothers how much of the leaflet they read in the survey: the median of the answer among immigrants is between 80 and 90%, and the median among each Swedish-born strata is between 90 and 100%. The use of different samples makes the two sets of estimates not directly comparable: they refer to different estimands for different populations. Table M.13 in the Appendix compares pre-treatment covariates in the two samples.

Table 2: ITT effect of information framing on actual vaccination uptake

Stratum	**Stratum definition**	**Uptake in control group**	**T1** *vs* **C** **Emotional**	**T2** *vs* **C** **Scientific**	**T2** *vs* **T1**
1.	Immigrants	0.773	-0.016	-0.013	0.002
			(0.020)	(0.020)	(0.017)
Swedish-born mothers					
2. Educ-level-1	$\leq$ 3 yrs high school	0.786	0.037	0.057**	0.029
			(0.025)	(0.024)	(0.021)
3. Educ-level-2	Up to high school	0.887	-0.048**	0.004	0.041**
			(0.022)	(0.021)	(0.020)
4. Educ-level-3	Up to UG	0.905	-0.016	-0.021	-0.010
			(0.026)	(0.025)	(0.023)
5. Educ-level-4	Graduate	0.930	0.003	0.005	-0.006
			(0.020)	(0.021)	(0.018)

Notes: *** p< 0.01, ** p< 0.05, * p< 0.10. Results are estimated on the entire sample of invited subjects: they can be interpreted as an ITT effect for the entire population of reference. Immigrants are mothers born in Iraq, Iran, Syria, Afghanistan, Eritrea or Somalia. Stratum 2 comprises mothers with at most 3 years of high school: this corresponds to Swedish *högstadiet* (grades 7-9), the last compulsory grades under Swedish law. Mothers in stratum 3 completed high school (*gymnasium*, grades 10-12), which is not compulsory and comprises different tracks, including vocational ones.

Table 3: ATE of information framing on the intention to vaccinate

Stratum	Stratum definition	Uptake in control group	T1 *vs* C Emotional	T2 *vs* C Scientific	T2 *vs* T1
1.	Immigrants	0.830	-0.039	-0.003	0.003
			(0.053)	(0.047)	(0.048)
Swedish-born mothers					
2. Educ-level-1	$\leq$ 3 yrs high school	0.862	0.002	0.115**	0.025
			(0.045)	(0.046)	(0.036)
3. Educ-level-2	Up to high school	0.929	-0.021	0.022	0.029
			(0.033)	(0.032)	(0.028)
4. Educ-level-3	Up to UG	0.931	0.036	-0.010	-0.042
			(0.036)	(0.035)	(0.032)
5. Educ-level-4	Graduate	0.967	-0.003	-0.018	-0.008
			(0.021)	(0.025)	(0.021)

Notes: *** p< 0.01, ** p< 0.05, * p< 0.10. The outcome variable is the self-reported intention to vaccinate (binary indicator). Results are estimated on the subsample of survey respondents for whom the outcome is observed: they can be interpreted as an ATE effect for this subpopulation. Immigrants are mothers born in Iraq, Iran, Syria, Afghanistan, Eritrea or Somalia. Stratum 2 comprises mothers with at most 3 years of high school: this corresponds to Swedish *högstadiet* (grades 7-9), the last compulsory grades under Swedish law. Mothers in stratum 3 completed high school (*gymnasium*, grades 10-12), which is not compulsory and comprises different tracks, including vocational ones.

Table 2 reports that for mothers with only compulsory schooling in stratum 2, only the scientific framing (T2) has a significant effect, leading to a 5.7 percentage points increase in uptake (+7.25%). On the contrary, for mothers with a high school degree in stratum 3, scientific framing is ineffective and emotional framing (T1) has a negative ITT effect, leading to a 4.8 percentage points decrease in uptake (−5.41%). Concerning null results, in Section H in the Appendix we show that they are

unlikely to be driven by spillover effects.

To rationalize these results and investigate mechanisms, in Section 7 we show that the positive effect in stratum 2 is driven by mothers who answered the first survey, whereas the negative effect in stratum 3 is driven by mothers who did not. We find that respondents are not only less hesitant towards vaccines at baseline and therefore less reluctant to receive information: they also pay more attention to the leaflet's content.

Table 3 reveals that defining the outcome as the intention to vaccinate rather than actual vaccinations makes a difference. First, a comparison of the objective and subjective uptake measures for the control group in Table 2 and Table 3 reveal that in all strata, mothers overstate their intention to vaccinate by at least 3 percentage points. Moreover, the mismatch between intentions and actual vaccination choice is larger among immigrants and lowly educated mothers.

The positive effect of scientific (T2) framing in stratum 2 is also found when using the subjective measure of the mother's intention to vaccinate. This estimate is not directly comparable to the one in Table 2, because of the different populations to which they refer, and so in Section 7 we replicate the analysis for both measurements after restricting the sample to survey respondents. Conditional on responding, scientific framing increases objective uptake by 16.1 p.p., whereas with the subjective intention to vaccinate the estimate is 11.5 p.p.. Therefore, mothers understate their willingness to vaccinate. In Section L we show that survey respondents and non-respondents differ on mothers' characteristics, whereas fathers are not statistically different. This suggests that the understatement of intention to vaccinate is not driven by mothers answering the questions whereas the entire household decides whether to actually vaccinate: mothers are likely to be behind both the answers and the decision. Further descriptive statistics that compare intention to vaccinate (on a 7-point Likert scale) and actual vaccination by stratum are presented in Section N in the Appendix.

Finally, in Section I in the Appendix, we discuss qualitative evidence of the impact of Covid-19 on our randomized study.

6 Heterogeneity analysis: causal forest

The high variance of our estimates even with a large sample suggests the effects might be characterized by a large degree of heterogeneity. To investigate this possibility while exploiting the high number of pre-treatment covariates, we resort to causal forests (Athey and Imbens, 2016). The method builds upon supervised machine learning, and in particular on CART models, to estimate conditional treatment effects. In our case, we formally estimate the CITT (Conditional Intention To Treat effect), as we focus on actual vaccination as the dependent variable.

The estimand is defined as $\mathbb{E}[Y_{1i} - Y_{0i} \mid \boldsymbol{X_i} = \boldsymbol{x}]$, where Y_{1i} and Y_{0i} are potential outcomes under treatment and control, respectively, and $\boldsymbol{X_i}$ are observable characteristics of individual i. For estimation, within each stratum we compare $T2$ and $T2$ with C, and we follow Athey and Wager (2019) and adopt an honest approach. Namely, we use half the sample to grow a forest with 1000 trees, where each tree's leaf can contain no less than 5 observations. The other half of the sample which has not been used for classification is used for the estimation.

We follow Carlana et al. (2022) in reporting the results. Since the CITT is estimated for each subject, we split the sample in two: the subsample with a CITT equal to or above average and the subsample with a CITT below average. We then test if the difference in means of each covariate in these two subsamples is statistically significant. Given the high number of covariates and the presence of five strata, we only report the covariates which return a statistically significant difference in means at the 95% significance level. These are shown in Section P of the Appendix along with the list of covariates considered in the analysis.

Among immigrants (stratum 1), we generally find that both treatments are more effective on mothers who are less educated, less likely to have any education in a scientific, numerical or medical subject, who have more misconceptions about vaccines and whose children have received on average fewer doses of the MMR vaccine before treatment. This is in line with the main results on Swedish-born mothers, where we only find an impact on the least educated. Both emotional and scientific framing have a higher impact on the segment of the population which is important to reach, namely mothers who are less likely to have received information on vaccines at baseline.

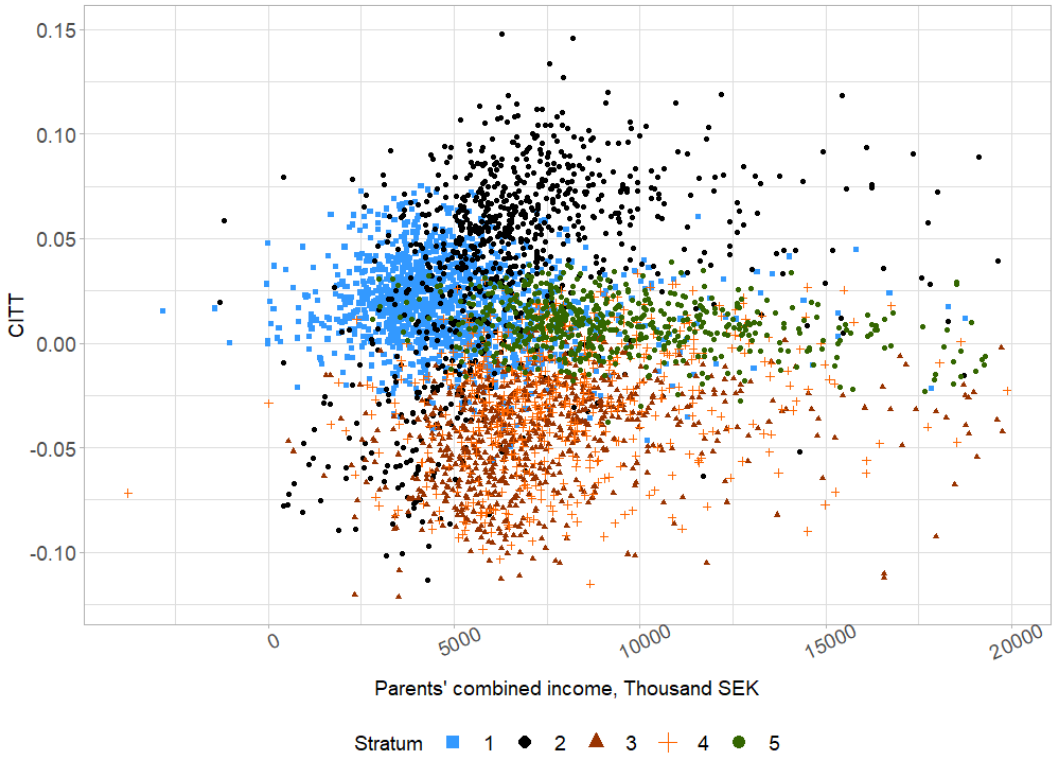
More interesting differences between the two treatment effects emerge from Swedish-born mothers. Emotional framing (T1) is generally more effective on mothers who have a higher labour and

capital income, and who read more carefully the leaflet (measured by the self-reported percentage they read, and by whether they answered the first survey). It is less effective for mothers with a job in healthcare. If the mother has a graduate education (stratum 5), it is more effective when their field of education is not numerically intensive, as expected, and when they declare to read a high portion of the leaflet. In the next Section, we will argue that when emotional framing has a negative effect, it is driven by mothers who were more vaccine-hesitant at baseline and pay less attention to our leaflets. These results could be rationalized by considering that attentive reading could activate different modalities of absorbing the information, thus leading to different results. Dual-process theories go in this direction, as they predict different behavioural responses based on whether the decision follows faster heuristic rules or cognitively demanding reasoning (Petty and Cacioppo, 1983; Evans, 2008; Evans and Frankish, 2009): we leave this for future research.

Scientific framing (T2) relates to socioeconomic status differently depending on the highest educational attainment. For mothers with just compulsory education, it is more effective when they (and their partners) pursued a more numerical high school track and have a higher income. For mothers with a high school degree (stratum 3) instead, it is more effective when they obtained a lower grade: this indicates both less memory of what was learned in school and worse job prospects. Indeed, in stratum 3 scientific framing is also more effective on mothers with a lower income. Finally, in strata 4 and 5, where mothers have a university education, scientific framing is more effective when both parents have a lower income despite being more likely to be active workers, are less likely to work in research, and less likely to reply to the survey.

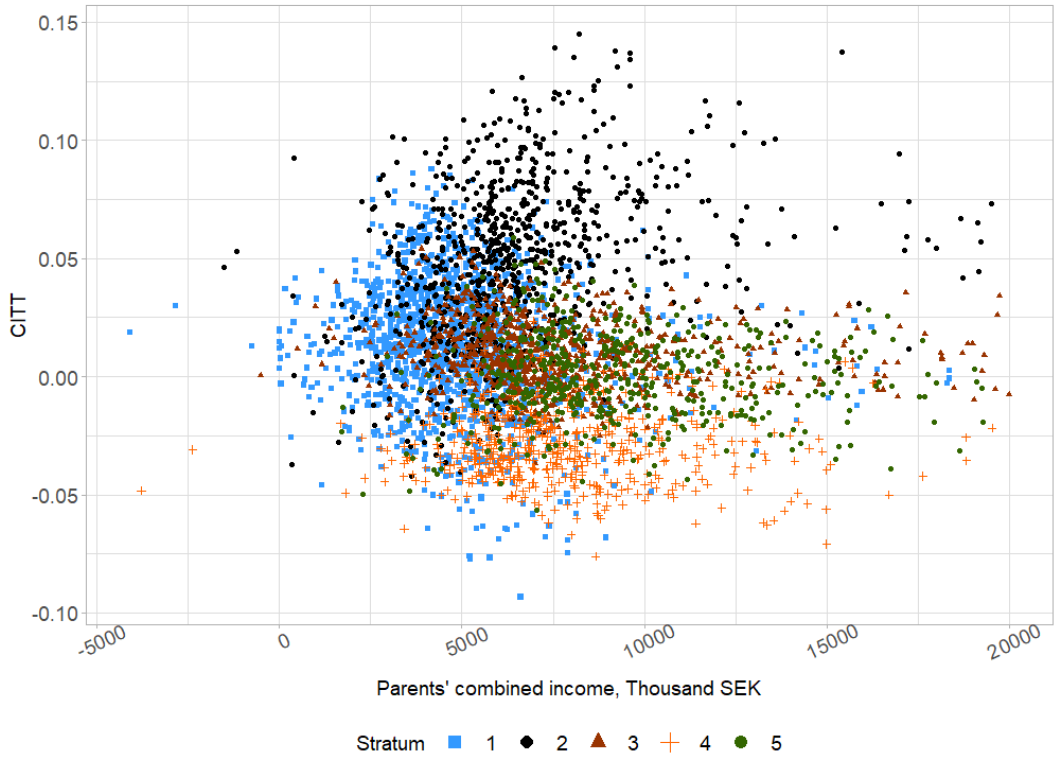
Figure 1 and Figure 2 show the distribution of CITT of both treatments by parents' combined income. The figures also reveal that the causal forest estimation confirms the ITT analysis results: scientific framing (T2) has a positive impact on uptake in stratum 2 (compulsory education), whereas emotional framing (T1) has a negative impact on uptake in stratum 3 (high school degree). Figure 3 and Figure 4 provide a visual summary of CITT effects for parents with a medical or research occupation. The average CITT in stratum 2 is highest when at least one parent is a researcher, and is zero when at least a parent is a medical doctor. Since stratum 2 coincides with compulsory education, this sheds light on the role of fathers' education in shaping mothers' opinions.

Figure 1: CITT effect of Emotional framing (T1) by parents' income



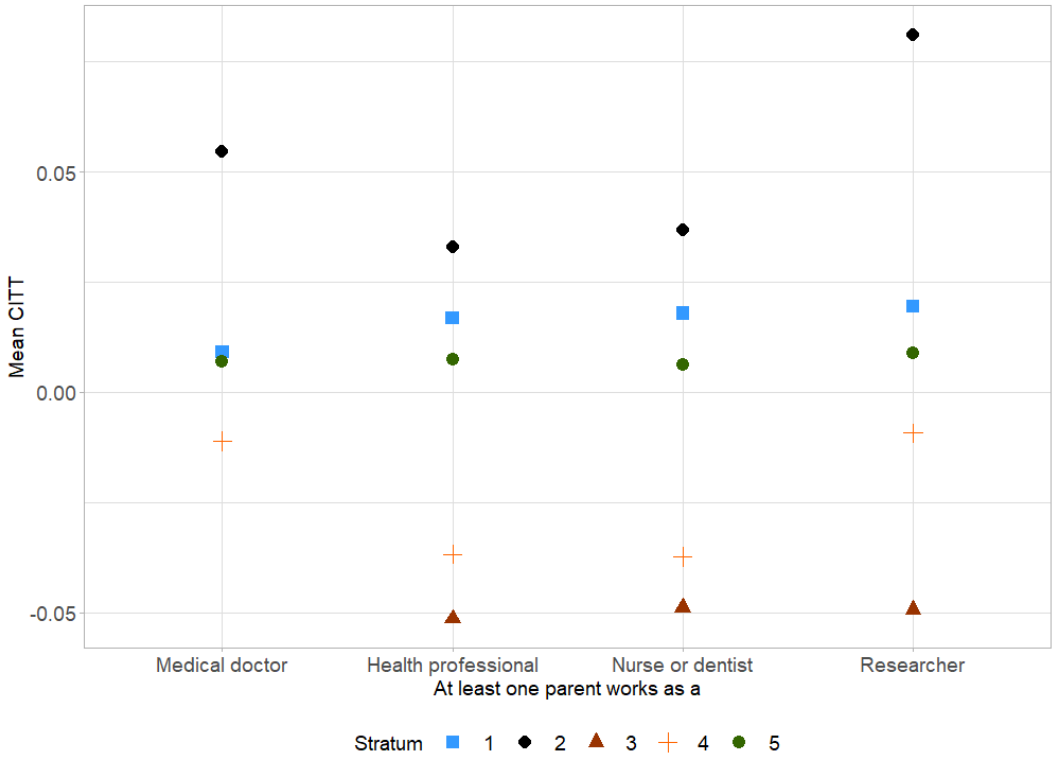
Notes: The figure is a scatterplot with combined parents' income on the x-axis (both capital and labour income) and CITT on the y-axis, restricting to the effect of Emotional framing (T1). Colours of the points indicate the stratum.

Figure 2: CITT effect of Scientific framing (T2) by parents' income



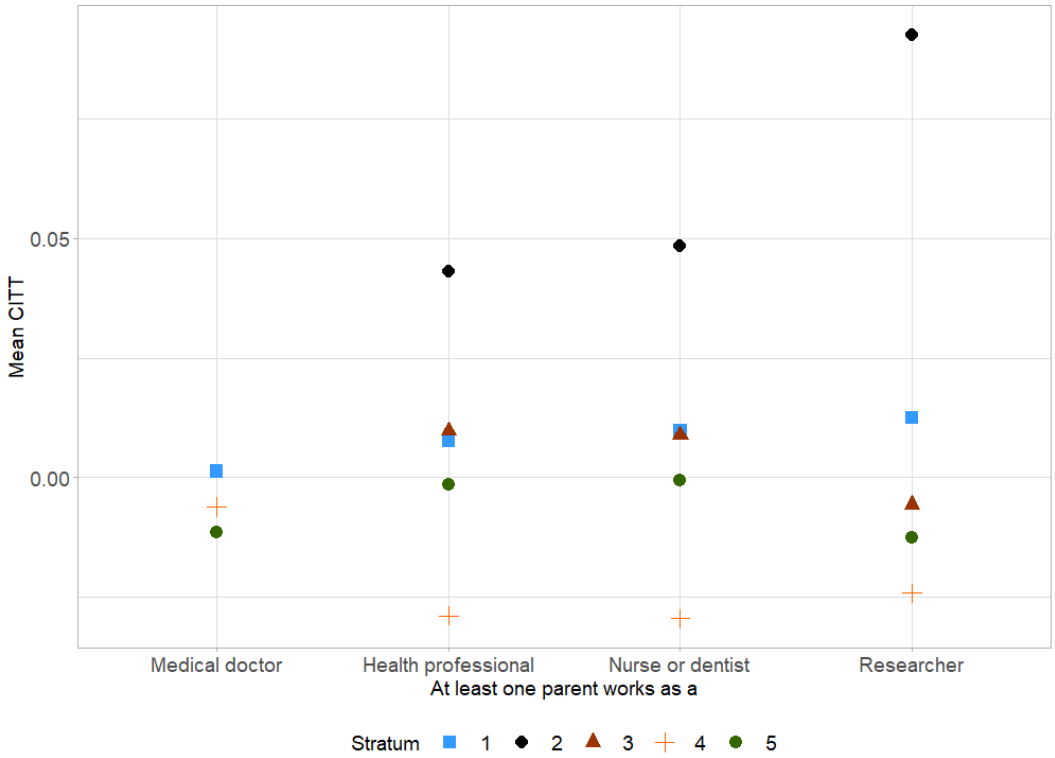
Notes: The figure is a scatterplot with combined parents' income on the x-axis (both capital and labour income) and CITT on the y-axis, restricting to the effect of Scientific framing (T2). Colours of the points indicate the stratum.

Figure 3: Mean CITT effect of Emotional framing (T1) by parents' occupation



Notes: The figure shows the average CITT of Emotional framing (T1) when at least one parent has a medical or research occupation. Health professionals include medical doctors, nurses and dentists, and other occupations in the health sector. Colours of the points indicate the stratum.

Figure 4: Mean CITT effect of Scientific framing (T2) by parents' occupation



Notes: The figure shows the average CITT of Scientific framing (T2) when at least one parent has a medical or research occupation. Health professionals include medical doctors, nurses and dentists, and other occupations in the health sector. Colours of the points indicate the stratum.

7 Mechanisms

In this section, we explore two sets of mechanisms to rationalize our results. First, we will show that the positive effect of scientific framing (T2) and the negative effect of emotional framing (T1) come from different types of parents. The positive effects from T2 are experienced by those who are less hesitant towards vaccines at baseline and read our leaflets more attentively, where attention is influenced by treatment status. Second, we show that both the positive and negative effects are driven by parents who had little or no previous knowledge of HPV, precisely those that should be targeted by informational campaigns. Taken together, these results show that framing makes a difference: nevertheless, emotional framing should be avoided for its negative effect on the less attentive and more hesitant parents and the lower efficacy on the more attentive.

7.1 Hesitancy and attentive reading

In order to understand what drives our results, we re-estimate our main ITT analysis from Equation (1) separately for subjects who never replied to our survey and subjects who replied at least to the first one. As we will discuss below, replying to the survey proxies both parents' reluctance to be a target of an informational campaign – similar to Hirani (2021) –, and how attentively they read and absorb the information in our leaflets.[24] Results are reported in Table E.4 and Table E.5. We find that the negative effect of emotional framing (T1) in stratum 3 is driven only by parents who never responded, whereas in stratum 2 respondents are the only ones displaying the positive effect of scientific framing (T2), with a much higher magnitude. Indeed, the estimate after restricting to respondents is 16.1 p.p., whereas the ITT estimate on the full sample was 5.7 p.p. We also notice that non-respondents have a lower vaccination uptake at baseline in all strata, most notably among immigrant mothers. The positive effect of emotional framing (T1) among non-respondents in stratum 5 is not robust to an LPM/OLS estimation (see Section E in the Appendix).

Table 4: The effect of framing conditional on responding to the first survey

Stratum	**Stratum definition**	**Uptake in control group**	**T1** *vs* **C Emotional**	**T2** *vs* **C Scientific**	**T2** *vs* **T1**
1.	Immigrants	0.916	-0.041	-0.021	0.036
			(0.034)	(0.023)	(0.035)
			N=137	N=128	N=165
Swedish-born mothers					
2. Educ-level-1	$\leq$ 3 yrs high school	0.875	0.006	0.161***	0.094**
			(0.047)	(0.045)	(0.033)
			N=232	N=215	N=259
3. Educ-level-2	Up to high school	0.928	-0.030	0.000	0.045*
			(0.034)	(0.029)	(0.027)
			N=315	N=281	N=372
4. Educ-level-3	Up to UG	0.916	-0.025	-0.022	0.015
			(0.036)	(0.033)	(0.033)
			N=269	N=249	N=316
5. Educ-level-4	Graduate	0.940	-0.036	-0.012	0.003
			(0.026)	(0.026)	(0.025)
			N=335	N=321	N=412

Notes: *** p< 0.01, ** p< 0.05, * p< 0.10. The outcome variable is the actual vaccination choice (binary indicator). Results are estimated by Logit on the subsample of mothers who read our leaflet attentively, proxied by having answered our first survey. Immigrants are mothers born in Iraq, Iran, Syria, Afghanistan, Eritrea or Somalia. Stratum 2 comprises mothers with at most 3 years of high school: this corresponds to Swedish *högstadiet* (grades 7-9), the last compulsory grades under Swedish law. Mothers in stratum 3 completed high school (*gymnasium*, grades 10-12), which is not compulsory and comprises different tracks, including vocational ones.

[24] This analysis is not explicitly included in the pre-registered pre-analysis plan if not under the more generic intention to investigate heterogeneity along a variety of indicators. The rationale for comparing respondents and non-respondents lies in how responding relates to attentiveness, and hence to refer to dual-process theories to explain the mechanism behind the observed results (Evans, 2008; Evans and Frankish, 2009; Taute et al., 2011; Hirani, 2021).

Table 5: The effect of framing conditional on not responding to the first survey

Stratum	Stratum definition	Uptake in control group	T1 *vs* C Emotional	T2 *vs* C Scientific	T2 *vs* T1
1.	Immigrants	0.759	0.027	0.017	-0.007
			(0.023)	(0.023)	(0.020)
			N=619	N=635	N=784
Swedish-born mothers					
2. Educ-level-1	$\leq$ 3 yrs high school	0.802	0.029	0.044	0.020
			(0.029)	(0.028)	(0.024)
			N=777	N=795	N=974
3. Educ-level-2	Up to high school	0.848	-0.057*	0.002	0.047*
			(0.030)	(0.028)	(0.027)
			N=557	N=597	N=704
4. Educ-level-3	Up to UG	0.863	-0.000	-0.008	-0.018
			(0.037)	(0.036)	(0.032)
			N=359	N=375	N=450
5. Educ-level-4	Graduate	0.922	0.065*	0.020	-0.013
			(0.035)	(0.032)	(0.028)
			N=294	N=311	N=365

Notes: *** p< 0.01, ** p< 0.05, * p< 0.10. The outcome variable is the actual vaccination choice (binary indicator). Results are estimated by Logit on the subsample of mothers who did not answer our first survey. Immigrants are mothers born in Iraq, Iran, Syria, Afghanistan, Eritrea or Somalia. Stratum 2 comprises mothers with at most 3 years of high school: this corresponds to Swedish *högstadiet* (grades 7-9), the last compulsory grades under Swedish law. Mothers in stratum 3 completed high school (*gymnasium*, grades 10-12), which is not compulsory and comprises different tracks, including vocational ones.

To further investigate the mechanisms, we then turn to characterize respondents and non-respondents. We do so by comparing observable characteristics between non-respondents and respondents (to at least the first survey), and between respondents to the first survey and respondents to both the first and second survey (in this case, we are able to show differences in their answers to the first survey). Both these comparisons are performed twice, with and without conditioning on treatment status. The full tables are shown in Section M in the Appendix. Table 6 compares some crucial variables between respondents to the first survey and respondents to both surveys.

We first compare never-respondents and respondents to at least the first survey, respectively those who experience a drop in uptake from emotional framing in stratum 3 versus those who experience an increase in uptake from scientific framing in stratum 2. We find that respondents are slightly less vaccine-hesitant while also less expert in health or science, and have a higher socioeconomic status. Respondents have a higher uptake of the second dose of the MMR vaccine, even though the baseline uptake even among non-respondents is high and in line with coverage targets for the MMR (95%). To clarify whether this difference in MMR uptakes actually indicates that never-respondents are more vaccine-hesitant, we rely on the comparison between respondents to the first survey only (R) and respondents to both surveys (RR), because in this case, we can also

compare self-reported variables (from the first survey) that are more closely connected to vaccine hesitancy and attentiveness. In doing so, we are implicitly assuming that this comparison is also informative of the differences between never-respondents and respondents, i.e. that there is a linear change in subjects' characteristics with the number of surveys they answer. To corroborate this assumption, we highlight that the demographic, educational and occupational characteristics that change between never-respondents and respondents also change with the same sign when comparing R and RR, although the difference is not always significant.

Table 6: First survey answers by treatment and number of surveys answered ($N = 2204$)

	Control (C)			**Emotional framing (T1)**			**Scientific framing (T2)**		
First survey answers	**ASD**	**Replied once**	**Replied twice**	**ASD**	**Replied once**	**Replied twice**	**ASD**	**Replied once**	**Replied twice**
Believes vaccines cause the disease	0.217**	1.854	1.532	0.202***	1.867	1.567	0.158**	1.859	1.616
Believes vaccines weaken the immune system	0.179**	1.747	1.504	0.17***	1.859	1.604	0.165**	1.822	1.58
Trusts health authorities	0.236***	4.237	4.54	0.116**	4.353	4.5	0.123**	4.333	4.494
Searched vaccine info from unreliable sources	0.126*	0.229	0.158	0.028	0.182	0.198	0.04	0.215	0.192
% of leaflet read	0.04	7.705	7.878	0.161**	7.679	8.358	0.177**	7.634	8.371
Distraction question	0.15**	0.948	0.986	0.059	0.936	0.955	0.078	0.935	0.959
Heard of HPV before the study	0.107	0.824	0.878	0.088*	0.85	0.892	0.163**	0.828	0.906

Notes: *** p< 0.01, ** p< 0.05, * p< 0.10. The table shows, after conditioning on treatment status, the difference in first survey answers between subjects who only replied to the first survey, and subjects who replied to both the first and the second survey. The Average Standardized Difference, also known as Cohen's D, is computed as $ASD(X) = \frac{|\bar{X}_{RR} - \bar{X}_R|}{\sqrt{Var_{RR}(X) + Var_R(X)}}$ where X is the variable, RR denotes respondents to both surveys and R denotes respondents to the first survey only. The distraction question asked subjects to select the first option from a list of two options. The self-reported % of the leaflet read is measured on a 1-10 scale where 1 is "between 0% and 10%" and 10 is "between 90% and 100%. Trust in health authorities and beliefs about vaccines are measured with a 1-5 Likert scale. All other variables are dummies.

The comparison between R and RR reveals that those who answer twice (RR) are more likely to have correct beliefs about vaccines and have a higher uptake of the MMR vaccine. Moreover, the beliefs are more correct for RR in all treatment statuses, suggesting that these answers reflect baseline beliefs and are not affected by our information in T1 and T2. In Section F in the Appendix we test this formally and indeed we find that misconceptions around vaccines are largely unaffected by our treatments. Moreover, in all treatment groups trust in health authorities slightly increases with the number of answered surveys. These results confirm Hirani (2021)'s finding that people who do not vaccinate following a written reminder are reluctant. However, we also show that attentiveness contributes to their participation: in the control group that only received a reminder

(C), RR were significantly less distracted than R.[25]

Nevertheless, by comparing the results across treatment groups we find evidence that, once information is delivered on top of a reminder (i.e. in T1 and T2), new elements related to attentiveness emerge. Indeed, RR subjects report having read a significantly higher percentage of our leaflet compared to R only in our treatment groups – which also shows that the results are unlikely to be affected by social desirability bias. Taken together, these two elements provide suggestive evidence that attentiveness is an important channel of action in informational campaigns, especially when they provide active information on top of a simple reminder. Finally, previous knowledge of HPV is only significantly different for the treatment groups: in the next subsection, we will show evidence that attention is associated with subjects' baseline knowledge of HPV and their exposition to previous informational campaigns.

7.2 The role of previous information

Being exposed to information on HPV before treatment can affect the impact of our intervention, also by changing how attentively subjects read our leaflet. Figure 5 and Figure 6 show CITT estimates from the causal forest by baseline knowledge of HPV. Both the positive effect of scientific framing (T2) in stratum 2 and the negative effect of emotional framing (T1) in stratum 3 are less dispersed for mothers who had not heard of HPV before our intervention, who are the ones driving the significant results in the main analysis. To corroborate this evidence, in Section O in the Appendix we consider the heterogeneity of effects by child's gender. Since boys were included in the HPV vaccination program only one year before our intervention, their mothers were less exposed to HPV information. There is also less disinformation on the HPV vaccine targeted to boys. We find evidence that boys drive our results. We conclude that vaccine information has diminishing returns: it is only effective when the recipients have little or no prior information. This complements our heterogeneity analysis results, which showed a higher treatment effect for those segments of the population that are less vaccinated, on average. In other words, our intervention has an effect where information is needed. From a policy perspective, our results highlight that people's attention to information is limited: ineffective or counterproductive informational campaigns are not just an economically inefficient policy intervention, they can also backfire by reducing the attention dedi-

[25] We measure distraction by asking to select the first option out of two options, simply labelled as "first option" and "second option".

cated to future, more impactful campaigns. This leads to two policy recommendations: sticking to scientifically framed information (since emotional framing can be counterproductive) and avoiding campaigns that are not informative.

Figure 5: CITT effect of Emotional Framing (T1) by baseline knowledge of HPV

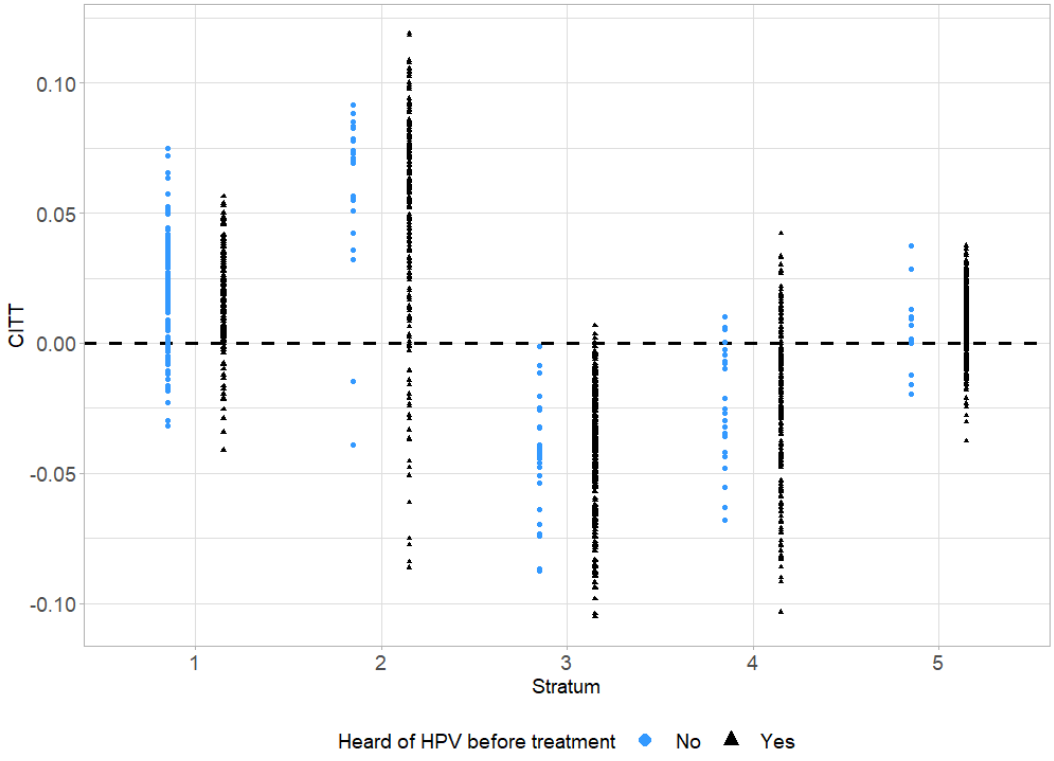
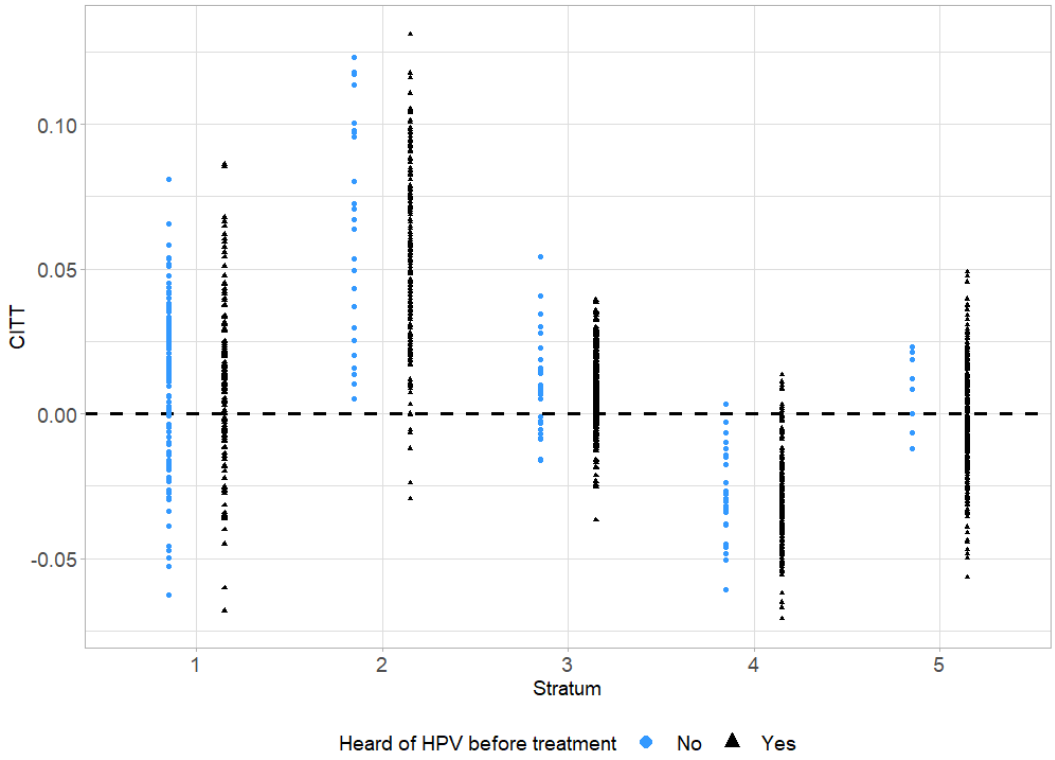


Figure 6: CITT effect of Scientific Framing (T2) by baseline knowledge of HPV



8 Conclusions

In this paper, we investigate how information framing interacts with recipients' educational and cultural backgrounds in raising vaccination uptakes. We did so after a pandemic that has radicalized pre-existing attitudes towards vaccinations and has increased the policy relevance of contrasting vaccine hesitancy.

During the summer of 2021, we sent a written leaflet to mothers living in Stockholm County, Sweden, whose children were due to receive the HPV vaccine in the autumn. The leaflets were written following the example of actual reminder campaigns used by Swedish government authorities, which are more suitable to target under-vaccinated populations directly in schools relative to other digital media. To study the interaction of the information with recipients' education, we stratified mothers into 4 strata defined by education level and one stratum dedicated only to mothers born in the largest non-European origin countries of immigrants. We observe rich administrative information on mothers and the other child's parent, and we asked mothers about their intention to

vaccinate and their previous exposition to HPV information in a short survey. We randomized the framing of leaflets, which is based on techniques that are also employed by vaccine disinformation: emotional framing relies on emotionally charged anecdotes from cervical cancer survivors, whereas scientific framing uses medical and statistical jargon that is not immediately understandable for all laypeople. Content-wise, both leaflets shift the focus away from the vaccine's adverse effects and towards the dire consequences of catching HPV-induced cancers. All leaflets covered the invasiveness of cancer medical treatment and its negative consequences on fertility, a theme that is particularly important for immigrant communities in Europe. To understand the additional effect of information framing with respect to traditional reminder campaigns, we include a control group that receives a written reminder of the same length.

In terms of actual vaccination choices, we find that only Swedish-born mothers with at most a high school degree react to our intervention. Those with just compulsory education (3 years of high school) react positively to scientific framing. On the other hand, mothers with a high school degree do not respond to scientific framing, and they react negatively to emotional framing by reducing their uptake. While the positive effects are driven by mothers who replied to our first survey, negative effects are due to non-respondents. We characterize these two groups: respondents who enjoy a positive effect are less sceptical towards vaccines at baseline, and there is suggestive evidence that they also pay more attention to our informational leaflets. By looking at mothers' survey answers concerning their exposition to previous information, we also conclude that there are diminishing returns to information. In other words, only mothers with little or no previous knowledge of HPV react to our intervention.

From a policy perspective, then, we recommend maximizing the efficacy of informational campaigns and reducing their number not just because of monetary costs, but also to avoid jeopardizing future campaigns of higher quality. We also recommend avoiding emotional framing: we find no evidence of a positive effect on the uptake regardless of recipients' education, and we find evidence of counterproductive effects on mothers with high school education.

The finding that emotional framing of truthful information is ineffective or counterproductive is surprising, considering the high efficacy of emotional framing in the context of disinformation. One possible explanation, which we leave to future research, is to study the role of the sender's identity and how it interacts with the reception of framed information.

We contribute by showing how the measurement of vaccinations can affect the results. Indeed, in all strata – and especially among immigrants and lowly educated mothers – the self-reported intention to vaccinate understates actual vaccination uptake. This is particularly important from a methodological point of view since access to objective vaccination records is often impossible or strongly limited. In those cases, it is likely that results based on self-reported intentions are likely to be lower-bound estimates of the effects on actual uptakes.

Overall, our findings highlight that the relationship between information framing and recipients' education is complex and non-linear. Our heterogeneity analysis also reveals that other socioeconomic components such as income, wealth and field of occupation interact with framing differently after conditioning on the education level.

Taken together, our results point in the direction of a highly customized policy strategy to raise vaccination uptake, which we suggest as a future research avenue. This is particularly true for immigrants, for whom we could not find a generally effective framing treatment, but only indications based on socioeconomic status and country of birth from our heterogeneity analysis.

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APPENDIX

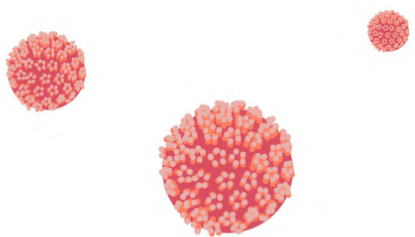
A Informational leaflets

Informational intervention: group C (Placebo: only reminder)

Information sheet

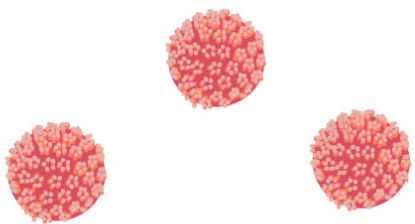
HPV

The HPV vaccine is one of the vaccines offered to school children under the **national vaccination programme in Sweden**, in grade 5. It has previously been offered to girls, but starting in fall 2020 it is offered on the same terms to boys. The other vaccines that are part of the program are: **rotavirus** infection, **diphtheria, tetanus, whooping cough, polio**, infections caused by **Haemophilus influenzae type B, measles, mumps, rubella** and serious diseases caused by **pneumococcus**. The HPV vaccine has been included in the national vaccination programme in 2010: Elevhälsan started offering it in school for free in the fall of 2012. The Swedish child vaccination program is governed by the **Communicable Diseases Act** and regulations issued by the Public Health Agency of Sweden. The administration of the national vaccination programme directly in schools via Elevhälsan is specific of the Nordic countries. It is meant to ensure every child living in Sweden, regardless of his or her characteristics or those of his/her family, has equal and free access to vaccinations.



The vaccine

The vaccine that your child will be offered in **September** protects against nine types of HPV. It is administered via two shots in the upper arms, which are given at least six months apart. However, adults taking the HPV vaccine and immunodepressed children receive three doses. The second dose is given one to two months after the first dose and the third dose is given four months later. Previously, the national vaccination programme offered a vaccine that covered only four types of HPV: girls who got a first shot of this first vaccine can continue with the current one, although there is no recommendation to also be vaccinated with the most recent vaccine among those who already completed all doses of the first vaccine. The HPV vaccine is offered in **more than 90 countries**, but in most of them it is not free. In nine other countries, as in Sweden, the vaccine is also offered to boys, while in most countries it is still only offered to girls.



This is important

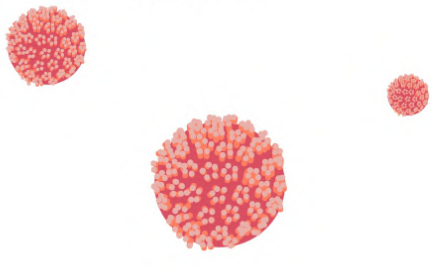
The Swedish national vaccination programme has been instrumental in **eradicating many diseases**, which for this reason are now referred to as "preventable". The programme was officially established in the **1940s**. However, public vaccination campaigns were not a new phenomenon: already in the 1800s, there were public campaigns of vaccination against smallpox, which at the time was a great **technological advance** for medicine. Between 1750 and 1800, it is estimated that approximately 300,000 people died of smallpox, and the most affected were children below 10 years of age. Eventually, smallpox was eradicated in Sweden and the vaccine was removed from the national vaccination programme in 1976. Another major threat to childhood health used to be tuberculosis. A vaccine was introduced in 1940 and was offered to all children until 1975. After that, since the incidence of **tuberculosis** fell notably, the vaccine was only offered to immunodepressed children. Indeed, the national vaccination programme follows **two different vaccination schedules** depending on the **needs of the individual child**: particularly vulnerable children receive more vaccines than those normally included for all children. The vaccine against diphtheria and tetanus was also added to the national vaccination programme in the 1940s, although the most recent vaccination schedule was introduced in 2007. The main change concerned the measles vaccine – it was first introduced as a standalone vaccine in 1971, and then in 1982 it was replaced by the **trivalent vaccine against measles, mumps and rubella**, which is still in use. More recently, in 1993, the vaccine against Haemophilus influenzae type b also became part of the national vaccination programme. The HPV vaccine, which was previously only available for a fee (although subsidised), was finally introduced as part of the national vaccination programme **as recently as 2010**, initially just for girls.

Informational intervention: group T1 (Emotional framing)

Information sheet

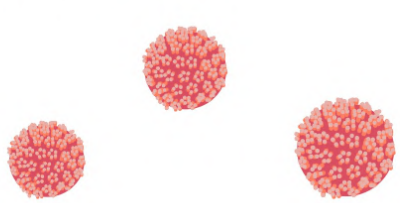
HPV

HPV is a virus that comes in many types. It is **highly infectious: contact** between skin, mouth and genitals is sufficient for transmission. Approximately **8 in 10** adults have had some type of HPV in their life, often when they were **young**, between 25 and 35 years. Some types are particularly dangerous for both sexes, since they can lead to **cancer** of the **cervix**, the **vulva**, the **anus**, the **penis** and the **mouth**. Some cause genital warts: while benign, they can be distressing. HPV causes almost all cases of cervical cancer, for which **538 women were diagnosed and 222 died** in Sweden in 2018. Every year, about 800 women and 300 men develop a cancer attributable to HPV: men are mostly affected by penis, anus and head-neck cancers. After infection, the virus remains in the body and never goes away: **asymptomatic** individuals (the majority) can infect others. Symptoms usually appear when cancer has arisen, and the consequences can be **extremely painful**. When children grow up and become sexually active, they can catch HPV, and risk developing a cancerous disease and infecting others.



The vaccine

Luckily, you can do something to avoid it. In September, your child will be offered the vaccine against HPV within the national vaccination programme. The vaccine is free, administered in school, and protects against 9 HPV types that are known to cause most cases of cancer and precancerous lesions. Two doses of the vaccine are administered with a 6 months' interval. It is **safe** and **effective** against HPV: we know it from numerous clinical studies that have been done for its approval by the European Medical Agency (EMA), and other health authorities. Because the vaccine **does not contain HPV DNA**, it is impossible for it to infect with HPV and cause disease. In Sweden, thanks to vaccination registers, possible adverse effects are closely monitored. They are typically mild, such as pain in the inoculation site and, very rarely, light fever. On the other hand, the consequences of catching HPV are not as rare, and developing a cancerous disease can have highly distressing consequences, both physically and emotionally.



This is important

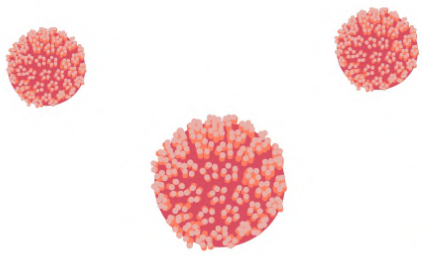
Michaella had cervical cancer. As an adverse effect of radiotherapy, she went into menopause and became **sterile at 36 years**, but she recounts: "My doctor told me his youngest patient was **17 years old**. Then I thought, I have 3 children […]. But if you are 17, what can you do?". Even when they do not cause sterility, therapies still **increase the risk of miscarriage**. Malin was diagnosed at 29 years: she discovered it reading a Medical certificate stating that that she had a "**cancer for which a cure is probably not possible**". After unsuccessful chemotherapy, she was offered a 10-hour surgery, which led to many complications, from intestinal problems to severe infections (lung, kidney, and urethra infections): she was constantly at the hospital, admitted to **intensive care**, and underwent three surgeries in eight months. Katarina was **diagnosed while pregnant** with her second child. The day she was diagnosed, doctors told her that she would need to give birth within two weeks and that her **uterus would be removed** to avoid the spread of cancer: **she would not conceive again**. She says "My husband and I sit every night, talking and **crying** […], we are afraid that I may not see our children grow up. […] The night before the scheduled birth and surgery, I stood in the shower caressing my pregnant belly, crying because this was my **last day as a pregnant woman in my life**". Her child was born one month prematurely and needed intensive care. Even though she has now recovered, she says that "after 11 months […], I feel depressed and burnt out, some days I cry a lot […] ". Joakim's wife wasn't as lucky: she **passed away leaving behind 2 kids**, 2 and 5 years old. All their testimonies are available at *Nätverket mot gynekologisk cancer.*

Informational intervention: group T2 (Scientific/statistical framing)

Information sheet

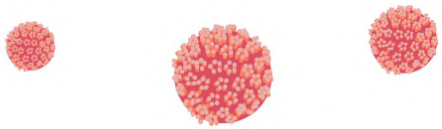
HPV

HPV is a family of viruses causing **dysplastic (cancerous) diseases**, localized primarily in the anogenital area and aerodigestive tract, in both genders. It is transmitted by skin and mucosae contact. Persistent HPV infection significantly increases the risk of **cervical** and **anal**, **vulvar**, **penile**, and **oropharyngeal cancers**, as well as benign lesions such as anogenital warts. It is estimated that **80%** of the sexually active population has contact with HPV, especially **between 25 and 35 years old**. Upon contact, the virus remains latent, so that asymptomatic individuals (the majority) can transmit it. Symptoms typically appear when cancer has arisen. HPV is responsible for nearly 100% of cervical cancers: in Sweden, in 2018, the crude incidence rate was **11.2 per 100.000 women**, and the death rate **4.5.** Other cancers are also known to be caused by HPV (in Sweden, c.a. 80% of anal, 50% of penis, and 60% of oropharyngeal cancers, which are the main cancers HPV causes in men). Each year, approximately 800 women and 300 men in Sweden develop a cancer attributable to HPV.



The vaccine

There is a vaccine that your child will be offered for free in September under the national vaccination programme, and that has proven to have **almost 100% efficacy** against cervical cancer and other cancerous diseases caused by nine types of HPV. The vaccine is administered in a two-dose series at a six-month interval. The vaccine **does not contain viral DNA**, and acts by triggering an immune response that is effective against the real viruses; therefore, the vaccine cannot cause infection or disease. As part of numerous tests carried out for the approval of the drug by the European Medical Agency and other authorities, efficacy was proven with one-sided tests that assessed the increase in immune response indicators, with a significance of 97.5% and a statistical power of at least 90%. The approval process also required extensive data collection on the onset of any adverse effects, from mild to serious. Swedish vaccination registers allow monitoring of adverse effects. These are typically mild, such as pain at the inoculation site and, very rarely, temporary light fever.



This is important

Gynecological cancers are typically treated with combinations of **radiotherapy, chemotherapy** and, if the cancer is not too spread, **surgery**. These can have serious side effects, in the short-term and even permanent. Both radio and chemotherapy affect the immune system, which increases risk of infections, affect normal cells in the treated area, and decrease blood cells' count. In particular, the reproductive system, affecting patients' **fertility**, bowels, the bladder and the urethra, (possibly causing urinary incontinence). If they affect ovaries, they can induce sudden menopause, causing **temporary or permanent sterility**. The damage to tissues, and in particular vaginal stenosis (dryness, fragility and adhesions), as well as the increased risk of pelvic fractures, **increases the risk of miscarriages** in future pregnancies even if fertility is not affected. Higher miscarriage risk is also caused by the removal of the cervix (thachelectomy), a possible intervention for early stage cervical cancer, whereas removal of the uterus (uterectomy), which in Sweden is only performed at very advanced stages, implies permanent loss of fertility. Treatments' side effects typically require in turn more treatment, possibly invasive. The modalities of treatment and the emotional consequences can be highly distressing. HPV-induced cancers **can affect people of all ages**. In 2018 in Sweden, for instance, there were 80 new cases of cervical cancer in girls between 15-29 years old (incidence rate 8.1 per 100.000 girls in the age group), and 2 deaths (death rate 0.11 per 100.000). In the age group 30-44, 202 new cases and 17 deaths (incidence rate 21.9 and death rate 1.8, per 100.000), and above 60 years old, 276 new cases and 203 deaths (incidence rate 12 and death rate 8.8, per 100.000). You can consult these and other statistics on the *WHO International Agency for Research on Cancer's website.*

B Invitation letter

Guardians' attitudes and willingness to vaccinate children against HPV

Any questions?
You are welcome to contact us!
Questions on information delivery
Statistics Sweden reporting service
010-479 63 30
enkat@scb.se
SCB, INS/IHU, 701 89 Örebro
www.scb.se

Opening hours
Monday-Thursday: 8.00 – 21.00
Friday: 8.00 – 17.00
Sunday: 16.00 – 21.00

Questions on the study
Lisen Arnheim Dahlström
lisen.arnheim.dahlstrom@ki.se
Alice Dominici
alice.dominici@eui.eu

Vill du svara på svenska?
På hemsidan kan du välja huruvida du vill svara på svenska eller engelska. Du kan svara på frågorna här:
www.insamling.scb.se
Logga in med ditt användarnamn och lösenord. Du behöver inte svara på alla frågor på en gång utan kan också logga in flera gånger.

SCB describes Sweden
Statistics Sweden provides society with statistics for decision-making, debate and research. We do this on behalf of the government, authorities, researchers and the business community. Our statistics contribute to a fact-based public debate and well-founded decisions.

Dear guardian,

You are receiving this letter because researchers at Karolinska Institute want to investigate attitudes of guardians towards the HPV vaccination in the context of the national vaccination program, and the role of information.
You are one of 7,616 guardians who were randomly selected to participate in the survey. In September, you will be offered to vaccinate your child against HPV as part of the national vaccination program.

You have received an information sheet about the HPV vaccine in this envelope. The information sheet is available in several versions. The information sheet that guardians receive is randomly selected. The researchers assure that the information you receive is always truthful: if you want to know more about the study or the information you received, contact the researchers Lisen A. Dahlström or Alice Dominici. We would be grateful if you could read the short information sheet and then answer some questions.

The survey is conducted by Statistics Sweden on behalf of Karolinska Institute. On the next page, you will find more information about the survey.

Your answers are important

It is voluntary to participate in the survey, but we hope you want to participate, because your answers are very important. You help to give a complete picture of the willingness to vaccinate and we are interested in all opinions.

How you can answer

First, read the information sheet on the HPV vaccine contained in the envelope. Then, go to **www.insamling.scb.se** to answer the questions. Online, you can answer in Swedish or English.

Your credentials are:

Användarnamn:	
Lösenord:	

If you instead choose to answer on paper, you can send the paper form in the postage-free reply envelope that you received in this letter.

You can log in several times and save your progress each time.

Sincerely,

Joakim Stymne
General Director *SCB*

Lisen Arnheim Dahlström
Principal Investigator, Karolinska Institute

Alice Dominici, *Project leader, Karolinska Institute*

Consent to participate in the study

By answering this survey, you confirm your consent to participate in this study. This has been approved by the Ethics Review Board with decision number 2021-01225. You can cancel your participation in the study at any time without any consequences, and you do not need to state why. To cancel your participation, please contact the person responsible for the study (lisen.arnheim.dahlstrom@ki.se). Everyone who chooses to participate in this survey will be invited to a follow-up survey this autumn. This means that Statistics Sweden saves information about who participated until the follow-up study is completed.

How are my answers protected?

When survey results are published, your individual answers will never be identifiable. Information about individuals' personal and financial circumstances is protected by confidentiality and everyone who works with the survey has a duty of confidentiality. Confidentiality applies according to ch. Section 8 of the Public Access to Information and Secrecy Act (2009: 400). The same confidentiality regulations apply to Karolinska Institute.

How is personal data processed?

SCB is responsible for personal data processing performed by SCB. Karolinska Institute is responsible for personal data processing performed by Karolinska Institute. Rules for personal data processing are laid out in the EU Data Protection Regulation, in the Act (2001: 99) and in Ordinance (2001: 100) on official statistics. In addition, law (2018: 218) provides supplementary provisions to the EU Data Protection Regulation and to regulations that have been issued in connection with that law. More information on how SCB processes personal data can be found at www.scb.se/personal data. You have the right to receive a free copy, in the form of a so-called register extract, of the personal data processed by SCB in your capacity as personal data controller. More information can be found at www.scb.se/registerutdrag. If you believe that SCB has processed your personal data in a way that violates the EU Data Protection Regulation, you have, under certain conditions, the right to have the data deleted. You have the same rights towards Karolinska Institute. The number at the top, in the middle of the first page of the letter, allows SCB to see who has responded during the data collection, among other things.

Do you have questions on personal data?

Contact the data protection officer:
SCB: 010-479 40 00, dataskyddsombud@scb.se,
701 89 Örebro
Karolinska Institutet: 08-524 864 73,
dataskyddsombud@ki.se,
UF Universitetsförvaltningen, UF JA JUR, 171 77
Stockholm

Possible consequences and risks of participation

As your answers are analyzed anonymously and presented at the aggregate level, there is no risk that your answers may end up in the wrong hands or be used in an unintended way. There is no link to information that could reveal your identity in an unwanted way.

Where will the results be published?

The results of the study will be summarized scientifically and published in scientific journals. A summary will also be published on Karolinska Institute's website. If you are interested in results, you can contact the researchers by e-mail (alice.dominici@eui.eu).

Who uses the answers and how?

SCB processes and deidentifies the data and then submits them to Karolinska Institute for further processing and analysis. SCB and Karolinska Institute may disclose the information to researchers or others who produce statistics. Such research and statistical activities are also covered by confidentiality. In order not to ask more than necessary, we will supplement your answers with information that is already available at SCB. This is information about your age, marital status, education, occupation, income, number of children and any year of immigration. We also supplement your answers with information about the child who might be vaccinated. It is information about gender, the child's order of birth, if the child is your biological or adopted child and a deidentified code of the school attended by the child. Information on vaccinations is obtained from the Swedish Public Health Agency's vaccination register. We also supplement your answers with information about the child's other guardians. It is information about education, occupation and income. Your answers and the other information are saved at SCB. Submitted information is stored at SCB for 12 months after the completion of the assignment.

C List of variables from population registers

C.1 List of variables

The following variables are extracted and elaborated from Swedish population registers:

For both parents:

- Demographic variables: is married (dummy), was born in Sweden (dummy), country of origin, age;
- Education variables: highest educational attainment, grade at national high school examination, graduation year, has received medical education (dummy), has received scientific education (dummy), has received a numerical education (dummy);
- Labour variables: is an active worker (dummy), is retired (dummy), is a medical doctor (dummy), , has an occupation in healthcare (dummy), is a nurse or a dentist, has an occupation in research;
- Economic variables: disposable income (earned from labour income and any property income in the 12 months before treatment), capital income (net financial gains in the 12 months before treatment), amount of government transfers received in the 12 months before treatment;
- **Only for immigrant parents:** has received any medical education (dummy), has received any scientific education (dummy), has received any numeric education (dummy), has received a formal degree in Sweden, years since immigration date. *Note*: the educational variables are extracted from immigration registers and are meant to account for the education received prior to immigration.

Child: is female (dummy), is adopted (dummy), birth order (relative to the mother's children), number of MMR vaccine doses received at baseline.

School: anonymized code, anonymized code for the municipality where it is located.

C.2 Classification of education fields

We classify education as:

Scientific: Natural sciences high school track. Degrees and specializing degrees in any of the following subjects: Biology, Chemistry, Biochemistry, Physics, Environmental Sciences, Geology, Mathematics, Statistics, Engineering, Food Sciences, Agronomy, Botany, Veterinary science, Medicine, Nursing, Pharmacy, Dietology, Logopedy, Naturopathy;
Medical: Degrees and specializing degrees in any of the following subjects: Veterinary science, Medicine, Nursing, Pharmacy, Dietology, Logopedy, Naturopathy;
Numerical: Degrees and specializing degrees in any of the following subjects: Mathematics, Statistics, Engineering, Economics, Finance, Business.

D Survey

The survey has been re-programmed by *Statistics Sweden* and administered via both their internal software (online) and on paper. It was available in English, Swedish, Persian, Arabic and Farsi. Before the questions, parents will see a screen containing the consent form for participation in the study.

D.1 First survey - administered right after treatment

1. Have you heard about HPV (Human Papilloma Virus) before receiving our letter?
   (Yes/No/I am not sure)

2. As of now, how likely is it that you will authorize HPV vaccination for your child in September?
   (Definitely not/ Unlikely/ Slightly unlikely/ I don't know yet/ Slightly likely/ Likely/ For sure)

3. Up until now, have you read any information on the HPV vaccine? (You can select multiple answers)
   Yes, I was given information from the school, my clinic or other health professionals / I am

not sure or I don't remember/ I haven't received nor searched for any information on the HPV vaccine/ Other (open field)

4. If you have received information, from which of the following sources? (You can select multiple answers)
   School nurse/ 1177 (Swedish public information service)/ My local public clinic/ Social networks/ Radio and television/ Friends and family/ Other (open field)

5. If you have searched information, which of the following sources did you consult?
   School nurse/ 1177 (Swedish public information service)/ My local public clinic/ Social networks/ Radio and television/ Friends and family/ Other (open field)

6. Is any of your close friends and relatives a doctor or a health professional?
   Yes, a medical doctor/ Yes, a nurse or other health professional/ No

7. Before September, do you think you will look for more information about the HPV vaccine? (You can select multiple answers)
   Yes, from the school nurse/ Yes, from 1177/ Yes, from my local public clinic/ Yes, from friends and family/ Yes, on social networks/ Yes, on health authorities websites (Public Health Agency, World Health Organization etc.)/ Yes, on other websites and private blogs/ No, I am sufficiently informed already/ No, I am not interested/ Other (open field)

8. Please, indicate how much you agree with the following statements (Likert scale: Strongly agree/ Agree/ Somewhat agree/ Neither agree nor disagree/ Somewhat disagree/ Disagree/ Strongly disagree):

   - Vaccines weaken and overload the immune system
   - Vaccines can cause the disease against which they protect
   - Vaccines can produce serious side-effects
   - I trust the opinion of health professionals and health authorities about vaccines
   - I am an informed parent when it comes to vaccines

9. Please select the first option below:

   - First option
   - Second option

D.2 Second survey - administered at endline

Last summer, you received some information on the HPV vaccine. Recently, you had to decide whether to vaccinate your child against HPV. We'd like to ask a few more questions, and we thank you for participating in this study.

1. How important is it to you that your child (Likert scale: Not at all important/ Slightly important/ Moderately important/ Very important/ Extremely important):
    - Can become a parent one day
    - Does not have sex before marriage
    - Does not have any serious illness while young (less than 35)
    - Does not have cancer while young (less than 35)
    - Does not have any serious illness when older (more than 35)
    - Does not have cancer when older (more than 35)
    - Does not need to undergo invasive and distressing medical procedures
2. In your opinion, what is the effect of doing the HPV vaccine on the probability of these events (Scale: Strongly decreases the probability/ Decreases the probability/ Slightly decreases the probability/ No effect/ Slightly increases the probability/ Increases the probability/ Strongly increases the probability):
    - Your child has sex before marriage
    - Your child develops a serious health issue before age 35
    - Your child gets cancer before age 35
    - Your child develops a serious health issue when older than 35
    - Your child gets cancer after age 35
    - Your child needs to undergo invasive and distressing medical procedures
3. Please, indicate how much you agree with the following statements (Likert scale: Strongly agree (1)/ Agree (2)/ Somewhat agree (3)/ Neither agree nor disagree (4)/ Somewhat disagree (5)/ Disagree (6)/ Strongly disagree (7)):

- Vaccines weaken and overload the immune system
- Vaccines can cause the disease against which they protect
- Vaccines can produce serious side-effects
- I trust the opinion of health professionals and health authorities about vaccines
- I am an informed parent when it comes to vaccines

E Alternative specifications

Table E.1: ITT effect of information framing on actual vaccination uptake by LPM/OLS

Stratum	**Stratum definition**	**Uptake in control group**	**T1** *vs* **C Emotional**	**T2** *vs* **C Scientific**	**T2** *vs* **T1**
1.	Immigrants	0.773	0.016	0.014	0.002
			(0.020)	(0.021)	(0.018)
Swedish-born mothers					
2. Educ-level-1	$\leq$ 3 yrs high school	0.786	0.033	0.049**	0.026
			(0.026)	(0.024)	(0.021)
3. Educ-level-2	Up to high school	0.887	-0.049**	0.009	0.046**
			(0.024)	(0.020)	(0.002)
4. Educ-level-3	Up to UG	0.905	-0.022	-0.028	-0.007
			(0.027)	(0.026)	(0.024)
5. Educ-level-4	Graduate	0.930	0.003	0.002	-0.009
			(0.021)	(0.021)	(0.019)

Notes: *** p< 0.01, ** p< 0.05, * p< 0.10. The significance is robust to Bonferroni-corrected p-values with 2 classes of hypotheses. Results are estimated on the entire sample of invited subjects: they can be interpreted as an ITT effect for the entire population of reference. Immigrants are mothers born in Iraq, Iran, Syria, Afghanistan, Eritrea or Somalia. Stratum 2 comprises mothers with at most 3 years of high school: this corresponds to Swedish *högstadiet* (grades 7-9), the last compulsory grades under Swedish law. Mothers in stratum 3 completed high school (*gymnasium*, grades 10-12), which is not compulsory and comprises different tracks, including vocational ones.

Table E.2: ITT effect of information framing on actual vaccination uptake, structural LPM

Stratum	Stratum definition	Uptake in control group	T1 *vs* C Emotional	T2 *vs* C Scientific	T2 *vs* T1
1.	Immigrants	0.773	0.014	0.016	0.002
			(0.020)	(0.020)	(0.018)
Swedish-born mothers					
2. Educ-level-1	$\leq$ 3 yrs high school	0.786	0.030	0.054**	0.024
			(0.025)	(0.024)	(0.022)
3. Educ-level-2	Up to high school	0.887	-0.042*	0.005	0.047**
			(0.023)	(0.023)	(0.020)
4. Educ-level-3	Up to UG	0.905	-0.021	-0.027	-0.005
			(0.027)	(0.026)	(0.023)
5. Educ-level-4	Graduate	0.930	0.008	0.001	-0.007
			(0.021)	(0.021)	(0.018)
All Swedish-born mothers			-0.003	0.014	0.017*
			(0.012)	(0.012)	(0.010)

Notes: *** p< 0.01, ** p< 0.05, * p< 0.10. The model is a Linear Probability Model that includes both treatments as regressors: the "structural" interpretation derives from the fact that they can never be equal to 1 at the same time by design. Significant results are robust to Bonferroni-corrected p-values with 2 classes of hypotheses. Results are estimated on the entire sample of invited subjects: they can be interpreted as an ITT effect for the entire population of reference. Immigrants are mothers born in Iraq, Iran, Syria, Afghanistan, Eritrea or Somalia. Stratum 2 comprises mothers with at most 3 years of high school: this corresponds to Swedish *högstadiet* (grades 7-9), the last compulsory grades under Swedish law. Mothers in stratum 3 completed high school (*gymnasium*, grades 10-12), which is not compulsory and comprises different tracks, including vocational ones.

Table E.3: ATE of framing on intention to vaccinate among survey respondents, structural LPM

Stratum	Stratum definition	Uptake in control group	T1 *vs* C Emotional	T2 *vs* C Scientific	T2 *vs* T1
1.	Immigrants	0.830	-0.044	-0.033	0.011
			(0.055)	(0.053)	(0.049)
Swedish-born mothers					
2. Educ-level-1	$\leq$ 3 yrs high school	0.862	0.020	0.084*	0.064
			(0.043)	(0.045)	(0.040)
3. Educ-level-2	Up to high school	0.929	-0.022	0.006	0.028
			(0.033)	(0.034)	(0.030)
4. Educ-level-3	Up to UG	0.931	0.024	-0.005	-0.030
			(0.035)	(0.036)	(0.031)
5. Educ-level-4	Graduate	0.967	0.005	-0.028	-0.033
			(0.024)	(0.024)	(0.021)

Notes: *** p< 0.01, ** p< 0.05, * p< 0.10. Results are estimated on the sample of survey respondents: within the corresponding population, they can be interpreted as the ATE of information framing on self-reported intention to vaccinate. Immigrants are mothers born in Iraq, Iran, Syria, Afghanistan, Eritrea or Somalia. Stratum 2 comprises mothers with at most 3 years of high school: this corresponds to Swedish *högstadiet* (grades 7-9), the last compulsory grades under Swedish law. Mothers in stratum 3 completed high school (*gymnasium*, grades 10-12), which is not compulsory and comprises different tracks, including vocational ones.

Table E.4: The effect of framing conditional on not responding to the first survey: LPM

Stratum	Stratum definition	Uptake in control group	T1 *vs* C Emotional	T2 *vs* C Scientific	T2 *vs* T1
1.	Immigrants	0.759	0.022	0.028	-0.010
			(0.034)	(0.034)	(0.029)
			N=619	N=635	N=784
Swedish-born mothers					
2. Educ-level-1	$\leq$ 3 yrs high school	0.802	0.026	0.033	0.016
			(0.030)	(0.029)	(0.025)
			N=777	N=795	N=974
3. Educ-level-2	Up to high school	0.848	-0.054*	0.011	0.052*
			(0.030)	(0.029)	(0.028)
			N=557	N=597	N=704
4. Educ-level-3	Up to UG	0.863	-0.016	-0.017	-0.020
			(0.038)	(0.038)	(0.034)
			N=359	N=375	N=450
5. Educ-level-4	Graduate	0.922	0.044	0.019	-0.006
			(0.032)	(0.035)	(0.029)
			N=294	N=311	N=365

Notes: *** p< 0.01, ** p< 0.05, * p< 0.10. The outcome variable is the actual vaccination choice (binary indicator). Results are estimated by LPM/OLS on the subsample of mothers who did not answer our first survey. Immigrants are mothers born in Iraq, Iran, Syria, Afghanistan, Eritrea or Somalia. Stratum 2 comprises mothers with at most 3 years of high school: this corresponds to Swedish *högstadiet* (grades 7-9), the last compulsory grades under Swedish law. Mothers in stratum 3 completed high school (*gymnasium*, grades 10-12), which is not compulsory and comprises different tracks, including vocational ones.

Table E.5: The effect of framing conditional on responding to the first survey: LPM

Stratum	Stratum definition	Uptake in control group	T1 *vs* C Emotional	T2 *vs* C Scientific	T2 *vs* T1
1.	Immigrants	0.916	-0.066	-0.009	0.047
			(0.086)	(0.072)	(0.057)
			N=137	N=128	N=165
Swedish-born mothers					
2. Educ-level-1	$\leq$ 3 yrs high school	0.875	0.051	0.163***	0.091**
			(0.051)	(0.048)	(0.039)
			N=232	N=215	N=259
3. Educ-level-2	Up to high school	0.928	-0.037	0.016	0.048
			(0.036)	(0.031)	(0.029)
			N=315	N=281	N=372
4. Educ-level-3	Up to UG	0.916	-0.024	-0.024	0.013
			(0.039)	(0.036)	(0.035)
			N=269	N=249	N=316
5. Educ-level-4	Graduate	0.940	-0.033	-0.016	-0.010
			(0.029)	(0.028)	(0.026)
			N=335	N=321	N=412

Notes: *** p< 0.01, ** p< 0.05, * p< 0.10. The outcome variable is the actual vaccination choice (binary indicator). Results are estimated by LPM/OLS on the subsample of mothers who answered our first survey. Immigrants are mothers born in Iraq, Iran, Syria, Afghanistan, Eritrea or Somalia. Stratum 2 comprises mothers with at most 3 years of high school: this corresponds to Swedish *högstadiet* (grades 7-9), the last compulsory grades under Swedish law. Mothers in stratum

F Misconceptions on vaccines

In this section, we test whether our treatments affect vaccination choices through a change in beliefs about vaccines. Our intervention addresses misconceptions about vaccines by shifting the attention away from the low probability and low severity of the HPV vaccine towards the more likely and far more severe consequences of catching a preventable HPV-induced cancer. We assess the effect of our intervention on 2 common misconceptions that we measure in the first survey (immediately after treatment). We ask parents how much they agree with the following statements on a 5-point Likert scale:

1. Vaccines weaken and overload the immune system;
2. Vaccines can cause the disease against which they protect.

Our outcome indicator is the average of the two answers and we estimate results by a Linear Probability Model

The results in Table F.6 show that there is no reduction in misconceptions: on the other hand, highly educated mothers worsen their beliefs when exposed to emotional framing (T1). Therefore, the effects of informational framing in strata 2 and 3 do not pass through a change in misconceptions about vaccines.

Table F.6: ATE of information framing on vaccine misconceptions

Stratum	Stratum definition	Value in the control group	T1 *vs* C Emotional	T2 *vs* C Scientific	T2 *vs* T1
1.	Immigrants	2.495	0.140	0.005	-0.126
			(0.150)	(0.155)	(0.137)
Swedish-born mothers					
2. Educ-level-1	$\leq$ 3 yrs high school	1.780	0.088	0.054	-0.031
			(0.141)	(0.147)	(0.130)
3. Educ-level-2	Up to high school	1.66	0.108	0.063	-0.027
			(0.107)	(0.118)	(0.100)
4. Educ-level-3	Up to UG	1.58	-0.098	0.008	0.042
			(0.108)	(0.111)	(0.095)
5. Educ-level-4	Graduate	1.24	0.165**	0.071	-0.059
			(0.080)	(0.075)	(0.071)

Notes: *** p< 0.01, ** p< 0.05, * p< 0.10. The outcome variable is the mean of the degree to which subjects agree with two common misconceptions about vaccines (5-point Likert scale). Results are estimated on the subsample of survey respondents for whom the outcome is observed: they can be interpreted as an ATE effect for this subpopulation. Immigrants are mothers born in Iraq, Iran, Syria, Afghanistan, Eritrea or Somalia. Stratum 2 comprises mothers with at most 3 years of high school: this corresponds to Swedish *högstadiet* (grades 7-9), the last compulsory grades under Swedish law. Mothers in stratum 3 completed high school (*gymnasium*, grades 10-12), which is not compulsory and comprises different tracks, including vocational ones.

G Power calculations

This section presents the Minimum Detectable Effects (MDE) in each stratum (1-5) and for each comparison: (T1 vs C) and (T2 vs C), for both the primary outcome of actual vaccination records and the secondary outcome of self-reported willingness to vaccinate.

They are computed on observations from the control group (C). First, we compute the variance of the residual after regressing the actual HPV vaccination record on all the covariates used in the

main analysis.

Then, we compute the MDE with the following formula:

$$MDE = (z_{1-\beta} + z_{\alpha}) \times \frac{1}{\sqrt{P(1-P)}} \times \frac{\sigma_{\text{res}}}{\sqrt{N}}$$

where $z_{1-\beta}$ is the critical value when $1-\beta = 0.8$, z_{α} is the critical value for a two-tailed test when $\alpha = 0.05$, $P = \frac{N_t}{N_t+N_c}$ is the proportion of treated units, σ_{res} is the standard deviation of the residual from the regressions described above, and $N = N_t + N_c$ is the total sample size.

The sample sizes and P change depending on whether we consider the analysis to be performed by reduced or structural form equations. These are respectively:

$$Y_i = \alpha + \tau T_i + \boldsymbol{X_i'}\boldsymbol{\beta} + \eta_m + \varepsilon_i \qquad \text{(Red.)}$$

$$Y_i = \alpha + \tau_1 T1_i + \tau_2 T2_i + \boldsymbol{X_i'}\boldsymbol{\beta} + \eta_m + \varepsilon_i \qquad \text{(Struct.)}$$

Table G.7: Minimum Detectable Effects in the primary analysis

Stratum	σ_{res}	N_C	N_{T1}	N_{T2}	MDE T1 vs C Reduced form	MDE T2 vs C Reduced form	MDE T1 vs C Structural form	MDE T2 vs C Structural form
1	0.133	611	961	976	0.053	0.053	0.042	0.042
2	0.127	393	616	617	0.064	0.064	0.051	0.051
3	0.079	337	535	541	0.055	0.055	0.043	0.043
4	0.072	243	385	381	0.062	0.062	0.049	0.049
5	0.049	242	387	390	0.051	0.051	0.040	0.040

Notes: MDE for power $1-\beta = 0.8$ and $\alpha = 0.05$ in two-tailed comparisons. σ_{res} is the variance of residuals obtained from regressing the outcome of interest (vaccination records) on all covariates used in the main analysis, within the control group. "Reduced" and "Structural" refer to the equations used to estimate causal effects in the main analysis, Equations (Red.) and (Struct.).

Table G.8: Minimum Detectable Effects in the secondary analysis

Stratum	σ_{res}	N_C	N_{T1}	N_{T2}	MDE T1 vs C Reduced form	MDE T2 vs C Reduced form	MDE T1 vs C Structural form	MDE T2 vs C Structural form
1	0.133	106	148	162	0.130	0.128	0.105	0.101
2	0.127	94	138	121	0.133	0.137	0.109	0.115
3	0.079	112	203	169	0.093	0.096	0.073	0.078
4	0.072	101	168	148	0.095	0.097	0.075	0.079
5	0.049	122	213	199	0.070	0.071	0.055	0.056

Notes: MDE for power $1 - \beta = 0.8$ and $\alpha = 0.05$ in two-tailed comparisons. σ_{res} is the variance of residuals obtained from regressing the outcome of interest (vaccination records) on all covariates used in the main analysis, within the control group. "Reduced" and "Structural" refer to the equations used to estimate causal effects in the main analysis, Equations (Red.) and (Struct.).

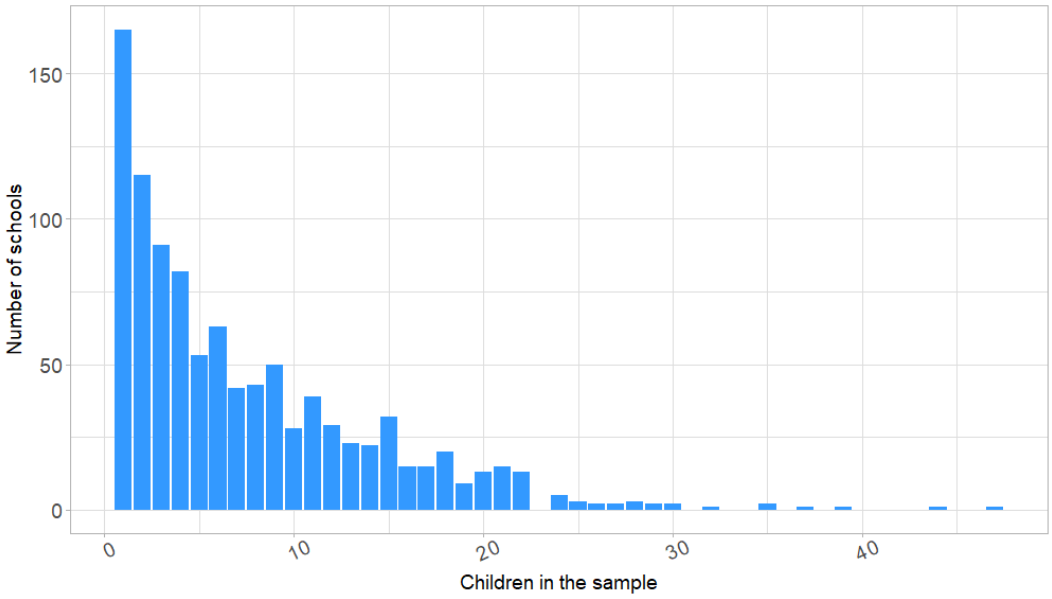
H Robustness check: spillover effects

In this section, we use our causal forest estimates to show that spillover effects between children in the same school are unlikely to drive the null results.

Our sample comprises 7616 children from 611 schools in 49 municipalities. Figure H.1 shows the distribution of the number of children in the same school. 6303 children (83% of the total) are from schools with 6 or more children included in this study. 4546 (60% of all children) are from schools attended by more than 10 children in the study. For privacy reasons, we do not know the total number of students in each school nor the class of each child and therefore cannot evaluate the likelihood that these children (or their parents) meet and exchange information. Since many of our estimates are not statistically significant, one might wonder whether this is driven by spillover effects. To exclude this possibility, we look at Conditional Intention-To-Treat effects (CITTs) from our causal forest analysis, and we correlate them with the number of children in the school. Specifically, conditional on the number of children in the same school, we compute the mean CITT. If null results are driven by spillover effects, one would expect the mean CITT to tend to zero as the number of children increases, because children in the control group are more likely to communicate with children (or parents) in treatment groups. Figure H.2 and Figure H.3 show that is not the

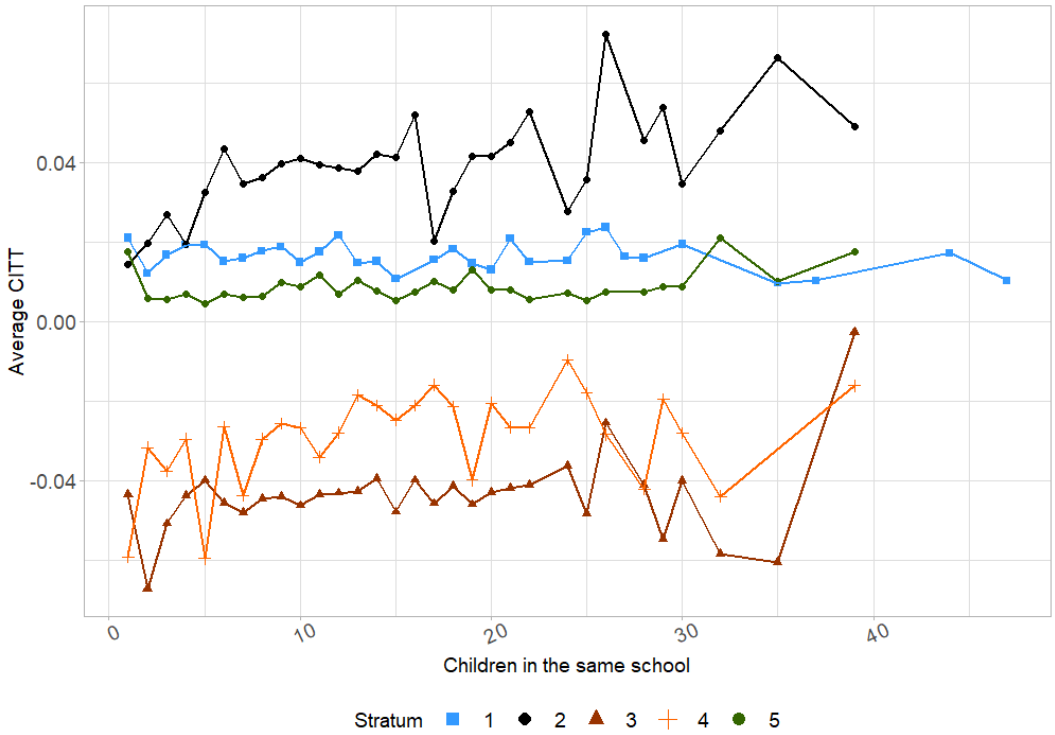
case, respectively for the effect of emotional Framing (T1) and scientific framing (T2). The CITT effects show no significant negative correlation with the number of children in the same school.[26]

Figure H.1: Distribution of the number of children in the same school



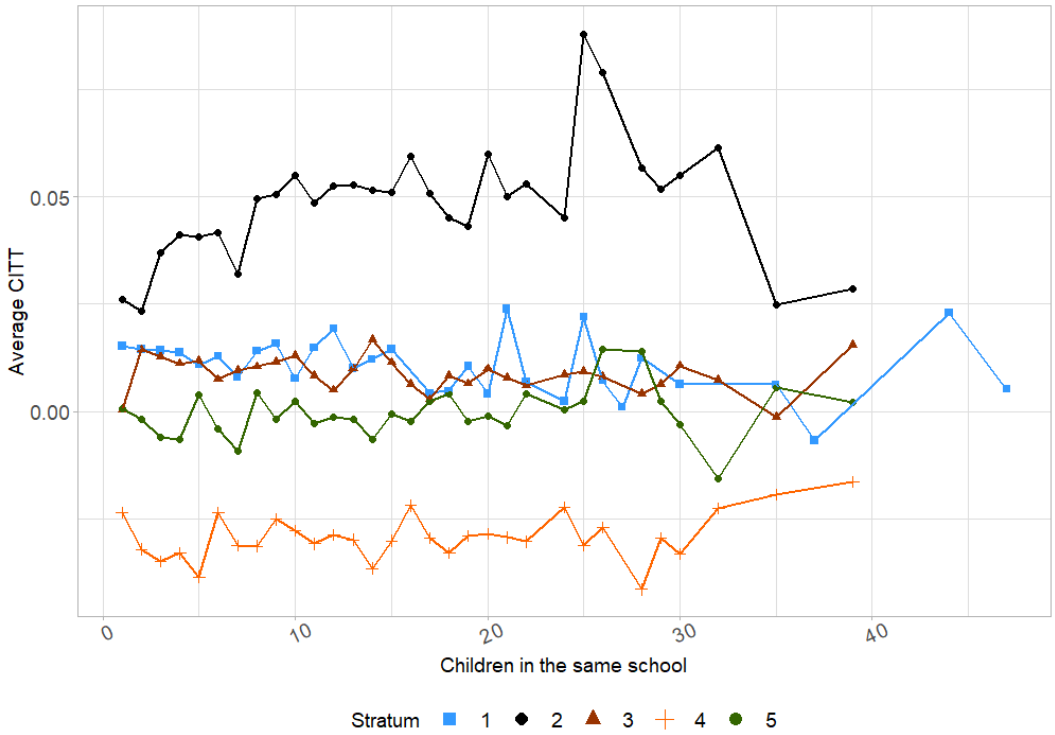
[26]The absence of correlation is maintained also by looking at individual CITT effects instead of computing the mean CITT for each number of children in school.

Figure H.2: Mean CITT (Emotional Framing - T1) by the number of children in the same school



Notes: The figure shows, for each stratum, the average Conditional ITT Effect of emotional Framing (T1) on actual vaccinations by the number of children attending the same school. Namely, within each cell defined by the number of children attending the same school, we compute the average individual ITT effect from our causal forest analysis. We do not show standard errors to improve readability: the only significant effect is in stratum 3, as in the main analysis. If there were any spillover effects between the treatment groups and the control group, they should be more likely as the number of children in the same school increases.

Figure H.3: Mean CITT (Scientific Framing - T2) by the number of children in the same school



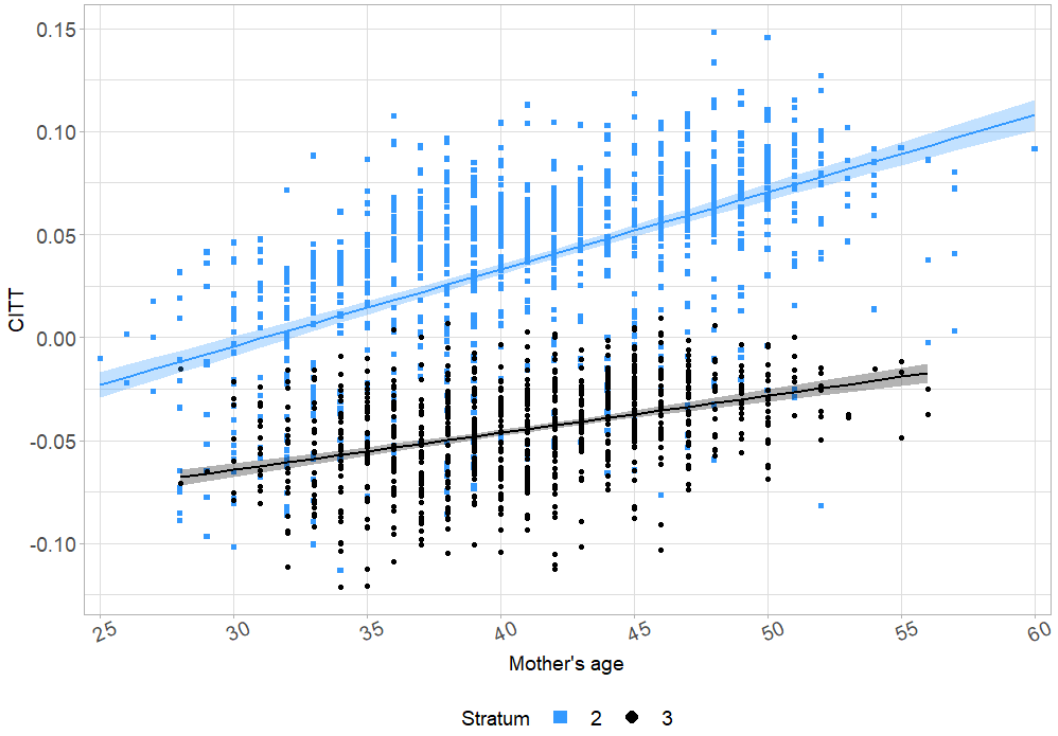
Notes: The figure shows, for each stratum, the average Conditional ITT Effect of scientific Framing (T2) on actual vaccinations by the number of children attending the same school. Namely, within each cell defined by the number of children attending the same school, we compute the average individual ITT effect from our causal forest analysis. We do not show standard errors to improve readability: the only significant effect is in stratum 2, as in the main analysis. If there were any spillover effects between the treatment groups and the control group, they should be more likely as the number of children in the same school increases.

I Interactions between our intervention and Covid-19: qualitative evidence

Our intervention concerns a childhood vaccine. It was carried out in the summer of 2021 when the volume of (dis)information on Covid-19 vaccines was high and possibly interacted with our intervention. We investigate this possibility, given the importance of pre-treatment exposition to information vaccines for our treatment effects. To do so, we rely on the results by Eichengreen et al. (2021). By looking at global epidemics since 1973, the authors find that being exposed to one

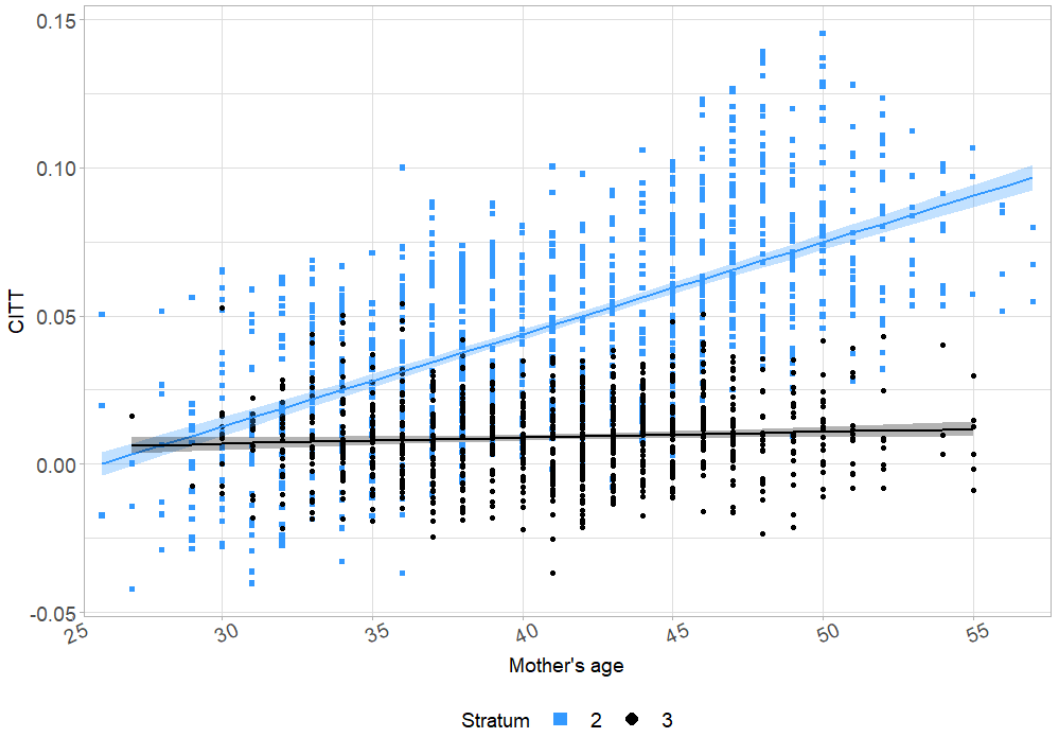
between ages 18 and 25 decreases trust in scientists and translates into lower uptake of childhood vaccinations. The negative effects are driven by individuals with little or no scientific training. Moreover, it is not found among health professionals. In strata 2 and 3, we find that all our significant effects are larger in magnitude the older the mother, and are close to zero for mothers aged 25 (Figure I.4 and Figure I.5).

Figure I.4: Effect of emotional framing (T1) by mother's age



Notes: The figure shows, separately for stratum 2 and 3, the scatterplot of mother's age and the Conditional ITT effect of emotional framing (T1).

Figure I.5: Effect of scientific framing (T2) by mother's age



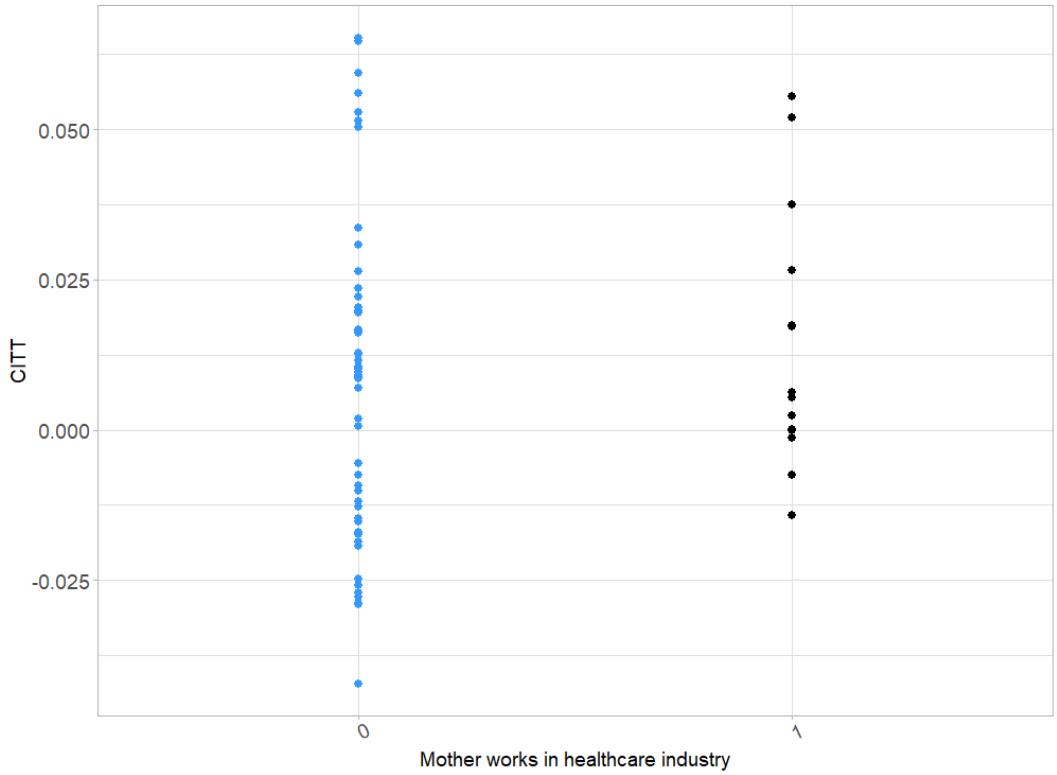
Notes: The figure shows, separately for stratum 2 and 3, the scatterplot of mother's age and the Conditional ITT effect of scientific framing (T2).

In stratum 2, where scientific framing (T2) has a positive average effect, we can look at mothers who have a job in the healthcare industry.[27] For mothers younger than 30 who work in the industry, the distribution of CITT from the causal forest is more concentrated around positive values, as shown in Figure I.6.

Indeed, even when our intervention is effective on average, the impact is concentrated among older mothers, and it is more pronounced for those in the healthcare industry. This suggests that Covid-19 impacted our results.

[27] We do not have a sufficient number of young mothers with a high school scientific major in stratum 2. In any case, stratum 2 mothers attended at most 3 years of high school and thus the major is unlikely to have a lasting impact.

Figure I.6: CITT of scientific framing (T2): young mothers in stratum 2 by healthcare occupation



Notes: The figure shows the distribution of the Conditional ITT of scientific framing (T2) for stratum 2 mothers below 30 years old, differentiating by whether they work in the healthcare industry. According to Eichengreen et al. (2021), individuals exposed to an epidemic between ages 18 and 25 who do not work in healthcare develop more negative views of vaccines.

J Information sources and intervention timeline

Table J.9: Sources of information by treatment group and topic

	Sources			
Information leaflet	**Public Health Agency of Sweden**	**International Agency for Cancer Research (2019)**	**European Medical Agency (2015)**	**Nätverket mot gynekologisk cancer**
C	History of the Swedish vaccination program			
T1	Introductory HPV information	•Swedish cervical cancer statistics •Introductory HPV information	Vaccine safety and efficacy	Swedish cancer survivors' testimonies
T2	Introductory HPV information	•Swedish cervical cancer statistics •Introductory HPV information	•Vaccine safety and efficacy •Vaccine clinical trial statistical information	

Table J.10: Content of envelopes by date, and printed/online version

Date of dispatch	Swedish-born mothers		Immigrant mothers	
	Printed	**Online**	**Printed**	**Online**
16th June	• Invitation letter[1] •Leaflet[1] •First survey[1]	•Invitation letter[1] •Leaflet[1] •First survey[1]	•Invitation letter[2] •Leaflet[2] •First survey[2]	•Invitation letter[2] •Leaflet[2] •First survey[1]
5th July	Reminder letter[1]	•Invitation letter[1] •Leaflet[1] •First survey[1]	Reminder letter[2]	•Invitation letter[2] •Leaflet[2] •First survey[1]
11th August	•Reminder letter[1] •First survey[1]	•Invitation letter[1] •Leaflet[1] •First survey[1]	•Reminder letter[2] •First survey[2]	•Invitation letter[2] •Leaflet[2] •First survey[1]
20th August	Reminder letter[1]	•Invitation letter[1] •Leaflet[1] •First survey[1]	Reminder letter[2]	•Invitation letter[2] •Leaflet[2] •First survey[1]
September - October		**HPV vaccination is offered**		
15th November	•Invitation letter[1] •Endline survey[1]	•Invitation letter[1] •Endline survey[1]	•Invitation letter[2] •Endline survey[2]	•Invitation letter[2] • Endline survey[2]

Notes: 1: Swedish only
2: Swedish and Arabic/Dari depending on origin country.

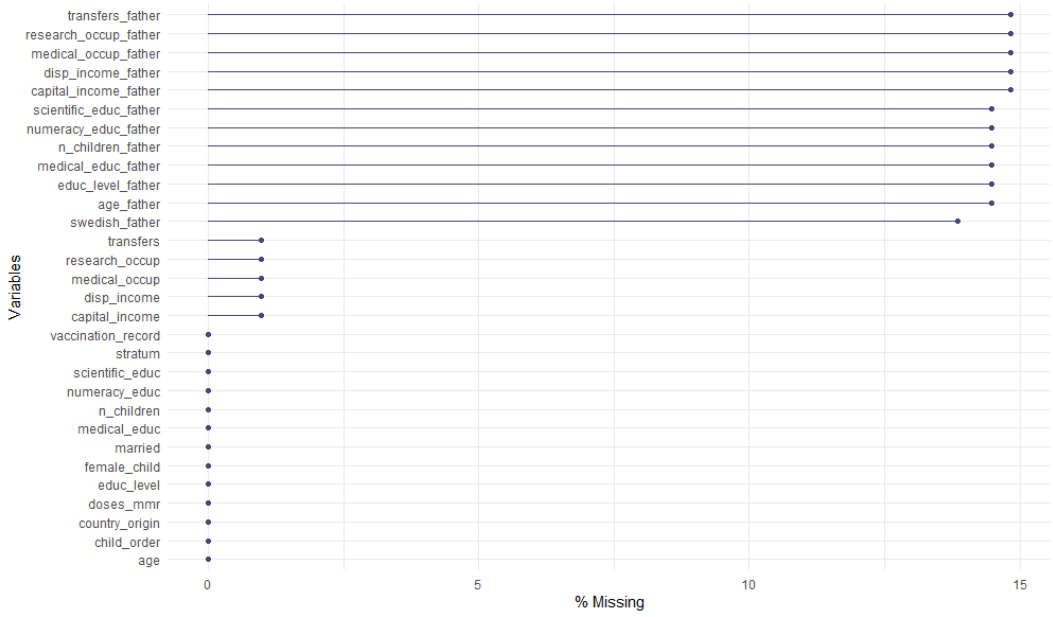
All invitation letters remind the presence of other languages options online (English included).

K Missing data and multiple imputation

We follow Little and Rubin (2019) and use multiple imputation to deal with missingness in baseline covariates from population registers. Importantly, we do not impute the outcome variable: the actual vaccination record has no missingness in our sample. We adopt CART models as a method for imputation, as they as suitable for all covariates, and pick $m = 5$ (the minimum number suggested by Little and Rubin (2019) to achieve consistency). The imputation is implemented using package *mice* in R, whereas aggregation is performed manually. We estimate the regressions in each of the 5 imputed datasets, compute the estimate as their mean and use Rubin's formula to aggregate the variance to compute standard errors.

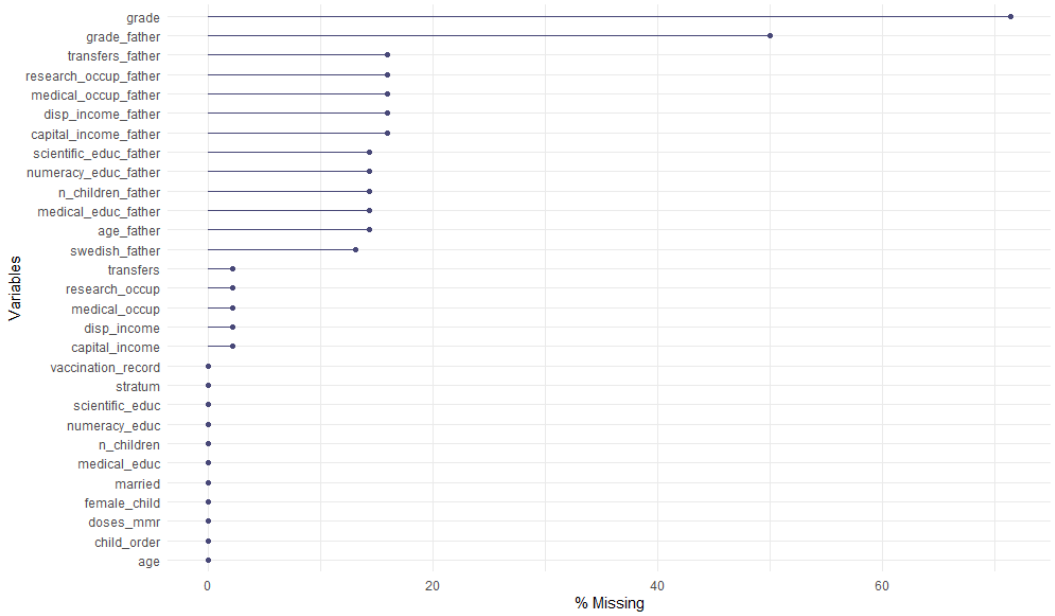
Figure K.7-Figure K.11 describe, for each stratum, the percentage of missing observations for each baseline covariate used in our main specification, plus some extra covariates on fathers. Note that in stratum 2 mothers have only completed 3 years of high school: high school grade is thus missing for the majority of them, and when it is observed it refers to the first 3 years.

Figure K.7: Stratum 1: missingness in baseline covariates



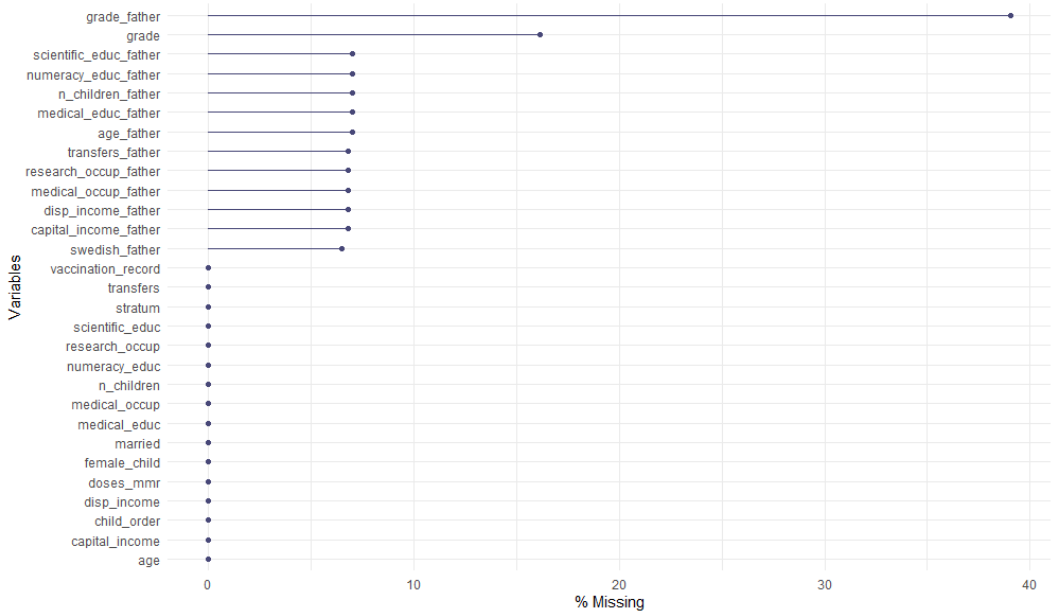
Notes: Stratum 1 contains immigrant mothers from selected origin countries.

Figure K.8: Stratum 2: missingness in baseline covariates



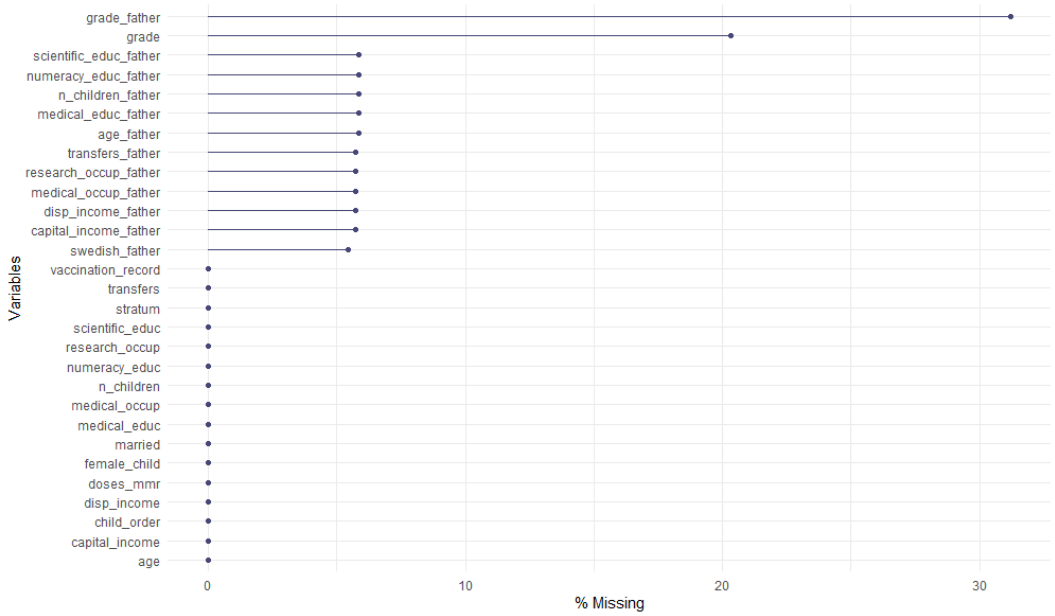
Notes: Stratum 2 contains mothers with compulsory education (3 years of high school). Grade indicates their grade at the end of those 3 years.

Figure K.9: Stratum 3: missingness in baseline covariates



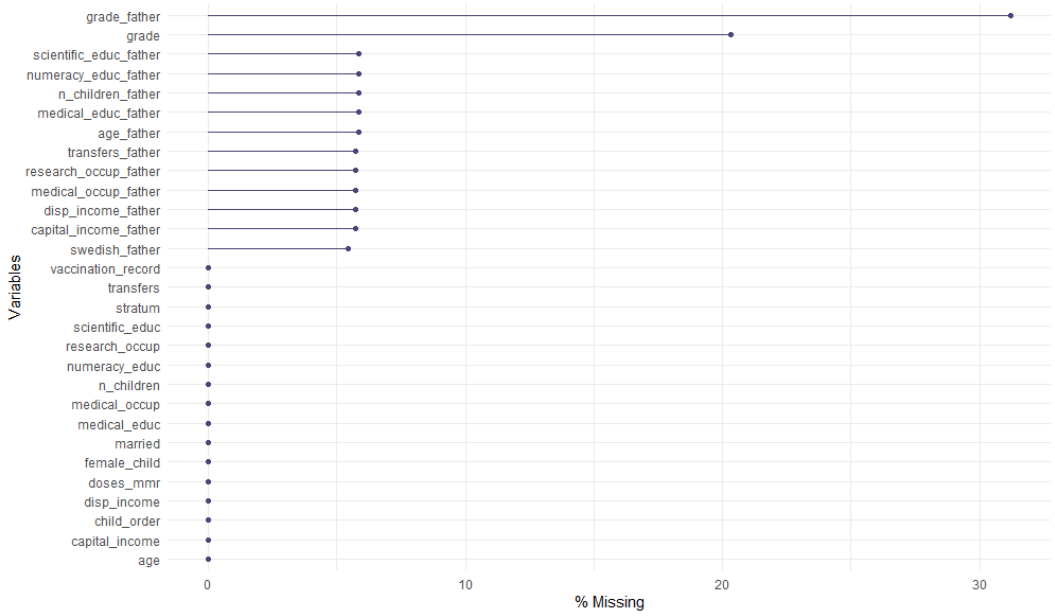
Notes: Stratum 3 contains mothers with a high school degree. "Grade" indicates their final high school degree.

Figure K.10: Stratum 4: missingness in baseline covariates



Notes: Stratum 4 contains mothers with some university education, up to a bachelor degree. "Grade" indicates their final high school degree.

Figure K.11: Stratum 5: missingness in baseline covariates



Notes: Stratum 5 contains mothers with some graduate education. "Grade" indicates their final high school degree.

L Balance tables

For each baseline covariate X, the following tables report the Absolute Standardized Difference (ASD), computed as:

$$ASD(X) \equiv \frac{|\bar{X}_T - \bar{X}_C|}{\sqrt{Var_T(X) + Var_C(X)}}$$

Table L.11: Balance table: overall sample (used to estimate main ITT results)

Covariate	**ASD: T1** *vs* **C**	**Mean (C)**	**Mean (T1)**	**ASD: T2** *vs* **C**	**Mean (T2)**
Mother's characteristics					
Age	0.019	41.095	40.933	0.014	40.977
Married (Dummy)	0.009	0.591	0.597	0.002	0.592
Capital income (Thousands SEK)	0.018	-7.571	519.213	0.017	63.581
Disposable income (Thousands SEK)	0.019	3,222.662	3,613.435	0.023	3,313.980
Scientific educ. (Dummy)	0.019	0.205	0.215	0.023	0.218
Medical educ. (Dummy)	0.018	0.134	0.143	0.021	0.145
Numerical educ. (Dummy)	0.008	0.163	0.167	0.012	0.157
Job in research (Dummy)	0.008	0.005	0.004	0.030	0.002
Answered the first survey (Dummy)	0.010	0.294	0.300	0.031	0.274
Child's characteristics					
Child order	0.022	1.029	1.024	0.041	1.040
Female (Dummy)	0.031	0.475	0.497	0.027	0.494
First dose MMR (Dummy)	0.010	0.905	0.901	0.033	0.891

Notes: *** p< 0.01, ** p< 0.05, * p< 0.10 on two-tailed tests of difference in means. The overall sample is used to estimate the main results (where the dependent variable is actual vaccination choice and the estimand is an ITT). Denoting treated units as T and untreated units as C, The Absolute Standardized Difference (ASD) for variable X is computed as: $ASD \equiv \frac{|\bar{X}_T - \bar{X}_C|}{\sqrt{Var_T(X)+Var_C(X)}}$.

Table L.12: Balance table: respondents sample (used to estimate secondary ATE results)

Covariate	ASD: T1 *vs* C	Mean (C)	Mean (T1)	ASD: T2 *vs* C	Mean (T2)
Mother's characteristics					
Age	0.013	42.518	42.420	0.016	42.401
Married (Dummy)	0.015	0.640	0.630	0.006	0.636
Capital income (Thousands SEK)	0.006	17.652	7.921	0.022	64.070
Disposable income (Thousands SEK)	0.039	3,634.945	3,749.006	0.040	3,786.175
Scientific educ. (Dummy)	0.019	0.205	0.216	0.065	0.243
Medical educ. (Dummy)	0.071	0.104	0.136	0.067	0.134
Numerical educ. (Dummy)	0.001	0.211	0.212	0.001	0.210
Job in research (Dummy)	0.054	0.013	0.006	0.072	0.004
Child's characteristics					
Child order	0.027	1.019	1.014	0.042	1.028
Female (Dummy)	0.028	0.499	0.479	0.051	0.535
Second dose of MMR (Dummy)	0.012	0.915	0.920	0.016	0.921

Notes: *** p< 0.01, ** p< 0.05, * p< 0.10 on two-tailed tests of difference in means. The sample of survey respondents is used to estimate the secondary results (where the dependent variables are self-reported intention to vaccinate and misconceptions about vaccines, and the estimand is an ATE). Denoting treated units as T and untreated units as C, The Absolute Standardized Difference (ASD) for variable X is computed as: $ASD \equiv \frac{|\bar{X}_T - \bar{X}_C|}{\sqrt{Var_T(X)+Var_C(X)}}$.

M The characteristics of survey respondents

In this section, we compare baseline covariates between:

- Subjects who never replied to any survey *vs* Subjects who replied at least to the first survey;
- Subjects who replied to the first survey *vs* Subjects who replied to both the first and the second survey.

Both comparisons are presented twice: first irrespective of treatment status, and then separately by treatment status (C, T1 or T2).

Table M.13: Respondents compared to never-respondents

Covariate	ASD	Non-respondents	Respondents
Mother's characteristics			
Age	0.254***	40.51	42.49
Married (dummy)	0.058**	0.63	0.669
Scientific educ. (dummy)	0.019	0.21	0.221
Medical educ. (dummy)	0.038**	0.147	0.128
Numerical educ. (dummy)	0.118***	0.15	0.214
Capital income (Thousands SEK)	0.014	341.682	25.115
Disposable income (Thousands SEK)	0.027*	3305.918	3753.373
Job in research	0.046**	0.003	0.007
Job in healthcare	0.108***	0.18	0.126
Father's characteristics			
Father is a researcher	0.038*	0.004	0.009
Father works in healthcare	0.083***	0.055	0.031
Child's characteristics			
Female (dummy)	0.026	0.484	0.502
Birth order	0.059***	1.035	1.021
Second dose of MMR (dummy)	0.121***	0.95	0.981
Treatment status			
T1	0.028	0.374	0.394
T2	0.041**	0.388	0.360

Notes: *** p< 0.01, ** p< 0.05, * p< 0.10 on two-tailed tests of difference in means. Respondents and non-respondents are used to estimate different estimands between primary and secondary outcomes. Responding to the survey is also used as a proxy of attentiveness to explain the mechanism behind ITT effects. Denoting respondents to the first survey as R and non-respondents as NR, The Absolute Standardized Difference (ASD) for variable X is computed as: $ASD \equiv \frac{|\bar{X}_R - \bar{X}_{NR}|}{\sqrt{Var_R(X) + Var_{NR}(X)}}$.

Table M.14: Respondents to first survey compared to respondents to both surveys

Covariate	ASD	Replied once (R)	Replied twice (RR)
Mother's characteristics			
Age	0.017	42.45	42.574
Married (dummy)	0.033	0.662	0.685
Scientific educ. (dummy)	0.003	0.22	0.222
Medical educ. (dummy)	0.056∗	0.136	0.11
Numerical educ. (dummy)	0.016	0.211	0.221
Capital income (Thousands SEK)	0.025	8.748	59.853
Disposable income (Thousands SEK)	0.065∗∗	3679.519	3910.129
Job in research	0.039	0.006	0.011
Job in healthcare	0.104∗∗	0.141	0.093
Father's characteristics			
Father is a researcher	0.013	0.009	0.008
Father works in healthcare	0.02	0.032	0.028
Child's characteristics			
Female (dummy)	0.008	0.504	0.498
Birth order	0.04	1.023	1.015
Second dose of MMR (dummy)	0.03	0.979	0.985
Treatment status			
T1	0.039	0.385	0.412
T2	0.033	0.353	0.375
Answers to the first survey			
Has heard of HPV before treatment	0.122∗∗∗	0.835	0.894
% leaflet read	0.141∗∗∗	76.696	82.634

Notes: *** p$<$ 0.01, ** p$<$ 0.05, * p$<$ 0.10 on two-tailed tests of difference in means. Denoting responding to the second survey as R and respondents only to the first survey as NR, The Absolute Standardized Difference (ASD) for variable X is computed as: $ASD \equiv \frac{|\bar{X}_R - \bar{X}_{NR}|}{\sqrt{Var_R(X)+Var_{NR}(X)}}$.

Table M.15: Respondents to compared to never respondents, by treatment

	Control (C)			Emotional framing (T1)			Scientific framing (T2)		
Covariate	**ASD**	**Never replied**	**Replied**	**ASD**	**Never replied**	**Replied**	**ASD**	**Never replied**	**Replied**
Mother's characteristics									
Age	0.257***	40.575	42.59	0.276***	40.381	42.526	0.23***	40.593	42.379
Married	0.063*	0.625	0.667	0.048	0.635	0.667	0.063**	0.632	0.674
Scientific education	0.001	0.198	0.199	0.002	0.217	0.216	0.052*	0.21	0.241
Medical education	0.088**	0.142	0.102	0.021	0.149	0.139	0.026	0.148	0.135
Numerical education	0.117**	0.153	0.217	0.114***	0.153	0.216	0.121***	0.146	0.211
Capital income	0.02	-15.524	17.735	0.023	843.331	-4.24	0.003	78.674	62.312
Disposable income	0.215***	3079.229	3664.339	0.005	3634.074	3766.232	0.133***	3129.774	3803.973
Research occupation	0.098**	0.002	0.014	0.023	0.004	0.006	0.024	0.002	0.004
Medical occupation	0.154***	0.184	0.108	0.117***	0.182	0.122	0.067**	0.176	0.142
Father's characteristics									
Age	0.121**	44.342	45.404	0.101***	44.262	45.152	0.1***	44.216	45.099
Married	0.047	0.633	0.665	0.036	0.645	0.669	0.042	0.642	0.67
Scientific education	0.059	0.313	0.353	0.074**	0.329	0.38	0.057*	0.315	0.353
Medical education	0.019	0.033	0.038	0.003	0.043	0.044	0.018	0.035	0.04
Numerical education	0.174***	0.185	0.289	0.184***	0.2	0.312	0.18***	0.196	0.305
Capital income	0.021	2268.592	857.763	0.052	303.392	966.207	0.001	541.168	527.097
Disposable income	0.01	5969.48	5312.478	0.099**	4226.021	5257.613	0.043	4512.62	5019.658
Research occupation	0.065	0.003	0.01	0.048	0.005	0.011	0.006	0.005	0.005
Medical occupation	0.14***	0.061	0.022	0.087**	0.055	0.03	0.041	0.05	0.038
Child's characteristics									
Female	0.033	0.469	0.492	0.022	0.501	0.486	0.072**	0.475	0.526
MMR 1st dose	0.032	0.907	0.92	0.062**	0.897	0.923	0.124***	0.878	0.929
MMR 2nd dose	0.124***	0.948	0.98	0.146***	0.95	0.986	0.092**	0.951	0.975
Order of birth	0.047	1.03	1.02	0.06**	1.027	1.015	0.063**	1.045	1.027

Notes: *** p< 0.01, ** p< 0.05, * p< 0.10 on two-tailed tests of difference in means. Denoting responding to at least the first survey as R and non-repondents units NR, The Absolute Standardized Difference (ASD) for variable X is computed as: $ASD \equiv \frac{|\bar{X}_R - \bar{X}_{NR}|}{\sqrt{Var_R(X)+Var_{NR}(X)}}$.

Table M.16: Respondents to first survey compared to respondents to both surveys, by treatment

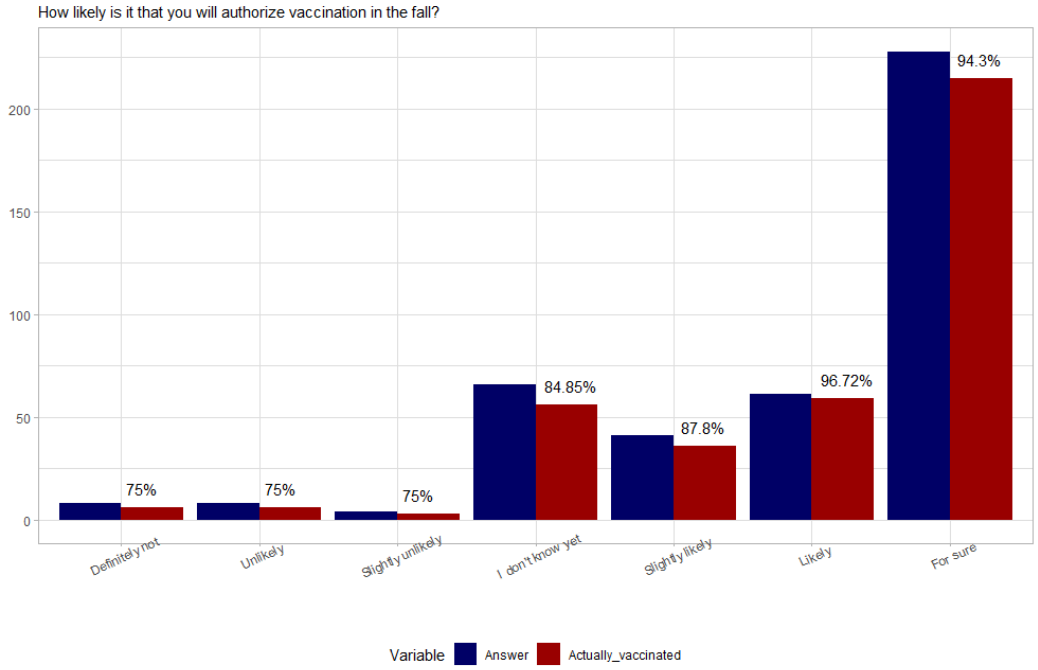
	Control (C)			Emotional framing (T1)			Scientific framing (T2)		
Covariate	**ASD**	**Replied once**	**Replied twice**	**ASD**	**Replied once**	**Replied twice**	**ASD**	**Replied once**	**Replied twice**
Mother's characteristics									
Age	0.032	42.656	42.417	0.043	42.42	42.735	0.024	42.319	42.498
Married	0.041	0.675	0.647	0.003	0.666	0.668	0.11**	0.65	0.722
Scientific education	0.023	0.196	0.209	0.038	0.223	0.201	0.029	0.235	0.253
Medical education	0.1	0.113	0.072	0.036	0.144	0.127	0.065	0.145	0.114
Numerical education	0.09	0.231	0.18	0.02	0.212	0.224	0.076	0.196	0.241
Capital income	0.106	-29.295	140.554	0.05	-37.184	61.28	0.032	87.092	12.853
Disposable income	0.124*	3566.237	3920.532	0.072	3690.572	3916.705	0.037	3750.047	3911.604
Research occupation	0.059	0.011	0.022	0.016	0.006	0.007	0.061	0.002	0.008
Medical education	0.118*	0.121	0.072	0.11**	0.139	0.09	0.098*	0.157	0.11
Father's characteristics									
Age	0.054	45.526	45.086	0.013	45.118	45.22	0.089	44.855	45.588
Married	0.022	0.669	0.655	0.014	0.666	0.675	0.119**	0.644	0.722
Scientific education	0.015	0.355	0.345	0.047	0.39	0.358	0.095*	0.331	0.396
Medical education	0.048	0.041	0.029	0.014	0.045	0.041	0.029	0.037	0.045
Numerical education	0.002	0.289	0.288	0.037	0.304	0.328	0.105*	0.282	0.351
Capital income	0.026	773.675	1077.36	0.057	1252.994	395.843	0.02	572.81	435.857
Disposable income	0.051	5123.609	5805.712	0.048	5442.537	4889.836	0.005	5034.456	4990.122
Research occupation	0.041	0.008	0.014	0.131**	0.017	0	0.086	0.002	0.012
Medical occupation	0.002	0.022	0.022	0.022	0.028	0.034	0.079	0.045	0.024
Child's characteristics									
Female	0.034	0.499	0.475	0.017	0.49	0.478	0.019	0.521	0.535
MMR 1st dose	0.055	0.915	0.935	0.011	0.921	0.925	0.027	0.933	0.922
MMR 2nd dose	0.099	0.975	0.993	0.011	0.987	0.985	0.029	0.973	0.98
Order of birth	0.04	1.022	1.014	0	1.015	1.015	0.075	1.033	1.016
First survey answers									
Attention	0.15**	0.948	0.986	0.059	0.936	0.955	0.078	0.935	0.959
Believes vaccines cause the disease	0.217**	1.854	1.532	0.202***	1.867	1.567	0.158**	1.859	1.616
Believes vaccines weaken the immune system	0.179**	1.747	1.504	0.17***	1.859	1.604	0.165**	1.822	1.58
Heard of HPV before the study	0.107	0.824	0.878	0.088*	0.85	0.892	0.163**	0.828	0.906
% of leaflet read	0.04	7.705	7.878	0.161**	7.679	8.358	0.177**	7.634	8.371
Searched vaccine info from unreliable sources	0.126*	0.229	0.158	0.028	0.182	0.198	0.04	0.215	0.192
Trusts health authorities	0.236***	4.237	4.54	0.116**	4.353	4.5	0.123**	4.333	4.494

Notes: *** p< 0.01, ** p< 0.05, * p< 0.10 on two-tailed tests of difference in means. Denoting responding to the second survey as RR and respondents only to the first survey as R, The Absolute Standardized Difference (ASD) for variable X is computed as $ASD = \frac{|\bar{X}_{RR} - \bar{X}_R|}{\sqrt{0.5(s^2_{RR} + s^2_R)}}$

N Intention to vaccinate and actual vaccination

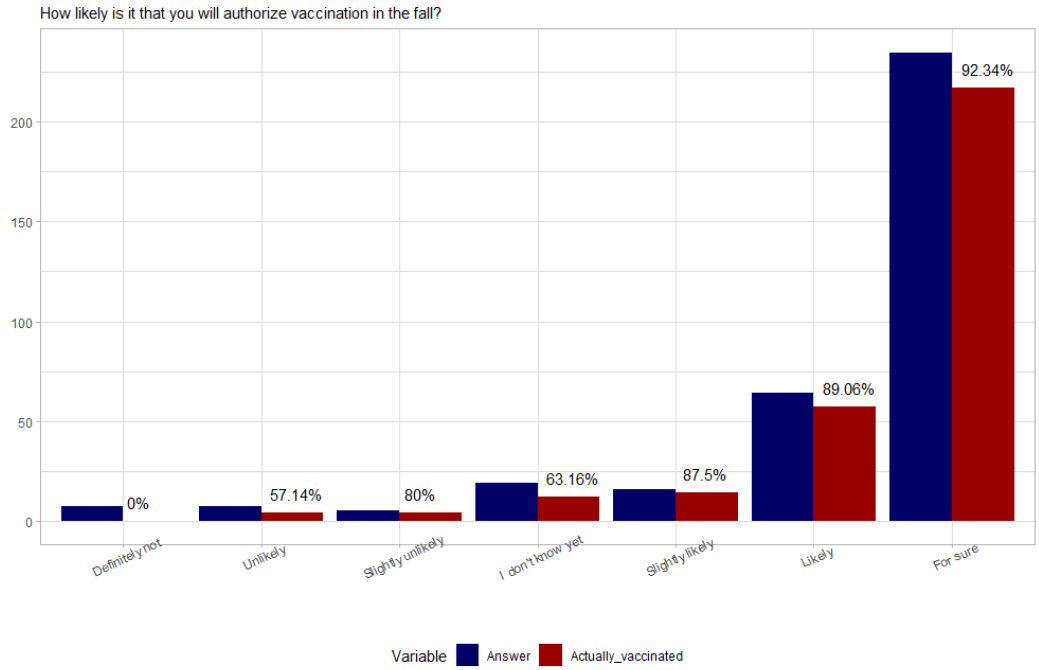
The following graphs summarize, for each stratum, the mismatch between the intention to vaccinate (measured in the first survey right after treatment) and actual vaccination status from the administrative records.

Figure N.12: Stratum 1: intention to vaccinate and vaccination



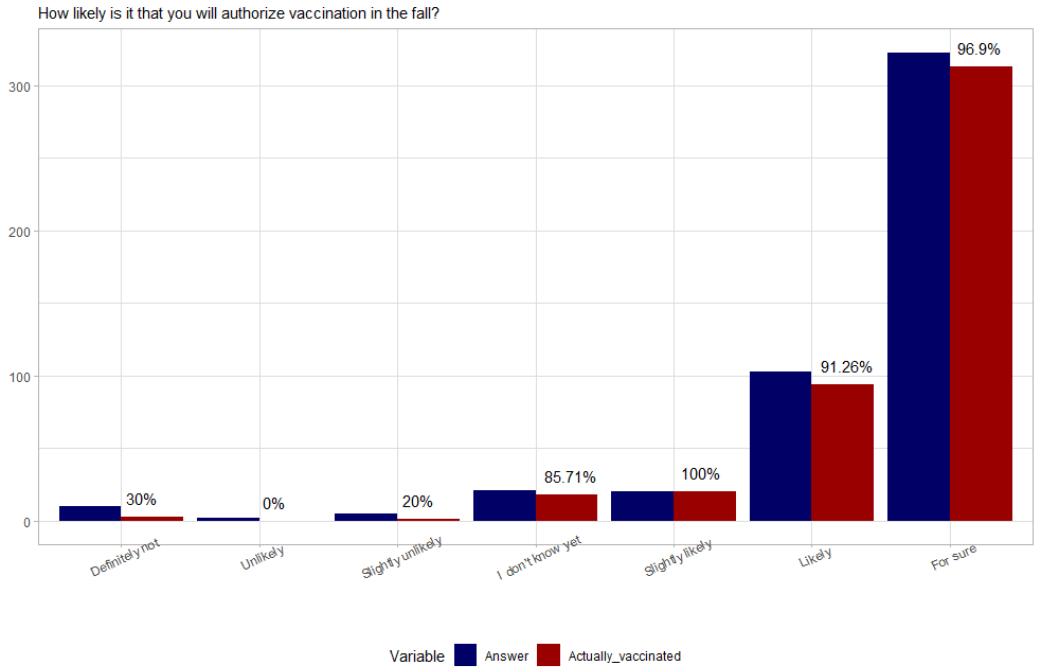
Notes: for each possible answer to the question "How likely are you to authorize vaccination in the fall?" the blue bar indicates the number of respondents, and the red bar the number of respondents who actually vaccinated in the fall. The percentage value of actually vaccinated respondents is reported on top of the red bar. Data are restricted to stratum 1 (immigrant mothers).

Figure N.13: Stratum 2: intention to vaccinate and vaccination



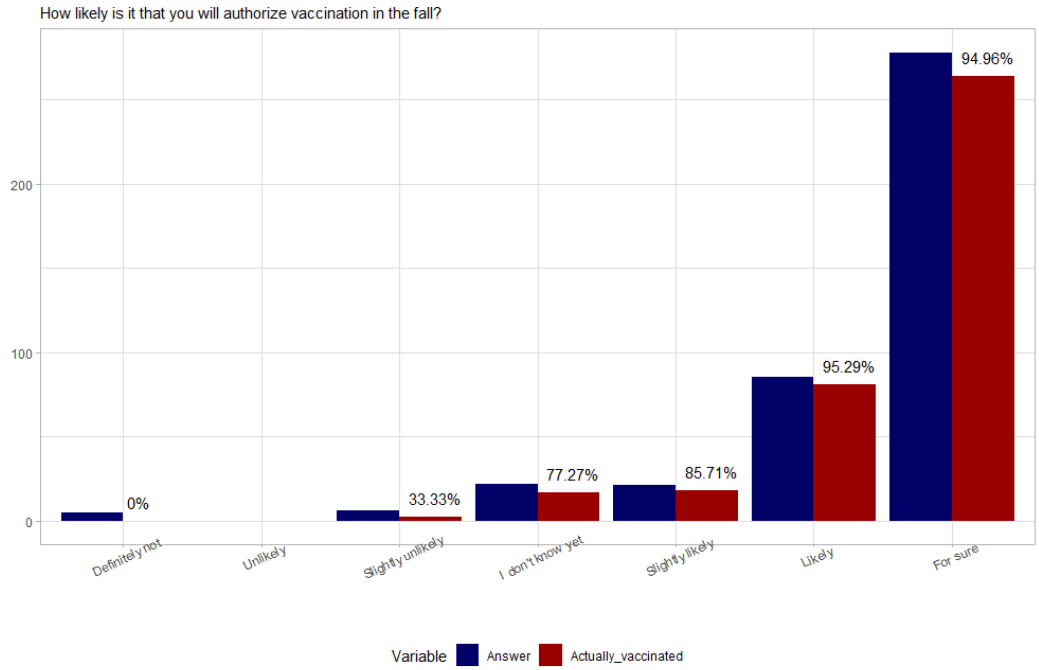
Notes: for each possible answer to the question "How likely are you to authorize vaccination in the fall?" the blue bar indicates the number of respondents, and the red bar the number of respondents who actually vaccinated in the fall. The percentage value of actually vaccinated respondents is reported on top of the red bar. Data are restricted to stratum 2 (mothers with compulsory schooling, equivalent to 3 years of high school).

Figure N.14: Stratum 3: intention to vaccinate and vaccination



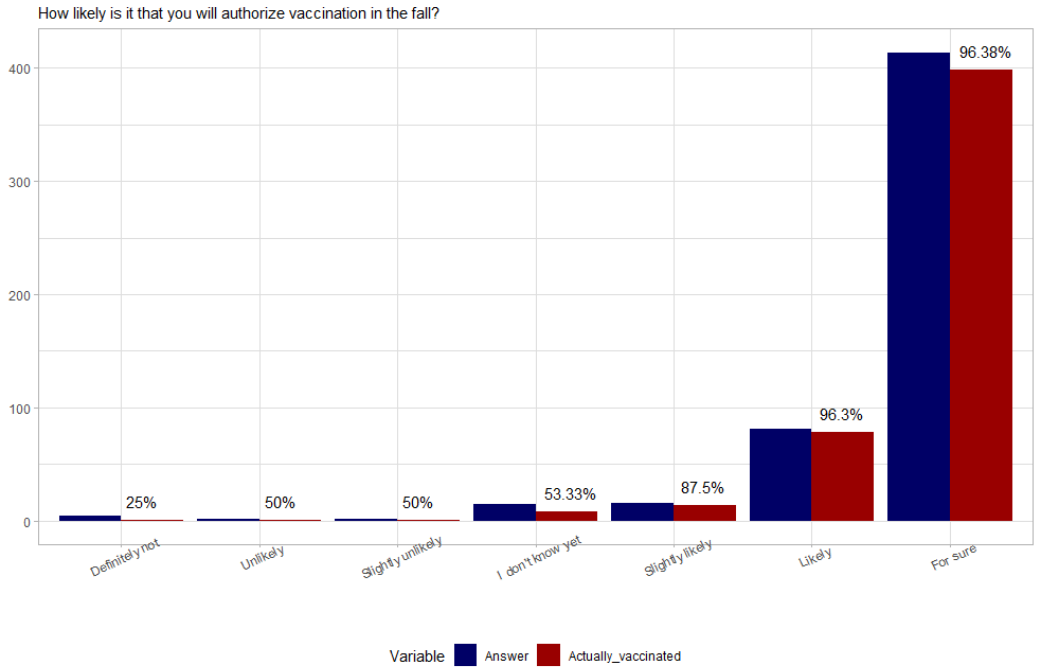
Notes: for each possible answer to the question "How likely are you to authorize vaccination in the fall?" the blue bar indicates the number of respondents, and the red bar the number of respondents who actually vaccinated in the fall. The percentage value of actually vaccinated respondents is reported on top of the red bar. Data are restricted to stratum 3 (mothers with a high school degree).

Figure N.15: Stratum 4: intention to vaccinate and vaccination



Notes: for each possible answer to the question "How likely are you to authorize vaccination in the fall?" the blue bar indicates the number of respondents, and the red bar the number of respondents who actually vaccinated in the fall. The percentage value of actually vaccinated respondents is reported on top of the red bar. Data are restricted to stratum 4 (mothers with some university education).

Figure N.16: Stratum 5: intention to vaccinate and vaccination



Notes: for each possible answer to the question "How likely are you to authorize vaccination in the fall?" the blue bar indicates the number of respondents, and the red bar the number of respondents who actually vaccinated in the fall. The percentage value of actually vaccinated respondents is reported on top of the red bar. Data are restricted to stratum 5 (mothers with more than a bachelor degree).

O Heterogeneity by gender

HPV is mostly known for causing cervical cancer, which only affects women. However, the incidence of HPV-induced head-neck and penile cancers is rising, and men can be asymptomatic vectors of the virus. In 2020 Sweden enlarged access to the free HPV vaccine to boys, and several European countries are planning to follow. The first HPV vaccine was launched in the US in 2006. Our mothers gave birth in 2009: unless they actively sought information about it, they were probably not targeted by informational campaigns to get vaccinated themselves. Moreover, since boys were just included in the program, it is likely that boys' mothers have been exposed to less information on the HPV vaccine, absent effects from previous children.[28] Table O.17 shows the average answer to survey questions on HPV information by child gender, and tests for significant differences in

[28] 97% of our sample is composed of children without siblings.

mean. Indeed, boys' mothers have received less information on HPV, have heard less often about HPV, and have read a slightly higher percentage of the leaflet. Therefore, we look at heterogeneity by gender as an additional indicator of previous information which does not depend only on self-reported survey answers.

Table O.17: Exposition to HPV information in male and female children mothers

Indicator	Males mean	Females mean	Means difference
% of leaflet read	79.85	77.60	2.25*
Has received HPV information passively before treatment	0.784	0.848	-0.064***
Has actively searched HPV information before treatment	0.475	0.51	-0.035
Intends to actively search HPV information after treatment	0.984	0.986	-0.002
Has actively searched HPV information before treatment from untrustworthy sources	0.202	0.199	0.004
Has heard about HPV before treatment	0.83	0.863	-0.034**

Notes: *** p< 0.01, ** p< 0.05, * p< 0.10, obtained with two-tailed T-tests for difference in means from two samples with unequal variance. The survey questions from which these indicators have been obtained can be found in Section D in the Appendix.

We investigate heterogeneity by including an interaction term:

$$Y_i = \alpha + \tau_1 T_i + \gamma \text{Female}_i + \tau_2 (T \times Female)_i + \boldsymbol{X_i'\beta} + \eta_m + \varepsilon_i \tag{3}$$

where Female_i is a binary indicator of the child's gender, τ_1 identifies the effect on males and $\tau_1 + \tau_2$ identifies the effect on females.

The following figures show the ITT effects of emotional (T1) and scientific (T2) framing on actual vaccination uptake, tested against the placebo group:

Figure O.17: ITT effect of emotional framing (T1) on actual vaccination by child's gender

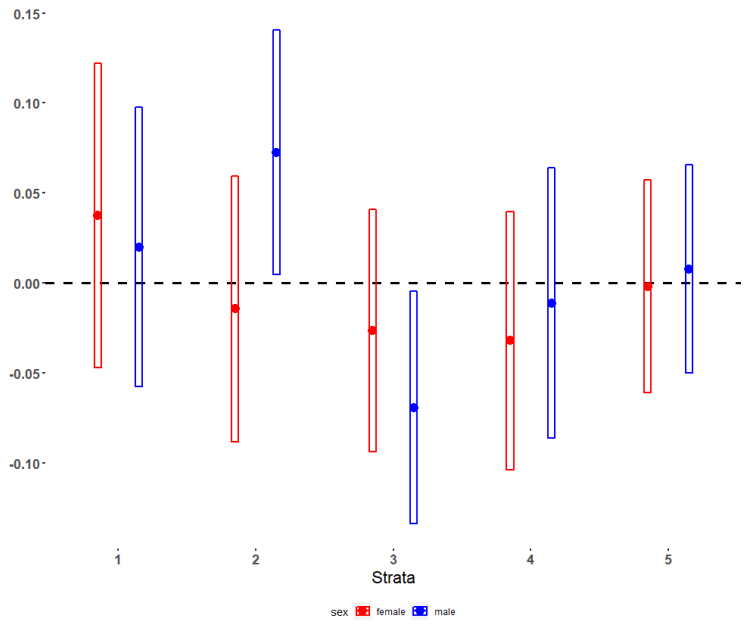
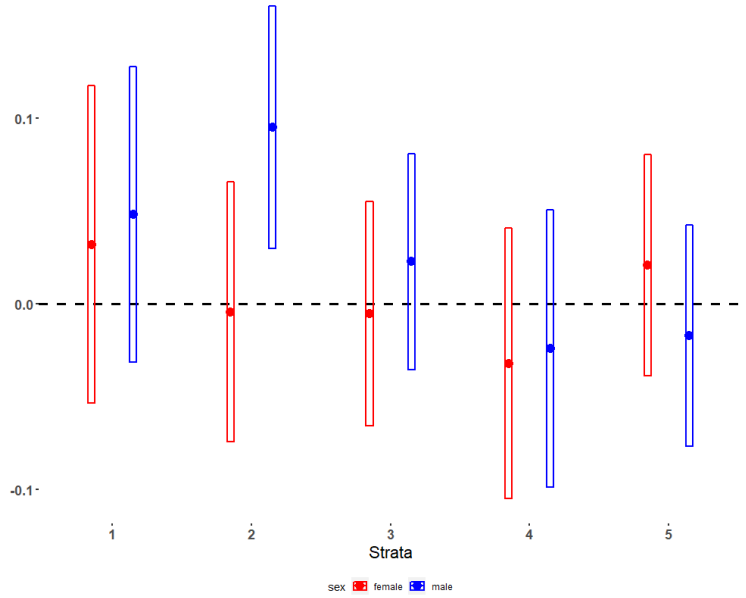


Figure O.18: ITT effect of scientific framing (T2) on actual vaccination by child's gender



In line with our hypothesis, the significant effects in our main analysis are driven by mothers of boys.

P Causal forest

We include the following covariates: child's gender, birth order among mother's children, the mother's and father's total number of children, mother's age, father's age, mother's civil status (married or not), whether the father is Swedish or not, number of MMR vaccine doses received by the child before treatment, whether the parents' education is specialized in scientific, numerical or medical subjects (two sets of dummies), both parents grade at the national high school's examination, whether any of the parents is employed as a researcher or as a medical doctor/nurse/dentist, parent's disposable income, net capital income and transfers in the last fiscal year, whether the mother had heard about HPV at baseline, how much of the leaflet she read, and if any of her close friends or relatives is a medical doctor, and survey variables on the reception and search of HPV information. For immigrant mothers, we also include country of origin dummies, the time since immigration date, the education level, whether they completed any formal degree in Sweden, and if they answered the survey in Swedish to proxy for integration.

Causal forest: Conditional ITT of Emotional framing (T1) on actual vaccination

Stratum	Variable	Mean high CITT	Mean low CITT	diff. means
1	Believes vaccines weaken the immune system	2.754	2.344	0.41**
1	Has been exposed to a previous informational campaign on HPV	0.31	0.43	-0.12**
1	Father's education level	3.043	3.474	-0.431***
1	Father has scientific education	0.268	0.344	-0.077***
1	Father is a medical doctor	0.043	0.071	-0.028**
1	Father has numerical education	0.118	0.155	-0.037**
1	Father works as a researcher	0.006	0	0.006**
1	Father is married	0.843	0.771	0.071***
1	Father is from a western country	0.039	0.062	-0.024**
1	Father is from a Muslim majority country	0.834	0.748	0.086***
1	Father is an immigrant	0.974	1	-0.026**
1	Mother's education level	3.106	3.635	-0.529***
1	Mother's yearly income	2174.798	2558.384	-383.586***
1	Mother's age	37.479	41.111	-3.633***
1	Mother's number of children	2.757	3.165	-0.407***
1	Mother is married	0.764	0.668	0.096***
1	Year of immigration	2003.745	1998.573	5.172***
1	Time since immigration	17.224	22.397	-5.174***
1	Completed formal degree in Sweden	0.354	0.579	-0.224***

1	Mother is from Somalia	0.102	0.184	-0.081***
1	Mother from Syria	0.244	0.185	0.059***
1	Parents have some education in Sweden	0.849	0.932	-0.083***
2	% of leaflet read	82.9	73.29	9.62**
2	Trusts health authorities	4.327	3.943	0.384**
2	Father's education level	3.402	2.902	0.501***
2	Father has numerical education	0.205	0.105	0.1***
2	Father's high school degree grade	12.436	11.029	1.407***
2	Father's high school graduation year	1993.044	1997.549	-4.504***
2	Father is an active worker	0.962	0.846	0.117***
2	Father receives transfers	0.013	0.105	-0.092***
2	Father's age	45.622	40.735	4.886***
2	Father is married	0.55	0.369	0.181***
2	Father is from a western country	0.803	0.686	0.117***
2	Mother's education level	2.793	2.57	0.223***
2	Mother is a medical doctor	0.114	0.158	-0.044**
2	Mother has a numerical education	0.156	0.059	0.096***
2	Mother is a nurse/dentist	0.109	0.158	-0.049**
2	Mother's high school grade	12.894	3.87	9.024***
2	Mother's high school graduation year	1991.206	2001.347	-10.141***
2	Mother's yearly income	3512.756	2258.717	1254.039***
2	Mother is an active worker	0.969	0.533	0.436***

2	Mother is retired	0	0.01	-0.01**
2	Mother receives government transfers	0.007	0.392	-0.385***
2	Mother has a medical occupation	0.153	0.221	-0.068***
2	Mother's age	43.737	37.114	6.623***
2	Mother is married	0.502	0.328	0.173***
2	Mother replied to the survey	0.268	0.173	0.095***
2	Total transfers received by parents	0.017	0.467	-0.45***
2	Any of the parents has another occupation in healthcare	0.192	0.275	-0.083***
2	Any of the parents is retired	0.002	0.028	-0.026***
3	Has searched HPV information before treatment	0.407	0.529	-0.122**
3	Believes vaccines cause the disease they should avoid	1.711	1.95	-0.239**
3	Trusts health authorities	4.51	4.231	0.279***
3	Father's education level	3.881	2.995	0.886***
3	Father has numerical education	0.318	0.148	0.17***
3	Father's high school degree grade	13.277	10.054	3.222***
3	Father's high school graduation year	1993.078	1998.017	-4.938***
3	Father's capital income	638.964	109.527	529.437**
3	Father's yearly income	5451.787	4050.743	1401.043***
3	Father receives transfers	0.016	0.046	-0.031**
3	Father's age	45.779	41.003	4.777***
3	Father is married	0.619	0.529	0.091***
3	Father is from a western country	0.832	0.761	0.071***

3	Father is from a Muslim majority country	0.038	0.076	-0.038**
3	Mother's education level	3.004	3.03	-0.026**
3	Mother's high school grade	12.879	11.765	1.114***
3	Mother's high school graduation year	1996.182	2000.266	-4.084***
3	Mother's yearly income	3789.535	3014.484	775.051***
3	Mother is an active worker	0.922	0.851	0.071***
3	Mother receives government transfers	0.069	0.126	-0.056***
3	Mother has a medical occupation	0.086	0.161	-0.075***
3	Mother's age	42.676	39.01	3.666***
3	Mother is married	0.571	0.489	0.082**
3	Mother replied to the survey	0.408	0.305	0.104***
3	Total transfers received by parents	0.076	0.169	-0.093***
3	Any of the parents has another occupation in healthcare	0.108	0.184	-0.076***
4	Birth order	1.038	1.01	0.028**
4	Father's education level	4.097	3.653	0.444***
4	Father's high school degree grade	13.841	12.162	1.679***
4	Father's high school graduation year	1993.223	1995.77	-2.547***
4	Father's age	45.756	43.19	2.566***
4	Father is from a Muslim majority country	0.012	0.049	-0.037***
4	Mother's high school grade	15.685	11.505	4.18***
4	Mother's high school graduation year	1995.12	1997.712	-2.592***
4	Mother's capital income	305.871	-219.77	525.641***

4	Mother's yearly income	4377.141	3321.551	1055.59***
4	Mother is an active worker	0.906	0.84	0.066**
4	Mother has a medical occupation	0.044	0.108	-0.064***
4	Mother's age	43.985	41.366	2.619***
4	Mother replied to the survey	0.484	0.362	0.122***
4	Any of the parents has another occupation in healthcare	0.069	0.126	-0.057**
5	% of leaflet read	82.29	69.87	12.41***
5	Father's high school degree grade	14.95	14.069	0.881***
5	Father's high school graduation year	1993.004	1994.53	-1.526***
5	Father's age	45.823	44.116	1.707***
5	Mother has a numerical education	0.241	0.317	-0.077**
5	Mother is a medical doctor	0.022	0.052	-0.03**
5	Mother's high school grade	15.036	15.703	-0.667***

Notes: *** p< 0.01, ** p< 0.05. The table shows the mean of baseline covariates for observations that have a CITT above average, the mean of baseline covariates for observations with a CITT below average, and a test for the difference in means. We restrict to variables where the difference is statistically different at the 95% s.l. for readability. Immigrants (stratum 1) are mothers born in Iraq, Iran, Syria, Afghanistan, Eritrea or Somalia. Stratum 2 comprises mothers with at most 3 years of high school: this corresponds to Swedish *högstadiet* (grades 7-9), the last compulsory grades under Swedish law. Mothers in stratum 3 completed high school (*gymnasium*, grades 10-12), which is not compulsory and comprises different tracks, including vocational ones. Stratum 4 comprises mothers with some undergraduate education, and stratum 5 mothers with some graduate education.

Causal forest: Conditional ITT of Scientific framing (T2) on actual vaccination

Stratum	Variable	Mean high CITT	Mean low CITT	diff. means
1	Has close friends/relatives who are doctors	0.425	0.566	-0.141**
1	Doses of MMR vaccine received before treatment	1.703	1.749	-0.046**
1	Father's education level	3.185	3.464	-0.279***
1	Father is a medical doctor	0.008	0.027	-0.019***
1	Father has another occupation in healthcare	0.076	0.114	-0.038**
1	Father's age	44.529	46.672	-2.143***
1	Father's number of children	2.662	2.858	-0.196**
1	Father is married	0.844	0.797	0.048**
1	Father is from a Muslim majority country	0.825	0.77	0.055***
1	Father is born in Sweden	0.023	0	0.023**
1	Mother's high school graduation year	2002.028	2000.444	1.583**
1	Mother's yearly income	2171.001	2711.842	-540.84***
1	Mother is an active worker	0.548	0.601	-0.053**
1	Mother has a medical occupation	0.216	0.267	-0.051**
1	Mother's age	38.344	40.835	-2.49***
1	Mother's number of children	2.773	3.354	-0.581***
1	Mother is married	0.765	0.689	0.076***
1	Completed formal degree in Sweden	0.504	0.401	0.103***
1	Mother from Eritrea	0.077	0.106	-0.029**

1	Mother is from Somalia	0.116	0.179	-0.062***
1	Mother from Syria	0.238	0.196	0.042**
1	Any of the parents has another occupation in healthcare	0.279	0.357	-0.078***
2	Birth order	1.05	1.02	0.03***
2	Doses of MMR vaccine received before treatment	1.902	1.807	0.095***
2	Father's education level	3.367	3.037	0.33***
2	Father has numerical education	0.241	0.139	0.102***
2	Father's high school degree grade	12.431	11.599	0.832**
2	Father's high school graduation year	1992.542	1997.761	-5.22***
2	Father is an active worker	0.935	0.884	0.051**
2	Father receives transfers	0.047	0.092	-0.044**
2	Father's age	45.87	41.237	4.633***
2	Father is married	0.535	0.411	0.124***
2	Father is from a western country	0.817	0.654	0.162***
2	Mother's education level	2.822	2.6	0.223***
2	Mother has a numerical education	0.181	0.061	0.12***
2	Mother's high school grade	12.593	6.986	5.607***
2	Mother's high school graduation year	1990.891	1998.095	-7.204***
2	Mother's capital income	-200.676	65.586	-266.262***
2	Mother's yearly income	3409.541	2672.049	737.491***
2	Mother is an active worker	0.877	0.687	0.19***
2	Mother receives government transfers	0.103	0.241	-0.138***

2	Mother has a medical occupation	0.153	0.237	-0.084***
2	Mother's age	44.332	37.868	6.464***
2	Mother is married	0.498	0.335	0.163***
2	Mother replied to the survey	0.237	0.187	0.05**
2	Total transfers received by parents	0.129	0.324	-0.195***
2	Any of the parents has another occupation in healthcare	0.19	0.296	-0.106***
3	% of leaflet read	73.65	81.23	-7.58**
3	Want to search HPV information from untrustworthy sources after treatment	0.183	0.097	0.086**
3	Doses of MMR vaccine received before treatment	1.949	1.902	0.047***
3	Father's high school graduation year	1994.093	1995.791	-1.698***
3	Mother's high school grade	11.744	12.261	-0.517**
3	Mother's capital income	-176.626	216.955	-393.581***
3	Mother's yearly income	3143.679	3928.667	-784.988***
4	Doses of MMR vaccine received before treatment	1.946	1.896	0.05**
4	Father's education level	4.004	3.746	0.258***
4	Father has numerical education	0.364	0.241	0.123***
4	Father is a medical doctor	0.018	0	0.018**
4	Father's high school degree grade	14.358	11.911	2.448***
4	Father's high school graduation year	1992.878	1995.906	-3.028***
4	Father's age	46.093	43.264	2.829***
4	Father is married	0.621	0.537	0.084**

4	Mother's high school grade	14.187	13.382	0.805***
4	Mother's high school graduation year	1994.836	1998.174	-3.338***
4	Mother's capital income	-69.899	190.384	-260.283**
4	Mother is an active worker	0.909	0.826	0.083***
4	Mother's age	44.125	40.902	3.223***
5	Birth order	1.02	1.061	-0.041**
5	Father's education level	4.369	4.579	-0.21***
5	Father's capital income	600.451	2519.909	-1919.458**
5	Mother's education level	5.017	5.058	-0.041***
5	Mother's high school grade	13.856	16.828	-2.972***
5	Mother's yearly income	4270.257	5306.508	-1036.25**
5	Mother is an active worker	0.964	0.918	0.046**
5	Mother is a researcher	0.003	0.036	-0.033***
5	Mother replied to the survey	0.462	0.55	-0.088**
5	Some parent is a researcher	0.017	0.057	-0.04***

Notes: *** p< 0.01, ** p< 0.05. The table shows the mean of baseline covariates for observations that have a CITT above average, the mean of baseline covariates for observations with a CITT below average, and a test for the difference in means. We restrict to variables where the difference is statistically different at the 95% s.l. for readability. Immigrants (stratum 1) are mothers born in Iraq, Iran, Syria, Afghanistan, Eritrea or Somalia. Stratum 2 comprises mothers with at most 3 years of high school: this corresponds to Swedish *högstadiet* (grades 7-9), the last compulsory grades under Swedish law. Mothers in stratum 3 completed high school (*gymnasium*, grades 10-12), which is not compulsory and comprises different tracks, including vocational ones. Stratum 4 comprises mothers with some undergraduate education, and stratum 5 mothers with some graduate education.

Q Endline survey

The second survey is administered at endline, i.e. after the vaccinations took place. Its text can be read in Section D.2 of this Appendix. Only mothers who replied to the first survey are invited to participate in the second. Table Q.22 shows, for each stratum, the number of respondents to the first survey (in round brackets, in blue), and the number of respondents to the second survey (in square brackets, in red).

The aim of the second survey is to investigate additional mechanisms of our effects and measure a self-reported indicator of vaccination status. However, the reduced sample size implies that any evidence from the second survey should be interpreted as qualitative and merely suggestive.

For what concerns mechanisms, based on these data we find that the only concern affected relates to the vaccine's safety. Figure Q.19 shows that in stratum 2 scientific framing (T2) – which is also effective on average – reduces the wrong perception that the vaccine might increase the risk of having to recur to invasive medical procedures. This is a dimension of vaccine safety concerns that is directly tackled by our information. The concern might be that medical invasive procedures might be required following vaccine adverse effects, and we shift the focus to those required following HPV-induced cancer that the vaccine can prevent. Concerns about the effect of the vaccine on fertility or the emergence of cancer and serious illness are not affected by treatment in this specific subsample.

Table Q.21 and Table Q.20 report the joint distribution of the self-reported vaccination status from the second survey and (i) the intention to vaccinate expressed in the first survey; (ii) the actual vaccination record from administrative data.

Table Q.20: Self-reported vaccination status and actual vaccination status

Self-reported	**Actual vaccination record**		
	Not vaccinated	**Vaccinated**	**Inconsistent answers**
"Did you vaccinate your child against HPV earlier this fall?"			
No	18	1	10 (5.263%)
I am not sure Probably not	0	3	3 (100%)
I am not sure Probably yes	0	10	0 (0%)
Yes	15	652	15 (2.249%)

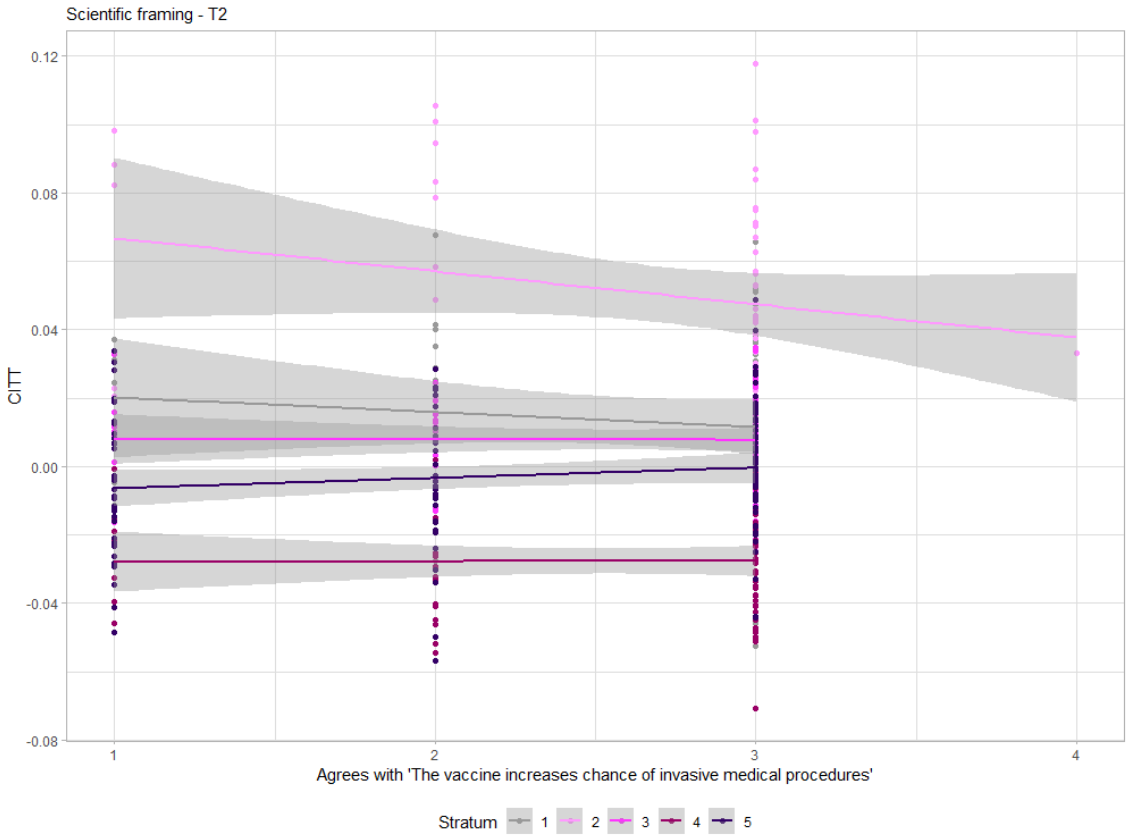
The table reports the joint distribution of self-reported vaccination status in the second survey (administered at endline) and the actual vaccination status from administrative records.

Table Q.21: Self-reported vaccination status and intention to vaccinate

Self-reported	**Willingness to vaccinate**		
	Does not intend to vaccinate	**Intends to vaccinate**	**Inconsistent answers**
"Did you vaccinate your child against HPV earlier this fall?"			
No	12	7	7 (36.842%)
I am not sure Probably not	1	2	2 (66.670%)
I am not sure Probably yes	2	8	2 (0.200%)
Yes	29	638	29 (4.348%)

The table reports the joint distribution of self-reported vaccination status in the second survey (administered at endline) and the willingness to vaccinate expressed in the first survey (immediately after treatment).

Figure Q.19: CITT of scientific framing (T2) by beliefs on vaccine safety



Notes: The figures shows the Conditional ITT of scientific framing (T2) by the agreement with statement "Vaccines increase the chance of invasive medical procedures". The values on the x-axis correspond to: (1) "Do not agree"; (2) "Partly disagree"; (3) "Neither disagree nor agree"; (4) "Partly agrees".

Table Q.22: Sample sizes: full sample and survey respondents

Stratum	Stratum definition	N	C units Placebo	T1 units Emotional	T2 units Scientific
1. Immigrants	Selected origin countries	2548	611	961	976
		(416)	(106)	(148)	(162)
		[96]	[14	[38]	[44]
Swedish-born mothers					
2. Educ-level-1	$\leq$ 3 yrs high school	1627	393	616	617
	End of compulsory schooling	(353)	(94)	(138)	(121)
		[101]	[30]	[38]	[33]
3. Educ-level-2	(3 yrs high school, high school degree]	1413	337	535	541
		(484)	(112)	(203)	(169)
		[137]	[28]	[61])	[48]
4. Educ-level-3	(High school degree, Undergrad]	1009	243	385	381
		(417)	(101)	(168)	(148)
		[144]	[26]	[65]	[53]
5. Educ-level-4	> Undegrad degree	1019	242	387	390
		(534)	(122)	(213)	(199)
		[221]	[51]	[85]	[85]
Total		7616	1826	2884	2905
		(2204)	(535)	(870)	(799)
		[699]	[149]	[287]	[263]

Notes: Numbers in blue, round brackets indicate respondents to the first survey. Numbers in red, square brackets indicate respondents to the second survey. Immigrants are mothers born in Iraq, Iran, Syria, Afghanistan, Eritrea or Somalia. Stratum 2 comprises mothers with at most 3 years of high school: this corresponds to Swedish *högstadiet* (grades 7-9), the last compulsory grades under Swedish law. Mothers in stratum 3 completed high school (*gymnasium*, grades 10-12), which is not compulsory and comprises different tracks, including vocational ones.