

Adding Nudge-based Reminders to Monetary Incentives for Promoting Rubella Antibody Testing and Vaccination*

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Abstract

We study effects of combining financial incentives with nudges to promote rubella antibody testing and vaccination. In FY2019, the Japanese government began providing vouchers for free testing and vaccination to men aged 40–57 years. Vouchers were mailed to 40–46-year-old men in FY2019. While those aged 47–57 received vouchers in FY2020, they could obtain vouchers and receive testing and vaccination in FY2019 through applying. Focusing on this policy distinction, we conduct a late-FY2019 online field experiment with Japanese 40–57-year-old men. We randomly send nudge-based reminder messages recommending antibody testing and vaccination, and track self-reported behavior until the end of FY2019. One nudge-based reminder with an altruistic message on fetal harm through infection from men to pregnant women significantly promotes antibody testing and vaccination among those who have already received vouchers as a financial incentive. For those who must apply for vouchers, nudge-based reminders have no promoting effect.

JEL classification: D90, I12, I18

Keywords: Rubella; Vaccination; Antibody Test; Text Messages; Reminders; Free Vouchers.

1 Introduction

Vaccination is an essential countermeasure against infectious diseases, including COVID-19, seasonal influenza, and rubella. Vaccination enables individuals to voluntarily acquire antibodies and immunity. They can thus prevent the onset of infectious diseases and even infection itself.

Vaccination has positive externalities and benefits for the vaccinated individuals, surrounding community, and society. For example, vaccination lowers the risk of developing an infectious disease or becoming severely ill. It also reduces the risk of the health-care delivery system becoming strained. Vaccination with infection-preventive effects, including the rubella vaccine, reduces the risk of infection for the vaccinated and the risk of spreading the infection. Vaccination can contribute to social stability during pandemics and the acquisition of herd immunity via these positive externalities.

However, economic theories suggest that vaccination rates may not reach the socially optimal level due to the positive externalities (Brito et al. 1991, Francis 1997, Stiglitz 2000). With the externalities, the marginal individual benefit of vaccination becomes lower than the marginal social benefit, and this feature discourages vaccination by those with selfish motives. Even if people are altruistic and gain utility from the social benefits

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of their vaccinations reducing the infection probability of others, they still have an incentive to free-ride on others' vaccinations and not receive the vaccines themselves, because the infection probability is lowered by the others' vaccinations. We find empirical studies reporting that others' increased vaccination rates reduce the likelihood of people being vaccinated (Hershey et al. 1994, Ibuka et al. 2014).

To overcome the challenge of vaccine coverage not achieving socially optimal levels, governments have used a variety of interventions, including monetary and non-monetary interventions (nudges in behavioral economics). Many countries subsidize COVID-19 vaccinations, making them free. Some local governments set subsidies above and beyond the amount required to make vaccination free, giving vaccinated people the right to join a lottery, and recent studies have confirmed the effectiveness of these measures (Barber & West 2022, Brehm et al. 2022). Nudge-based interventions include recommending a predetermined vaccination date, sending a reminder message, and changing message wording (Chapman et al. 2010, Sasaki et al. 2022, Yokum et al. 2018).¹

This study explores the possibility of combining financial incentives with nudges in vaccination and antibody acquisition. Many previous studies estimated or compared these two as independent or substitutive. However, Richard Thaler and Cass Sunstein define nudges as “an aspect of choice architecture that alters people’s behaviour in a predictable way without forbidding any options or significantly changing their economic incentives” (Thaler & Sunstein 2009, p.6). As mentioned, “without significantly altering economic incentives,” nudges include devising wordings and expressions for existing financial incentives. They further explain that nudges adjust the salience of financial incentives so that the incentives have the expected effect.² In other words, nudges and financial incentives are complementary in their original definition.

Recently, more studies have examined the two combinations in non-vaccination contexts. For example, Burtch et al. (2018) found that combining a nudge emphasizing social norms with a financial incentive improves the length and quality of online market reviews more than either intervention alone. Thorndike et al. (2016) reported similar results regarding healthy food choices in a hospital cafeteria. Meanwhile, in the study of Kullgren et al. (2014), combining nudges and financial incentives does not increase outdoor exercise among older adults. Furthermore, Pellerano et al. (2017) reported that adding a financial incentive to a social norm nudge undermines the energy-saving effect of the nudge-based intervention alone.³ We can expect relatively large facilitating effects in combining nudges and financial incentives, while in practice, the effects' direction and extent depend on contexts. Before applying the combinations to policies, we must confirm their effects empirically.

To the best of our knowledge, no study has focused on the combination of financial incentives and nudges in the context of vaccination. As previously stated, many previous studies have separately estimated the effects of financial incentives (Banerjee et al. 2010, Barber & West 2022, Barham & Maluccio 2009, Brehm et al. 2022) and nudges (Dai et al. 2021, Chapman et al. 2010, Milkman et al. 2021, Sasaki et al. 2022) as stand-alone measures. Although some studies focused on both, they compared the effects of the two interventions, examined which is larger, and seemed to regard the two as substitutive. For example, Bronchetti et al. (2015) conducted a randomized controlled trial with college students in Pennsylvania and found that a financial incentive increases their seasonal influenza vaccination rate. In this experiment, a peer-related nudge increases vaccine information exposure but does not increase vaccination rates. Campos-Mercade et al. (2021) reported that a €20 financial incentive increases vaccination rates by 4 percentage points (pp) in a Swedish field experiment and emphasized that some nudge-based interventions have little promotional effect.

We add new insights to the literature on the combination of financial incentives and nudges, by focusing on Japan’s policy on rubella antibody testing and vaccination and conducting a nationwide online field experiment. We estimate the effect of providing nudge-based messages in each of the situation where people

¹In the context of vaccines for seasonal influenza and COVID-19, some studies found that messages stimulating people’s ownership, “A vaccine dose is reserved for you,” promotes their vaccination uptake (Dai et al. 2021, Milkman et al. 2021).

²They mention “iNcentives,” “Understand mappings,” “Defaults,” “Give feedback,” “Expect error,” and “Structure complex choices” as the six principles of “NUDGES” for creating a good choice architecture. The first principle, “iNcentives,” explains the complementary relationship between financial incentives and nudges.

³Besides field experimental studies, some laboratory experimental studies have also tested the effects of the combination; Chen et al. (2021) show that combining a financial incentive with an informational nudge induces cooperative behaviors in a prisoner’s dilemma game among intrinsically motivated individuals.

can easily obtain financial incentives and where they must incur additional transaction costs to obtain the incentives. In the former situation, financial incentives and nudges are more closely combined.

In Japan, men born between April 2, 1962, and April 1, 1979 (aged 40–57 years as of 2019) have historically been excluded from routine rubella immunization (see Section 2 for details). Consequently, men in this age group have lower antibody prevalence than their female counterparts. Therefore, Japan has yet to achieve herd immunity against rubella. Unlike flu and COVID-19 vaccinations, rubella vaccine-induced immunity is long-lasting, and people without antibodies must receive a single vaccination to achieve herd immunity against rubella. The Ministry of Health, Labor, and Welfare (MHLW) then initiated an additional measure for routine rubella vaccination in FY2019 by mailing vouchers covering the costs of the rubella antibody test (approximately 5,000 JPY, which is equal to 45 US dollars) and vaccination (approximately 10,000 JPY) to men aged 40–57 years, to confirm whether they have an antibody and then encourage vaccination for those without it.⁴

Free vouchers were distributed progressively through local governments: vouchers were mailed to men aged 40–46 in FY2019 and those aged 47–57 years in FY2020. Men aged 47–57 years had to apply to their local government to receive the vouchers during FY2019. That is, in FY2019, men aged 40–46 years received the free vouchers as financial incentives by default, whereas men aged 47–57 years had to opt-in to receive the vouchers, incurring transaction costs.

We conducted an online field experiment in February–March 2020 (at the end of FY2019) with men aged 40–57 years living throughout Japan, including the aforementioned two age groups. In this study, we use a randomized controlled trial (RCT) and send reminders with nudge-based messages to encourage the uptake of antibody testing and vaccination. We ascertain their intentions to receive the test and vaccine, and their self-reported behaviors to receive them in a follow-up survey.

By focusing on the sample aged 40–46 years, we can capture the effects of providing additional reminders with nudged messages in one situation where they already obtained the vouchers as financial incentives. Meanwhile, we can capture the effects of providing reminders in another situation where they must incur transaction costs and opt-in to obtain financial incentives with the sample aged 47–57 years. In other words, this study focuses on the combination of nudges and the costs of acquiring financial incentives. The approach of reducing these costs by delivering vouchers to the target population is observed in a variety of policy issues. Therefore, exploring this realistic combination of financial incentives and nudges is important from a policy perspective.

In each of the group who obtain the financial incentive by default and the other group who needs to opt-in, our experiment randomly offers either of a control reminder message with no nudge and six nudge-based reminder messages. The main finding reveals that a reminder with an altruistic message is effective in promoting antibody testing and vaccination behaviors only in the former group. This altruistic message emphasizes the negative impact on newborns caused by infection from the men to pregnant women.

This study contributes to the literature exploring the conditions under which nudges work effectively. Evidence for the effectiveness of nudges has been mixed in recent years; according to a meta-analysis by DellaVigna & Linos (2022), nudges are not large in reality, and their effectiveness depends on various conditions, including topics and channels. This study focuses on the combination of financial incentives and nudges, which have often been treated as mutually substitutive measures, and demonstrates that nudges can be effective when given to a group that has already obtained financial incentives. This result is also consistent with the original definition of the two being complementary.

This research also contributes to acquiring global herd immunity against rubella; according to the World Health Organization, 101 of 194 countries have not yet eliminated rubella, accounting for 52% (Zimmerman et al. 2022). Specifically, in the Eastern Mediterranean, South-East Asia, and Western Pacific regions, the proportion of countries that have not yet achieved herd immunity is high. As cross-border traffic increases toward the end of the COVID-19 pandemic, achieving herd immunity against rubella will become increasingly important for the remaining countries. Japan is extremely close to achieving herd immunity. The nudge-based strategy used in such a country to acquire that last mile will be useful for many other countries in the future.

⁴We assume 1 USD = 110 JPY.

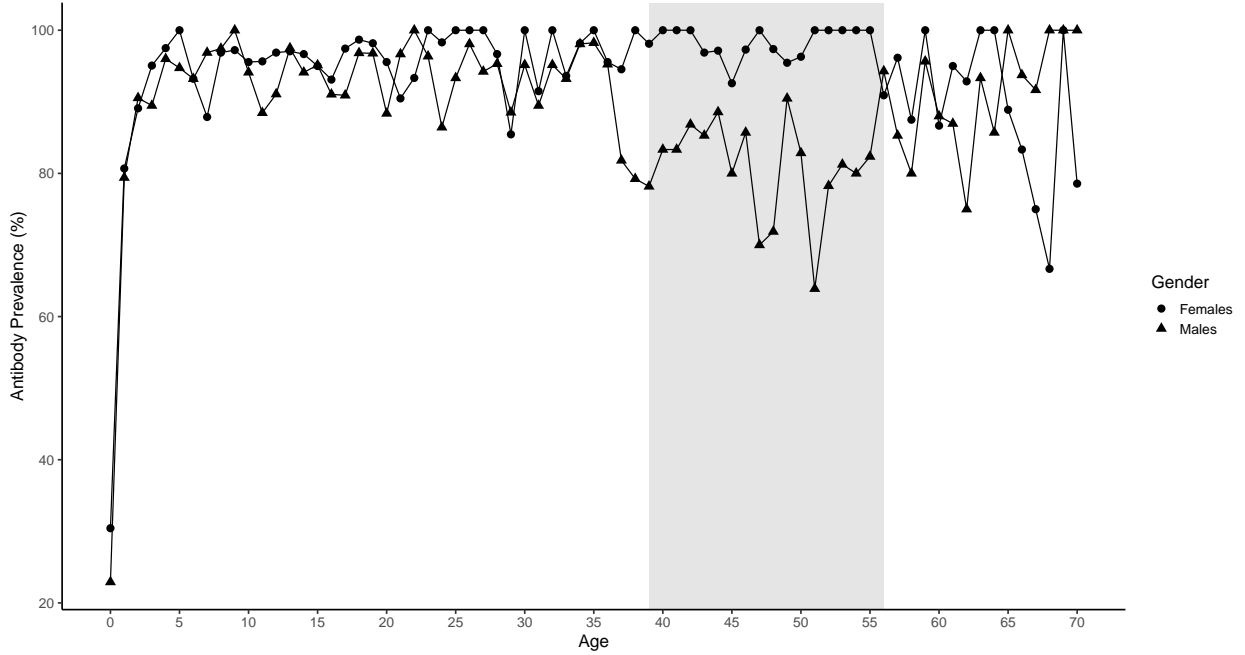


Figure 1: Percentage of Rubella Antibody Carriers at Each Age by Gender. Data: NIID "2018 National Epidemiological Surveillance of Vaccine-Preventable Diseases (NESVPD)."

The rest of this paper is structured as follows. Section 2 provides an overview of rubella in Japan. Section 3 describes the experimental design and Section 4 presents the results. Finally, Section 5 discusses results and concludes the paper.

2 Background of Rubella Vaccination in Japan

Rubella is a highly contagious disease spread through droplet transmission. The most common symptoms are fever and rashes, but the disease is rarely severe.⁵ The most serious problem is that women infected with rubella during early pregnancy may have children with congenital rubella syndrome (CRS), which includes eye and ear defects. Because the spread of rubella tends to increase the CRS incidence, the Japanese government has designated rubella as a disease requiring immunization to prevent its spread. According to Kinoshita & Nishiura (2016), Japan can obtain herd immunity against rubella if the antibody prevalence exceeds 90% in all generations.⁶

However, due to low antibody prevalence among men in their 40s and 50s, Japan has not achieved herd immunity to rubella. Thus, influx of virus of Southeast Asian origin caused rubella epidemic, mainly among males with relatively low antibody prevalence in 2013 and 2018 (National Institute of Infectious Diseases 2019).⁷ Figure 1 plots the prevalence of rubella antibodies by age and gender from the National Institute of Infectious Diseases (NIID) "2018 Infectious Disease Epidemic Prediction Survey." The antibody prevalence

⁵According to the NIID, subclinical transmission of rubella (the state in which a person is infected but has no symptoms) occurs in approximately 15–30% of cases. Fever is observed in approximately 50% of patients. Adults may also experience transient arthritis (5–30%). Rarely, complications such as thrombocytopenic purpura (0.02–0.03%) and acute encephalitis (0.01–0.03%) may require hospitalization (<https://www.niid.go.jp/niid/ja/kansennohanashi/430-rubella-intro.html>). Japanese. Access date: September 22, 2023).

⁶According to Plans-Rubió (2012), antibody prevalence of 83% to 95% achieves herd immunity against rubella. Nishiura et al. (2015) found that the antibody prevalence for herd immunity is 83.6%.

⁷In the 2018 epidemic, U.S. CDC advised pregnant women to travel to Japan (The Japan Times, October 24, 2018. <https://www.japantimes.co.jp/news/2018/10/24/national/science-health/u-s-cdc-warns-pregnant-women-traveling-japan-amid-rubella-outbreak/>. Access date: 2023/9/22).

among men aged 39–56 years (as of 2018) is approximately 81.5%, which is lower than that of women of the same generation (about 97.9%) and other generations because they have not received routine rubella vaccination and have not had less opportunity to infect naturally.⁸ The prevalence of antibodies in men and women aged 57 and older is 91.1% and 89.3%, respectively. Despite not having received routine vaccination, men and women aged 57 and older grew up during a time when rubella was common and people are likely to have antibodies from natural infection. The antibody prevalence of men and women aged 38 years and younger is 91.3% and 94.0%, respectively. They have had at least one dose of rubella vaccine administered as part of routine immunization.

To achieve herd immunity against rubella, Japan must raise the antibody prevalence among men in their 40s and 50s from 80% to 90%. To achieve this goal, MHLW has provided the rubella vaccine as an additional free routine immunization for men aged 40–57 years (as of 2019) between April 2019 and March 2022.^{9,10} For efficient utilization of vaccination, eligible men must first get antibody testing. Men who have a negative test can then be vaccinated against rubella.

Following the Immunization Act, eligible men can receive free antibody testing and vaccinations. MHLW requested local governments to send free vouchers for a rubella antibody test and vaccine to eligible men over a three-year period. Concerning whether they automatically receive the voucher in FY2019, we can divide eligible men into the following two age groups:

1. 40–46 years old: they automatically received the free voucher in FY2019;
2. 47–57 years old: they automatically received the free voucher after FY2020 but had to apply to obtain it in FY2019.

Thus, transaction costs for the monetary incentives in FY2019 differ between the two age groups. In particular, 40-to-46-year-old men have no transaction costs because they obtained monetary incentives by default in the form of free vouchers in FY2019. However, 47-to-57-year-old men have high transaction costs because they must contact their local government to obtain the free vouchers in FY2019 such as traveling cost to a city hall (opt-in incentives).¹¹

Although men aged 40–46 years automatically received monetary incentives, the uptake rate of antibody testing with vouchers remained as low as 18% as of January 2020.¹² Given adequate financial incentives, non-monetary interventions should be considered to increase antibody testing. Therefore, we developed reminders with behavioral science-based text messages for those who were not tested and vaccinated. Using a nationwide online survey, we tested how well those reminders improve antibody testing and vaccination rates among default voucher recipients (and the effect on those who incur a transaction cost to obtain them).

⁸Using this data, we predict antibody prevalence by a saturated model for three age groups (38 years and younger, 39–56 years, and 57 years and older) and a female dummy. The difference in antibody prevalence between men and women in the 39–56 age group is 0.164 (se = 0.034; $p < 0.01$). The difference in antibody prevalence between men aged 39 to 56 years and men aged 57 years and older is 0.96 (se = 0.036; $p < 0.01$).

⁹More precisely, eligible men were born between April 2, 1962, and April 1, 1979.

¹⁰If transmission to pregnant women is the most important issue, one might think that vaccinating pregnant women would be the optimal strategy. However, Japan has already implemented measures for pregnant women in advance of the 2019 vaccination campaign. Pregnant women (average age 30) have received at least one vaccination. In addition, since 2014, pregnant women and women who want to become pregnant, including their partners, have been offered free antibody testing. However, during the 2013 and 2018 epidemics, some infants were affected by CRS. Therefore, to eradicate CRS, interventions for pregnant women alone are not sufficient; interventions to achieve herd immunity are needed.

¹¹One local government has posted the application forms on its website. To obtain a vaccination ticket, eligible men must download the forms from the website, complete them, and either mail them to the local government or visit the city hall in person. The cost of obtaining the documents and traveling to the city hall is considered significant.

¹²More than half of eligible men are 40–46 years old (6.46 million). They received the free vouchers from April 2019 to March 2020. According to interviews conducted by the MHLW, approximately 96% of local governments planned to send them by October 2019. The cumulative number of antibody tests using vouchers through January 2019 was 1.17 million. We calculate antibody testing uptake by dividing the cumulative number of antibody tests using vouchers up to January 2019 (1.17 million) by the population of 40-to-46-year-old men (6.46 million).

3 Nationwide Online Survey Experiment

In collaboration with MHLW, we commissioned MyVoiceCome Co.~Ltd. to conduct two nationwide online surveys at the end of FY2019. On February 15–17, 2020, we conducted the first survey (wave 1) of 4,200 Japanese men aged 40–59 years living throughout Japan. Wave 1 randomizes seven text messages to test how they affect antibody testing and vaccination intentions. On March 17–25, 2020, we surveyed wave 1 respondents again for the second survey (wave 2). We received responses from 3,963 individuals (attrition rate = 5.64%).¹³ Wave 2 aims to test how the randomly assigned text messages in wave 1 affect the actual uptake of antibody testing and vaccination.

Online Appendix B contains detailed information about the survey. We obtained prior approval from the IRB of the Graduate School of Economics, Osaka University (approval number: R020114) for conducting the RCT on the online survey.

3.1 Wave 1: Treatments and Outcome Variables on Intention

We randomly sent one of the text messages in Table 1. The *MHLW (Control)* message is the control. Using this message, MHLW promotes antibody testing and rubella vaccination against rubella on its website (business-as-usual control). We developed six additional text messages based on the MHLW (Control) message to explore what elements to use and how to emphasize them. Recent behavioral science research has increasingly investigated the efficacy of multiple candidate messages (e.g., Dai et al. 2021, Milkman et al. 2021), similar to this study.

The six treated text messages alter the MHLW (Control) message to (1) a simple age expression and (2) behavioral economics content. In addition to the precise target age for the additional rubella measures, the *MHLW (Age)* message includes the simple phrase “men in their 40s and 50s,” which helps the reader understand if they are eligible for vaccination and pay attention to the message. The MHLW (Age) message only changed the age expression; the message’s content is identical to the control. The other five messages both add simplified age expressions and change message content based on behavioral economics.

The *Altruistic* message describes how one’s infection can harm others, particularly pregnant women and their children. As previously stated, vaccination has positive externalities. In the case of rubella, having antibodies through vaccination prevents infection in pregnant women, thus protecting their children. The Altruistic message is the inverse of this positive externality, emphasizing the negative externality of not being vaccinated. This message is intended to help altruistic readers imagine the negative externalities caused by the infection and change their behavior.¹⁴

The *Selfish* message and *Social Comparison* message aim to change behavior by increasing the importance of having rubella antibodies. The Selfish one describes in detail the damage caused by the infection to the individual, making it easier for the reader to imagine it. Meanwhile, the Social Comparison informs the reader that antibody prevalence is low and reminds them that they are susceptible to infection. This message can help people avoid underestimating the likelihood of infection and undervaluing vaccination.

The *Deadline* message and *Convenient* message describe the routine vaccination system. Deadline emphasizes that the FY2019 vouchers are valid until the end of March. This message aims to prevent people from postponing antibody testing and vaccination due to the present bias, which is one of behavioral economics’ key findings. Meanwhile, Convenient states that some people can get antibody testing as part of a regular health examination and emphasizes its convenience. This message aims to reduce the subjective cost of antibody testing.

We employed stratified randomization. The survey firm divided respondents into four age groups (40–44, 45–49, 50–54, and 55–59) and equally assigned messages within each stratum. The sample size for each group

¹³The seven experimental arms have similar attrition rates. We linearly regress an attrition dummy on treatment group dummies. F-test for joint null hypothesis is statistically insignificant (F-value = 1.434; p-value = 0.197).

¹⁴We define an altruistic person as someone who considers social benefits, including externalities.

Table 1: List of Text Message Reminders

Message	Contents		Age (as of Apr 2019)				All
			39	40–46	47–56	57–59	
MHLW (Control)	Dear all men born between 1962 and 1979. Get rubella antibody testing and be vaccinated to protect yourself and the upcoming generation!	N	20	210	321	49	600
MHLW (Age)	Dear men in their 40s and 50s (all men born between 1962 and 1979). Get rubella antibody testing and be vaccinated to protect yourself and the upcoming generation!	N	23	205	309	63	600
Altruistic	Dear men in their 40s and 50s (all men born between 1962 and 1979). If you get a pregnant woman infected with rubella, she may give birth to a child with a serious disability. Get rubella antibody testing and be vaccinated!	N	24	214	296	66	600
Selfish	Dear men in their 40s and 50s (all men born between 1962 and 1979). Rubella infection in adult men may have serious complications such as encephalitis and thrombocytopenic purpura. Get rubella antibody testing and be vaccinated!	N	16	225	302	57	600
Social Comparison	Dear men in their 40s and 50s (all men born between 1962 and 1979). Compared to other generations, more than twice as many people in your generation can get rubella because one in five of you does not have rubella antibodies. Get rubella antibody testing and be vaccinated!	N	18	204	321	57	600
Deadline	Dear men in their 40s and 50s (all men born between 1962 and 1979). The voucher for a free rubella antibody test and vaccine is valid on March 31, 2020. Get rubella antibody testing and be vaccinated!	N	18	216	299	67	600
Convenient	Dear men in their 40s and 50s (all men born between 1962 and 1979). You can use your coupon for a rubella antibody test at a growing number of workplaces and government agencies, in addition to your usual health examinations. Get rubella antibody testing and be vaccinated!	N	19	213	307	61	600

is 1,050, with 150 for one experimental arm within each group. Thus, the sample size for one experimental group is 600.¹⁵

In wave 1, after viewing a randomly assigned message, participants expressed their intention to get antibody testing and vaccinated on a 5-point Likert scale (5 = definitely yes; 1 = absolutely no). The question of willingness to take antibody testing is, “Are you willing to take an antibody test for rubella now?” Meanwhile, the intention to get vaccinated question asks, “If the antibody testing reveals that you have no antibodies, are you willing to get vaccinated?” We create a binary variable taking the value of 1 if the participant responds 4 or 5 for each question and use it as the outcome variable for intentions.

3.2 Wave 2: Outcome Variables on Behavior

Wave 2 investigates actual antibody testing and vaccination behavior since wave 1. We present exact questions and choices about antibody testing and vaccination in Online Appendix B. We create a binary variable taking 1 if the respondent has taken antibody testing since the end of wave 1.

To receive rubella vaccination through routine immunization, eligible men must first undergo antibody testing. However, they may have been vaccinated against rubella at their own expense without having their antibodies tested. To eliminate this possibility, we create a binary variable taking 1 if respondents have been tested and vaccinated since the end of wave 1. Then, we use it as the outcome variable on vaccination coverage.

Although self-reported behavioral measures may be subject to the experimenter demand effect and social desirability bias, the design and analysis of the current study addresses these biases in the following two ways. First, because this study is a randomized controlled trial and if these biases exist to the same extent in each group, they are not fatal to the identification of treatment effects. Second, even if these biases are heterogeneous across groups, our analysis directly controls for respondents’ psychological factors related to these biases (feeling pleasure from acting for others, accepting bad behavior in anonymous conditions) and then estimates treatment effects.

4 Results

4.1 Study Population

Our target population consists of men who did not have antibody testing or vaccinations. We exclude respondents who stated in wave 1 that they had already received either antibody testing or vaccination. In wave 2, we asked respondents whether they had already received either testing or vaccination until wave 1. Thus, when estimating the effect on behavior, we exclude respondents who stated in either wave that they had received either antibody testing or vaccination prior to wave 1.

Our aim is to estimate the effect of text messages in situations where men received monetary incentives as vouchers by default and where they had to incur transaction costs to obtain them. To accomplish this, we create a subsample of men aged 40–46 years and another of men aged 47–56 years. Men in the former subsample automatically received the free vouchers (*default incentive* group). Meanwhile, men in the latter subsample received no incentives or required a costly procedure to get it (*opt-in incentive* group). We believe that most men in the opt-in group did not receive free vouchers in FY2019 because 77.5% of respondents in wave 1 did not know that rubella routine immunization began in FY2019. Thus, in the default incentive group, monetary incentives and text message reminders are more closely combined than in the opt-in incentive group.

¹⁵The ages shown in Table 1 are as of April 2019, calculated using the year and month of respondents’ birth. Men aged 40–56 years as of April 2019 are eligible for the MHLW’s additional measures. Those aged 40–46 years automatically receive coupons for the first year. We assume that those born in April have not yet reached their birthday. Also, some men aged 39 years as of April 2019 were 40 years old at the time of the survey.

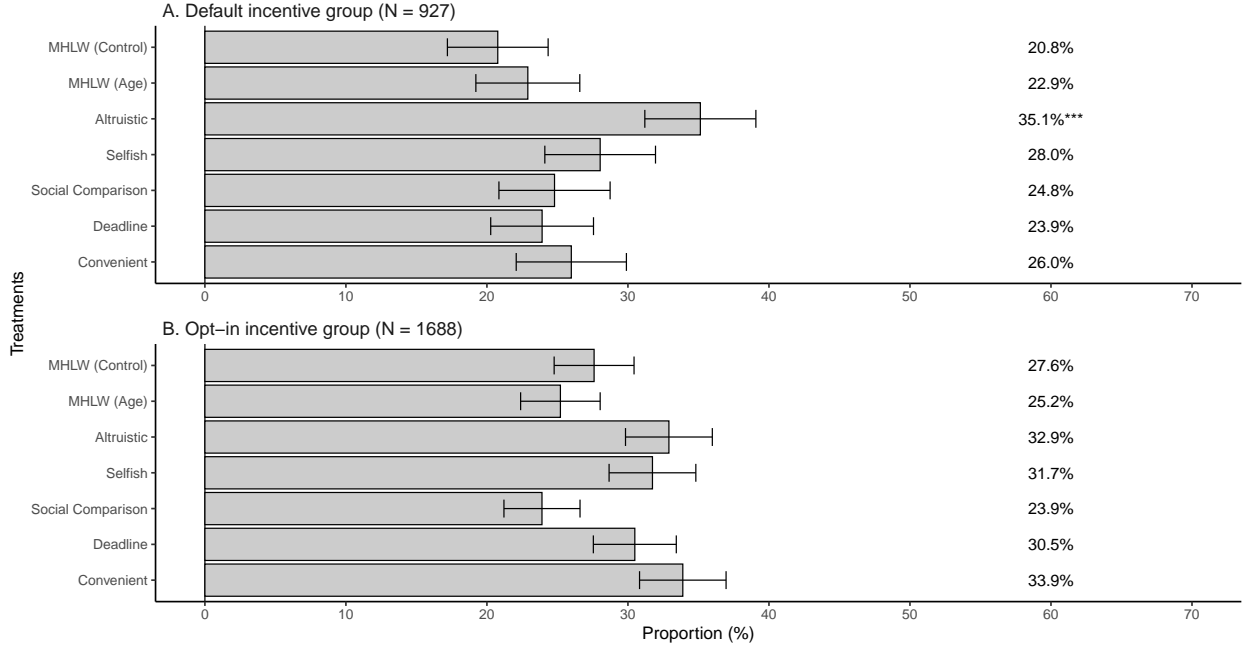


Figure 2: Effect of Text Messages on Intention for Antibody Testing Notes: Numbers in the figure indicate the proportion of each experimental arm. Error bars indicate the standard error of the mean. Asterisks are p-values of t-tests for the difference-in-mean: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

4.2 Effect of Text Messages on Intentions

This subsection estimates the effect of text messages on intentions. We find that individuals' observable characteristics are balanced across experimental arms in both default incentive and opt-in incentive group (See Table 8 and 9 in Appendix). Thus, we first report the difference-in-mean test (t-test) for each group.

4.2.1 Difference-in-mean Test

We show the proportion of intention for antibody testing in each experimental arm for the default incentive group (Panel A) and the opt-in incentive group (Panel B) in Figure 2. The results show that, in the default incentive group only, the Altruistic message increases the intention for antibody testing by a statistically significant 14.3 pp compared to the MHLW (control) message group (35.1% in the Altruistic message group versus 20.8% in the MHLW (control) message group). Because the Altruistic message changes both the age expression and the message content, the effect relative to MHLW (control) can be interpreted as the combined effect of the two changes. However, MHLW (Age), which only changes the age expression, does not increase intention. Thus, the effect of the Altruistic message is attributed to the message content. Compared to MHLW (Age), Altruistic message content increase the intention for antibody testing by 12.2 pp (35.1% in the Altruistic message group versus 22.9% in the MHLW (Age) message group), which is statistically significant (see Table 10 in the Appendix).

On the other hand, in the opt-in incentive group, altruistic messages increased intention by 5.3 pp, which is statistically insignificant (32.9% in the Altruistic message group versus 27.6% in the MHLW (control) message group).¹⁶ The regression analysis presented later suggests that the Altruistic message effects may differ between the two incentive groups.

¹⁶However, even in the opt-in incentive group, the Altruistic message content may increase testing intention. Compared to the MHLW(age) message group, the Altruistic messages increased the intention to take the antibody test by 7.7 pp (32.9% in the Altruistic message group versus 25.2% in the MHLW (age) message group), which is statistically significant at the 10% level (see Table 11 in the Appendix).

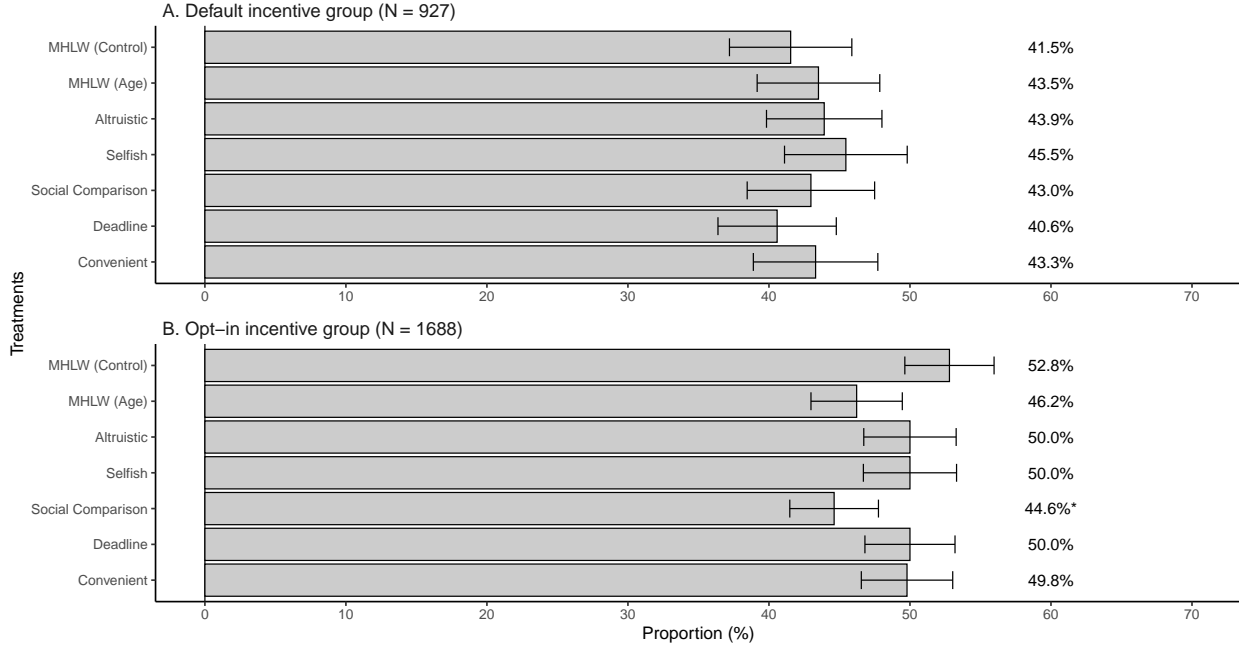


Figure 3: Effect of Text Messages on Intention for Vaccination Notes: Numbers in the figure indicate the proportion of each experimental arm. Error bars indicate the standard error of the mean. Asterisks are p-values of t-tests for the difference-in-mean: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Figure 3 depicts the proportions of intention for vaccination for the default incentive group (Panel A) and the opt-in incentive group (Panel B). Results show that in the two incentive groups, most text messages, including the Altruistic messages, do not statistically significantly increase vaccination intentions compared to NHLW (control).

In the opt-in incentive group, the Social Comparison message may lower vaccination intention than the MHLW (control) message (44.6% in the Social Comparison message group versus 52.8% in the MHLW (control) message group). This result is due to the age expression rather than the message content, as social comparison messages hardly lower intention compared to MHLW (age).¹⁷

Note that the intention ratio of vaccination in all experimental arms is higher than that of antibody testing in both incentive groups. This result may be explained by the stimulus of the question eliciting the vaccination intention. We asked respondents to report their willingness to vaccinate if they did not have antibodies. This condition may strongly stimulate the need for vaccination. Thus, when assessed by actual behavior, the results may differ.

4.2.2 Regression Analysis

Since age determines whether eligible men received the free vouchers automatically in FY2019, the different effect of text messages for two groups is influenced by the presence or absence of monetary incentives, and by the differences of other dimensions (especially, age) between the two groups. This motivates us to estimate

¹⁷Free-riding may explain why the Social Comparison message content does not increase intention. The Social Comparison message emphasizes that “one in five people do not have antibodies.” Conversely, four out of five individuals have antibodies. The readers of such a message may have believed that even if they lacked rubella antibodies, the likelihood of infection would be low because 80% of the population possesses them. When eligible men were required to undergo costly procedures to receive free vouchers, this belief may have made vaccination less beneficial.

Table 2: Regressions of Intention

	Testing		Vaccination	
	(1)	(2)	(3)	(4)
MHLW (Age)	0.021 (0.051)	0.039 (0.049)	0.020 (0.061)	0.047 (0.059)
Altruistic	0.144*** (0.053)	0.166*** (0.049)	0.024 (0.060)	0.050 (0.056)
Selfish	0.073 (0.053)	0.115** (0.050)	0.039 (0.061)	0.087 (0.058)
Social Comparison	0.040 (0.053)	0.067 (0.050)	0.014 (0.063)	0.039 (0.059)
Deadline	0.031 (0.051)	0.039 (0.048)	-0.010 (0.060)	0.003 (0.058)
Convenient	0.052 (0.053)	0.060 (0.050)	0.018 (0.062)	0.032 (0.058)
Opt-in	0.068 (0.046)	0.081 (0.050)	0.113** (0.054)	0.077 (0.059)
MHLW (Age) \times Opt-in	-0.045 (0.065)	-0.072 (0.061)	-0.086 (0.076)	-0.122* (0.072)
Altruistic \times Opt-in	-0.091 (0.068)	-0.121* (0.064)	-0.052 (0.075)	-0.088 (0.071)
Selfish \times Opt-in	-0.031 (0.068)	-0.097 (0.064)	-0.067 (0.077)	-0.141* (0.073)
Social Comparison \times Opt-in	-0.077 (0.066)	-0.111* (0.062)	-0.096 (0.077)	-0.126* (0.072)
Deadline \times Opt-in	-0.003 (0.065)	-0.006 (0.062)	-0.018 (0.075)	-0.024 (0.071)
Convenient \times Opt-in	0.011 (0.067)	-0.001 (0.064)	-0.048 (0.077)	-0.063 (0.072)
Covariates		X		X
Num.Obs.	2615	2615	2615	2615
R2	0.009	0.112	0.005	0.118

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. Robust standard errors are in parentheses. Covariates are age, education year, annual income, usual health behavior (exercise, medical checkup and ful shot habit) and preference for compliance with social norm.

a following linear probability model:

$$\begin{aligned}
Y_{ij} = & \alpha + \sum_j \beta_j \text{Message}_j + \sum_j \gamma_j (\text{Message}_j \times \text{Opt-in}_i) + \delta \text{Opt-in}_i \\
& + \lambda X'_{ij} + \epsilon_{ij},
\end{aligned} \tag{1}$$

where Message_j is a treatment dummy (the reference group is MHLW (control) message), Opt-in_i is a binary variable indicating the opt-in incentive group (47–56 years old), and X is a set of covariates including age. Our parameter of interest is β_j and γ_j . The parameter β_j represents a text message effect for the default incentive group. The linear combination of parameters, $\beta_j + \gamma_j$, is a text message effect for the opt-in incentive group. The parameter γ_j shows a difference in the message effect between the two groups.

The regression analysis also shows that the Altruistic messages increase the intention to take the antibody test only in the default incentive group (Table 2). Controlling for covariates, altruism messages increase the intention to take the antibody test by 16.6 pp in the default incentive group (column (2)). Furthermore, although marginally statistically significant, the effect of this message weakens by 12.1 pp as the cost of obtaining a free vaccination ticket becomes more expensive. As a result, the effect of the Altruistic message

Table 3: Text Message Effects for Opt-in Incentive Group Estimated by Regressions

	Testing		Vaccination	
	(1)	(2)	(3)	(4)
MHLW (Age)	−0.024 (0.040)	−0.033 (0.037)	−0.066 (0.045)	−0.074* (0.042)
Altruistic	0.053 (0.042)	0.045 (0.040)	−0.028 (0.046)	−0.038 (0.043)
Selfish	0.041 (0.042)	0.017 (0.039)	−0.028 (0.046)	−0.054 (0.043)
Social Comparison	−0.037 (0.039)	−0.044 (0.037)	−0.082* (0.045)	−0.087** (0.041)
Deadline	0.029 (0.041)	0.033 (0.039)	−0.028 (0.045)	−0.021 (0.042)
Convenient	0.063 (0.042)	0.059 (0.040)	−0.030 (0.045)	−0.031 (0.043)
Covariates	X		X	

Notes: * $p < 0.1$, ** $p < 0.5$, *** $p < 0.01$. Robust standard errors are in parentheses. Message effects are estimated by a sum of main term of treatment dummy and cross term between treatment dummy and opt-in dummy.

in the opt-in incentive group is 4.5 pp, which is not statistically significant (column (2) in Table 3). Also statistically insignificant or marginal, the effect of other nudge messages changes in a negative direction as the cost of obtaining free vaccination tickets increases.

Table 10 in the Appendix estimates the effect of modifying the message content, excluding age expression. In the estimation, we exclude from the sample those assigned to MHLW (control). The reference group is MHLW (Age). Controlling for covariates, the Altruistic message content in the default incentive group statistically significantly increased the intention to take the antibody test by 12.8 pp, which is the main driver of the positive effect of the Altruistic message in the default incentive group. However, the difference in the effect of message content in the two incentive groups is not statistically significant. Therefore, the F-test results suggest that the Altruistic messages may increase the intention to take the antibody test in the opt-in incentive group (Table 11 in the Appendix).¹⁸

4.3 Effect of Text Messages on Behavior

This subsection estimates the effect of text messages on behavior. We tested a balance of individual characteristics again because a few respondents dropped out between waves 1 and 2. The results show that the observable characteristics are balanced across experimental arms in both default incentive and opt-in incentive group (see Table 12 and 13 in the Appendix). Therefore, we first present the difference-in-mean test (t-test).

4.3.1 Difference-in-mean Test

We show the uptake rate of antibody testing in each experimental arm for the default incentive group (Panel A) and the opt-in incentive group (Panel B) in Figure 4. We find that, as in the intention case, the Altruistic message statistically significantly increases the antibody test uptake rate compared to the MHLW (control)

¹⁸An interesting finding is that only in the opt-in incentive group did the content of the Convenient message statistically significantly increase the intention to take the antibody test by about 9 pp. This group may not have a full understanding of the routine immunization campaign. In fact, the Wave 1 survey shows that only about 20% of the opt-in incentive group are aware of routine vaccination.

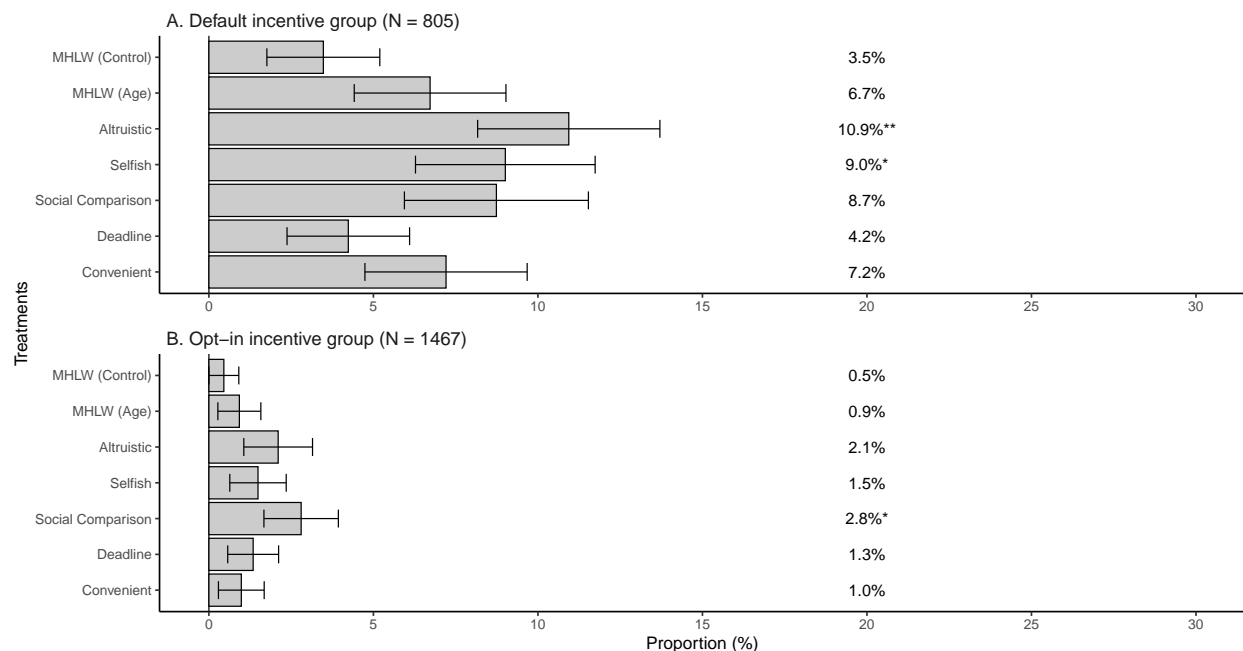


Figure 4: Effect of Text Messages on Behavior for Antibody Testing Notes: Numbers in the figure indicate the proportion of each experimental arm. Error bars indicate the standard error of the mean. Asterisks are p-values of t-tests for the difference-in-mean: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

message by 7.4 pp in the default incentive group only (10.9% in the Altruistic message group versus 3.5% in the MHLW (control) message group).

Unlike the intention case, the effect of the Altruistic messages on behavior is not solely due to the content of the message. Compared to MHLW (Age), which only changed the expression of age, the Altruistic message group increases the antibody test uptake rate by 4.2 pp (10.9% in the Altruistic message group versus 6.7% in the MHLW (Age) message group). However, regression analysis indicates that this increase is not statistically significant (see Table 14 in the Appendix). Also, although the regression analysis is not statistically significant, modifying the age expression increases the antibody test uptake rate by 3.2 pp (6.7% in the MHLW (Age) message group versus 3.5% in the MHLW (Control) message group). Thus, the effect of the Altruistic message on behavior is a combination of the addition of a simple age expression and the revision of the message content.

Selfish messages may boost antibody testing uptake in the default incentive group by 5.5 pp (9% in the Selfish message group versus 3.5% in the MHLW (control) message group). Moreover, Social Comparison message may also increase antibody testing uptake in the opt-in incentive group (4.9% in the Social Comparison message group versus 3.5% in the MHLW (control) message group). These effects are statistically significant at the 10% level.

Figure 5 shows the vaccination rates in each experimental arm for the default incentive group (Panel A) and the opt-in incentive group (Panel B).¹⁹ In the default incentive group, the Altruistic message may increase the vaccination rate by 3.8 pp (4.7% in the Altruistic message group versus 0.9% in the MHLW (control) message group). In the same group, the Social Comparison message may also increase vaccination rate by 4 pp (4.9% in the Social Comparison message group versus 0.9% in the MHLW (control) message group). These effects are statistically significant at 10% level.

¹⁹Vaccination is a dummy variable that takes the value of 1 if respondents have been tested and vaccinated. Thus, the vaccination rate can be regarded as the proportion of newly acquired antibodies through vaccination. This outcome variable matches MHLW's policy goal.

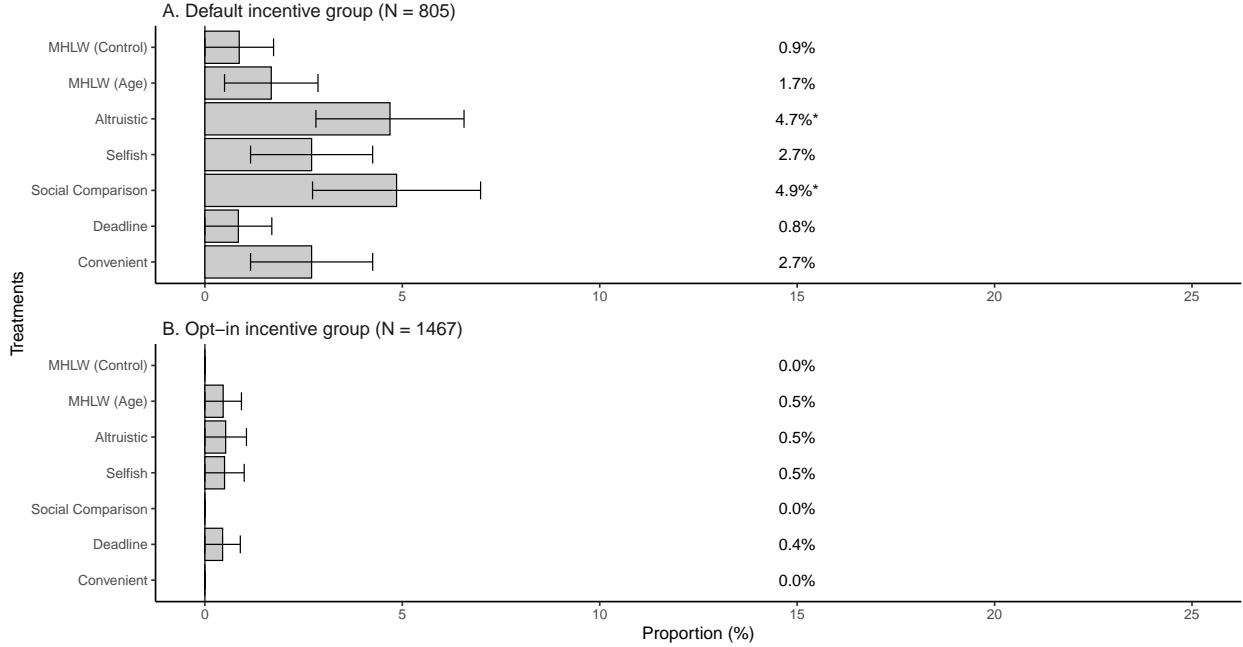


Figure 5: Effect of Text Messages on Behavior for Vaccination. Notes: Numbers in the figure indicate the proportion of each experimental arm. Error bars indicate the standard error of the mean. Asterisks are p-values of t-tests for the difference-in-mean: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

4.3.2 Regression Analysis

As in the case of intention, the different effects of text messages for two incentive group is influenced by dimentions including age difference other than the presence or absence free vouchers. Thus, we estimate a linear probability model ((1)) and shows results in Table 4.

Regression analysis also shows that the Altruistic messages increase antibody test uptake only in the default incentive group. Controlling for covariates, the Altruistic messages increase antibody test uptake by a statistically significant 7.3 pp in the default incentive group (column (2)). Furthermore, although the statistical significance is weak, the effect of this message weakens by 5.7 pp as the cost of obtaining a free vaccination ticket becomes more expensive. As a result, the effect of the Altruistic message in the opt-in incentive group is 1.6 pp, which is not statistically significant (column (2) in Table 5). A similar trend is observed for the effect on vaccination, but it is weakly statistically significant.

We summarize the results for the other messages. Controlling for covariates, the Selfish message may have increased the antibody test-taking rate in the default incentive group, although the statistical significance is weak (column (2) in Table 4). We also find that the Social Comparison message may have increased antibody testing rates in the two incentive groups (See column (2) in Table 4 and 5). However, the effect size is larger in the default incentive group than in the opt-in incentive group (not a statistically significant difference).

As confirmed by the difference-in-means test, the Social Comparison message may increase vaccination rates in the default incentive group (column (4) in Table 4). Although weakly statistically significant, the effect of this message weakens by 5.7 pp as the cost of obtaining vaccination tickets increases. As a result, the Social Comparison message does not increase vaccination rates in the opt-in incentive group (column (4) in Table 5). Again, the effect of the Altruistic message follows a similar trend.

Table 4: Regressions of Behavior

	Testing		Vaccination	
	(1)	(2)	(3)	(4)
MHLW (Age)	0.032 (0.029)	0.029 (0.028)	0.008 (0.015)	0.005 (0.015)
Altruistic	0.075** (0.033)	0.073** (0.032)	0.038* (0.021)	0.037* (0.021)
Selfish	0.055* (0.032)	0.061* (0.032)	0.018 (0.018)	0.018 (0.018)
Social Comparison	0.053 (0.033)	0.056* (0.033)	0.040* (0.023)	0.040* (0.023)
Deadline	0.008 (0.025)	0.005 (0.025)	0.000 (0.012)	-0.002 (0.012)
Convenient	0.037 (0.030)	0.038 (0.030)	0.018 (0.018)	0.018 (0.018)
Opt-in	-0.030* (0.018)	-0.018 (0.020)	-0.009 (0.009)	-0.003 (0.012)
MHLW (Age) \times Opt-in	-0.028 (0.030)	-0.026 (0.030)	-0.003 (0.015)	-0.002 (0.016)
Altruistic \times Opt-in	-0.058* (0.034)	-0.057* (0.034)	-0.033 (0.021)	-0.032 (0.021)
Selfish \times Opt-in	-0.045 (0.034)	-0.054 (0.033)	-0.013 (0.018)	-0.013 (0.018)
Social Comparison \times Opt-in	-0.029 (0.035)	-0.034 (0.035)	-0.040* (0.023)	-0.039* (0.023)
Deadline \times Opt-in	0.001 (0.027)	0.003 (0.026)	0.005 (0.013)	0.006 (0.013)
Convenient \times Opt-in	-0.032 (0.031)	-0.031 (0.031)	-0.018 (0.018)	-0.018 (0.018)
Covariates		X		X
Num.Obs.	2272	2272	2272	2272
R2	0.030	0.047	0.019	0.029

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. Robust standard errors are in parentheses. Covariates are age, education year, annual income, usual health behavior (exercise, medical checkup and flu shot habit) and preference for compliance with social norm.

Table 5: Text Message Effects on Behavior for Opt-in Incentive Group Estimated by Regressions

	Testing		Vaccination	
	(1)	(2)	(3)	(4)
MHLW (Age)	0.005 (0.008)	0.003 (0.008)	0.005 (0.005)	0.004 (0.005)
Altruistic	0.017 (0.011)	0.016 (0.011)	0.005 (0.005)	0.005 (0.005)
Selfish	0.010 (0.010)	0.007 (0.010)	0.005 (0.005)	0.005 (0.005)
Social Comparison	0.023* (0.012)	0.022* (0.013)	0.000	0.000 (0.001)
Deadline	0.009 (0.009)	0.009 (0.009)	0.004 (0.004)	0.005 (0.005)
Convenient	0.005 (0.008)	0.007 (0.009)	0.000 (0.000)	0.000 (0.001)
Covariates	X		X	

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. Robust standard errors are in parentheses. Message effects are estimated by a sum of main term of treatment dummy and cross term between treatment dummy and opt-in dummy.

4.4 Monetary Value of Text Messages

Altruistic (and possibly Social Comparison) messages encourage men who received free vouchers by default to obtain antibody testing and be vaccinated. In this subsection, we attempt to evaluate the effect of these messages in the default incentive group in terms of monetary value. That is, we seek to determine the extent to which the nudge messages increase the monetary value of the rubella vaccination. In other words, we are looking for an amount of additional subsidy equivalent to the message effects in terms of government subsidies.

We use willingness to pay (WTP) for the rubella vaccine.²⁰ Let WTP_i be an individual's willingness to pay and follow a distribution F . Then, for a given cost C , men will be vaccinated if $WTP_i \geq C$. The vaccination rate is $F_0 = 1 - F(C)$. Suppose that our treated message changes WTP by β . An individual who receives a treated message will be vaccinated if $WTP_i \geq C - \beta$. The vaccination rate of the treated message group is $F_1 = 1 - F(C - \beta)$. Thus, the treated message effect is $\tau = F_1 - F_0 = F(C) - F(C - \beta)$. From the perspective of government subsidies, the amount of subsidy equal to the effect of the nudge message τ is β . We want to estimate β .

Once F , C , and τ are determined, we obtain β . To begin, let us discuss the estimation of F (demand function). We elicit the WTP for vaccination in the first wave before participants read messages. If the vaccination costs 5,000 JPY, we ask respondents if they will get it if the local government pays s_j . The subsidy amounts are $s_j \in \{0, 1000, 2000, \dots, 10000\}$. Let s_i^{\min} be the lowest subsidy at which respondents indicate that they would vaccinate. Let s_i^{\max} be the highest subsidy that respondents indicate they would not vaccinate. We can identify the willingness to pay for vaccination within the range $[5000 - s_i^{\max}, 5000 - s_i^{\min}]$. Thus, without additional assumptions, the demand curve is step-wise, and we estimate the monetary value of the message effect with bounds.²¹ To obtain a point estimate, we assume that the true WTP is uniformly distributed within the range $[5000 - s_i^{\max}, 5000 - s_i^{\min}]$. Then, The vaccination demand curve can then be linearly interpolated (see Figure 6 in Appendix).

²⁰Several studies calculate the monetary value of text messages. For example, Bursztyn et al. (2019) calculated it using the two relative effects of financial incentives and text message treatment groups. Moriwaki et al. (2020) also surveyed WTP amounts and calculated monetary value. The latter study is similar to our approach.

²¹If respondents indicated that they would not vaccinate at all subsidy amounts, then $s_i^{\max} = 10000$. However, we cannot define s_i^{\min} in the data. Therefore, we assume $s_i^{\min} = 11000$. This assumption does not affect the monetary value of the messages.

Table 6: Estimated Monetary Value of Text Messages

Text messages	Effect	Baseline + effect	Monetary value (JPY)		Monetary value (USD)	
			pp	total	pp	total
MHLW (Age)	0.032	0.732	367.854	1.946	3.679	17.690
Altruistic	0.075	0.774	2037.553	10.779	20.376	97.988
Selfish	0.055	0.755	744.045	3.936	7.440	35.782
Social Comparison	0.053	0.752	596.335	3.155	5.963	28.678
Deadline	0.008	0.707	86.059	0.455	0.861	4.139
Convenient	0.037	0.737	422.789	2.237	4.228	20.332

We use the effect size of each text messages on antibody testing. Baseline is the sum of the rate of antibody test in the control and the free vaccination rates. The monetary value is the amount per person multiplied by the number of people who received the coupon in 2019 but did not use it until January 2020 (5.29 million). We valued it in Japanese Yen and US Dollars (1 USD = 110 JPY). The unit of monetary value per person is 1 JPY and 1 USD, respectively. The unit of total monetary value is 1 billion JPY and 1 million USD, respectively.

In the default incentive group, eligible males receive free vaccination at no cost. Therefore, the natural setting is $C = 0$. In addition, the message effect τ is used for the effect on antibody test uptake. The person taking the antibody test wants to get the antibody, i.e. the vaccination, against rubella. However, the effect of the message on vaccination is different from the effect on (true) vaccination intention, because people with a positive antibody test result cannot be vaccinated. Therefore, τ is not the effect on vaccination, but the effect on antibody testing.

In our framework, $F_0 = 1 - F(0)$, but one potential concern remains. The message effect τ is estimated by the difference from the MHLW (control) group, and $F(0)$ does not take into account the 3.5% antibody test uptake rate of the MHLW (control) (see Figure 4). Assuming that everyone who did not participate in our survey did not take the antibody test after the survey, the uptake rate of MHLW (control) can be considered as an effect of providing the message in the survey. To account for this explicitly, we use $F_0 = (1 - F(0)) + (F(0) - F(-\alpha))$. The second term is the antibody testing rate of the control group (3.5%) under no vaccination cost. The demand function is estimated to be $F_0 = 0.7$ and $\alpha = 394$.

We find β holding that $\tau = F(-\alpha) - F(-\beta)$. Table 6 shows the estimated message value. The second and third columns show τ and $F_1 = \tau + F_0$, respectively. The fourth column shows β in terms of the value of the Japanese yen (in U.S. dollar value, shown in the sixth column). The Altruistic and Social Comparison message, which promotes antibody testing, value about 2,000 JPY (about 18 USD; 40% of assumed vaccination price) and 600 JPY (about 5.5 USD; 12% of assumed vaccination price), respectively. The total monetary value is the product of the per capita value and the number of people who have not yet used the free vouchers issued in FY2019 (5.29 million as of January 2020). In the fifth column, the Altruistic and Social Comparison messages are worth 10 billion JPY (about 98 million USD) and 3 billion JPY (about 28 million USD), respectively.

5 Discussion and Conclusions

This study uses RCTs to investigate effective messages for promoting rubella antibody testing and vaccination in two situations regarding financial incentives. Our experiment reveals that the Altruistic message, which emphasizes the negative externality of infection, increases the intention for antibody testing uptake by 14.3 pp among men who already received free vaccination tickets in FY2019. However, this message is less effective for men who incur transaction costs to obtain the vaccination tickets. There may be a statistically significant difference in the effect of this message between the two groups.

Similar results are found for the antibody test uptake. Among men who had already received vaccination vouchers in FY 2019, the Altruistic message increases the antibody test uptake by 7.5 pp, which is equivalent to a subsidy of 40% of the vaccination price. However, this message is less effective for men who incurred the cost of obtaining the vaccination tickets. The effect between the two groups may be statistically significant.

This finding suggests that text message reminders are effective when financial incentives and reminders are closely combined. In addition to the Altruistic message, the Selfish and the Social Comparison message may also raise the intention and the actual uptake rate for the antibody testing among men who already received the vaccination tickets by default. However, these effect sizes are not large enough to maintain statistical power, requiring a re-examination with a large sample size.

One potential concern is that all behavior-related outcomes were self-reported. These outcomes may contain recall bias. We believe that these biases are less problematic because Wave 2 measures behavior within the last month (the time of Wave 1). The self-reported behavioral outcomes may also be subject to the experimenter demand effect and social desirability bias. To address these biases, our regression analysis directly controls for respondents' psychological factors related to these biases (e.g., following social norm). Even if these biases cannot be eliminated perfectly, they are not fatal to the identification of message effects since this study is a RCT and if these biases exist to the same extent in each group.

Finally, we discuss three points about mechanisms. The first is the mechanism of the Altruistic messages. The effect of Altruistic message (especially on the intention to test for antibodies) is due to a change in the content of the message rather than to the addition of a simple expression of age. The Altruistic message emphasizes the possibility of disability in infants and appeals to the negative externalities of not vaccinating. We analyze the heterogeneity of the message content effect to test which individuals respond more strongly to this message content.

First, in Wave 1, we examine the knowledge that infants born to infected pregnant women may have disabilities and test the heterogeneity of the effect of the altruistic message content on antibody testing intentions depending on whether respondents possessed this knowledge (see column (1) of Table 16 in the Appendix). The results show that the effect of the altruistic message content may be more effective for those who do not possess the knowledge than for those who do. Although there are no statistically significant difference between the effects with and without knowledge, the effects of message content for those with knowledge are not statistically significant. Thus, altruistic message content may modify knowledge about the negative externalities of infection.

It is also important whether a man is altruistic, caring about others' benefit (externality). We investigate whether he feels pleasure in actions for others on a 5 scale in Wave 1 and test the heterogeneous effect of the Altruistic message content by the extent to which he does (see column (2) of Table 16 in the Appendix). The results show that the more altruistic one is, the stronger the effect of the Altruistic message content (this trend is statistically significant). Thus, the Altruistic messages may not be effective for those who do not care about others, even if they perceive negative externalities from reading messages.

The second argument is the effect on vaccination rates. Our experiments reveal that the Altruism and the Social Comparison messages may increase vaccination rates among men who received free vaccination tickets by default. The message effect on vaccination is created through two channels. First, the messages increase the number of negative individuals who need to be vaccinated. Second, the messages encourage unvaccinated negative individuals to vaccinate. Our data suggest that the first channel is more important than the second.

Table 17 in the Appendix shows the number of men who had antibody testing, who had a negative antibody test, and who were vaccinated in each experimental arm in the default incentive group. This table shows that most of those with negative antibody test results were vaccinated in all experimental arms. Furthermore, the number of negative antibody tests varied between experimental arms. Especially, the 25% ($= 1/4$) antibody tests are negative in the MHLW (Control) message group. In contrast, the negative ratios of antibody tests for the Altruistic and Social Comparison messages, which may have a positive effect on vaccination, are 50% ($= 7/14$) and 56% ($= 5/9$), respectively.²² Thus, the experimental arms with higher vaccination rates have

²²The negative ratio of antibody testing for the Selfish message, which is only effective for antibody test uptake, is 30% ($= 3/10$). This value is similar to the MHLW (control) message.

a greater negative ratio, resulting in a positive effect on vaccination. However, the difference in the ratio of negative antibody tests is not statistically significant.

A final discussion is why text messages are ineffective in groups that must incur transaction costs to obtain the free vaccination tickets. Our messages may not increase the value of antibody testing and vaccination sufficiently to outweigh their cost. In addition, another possibility is low awareness of rubella immunization campaign beginning in FY2019. Before presenting the messages, we inquire about the MHLW’s policy in Wave 1. As a result, approximately 77.5% are unaware of the vaccination campaign. Thus, even if they read the messages and realized the importance of rubella antibody testing and vaccination, they would believe they had to pay for these preventive actions.²³

The last two arguments are important issues outside our context. The second argument concerns the targeting of interventions (e.g., Finkelstein & Notowidigdo 2019). That is, the question is whether marginal individuals whose behavior is changed by a policy intervention receive significant benefits from that policy. In our context, we suggest that the Altruistic message increases the number of negative individuals who receive a large benefit (vaccination) from the FY2019 vaccination campaign. The third argument relates to testing the effectiveness of vouchers (e.g., Kacker et al. 2022). The experimental data in this study alone do not allow us to fully explore these arguments, and they are a topic for future research.

²³The fact that many people are unaware of the additional routine rubella vaccinations precludes the possibility that they stopped getting antibody testing and were vaccinated in the first year (FY2019) because they expected to automatically receive the voucher the following year.

A Tables and Figures

Table 7: List of Covariates

	Description	Mean	Std.Dev.
age	(Wave1) Age as of April 2019 based on year of birth and month of birth.	48.66	5.69
married	(Wave1) Dummy variable taking one if a respondent is married.	0.58	0.49
education	(Wave1) Years of education.	14.75	2.31
income	(Wave1) Household income. For those who did not respond with household income, the overall average was substituted.	684.90	375.74
noinfo_income	(Wave1) Dummy variable taking one if a respondent did not answer household income.	0.15	0.36
exercise_w1	(Wave1) Dummy variable taking one if a respondent exercises or plays sports more than once a week.	0.22	0.42
health_check	(Wave1) Dummy variable taking one if a respondent has had a medical examination at his/her city or place of employment in the past year from the time of the wave 1.	0.68	0.46
flushot	(Wave1) Dummy variable taking one if a respondent is vaccinated against influenza every year.	0.27	0.45
norm	(Wave2) Five-point Likert scale for the question "I wash my hands and gargle frequently during the period from the end of the previous questionnaire response to today."	11.24	2.32
handwash	(Wave2) Five-point Likert scale for the question "I take my temperature frequently during the period from the end of the previous questionnaire response to today."	3.91	1.04
temp_check	(Wave2) Five-point Likert scale for the question "I am refraining from going out during the end of the previous questionnaire response to today."	2.26	1.22
avoid_out	(Wave2) Five-point Likert scale for the question "I avoid crowded places when I go out from the end of the previous questionnaire response to today."	2.96	1.20
avoid_crowd	(Wave2) Five-point Likert scale for the question "I always wear a medical mask when I go out or meet people during the period from the end of the previous questionnaire response to today."	3.38	1.10
wear_mask		3.14	1.38

Table 8: Balance Tests for Default Incentive Groups (Sample for Estimating Effect on Intention)

	MHLW (Con- trol)	MHLW (Age)	Altru- istic	Selfish	Social Com- pari- son	Dead- line	Con- ve- nient	F-test, p-value
age	42.862	43.046	43.135	43.045	42.909	42.906	42.866	0.874
married	0.408	0.458	0.412	0.417	0.455	0.478	0.480	0.785
education	14.654	14.473	14.595	14.205	14.099	14.348	14.575	0.446
income	557.562	645.556	613.156	623.542	569.530	590.422	633.487	0.149
noinfo_income	0.162	0.168	0.203	0.197	0.157	0.130	0.181	0.706
exercise_w1	0.246	0.176	0.277	0.189	0.165	0.217	0.213	0.285
health_check	0.654	0.626	0.696	0.538	0.603	0.674	0.614	0.150
flushot	0.238	0.260	0.203	0.144	0.140	0.239	0.236	0.055
norm	11.100	10.679	10.649	10.864	11.165	10.855	10.945	0.492

Notes: Table 7 describes variables. Columns 2–8 show sample averages for each experimental arm. Column 9 shows p-value of the joint null hypothesis (F-test).

Table 9: Balance Tests for Opt-In Incentive Group (Sample for Estimating Effect on Intention)

	MHLW (Con- trol)	MHLW (Age)	Altru- istic	Selfish	Social Com- pari- son	Dead- line	Con- ve- nient	F-test, p-value
age	51.632	51.408	51.226	51.657	51.582	51.545	51.502	0.712
married	0.600	0.588	0.628	0.657	0.602	0.549	0.619	0.334
education	14.572	14.655	14.530	14.830	14.566	14.634	14.393	0.578
income	712.622	707.190	687.764	677.141	656.419	707.708	710.713	0.540
noinfo_income	0.184	0.164	0.145	0.117	0.155	0.163	0.205	0.211
exercise_w1	0.156	0.193	0.239	0.230	0.183	0.203	0.218	0.252
health_check	0.632	0.664	0.701	0.683	0.653	0.659	0.644	0.742
flushot	0.228	0.244	0.197	0.270	0.275	0.228	0.251	0.433
norm	11.336	11.340	11.346	11.304	11.187	11.122	11.293	0.922

Notes: Table 7 describes variables. Columns 2–8 show sample averages for each experimental arm. Column 9 shows p-value of the joint null hypothesis (F-test).

Table 10: Message Content Effects on Intentions Compared to MHLW (Age)

	Testing		Vaccination	
	(1)	(2)	(3)	(4)
Altruistic	0.122** (0.054)	0.128** (0.051)	0.004 (0.060)	0.004 (0.057)
Selfish	0.051 (0.054)	0.075 (0.052)	0.019 (0.061)	0.040 (0.059)
Social Comparison	0.019 (0.054)	0.028 (0.052)	−0.005 (0.063)	−0.007 (0.059)
Deadline	0.010 (0.052)	0.000 (0.050)	−0.029 (0.060)	−0.045 (0.058)
Convenient	0.031 (0.054)	0.021 (0.051)	−0.002 (0.062)	−0.016 (0.058)
Opt-in	0.023 (0.046)	0.023 (0.052)	0.027 (0.054)	−0.031 (0.060)
Altruistic × Opt-in	−0.045 (0.068)	−0.050 (0.065)	0.034 (0.075)	0.032 (0.071)
Selfish × Opt-in	0.014 (0.068)	−0.026 (0.065)	0.018 (0.077)	−0.020 (0.073)
Social Comparison × Opt-in	−0.032 (0.067)	−0.039 (0.063)	−0.011 (0.077)	−0.006 (0.073)
Deadline × Opt-in	0.043 (0.066)	0.065 (0.063)	0.067 (0.076)	0.097 (0.072)
Convenient × Opt-in	0.056 (0.068)	0.071 (0.065)	0.038 (0.077)	0.059 (0.073)
Covariates		X		X
Num.Obs.	2235	2235	2235	2235
R2	0.008	0.108	0.004	0.113

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. Robust standard errors are in parentheses. We exclude from the sample those assigned to MHLW (control). The reference group is MHLW (Age). Covariates are age, education year, annual income, usual health behavior (exercise, medical checkup and flu shot habit) and preference for compliance with social norm.

Table 11: Message Content Effects for Opt-in Incentive Group Estimated by Regressions

	Testing		Vaccination	
	(1)	(2)	(3)	(4)
Altruistic	0.077* (0.042)	0.077* (0.040)	0.038 (0.046)	0.036 (0.043)
Selfish	0.065 (0.042)	0.049 (0.039)	0.038 (0.046)	0.020 (0.044)
Social Comparison	-0.013 (0.039)	-0.011 (0.036)	-0.016 (0.045)	-0.013 (0.042)
Deadline	0.053 (0.041)	0.065* (0.039)	0.038 (0.046)	0.053 (0.043)
Convenient	0.087** (0.042)	0.092** (0.039)	0.036 (0.046)	0.043 (0.043)
Covariates		X		X

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. Robust standard errors are in parentheses. We exclude from the sample those assigned to MHLW (control). The reference group is MHLW (Age). Message effects are estimated by a sum of main term of treatment dummy and cross term between treatment dummy and opt-in dummy.

Table 12: Balance Tests for Default Incentive Group (Sample for Estimating Effect on Behavior)

	MHLW (Con- trol)	MHLW (Age)	Altru- istic	Selfish	Social Com- pari- son	Dead- line	Con- ve- nient	F-test, p-value
age	42.861	43.059	43.102	43.036	42.893	42.898	42.964	0.953
married	0.391	0.454	0.391	0.360	0.437	0.466	0.477	0.467
education	14.496	14.471	14.547	14.126	14.010	14.407	14.595	0.474
income	548.244	649.778	614.512	599.124	555.083	591.597	637.056	0.102
noinfo_income	0.174	0.126	0.203	0.207	0.146	0.136	0.171	0.522
exercise_w1	0.252	0.185	0.266	0.171	0.165	0.195	0.225	0.375
health_check	0.643	0.639	0.680	0.532	0.631	0.661	0.640	0.391
flushot	0.235	0.261	0.227	0.135	0.146	0.246	0.207	0.082
norm	11.174	10.706	10.758	11.063	11.204	10.831	10.982	0.523
handwash	3.861	3.916	3.797	3.757	3.767	3.915	3.829	0.835
temp_check	2.139	2.235	2.414	2.126	2.204	2.203	2.117	0.535
avoid_out	3.096	3.034	3.047	2.793	2.932	3.025	2.928	0.544
avoid_crowd	3.296	3.336	3.273	3.234	3.350	3.305	3.324	0.990
wear_mask	2.930	3.076	3.109	3.009	3.010	3.144	3.207	0.794

Notes: Table 7 describes variables. Columns 2–8 show sample averages for each experimental arm. Column 9 shows p-value of the joint null hypothesis (F-test).

Table 13: Balance Tests for Opt-in Incentive Group (Sample for Estimating Effect on Behavior)

	MHLW (Con- trol)	MHLW (Age)	Altru- istic	Selfish	Social Com- pari- son	Dead- line	Con- ve- nient	F-test, p-value
age	51.695	51.394	51.179	51.662	51.421	51.605	51.512	0.564
married	0.591	0.560	0.611	0.652	0.598	0.547	0.596	0.407
education	14.505	14.620	14.553	14.876	14.593	14.610	14.345	0.472
income	712.165	707.809	686.355	671.407	644.798	699.289	718.575	0.370
noinfo_income	0.173	0.157	0.137	0.114	0.159	0.166	0.222	0.142
exercise_w1	0.159	0.194	0.232	0.229	0.173	0.211	0.202	0.432
health_check	0.632	0.667	0.684	0.677	0.645	0.673	0.631	0.849
flushot	0.223	0.245	0.189	0.264	0.280	0.215	0.241	0.376
norm	11.355	11.329	11.384	11.189	11.220	11.224	11.222	0.964
handwash	3.823	3.889	3.926	3.751	3.836	3.861	3.867	0.769
temp_check	2.095	2.204	2.221	2.100	2.136	2.085	2.182	0.841
avoid_out	2.886	2.889	2.932	2.866	2.855	2.964	2.941	0.960
avoid_crowd	3.295	3.361	3.447	3.239	3.313	3.309	3.433	0.437
wear_mask	3.082	3.176	3.116	3.144	2.977	2.942	3.010	0.533

Notes: Table 7 describes variables. Columns 2–8 show sample averages for each experimental arm. Column 9 shows p-value of the joint null hypothesis (F-test).

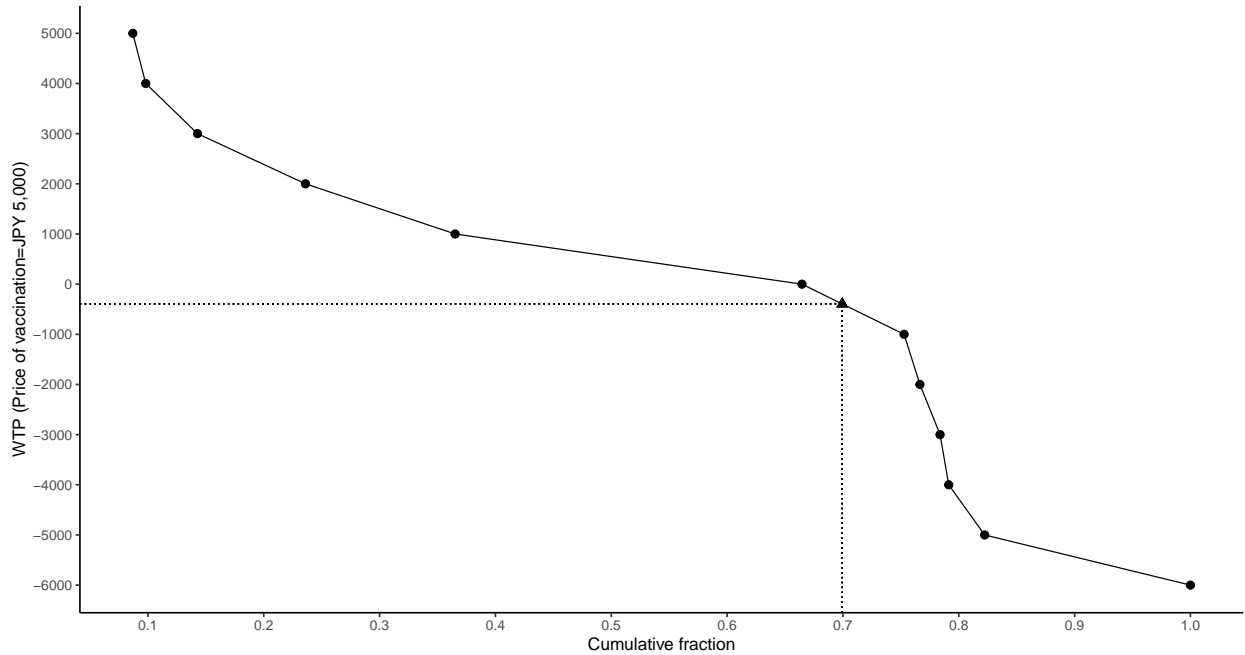


Figure 6: Demand Curve of Rubella Vaccination for Default Incentive Group. Notes: Black triangles indicate the baseline vaccination rate F_0 and the corresponding WTP.

Table 14: Message Content Effects on Behavior Compared to MHLW (Age)

	Testing		Vaccination	
	(1)	(2)	(3)	(4)
Altruistic	0.042 (0.036)	0.045 (0.036)	0.030 (0.022)	0.032 (0.022)
Selfish	0.023 (0.036)	0.032 (0.035)	0.010 (0.019)	0.013 (0.020)
Social Comparison	0.020 (0.036)	0.027 (0.036)	0.032 (0.024)	0.034 (0.025)
Deadline	-0.025 (0.030)	-0.024 (0.029)	-0.008 (0.015)	-0.007 (0.014)
Convenient	0.005 (0.034)	0.009 (0.034)	0.010 (0.019)	0.013 (0.019)
Opt-in	-0.058** (0.024)	-0.046* (0.026)	-0.012 (0.013)	-0.002 (0.015)
Altruistic \times Opt-in	-0.030 (0.038)	-0.031 (0.038)	-0.029 (0.023)	-0.031 (0.024)
Selfish \times Opt-in	-0.017 (0.037)	-0.027 (0.037)	-0.010 (0.021)	-0.012 (0.021)
Social Comparison \times Opt-in	-0.001 (0.038)	-0.008 (0.039)	-0.036 (0.025)	-0.038 (0.025)
Deadline \times Opt-in	0.029 (0.031)	0.030 (0.031)	0.008 (0.016)	0.008 (0.016)
Convenient \times Opt-in	-0.004 (0.035)	-0.004 (0.035)	-0.015 (0.020)	-0.017 (0.020)
Covariates		X		X
Num.Obs.	1937	1937	1937	1937
R2	0.029	0.047	0.019	0.030

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. Robust standard errors are in parentheses. We exclude from the sample those assigned to MHLW (control). The reference group is MHLW (Age). Covariates are age, education year, annual income, usual health behavior (exercise, medical checkup and ful shot habit) and preference for compliance with social norm.

Table 15: Message Content Effects for Opt-in Incentive Group Estimated by Regressions

	Testing		Vaccination	
	(1)	(2)	(3)	(4)
Altruistic	0.012 (0.012)	0.014 (0.013)	0.001 (0.007)	0.001 (0.007)
Selfish	0.006 (0.011)	0.004 (0.011)	0.000 (0.007)	0.002 (0.007)
Social Comparison	0.019 (0.013)	0.019 (0.013)	-0.005 (0.005)	-0.004 (0.005)
Deadline	0.004 (0.010)	0.006 (0.010)	0.000 (0.006)	0.001 (0.007)
Convenient	0.001 (0.010)	0.005 (0.010)	-0.005 (0.005)	-0.004 (0.005)
Covariates	X		X	

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. Robust standard errors are in parentheses. We exclude from the sample those assigned to MHLW (control). The reference group is MHLW (Age). Message effects are estimated by a sum of main term of treatment dummy and cross term between treatment dummy and opt-in dummy.

Table 16: Heterogeneous Effects of Altruistic Message Contents

	Intention for testing	
	(1)	(2)
Altruistic	0.199*** (0.068)	-0.115 (0.112)
Altruistic \times Handicap	-0.120 (0.081)	
Altruistic \times Generosity		0.079** (0.035)
Other nudges	0.034 (0.039)	0.031 (0.040)
Linear combination test		
Altruistic + Altruistic \times Handicap	0.079 (0.063)	
Altruistic + Altruistic \times Most generous		0.280*** (0.088)
Covariates	X	X
Num.Obs.	797	797
R2	0.136	0.150

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. Robust standard errors are in parentheses. We exclude from the sample those assigned to MHLW (control), The reference group is MHLW (Age). Covariate “Other nudges” is a dummy that indicating respondents are assigned to the Selfish, Social Comparison, Deadline, and Convenient message group. Covariate “Handicap” is a dummy that respondent knows that infants born to infected pregnant women may have disabilities. Covariates “Generosity” indicates on a 5-point scale the degree to which respondent feels pleasure in actions for others. Respondents who give a score of 5 to this are the most generous. Covariates are age, education year, annual income, usual health behavior (exercise, medical checkup and full shot habit) and preference for compliance with social norm.

Table 17: Number of Anitbody Testing, Negatives, and Vaccinations in Default Incentive Group

Text message	Sample size	Anitbody test		Negatives			Vaccination		
		N	% of sample	N	% of test	% of sample	N	% of negatives	% of sample
MHLW (Control)	115	4	3.5	1	25.0	0.9	1	100.0	0.9
MHLW (Age)	119	8	6.7	2	25.0	1.7	2	100.0	1.7
Altruistic	128	14	10.9	7	50.0	5.5	6	85.7	4.7
Selfish	111	10	9.0	3	30.0	2.7	3	100.0	2.7
Social Comparison	103	9	8.7	5	55.6	4.9	5	100.0	4.9
Deadline	118	5	4.2	1	20.0	0.8	1	100.0	0.8
Convenient	111	8	7.2	5	62.5	4.5	3	60.0	2.7

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