The Good Outcomes of Bad News.

A Randomized Field Experiment on Formatting Breast Cancer Screening Invitations*

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Abstract

We ran a randomized field experiment to ascertain whether a costless manipulation of the informational content (restricted or enhanced information) and the framing (gain or loss framing) of the invitation letter to the breast cancer screening program of the Province of Messina (Sicily) affects the take-up rate. We show that giving enhanced loss-framed information about the risks of not having a mammography increases the take-up rate by 25 percent with respect to the control group. The other treatments are instead ineffective. The effect is stronger for subjects living farther away from the screening site, in spite of longer travel time.

Keywords: breast cancer screening, nudging, randomized field experiment.

JEL codes: C93, H51, I11, I18.

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"An ounce of prevention is worth a pound of cure"

Benjamin Franklin

1. Introduction

Cancer is the second-greatest cause of death globally. In 2015, 8.8 million deaths were due to cancer, making it responsible for about 1 in 6 deaths (World Health Organization – WHO 2017). Among women, breast cancer is the most common neoplastic disease worldwide and the second most common cause of cancer mortality in developed countries (International Agency for Research on Cancer – IARC 2012). In addition, breast cancer is associated with very high costs for national health care systems. Overall, spending for breast cancer alone typically amounts to about 0.5-0.6 percent of the total health care expenditure of developed countries (Organization for Economic Co-operation and Development - OECD 2009).

Primary prevention and early detection through screening programs, improved awareness, and early clinical diagnosis are among the key components of cancer control, which in turn can lead to a decrease in cancer incidence and mortality. Screening programs have proved to be particularly effective in increasing cancer detection (Bleyer *et al.* 2012) and reducing mortality for breast cancer.[1] For women aged 50-69, having a mammography every two years can lower the risk of dying through breast cancer by up to 40 percent, equivalent to 8 deaths prevented per 1,000 screened women (Lauby-Secretan *et al*. 2015). This measure is also highly cost-effective (Cutler 2008, Moore *et al*. 2009). Hence, it is not surprising that many countries have

[1]Bitler and Carpenter (2016) study the state health insurance mandates requiring coverage of screening mammograms, and show that mammography mandates significantly increased screenings and, in turn, cancer detection. Kim and Lee (2017), investigate cost sharing in Korea's National Cancer Screening Program, which provides free screenings to those with an income below a certain cutoff. While take-up and cancer detection increase, compliers are less likely to have cancer than never takers, and the increase in cancer detection is crowded out by cancer detection through other channels. Overall, the program has no effect on cancer mortality. From a different perspective, Banerjee and Zanella (2016) find that having a co-worker diagnosed with breast cancer decreases women's own screening probability.

introduced publicly-financed screening programs. For instance, in 2003 the European Council recommended population-based screening for women aged 50–69 years, with a target coverage rate of 75%. As of March 2014, screening programs based on EU indications were active in almost all the EU28 member states, although screening rates were still below the EU target rate in many states (Altobelli and Lattanzi 2014).

In Italy, the country of interest for this study, the national breast cancer screening program has been included in the Basic Healthcare Parameters (Livelli Essenziali di Assistenza). It provides free breast cancer screening every two years to all women aged 50-69. Despite the efforts of the Italian NHS to promote the screening program, attendance rates are still relatively low (the average is 53%) and exhibit a marked North-South gradient.

Low attendance is rather puzzling, given that mammographies are offered free of charge, and their effectiveness is well established by now. Medical literature has identified the lack of knowledge about the disease and about the risks related to non-participation, as well as organizational barriers (e.g., screening invitations during working hours or the need to reach a screening center located far away) as relevant factors that may hamper participation (Altobelli and Lattanzi 2014, James *et al.* 2006).

In this study, we developed a field experiment to shed some light on the effectiveness of policies aimed at increasing the take-up rate for breast cancer screening at a low cost. We ran our experiment in the Province of Messina, Sicily. The Messina Local Health Authority (LHA) has only recently implemented a population-level breast cancer screening program. The program started with a pilot in 2014, and was scaled up to reach population-level coverage by 2015, allowing all women aged 50-69 who are resident in the Province to have a free mammography every two years. Take-up rates have been very low since its very beginning. Of those invited for screening, less than 15 percent of subjects took part in it. To improve upon this unsatisfactory outcome, in 2016 we teamed up with the Local Health Authority (LHA) of Messina to design and experimentally evaluate a set of policies aimed at increasing take-up rates at zero cost, by manipulating the content of the invitation letter.

The available empirical evidence shows that the use of invitation letters and reminders sent to women at their homes increases take-up rates for breast cancer screening (Baron *et al*. 2008, Carrieri and Wuebker 2016). However, knowing which specific elements of the invitation letters affect take-up rates is very relevant for health policy makers. This would enable tailoring interventions to induce the participation of more women in the screening programs. Most notably, sending invitation letters with a different content would be at (almost) zero cost for the existing health care systems (Sunstein 2014, Purnell *et al.* 2015).

The design of our experiment is grounded in two strands of behavioral economics literature: "nudging" and "gain-loss framing". Nudging has recently received considerable attention from economists and policy makers, as witnessed by the awarding of the 2017 Nobel Prize to Richard Thaler. A “nudge” can be defined as “any aspect of the choice architecture that alters people’s behavior in a predictable way without forbidding any options or significantly changing their economic incentives” (Thaler and Sunstein 2008). A possible form of nudging is “information disclosure”, that is giving individuals enhanced information about the choice they need to make and the possible consequences of their choices (Sunstein 2014). There is evidence that information disclosure as a form of nudging can improve school choice (Hastings and Weinstein 2008, Hussein 2013, McGuigan *et al.* 2016, Ehlert *et al.* 2017), increase healthy eating (Wisdom *et al.*, 2010), energy efficiency (Newell and Siikamäki 2014), tax compliance (Bott *et al.*, 2017), and discourage expensive borrowing behavior (Bertrand and Morse 2011).

The "gain-loss framing" theory has been the object of debate over the last two decades. On the basis of Prospect Theory (Tversky and Kahneman 1981), the seminal paper of Rothman and Salovey (1997) put forward the hypothesis that different levels of risk or uncertainty are involved in different health behaviors, such as prevention (i.e. vaccines) and detection (i.e. cancer screening). Prevention behaviors are perceived as relatively non risky since they help in maintaining good health (a *gain*), while detection behaviors serve to identify illnesses (a *loss*) and therefore they are perceived as relatively risky. According to Prospect Theory, individuals are risk-averse when they consider gains, and risk-seekers when considering losses. Therefore, gain-framed messages are hypothesized to be more effective at promoting prevention behaviors and loss-framed messages at promoting detection behaviors.

On these bases, we hypothesize that invitation letters containing a loss-framed message with enhanced information about the consequences of not taking part in the program be more effective at increasing take-up rates than letters with a gain-framed content or with restricted informational content. We test this prediction empirically by comparing the take-up rates of four different treatments: gain or loss framed messages with enhanced or restricted information, compared with a baseline of no information.

To experimentally assign women to the different treatment groups, we make use of the random allocation of subjects in the Messina screening program based on the date of having the mammography. Every year, eligible women are invited to have a mammography at the health care center serving the health district of residence. There are five health care centers in the Province, serving eight health districts; annually these health care centers offer sufficient mammography appointment slots for the target population. Slots are distributed throughout the year and the LHA invites eligible women to have a mammography on an available date. Importantly for our purposes, patients are randomly assigned to screening dates by the LHA computer system. As shown in Figure 1, our manipulations affected women invited for screening during the 7^{th} to 11^{th} week of 2017, the dates being from February 13 to March 19. We sent a different invitation letter to women for each week. For the rest of the year, a standard letter similar to our baseline was used. Successful random assignment is achieved for the invitations sent in different weeks. In fact, women invited in different weeks are balanced in terms of a comprehensive set of pre-determined characteristics. Random allocation of subjects to treatment groups grants a causal interpretation of the differences in take-up rates in terms of average treatment effects of the different manipulations.

Our data comes from the administrative archives of Messina's LHA and of the mail company managing the delivery of the invitation letters. From the former, we obtained information on: screening take-up (our outcome), the hospital providing the screening, subjects' demographic information, and previous screening experience. From the mail management company, we gathered data on: the date of invitation (and hence on treatment status), and on subjects' home addresses. From this, we could compute home-hospital travel time. We observe a total of 6,194 subjects evenly distributed among the five weeks of our experiment.

Overall, the empirical results provide evidence in favor of our hypothesis. In fact, the take-up rate in the group that received the letter combining the loss frame with enhanced information on the negative consequences of not taking the mammography is close to 2.5 percentage points higher than in the baseline group. This is a sizeable effect, as it corresponds to 25% of the take-up rate in the baseline group (9.9%). Importantly, this effect appears to be particularly relevant for subjects living farther away from the screening sites, a group that has been identified by the literature as having a high risk of non-participation (Altobelli and Lattanzi 2014). On the contrary, we do not detect any significant difference in take-up rate among other treatments.

Our results are robust to several specification tests. In particular, as our treatment varies by week, we provide evidence against the hypothesis that our findings could be attributed to seasonality in screening behavior. We do so by showing that there were no differences in screening take-up rates during the same weeks of the experiment in the years before 2017, when all subjects received the same invitation letter. We also provide evidence supporting the idea that potential confounding factors that are specific to a given treatment week (such as the presence of concurring campaigns or policies concerning breast cancer screening) cannot explain differences in take up rates. Additionally, the statistical significance of the estimated effect is confirmed even when we take into account the problem of multiple testing.

Our contribution to the literature is twofold. First, as far as we know, no other study analyzes how the framing of the invitation letter interacts with its informational content to induce a subject to participate in a screening program. According to our results, the simple use of a loss frame or the simple provision of additional positively framed information does not enhance mammography take-ups. Instead, extensively listing the potential negative consequences of not taking the mammography is what really matters to trigger participation. Second, important methodological aspects distinguish our contribution from most existing studies on framing and information provision effects on breast cancer screening take-up. On the one hand, while most of the literature focuses on small-scale experiments involving specific samples of individuals - such as young college students - our population-level randomized field experiment targets the whole population of women participating in the national breast screening program in a geographical area. On the other hand, instead of relying on self-reported measures of perceived importance of screening, future screening intentions, or recall data about mammography attendance - as done by most existing studies - the *actual* decision of women to have a mammography, derived from administrative data, is the outcome variable used in our analysis.

The remainder of the paper unfolds as follows. Section 2 provides a review of the relevant literature. Section 3 presents the institutional context and Section

4 describes our experimental design. Our data and empirical methodology are presented in Sections 5 and 6, respectively. We describe our results in Section 7, followed by our conclusions.

2. Background literature

Our work is broadly related to two areas of research in behavioral economics: "nudging" and "gain-loss framing". In recent years both public and private institutions have shown a growing interest in the use of "nudges" to induce individuals to make choices which can increase their wellbeing. Thaler and Sunstein (2008) have been the first to propose "nudging" as a strategy to influence behaviors. They define a nudge as "any aspect of the choice architecture that alters people's behavior in a predictable way without forbidding any options or significantly changing their economic incentives". When considering healthy eating, for instance, "putting fruit at eye level counts as a nudge. Banning junk food does not" (Thaler and Sunstein 2008).[2] Policies based on nudging can span a wide range. They include, for instance, setting "default rules" (e.g. automatic enrolment in programs), making "healthy" choices more easy and convenient (e.g. making healthy food more visible), and exploiting social norms (e.g. informing individuals that most people are already engaged in the behavior the policy makers wish to promote). One of the possible forms of nudging is "information disclosure", that is, providing individuals with more information about the choice they need to make (e.g., about products, health plans, health behaviors, etc.) and the possible consequences of their choices (Sunstein 2014). Empirical evidence on the importance of information disclosure on individuals' ability to make "better" choices has been documented in many economic fields, including school choice (see Hastings and Weistein 2008, Hussein2013, McGuigan *et al*. 2016, Ehlert *et al*. 2017), the consumption

[2] Policies based on nudging have been proved as effective in the domains of financial choices (Madrian and Shea 2001, Choi *et al*. 2004, Bertrand and Morse 2011), pro-environmental behaviors (Pichert and Katsikopoulosa 2008, Egebark and Ekström 2016), charity donations (Croson and Shang 2008) and health related behaviors (Johnson and Goldstein 2003, Wisdom *et al*. 2010, Hanks *et al*. 2012, Altmann and Traxler 2014).

of junk food (Wisdom *et al.* 2010), borrowing money (Bertrand and Morse 2011), and energy efficiency investments (Newell and Siikamäki 2014).[3]

The second strand of literature related to our study concerns gain-loss framing in choices. Decades of research have highlighted that individual choices are affected not only by the provision of information but also by the way such information is framed. Individuals can be sensitive to whether an alternative is framed in terms of its associated costs (*loss* frame) or benefits (*gain* frame) (Tversky and Kahneman 1981). To account for this shift of preferences, Prospect Theory proposes that people take more risks when they evaluate options in terms of associated costs, whilst they are more risk adverse when the same options are described in terms of associated benefits.[4] Evidence in favor of the "gain-loss" framing effect has been provided in several field of economics, for instance, with regard to consumption of private goods (Levin and Gaeth 1988), cooperation games and provision of public goods (Andreoni 1995, Rage and Telle 2004) and environmentally sustainable behaviors (Cheng 2011).

Extending the logic of Prospect Theory to the domain of health persuasion, Rothman and Salovey (1997) (also see Rothman *et al*. 2006) contend that different levels of risk or uncertainty are involved in different health behaviors. They make a primary distinction between prevention and detection behaviors: "A behavior can prevent the onset of a health problem (e.g., condoms can prevent the spread of sexually transmitted diseases), [or] it can detect the development of a health problem (e.g., mammography can detect a potentially cancerous tumor)." Prevention behaviors are perceived as relatively non-risky since they help in maintaining good health (a *gain*), but on the other

[3] Still, some empirical studies have shown that information overload discourages cancer prevention and detection behaviors (Jensen *et al*. 2014a).

[4]For example, if people have to choose between two treatment programs concerning the number of lives that will be lost, they are quite risk-takers if they are asked about avoiding a certain loss. However, if the same program is described in terms of the number of lives that will be saved, individuals are more risk-adverse.

hand, detection behaviors serve to identify illnesses (a *loss*) and therefore they are perceived as relatively risky. On the basis of this difference, gain-framed messages are hypothesized to be more effective at promoting prevention behaviors and loss-framed messages at promoting detection behaviors. Several studies have provided evidence in favor of this hypothesis. Gain-framed messages have been shown to help in increasing the prevention behaviors such as walking and exercising (Latimer *et al*. 2008, Northoff and Carstensen 2014, Mikels *et al*. 2016. O'Keefe and Jensen 2007 provide a meta-analytic review). However, loss-framed messages appear to be more effective than gain-framed ones in advocating breast cancer detection behaviors (see O'Keefe and Jensen 2009 for a meta-analytic review). For instance, in a seminal paper on the topic, Meyerowitz and Chaiken (1987) show that – among 90 female college students – those exposed to loss-framed messages were more motivated to perform breast self-examinations than the ones exposed to gain-framed messages. Similarly, by using a sample of 130 women aged 40+, Banks *et al*. (1995) show that exposure to loss-framed videos on breast cancer screening is more effective than exposure to gain-framed videos at enhancing self-reported mammography utilization measured 12 months after the intervention took place. Analogous experiments with similar findings have been carried out, such as that by Cox and Cox (2001) and Schneider *et al*. (2001) while more mixed findings are provided – among others – by Finney and Iannotti (2001), who sent differently framed reminder letters to 900 women involved in a breast cancer screening program in Indiana and Ohio.[5]

Two recent papers are especially close to ours in terms of the research question and the methodology adopted. First, Goldzahl, Hollard and Jusot (2017) test four manipulations of the invitation letter to a breast cancer

[5]Additionally, recent evidence shows that message framing effects can depend on the characteristics of the message recipient, which act as moderator variables (van't Riet *et al*. 2008, Zhao *et al*. 2012, van't Riet *et al*. 2014, Wansink and Pope 2014, van't Riet *et al*. 2016, Jensen *et al*. 2017).

screening program in two French departments: *i.* a new logo on the envelope; *ii.* patient-approved clarity in the letter's content; *iii,* a combination of the two previous treatments; *iv,* information on the number of women receiving mammograms in the recipient's area of residence. The authors find no significant effect on take-up rate. Second, Bourmand *et al* (2016) assessed the effect of providing a 12-page information leaflet on take-up rate for breast cancer screening on a randomly selected sample of French women, and also found no significant effect on take-up rate.

The manipulations of the invitation letters designed in the aforementioned studies are very different from ours. Specifically, they do not consider the role played by the *interaction* of framing and information provision, that we consider to be the main contribution of this paper. In fact, combining the evidence from the two strands of literature reviewed, we expect that invitation letters with enhanced information about the consequences of not taking part in the program - that is, containing a loss-framed message - are more effective at increasing take-up rates than letters with a restricted informational or a gain-framed content.

3. Institutional context

3.1. Breast cancer and screening programs

Breast cancer is the most widespread neoplastic disease among women in the world, with the incidence rate presenting no systematic variation across countries (see Bray *et al*. 2012). Around 1.7 million new cases were diagnosed in 2012, accounting for 25% of all new cancer cases in women (International Agency for Research on Cancer - IARC 2012). In addition, with an estimated number of 521,900 deaths in 2012, breast cancer is the leading cause of cancer death among women in developing countries and the second leading cause of cancer death (following lung cancer) among women in developed countries (American Cancer Society 2015).

Given its social relevance and the consequences for healthcare costs, policy makers and health institutions have devoted substantial effort implementing policy interventions aimed at reducing the death rates for breast cancer. Of course, the design of effective screening programs that conform to internationally accepted standards plays a key role in fighting breast cancer. Nowadays there is robust empirical evidence documenting the advantages of participation in national breast cancer screening programs. Early detection of breast cancer increases the effectiveness of medical treatments and therefore reduces the risk of dying from breast cancer, with this effect ranging between 30% and 40% according to data from modern mammography screening programs (Paci *et al*. 2014, Weedon-Fekjaer *et al*. 2014, Coldman *et al*. 2014, Lauby-Secretan *et al*. 2015, Fang and Wang 2015).

EU member states have endorsed a number of recommendations to guarantee high quality standards with implementing and administering nationwide breast cancer screening programs. In line with two specific resolutions of the European Parliament (European Parliament, 2003, 2006) in the field of prevention, diagnosis and treatment of breast cancer screening, programs should satisfy four main requirements:

i) Breast cancer screening must be offered as a public health program to women aged between 50 and 69, encouraging them to have a mammography every two years;[6]

ii) The invitation letter sent to targeted women must provide information about the aims of the screening program, the screening interval, the potential benefits of breast screening, possible monetary

[6] The specific age range targeted by the screening programs is motivated by the fact that, as empirically observed, risk of breast cancer increases with age, with a cumulative incidence among women in Europe and North America of about 2.7% by age 55, 5.0% by age 65, and 7.7% by age 75 (Key *et al.*, 2001). According to estimates based on data between 2008 and 2013 (see Italian Association for Medical Oncology - AIOM 2017), the probability of breast cancer in Italy is 2.4% up to 49 years (1 out of 42 women), 5.5% between 50 and 69 years (1 out of 18 women), and 4.7% between 70 and 84 years (1 out of 21 women).

charges to the participant, how to change the appointment, obtain the medical report and interpret results;

iii) Mammographies conforming to accepted protocols and clinical standards must be carried out by qualified radiologists using modern dedicated X-ray equipment and appropriate image receptors;[7]

iv) In order to increase the precision of breast screening tests and limit the risk of false positive/negative results, medical reports must be based on a double reading procedure in which two radiologists independently carry out their assessments.

The organization of the national public breast cancer screening program in Italy according to the European guidelines has been promoted by the Decree Law n. 81 (March 29, 2004) and the Law n. 138 (May 26, 2004) and it has been defined through a series of State-Region agreements. By these dispositions, LHAs are responsible for the implementation of the national breast cancer screening program. This includes the administration of the screening program, the invitation of targeted women, the organization of training activities for radiologists and medical staff involved in the program, and the periodic evaluation of the results of the screening program. However, the need to comply with the EU guidelines assures that the quality of the screening service provided is the same irrespectively of the quality standards offered by each local health care center for other health care services.

Despite the potential benefits of participating in the national breast cancer screening program, women's participation, or lack of, still represents an important issue. In Italy, between 2013 and 2016 only 53.5% of women aged 50-69 had a mammography within the national breast cancer screening program (Italian National Health Institute - ISS 2017), with northern regions being the best performers and southern regions being associated with the lowest coverage

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[7] In order to ascertain his/her qualification, a radiologist is required to evaluate a minimum of 5,000 screening cases per year and participate in specific training programs.

(the highest and lowest average take-up rates are respectively recorded in the Province of Trento – 77% – and in Campania – 21%).

3.2. The national breast cancer screening program in the Province of Messina

We ran our field experiment in the Province of Messina, located in the north-east of Sicily. It includes 107 municipalities with a resident population of 636,653 individuals (306,911 males and 329,742 females, ISTAT, 2017), distributed over a geographical area of about 3,247 km^2. The female population aged between 50 and 69, actively targeted by the screening program, comprises 92,048 individuals.

Starting with a pilot study in 2014 and reaching population-level coverage in 2015, the Messina LHA has implemented the national breast cancer screening program by inviting all women aged 50-69 living in the Province to have a free mammography every two years. The Province of Messina is divided into eight public health districts, and five health care centers (hospitals and clinics) offer this screening program, all satisfying the main quality and procedural requirements imposed by the European guidelines described in the previous section.[8] Health districts are assigned to one of the centers according to geographical proximity.[9] Figure 2 shows the boundaries of the eight health districts in the Province of Messina and the geographical localization of the five health care centers involved in the national breast cancer screening program.

[8] The eight districts are: the city of Messina, Taormina, Milazzo, Lipari, Barcellona Pozzo di Gotto, Patti, Mistretta, Sant'Agata Militello.

[9] Specifically, the Ospedale "San Vincenzo" in Taormina, the Poliambulatorio in Messina, and the Ospedale "Barone Romeo" in Patti serve the targeted population in the corresponding districts; the Presidio Ospedaliero in Sant'Agata Militello serves the districts of Sant'Agata Militello and Mistretta; the Presidio Ospedaliero "G. Fogliani" in Milazzo serves the districts of Milazzo, Barcellona Pozzo di Gotto and Lipari.

The screening unit of the Messina LHA is responsible for inviting the targeted women to take part in the breast cancer screening program, which in turn includes the following main activities:

i) Defining the target population. The screening unit collects the relevant information about all women that, at the beginning of the year, are aged 50-69, reside in the Province of Messina, and have not had a mammography in the previous year;

ii) Scheduling the mammographies. The unit collects the time slots that the health care centers can devote to the screening program, guaranteeing that there are enough slots to cover the entire targeted population in the district for that year. Then each participant is randomly assigned to one of the time slots made available by the health care center serving her district of residence;

iii) Preparing and sending the invitation letter. The invitation letter describes how the national breast cancer screening program works and the advantages of participating in it. In addition, it contains all the necessary information about their scheduled appointment, including date and time of the mammography, as well as the address of the health care center where the mammography will be undergone. The letter also contains information on how to change the date and time of the mammography – if needed. Letters are sent to the (postal) address of each woman through professional mail services.

In spite of the financial and organizational effort of the LHA of Messina, as well as of the high quality of the health care centers, the participation rate in the national breast cancer screening program in the Province of Messina has been very low. Of all the invited women, only 14.7%, and 13.3% had a mammography within the national breast cancer screening program in 2015 and in 2016, respectively. Hence, we are purposively focusing our attention on an area with a very low participation rate, where the need and margins to improve take up rates are higher.

4. The experimental design and procedures

4.1. The invitation letters

Our field experiment aims to assess the effects of specific manipulations of the invitation letter format on the participation rate of targeted women in the national breast cancer screening program in the Province of Messina. In designing our experiment, we actively collaborated with the screening unit to modify the wording of the invitation letter while always satisfying the main requirements imposed by the European guidelines, as described in the previous section.

The baseline version of the invitation letter includes two pages, and we provide an example of this, as used in our experiment, in the Appendix. On the first page, after briefly introducing the national breast cancer screening program as offered in Messina, the invitee finds all the information about the date, time and venue of the mammography, as well as other useful information to attend the mammography and, if needed, to change the date and time of the appointment. The first page also carries the letterhead and the address of the LHA of Messina, as well as other information about the institutions in charge of implementing the program in question. The second page contains a short description of the aims of the national screening program, as well as the usual form required by the Italian law for the processing of personal data. The patient must sign and hand in this form when attending the mammography.

Our baseline invitation letter contains no information on the consequences of screening. We used this during the first week of our experiment. Over the following four weeks, we employed a 2x2 design and manipulated the invitation letter by changing the brief introduction and description of the national breast cancer screening program offered for Messina along two dimensions:

i) The *framing*: either *gain-framed*, by pointing out the potential benefits of participating in the national breast cancer screening program, or *loss-framed*, by emphasizing the potential negative consequences of not taking the mammography;

ii) Including *enhanced* or *restricted information* about the potential benefits (negative consequences) of participating/not participating in the national breast cancer screening program;

The paragraphs of the invitation letters that have been manipulated in our design are reported in Table 1. It is worth noting that the information provided in the "Enhanced" treatments contains general statements on the potential advantages/disadvantages of participating/not participating in the national breast cancer screening program that do not require any specific medical knowledge to be understood.

4.2. Procedures

Our experiment focuses on the invitation letters sent to women targeted for mammography slots during working days of the five consecutive weeks, from February 13 to March 19 (weeks 7-11 of 2017). Each week was associated with a specific version of the invitation letter, with all invitations in the same week receiving the same letter format. Once women were assigned to the mammography slots, the screening unit gave the lists with names, tax codes and addresses, as well as the instructions about which letter format to send, to a professional private mail company. Finally, this mail company sent these invitation letters to the targeted women three weeks before the assigned appointments, thus keeping a fixed time interval between the invitation dispatch and the screening date. As discussed above, Figure 1 shows the order in which the five versions of the invitation letters were sent to targeted women, together with the weeks of the corresponding mammographies.

5. The Data

Our data came from two administrative sources. From the administrative archives of Messina's LHA we obtained: the date of birth, whether the woman had undergone a mammography scan in the public health system between January 2014 and June 2016 (as a consequence of previous screening invitations in the 2014 pilot or in the population-level program started in 2015, or due to a GP prescription), whether she had already been invited to have a mammography in the LHA screening program in previous years (either in the 2014 pilot or in the population-level program started in 2015), the allotted health care center and actual screening take-up after the invitation – our outcome. Secondly, we used the unique national tax number (*codice fiscale*) to merge this information with the administrative archive of the mail company that managed the delivery of the invitation letters. This archive contains information on the date of the invitation (and hence on the treatment status), home address and whether the letter was sent by regular or express mail. Although the latter was the default option, some remote areas of the Province of Messina are not covered by express mail services. In those instances, regular mail was the only feasible option.[10] We also used home and health care center addresses to compute home-hospital travel time.[11] In total, we used data for 6,194 women.[12]

We report the allocation of subjects in our sample among the various treatment groups in Table 2, and show descriptive statistics for the other variables used in the analysis in Table 3. Table 2 shows that by design the sample is evenly distributed across the five treatment groups. Table 3 reveals

[10] As shown in Table 4 below, the distribution of delivery by express mail is balanced across treatment groups. Additionally, data on actual letter delivery is not available.

[11] We compute travel time by car under standard traffic conditions by using the *georoute* routine for STATA.

[12] This corresponds to 95% of the full population involved in the screening program during the experimental weeks. For the remaining group (347 observations), either we cannot merge the two data sources because of reporting errors in the individual identifier (77 observations), or there are missing data in the variables used in the analysis (207 observations). Since the distribution of travel time has a long right tail, we also drop outliers in terms of travel time (the top 1% – 63 observations). Results are unaltered if we do include these observations. Subjects with missing data and travel time outliers are evenly distributed across treatment groups (the p-value of a test for joint equality of prevalence among treatments is 0.54).

that, on average, only a small fraction of subjects actually chose to take part in the screening program, as only 10.4 percent of subjects showed up for the mammography after receiving the invitation. Similarly, only 13.6 percent of subjects had previously undergone a mammography in the public health system between January 2014 and June 2016, when we started to engage with the LHA. This is in spite of the fact that, given the population-level coverage of the LHA's screening program, close to 95 percent of all subjects in our sample had already been invited to the screening in previous years, with the rest is likely to have being excluded either because they were too young to be invited before or because they had recently moved from other LHAs. The average year of birth is 1958 (so the average age is 59), close to 85 percent of the subjects received the invitation letter via express mail, and the average home-hospital travel time is about 27 minutes. The distribution of travel time – reported in Appendix Figure 1 – is skewed to the left, with a long right tail including people living in remote rural areas of the Province or on the Aeolian Islands. The median travel time is much lower than the mean (almost 7 minutes lower). Therefore, all analyses that involve travel time as the outcome focus on the median instead of the mean, as the former is less sensitive than the latter to the presence of outliers. Finally, the largest fraction of women in our sample was invited to have their mammography at health care center 5.[13]

6. Empirical Methodology

We use the following regression model:

$$Screened_i = \alpha + \beta_1 RestrictedGain_i + \beta_2 RestrictedLoss_i + \quad (1)$$

$$+\beta_3 EnhancedGain_i + \beta_4 EnhancedLoss_i + \gamma X_i + \varepsilon_i$$

[13] Health care center names have been anonymized for confidentiality reasons. We take health care center 1 as the omitted reference category in all analyses. It is worth remembering that women are invited to take the screening in the hospital of the district of residence, and that all hospitals follow the same scanning protocol.

where the index i stands for the individual, and the outcome is a dummy variable equal to 1 if the subject takes part in the screening program, and to 0 otherwise. We regress this variable on a constant, a set of four dummy variables for belonging to each treatment group and the covariates in vector X, that include: a dummy equal to 1 if the subject received an invitation to have a mammography within the LHA's screening program between January 2014 and June 2016 and to 0 otherwise; a dummy equal to 1 if the woman had a mammography in the public health system between January 2014 and June 2016 and to 0 otherwise; year of birth fixed effects; a dummy equal to 1 for letter delivery via express mail and to 0 for regular mail; fixed effects for the health care center where the subject is invited to have the mammography; home-hospital travel time.

In Equation (1), the constant identifies the mean outcome (screening prevalence) for the baseline group. Given randomization, the coefficient β_j, $j=1, ..., 4$, associated to each of the treatment indicators identifies the average treatment effect on screening prevalence of each manipulation with respect to the baseline.

In Table 4 we provide evidence in favor of successful randomization by reporting the mean (median for travel time) by treatment group of each of the covariates listed in Table 3. The last column reports the p-value of a joint test of equality in means (medians for travel time) among treatments. The distribution of covariates is comparable among treatments, suggesting that randomization worked well. This is confirmed by the p-values reported in the last column, that are always above 0.1.[14]

The evidence regarding balancing presented in Table 4 suggests that the inclusion of covariates in vector X shall not affect the estimation of the treatment

[14] We also estimated a multinomial logit model for predicting treatment group on the basis of the covariates in vector X. The pseudo R-squared of the model is equal to 0.0012 and the correlation between actual and predicted treatment status is also close to zero, reinforcing the evidence on balancing shown in Table 4.

effects of each manipulation, but may still be useful to increase precision. We verify this by estimating Equation (1) both with and without controls.

Since we are analyzing a binary dependent variable, we estimate Equation (1) using both a logit model and a linear probability model (i.e. using Ordinary Least Squares, OLS).[15] We always estimate standard errors that are robust to the presence of heteroscedasticity.

7. Results

7.1. Main results

Table 5 reports average marginal effects on screening prevalence of each treatment with respect to the baseline. We estimate Equation (1) with logit (Columns 1 and 2) and linear probability (Columns 3 and 4) models, with (Columns 2 and 4) and without (Columns 1 and 3) the inclusion of the covariates in vector *X*. As a benchmark, in the last line of the table we also report the mean outcome in the baseline group.

The main result is that receiving a letter with enhanced information content that is loss-framed to highlight the risks related to the decision of not taking part in the screening program increases participation with respect to the control group by 2.3 to 2.8 percentage points, depending on the specification. Compared to the prevalence of screening in the baseline group – equal to 9.9 percentage points – this effect is equivalent to a 23 to 28 percent increase, a very pronounced one.[16] On the other hand, none of the other manipulations deliver significant effects.[17] Finally, as expected, the inclusion of covariates and the

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[15] The linear probability model that does not include covariates in vector *X* delivers simple estimates of mean-comparisons of the outcome among the various treatments.

[16] For the logit specifications, we can also express these estimated effects in terms of odds-ratios, as commonly done in epidemiology. When we do so, we get an effect of 1.318 and 1.316 for the models without and with covariates, respectively, suggesting that subjects exposed to the "enhanced-loss" manipulation are close to 32 percent more likely to participate in the program than subjects in the control group.

[17] In Appendix Table A1 we report the estimated differential effects between the "Enhanced - Loss" manipulation and all of the other ones, and show that the former leads to significantly higher screening rates compared with any of the latter.

choice of different estimation methods do not alter estimation outcomes in a relevant way.

7.2. Threats to identification

Our experiment compares the outcomes of five treatment groups to which subjects were randomly allocated. Still, for feasibility reasons, each group received an invitation to take the screening in a different week: the 7th to 11th weeks of the year. Although these are five consecutive weeks, it could still be that the observed differences in screening rates among treatment groups are due to seasonality in screening behavior, that would have been present even if all subjects had received the same letter.

To provide evidence against this hypothesis, we compare the take-up rate of the screening program in the Province of Messina for the two years before our manipulation – 2015 and 2016 – among subjects who were invited to take the screening in the same week of the year as subjects in each of the treatment groups of our experiment.[18] While the timing of the invitation was selected in the same way across all years, in the previous years all subjects received the same invitation letter, comparable to our baseline invitation letter. Therefore, detecting a treatment effect in the 11th week of the year in the years before 2017 would be evidence in favor of seasonality and against a treatment effect. Table 6 compares the estimates of Equation (1) obtained from logit models without controls for the weeks 7th to 11th of 2015, 2016 and 2017, and shows that no significant pattern can be detected in years before 2017, when our manipulations were not active, supporting a causal interpretation of our main results for 2017.[19]

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[18] There is no data available before 2014, as the screening program started in that year. We omit 2014 as only a pilot study was implemented in that year.

[19] Covariates are not available in the data for years before 2017. Results using linear probability models are fully comparable and available from the authors. The different number of observations between years is due to the changes in weekly availability of mammography slots across the years.

Although we had verified ex-ante that our experimental period included no special festivities or public holiday, an additional concern for identification is the presence of confounding factors that are specific to a given treatment week and can affect take-up rates, as all subjects invited in a given week received the same letter. For instance, every October the major breast cancer charities organize the "Breast cancer awareness month", and advertise participation to breast cancer screening programs. Had we selected a treatment week in the month of October, this initiative would have confounded identification of our treatment effects.

We provide indirect evidence that it is unlikely that subjects invited to take a mammography in different weeks were exposed to different concurring campaigns or policies concerning breast cancer screening in Figure 3. We report the results of Google trend searches (see D'Amuri and Marcucci, 2017) for the keywords "breast cancer" and "mammography" ("*tumore alla mammella*" and "*mammografia*") for the whole Sicily (no finer geographic disaggregation is possible) for the period between the dispatch of the first invitation letters – three weeks before the first treatment week – and the last treatment week. If there was any concurring campaign active in a specific week but not in the others, then we would expect to find different trends in Google searches among weeks. Still, Figure 3 shows that there is no clear different search pattern by week, dispelling this concern.[20]

We have also investigated two additional potential week-specific confounding factors. First, Table A2 in the Appendix reports balancing tests like the ones shown in Table 4 for the millimeters of rainfall per day in the municipality of the assigned health care center in the day when the woman was invited to take the mammography. Rainfall data are provided by the *Osservatorio Acque Regione Siciliana*, and are collected by weather stations

[20] Search trends for these keyword for the whole Italy, and even the whole world, are also rather homogeneous over these weeks (results are available from the authors).

placed in the municipalities of interest. On the one hand, rain could decrease the opportunity cost of leisure, increasing the likelihood of screening. On the other hand, it could cause travel difficulties, decreasing participation.[21] Results show that the incidence of rain is close to zero in all weeks but the one when we implemented the "Enhanced – positive" manipulation, when it is close to 5mm/day. Although the difference is significant, 5 mm/day are an insufficient amount of rain to cause disarray. In fact, as shown in Appendix Table A3, all of our estimated effects are wholly unaltered by the inclusion of rainfall among the controls. In addition, the estimated coefficient for rainfall is never significant and always close to zero (see Appendix Table A3). If one believes that rainfall is randomly assigned, this suggests that it has no causal effect on program participation.

Second, a strike organized on March 8th 2017 – a date that falls during the "Enhanced – positive" manipulation week – could also have affected take-up. First, aggregate data from the Ministry of Public Administration[22] for the whole of Italy show that participation in the strike was modest (25 percent of the interested workforce) and mostly concentrated in the school sector. Second, if the strike affected participation in the breast cancer screening program – either because women were involved in the protests or because they were unable to reach the hospital as a consequence of the strike – we would expect to see a sharp drop in participation during that specific day of that week. Yet in Appendix Table A4 we show that the estimated differences in participation across the days of the week interested by the strike are not significant ($p = 0.36$), weakening this concern. In fact, even if we assumed that the take-up rate for the 8th of March was as high as the highest take-up rate during the week (11.7%, for the 9th of March), the weekly take-up rate would have changed only

[21] This might be especially true for the 342 subjects residing in the Aeolian Islands. Still, both the magnitude and the significance of our results is unaltered when we drop these subjects (results are available from the authors).
[22] http://www.funzionepubblica.gov.it/sites/funzionepubblica.gov.it/files/8_marzo_dati_adesione.pdf

marginally, from 10.3% to at 11.1%. Hence, the difference with the take-up rate of the baseline group would have been equal to 1.2 percentage points. Given a standard error of the estimated effect of 1.2 percentage points, this is still below the minimum effect that we can significantly detect in our design.

A final threat to identification in our setup could be the presence of spillover effects. In fact, it could be that women receiving different letters interact with each other and discuss about the differences in the content of the letters. If this was the case, then we would be estimating a lower bound of the true treatment effects. Still, we believe that the likelihood of interactions is rather low, because of the relatively small scale of our intervention. In fact, out of a target population of the program of close to 90,000 women, only 6,000 were invited to take the mammography in the experimental weeks. Hence, each different type of letter was received by less than 1.5 percent of the population of interest, dampening this concern.

7.3. Multiple hypothesis testing

Our empirical analysis compares the effectiveness of four different manipulations with respect to a baseline. Let the family wise error rate (FWER) be the probability of rejecting at least one true null hypothesis, that is, of making at least one type I error. If a single test is performed at the 5% level of confidence and the null hypothesis being tested is true, we expect a 5% chance of incorrectly rejecting it. If N independent tests are simultaneously carried out and all corresponding null hypotheses are true, the probability of at least one incorrect rejection is $1\text{-}0.95^N$. In our case, since $N=4$, this probability is equal to 18.5%, well above the assumed 5%.

List, Shaikh and Xu (2016) have devised a bootstrap-based methodology for testing multiple null hypotheses simultaneously in experimental settings with multiple treatments. This procedure asymptotically controls the FWER and, by incorporating information about dependence ignored in classical multiple testing procedures (Bonferroni and Holm 1979), it has a greater ability to detect truly false null hypotheses.

To verify that the significance of the estimated effect of the "enhanced – loss" manipulation is confirmed even when we account for multiple testing, we apply the List, Shaikh and Xu (2016) method to our data. Focusing on unconditional take-up rate comparisons across treatments and using 1,000 bootstrap iterations we obtain a p-value of 0.082, still below 0.1, confirming the statistical significance of our main empirical result.[23]

7.4. Heterogeneous effects

To gain some insight about the subpopulation mostly affected by our manipulation, we estimate heterogeneous effects by travel time to the hospital. This gives us a useful piece of information when it comes to policy targeting and understanding mechanisms behind our effects.[24] The first four columns of Table 6 reports the outcome of split-sample estimation of Equation (1) between those who have travel times below and above the sample median (close to 20 minutes), using logit models with and without covariates. [25] Results show that the "Enhanced Loss" effect is larger and only statistically significant for the latter group (3.5 vs. 0.8 percentage points in the model with covariates).[26] Unsurprisingly, given that the screening prevalence in the baseline group is smaller among those living farther away from the hospital, the differential effect is even starker in percentage terms (40 percent vs. 7.3 percent in the model with covariates). To test for the significance of the difference between the effects in the two subsamples, we jointly estimate the models using seemingly unrelated estimation. We reject that the two effects are equal with a p-value of 0.08 and

[23] We obtain a p-value below 0.1 even when we increase the number of bootstrap iterations to 10,000 (p = 0.092) and when we apply the Bonferroni and Holm (1979) procedure (p = 0.096).
[24] We have also estimated differential effects by age, but detected no relevant pattern.
[25] Results using linear probability models are fully comparable and available from the authors.
[26] When we include covariates, we find that the effect of the "Enhanced Gain" manipulation is also different with respect to the baseline across travel time. Yet, these effects and differences are only significant at the 10 percent level.

0.09 for the models without and with controls. It appears that for subjects living farther away from the screening site, the manipulation significantly increases the perceived risks of negative outcomes related to non-participation, enough to compensate for the higher travel time and hence trigger participation.

One remaining concern about this finding could be that, as screening centers are located in urban areas, subjects residing farther away from the screening sites come from remote areas and may have lower education, a relevant determinant of screening take-up.[27] If this was the case, our heterogeneous effects by distance could instead be capturing heterogeneities by education of subjects. Although we do not have data on the education of subject in our study, we can still measure the share of inhabitants with at least a high school degree in the municipality of residence of each subject in our sample, using data from the Italian 2011 Population Census. The last two columns of Table 6 show that our results on heterogeneous effects by distance hold even when we include this variable (as well as population density by municipality) among the controls, dispelling this concern.[28]

8. Discussion and conclusion

In this study, we ran a population-level randomized field experiment on about 6,000 women involved in the national breast cancer screening program of the Province of Messina in Sicily. We investigated whether a cost-free manipulation of the framing (gain vs loss) and informational content (restricted or enhanced information) of the program invitation letter, increases take-up rates.

In line with our theoretical predictions, we find that the treatment containing loss framed messages with enhanced information about the negative

[27] For instance, Palència et al., 2010, estimate that in Italy the prevalence of breast cancer screening is 25% higher among women with tertiary education than among women with primary or lower education.

[28] The effect of the “enhanced-loss” manipulation in the full sample is unaltered by the inclusion of these covariates.

consequences of declining a mammography increases the take-up rate significantly of close to 25% with respect to the take-up rate in the control group. The other treatments (restricted gain-framed information, restricted loss-framed information, enhanced gain-framed information) are instead ineffective. A plausible explanation of the estimated effect is that providing negatively framed information on the consequences of the choice enhances salience of the letter and increases the perceived importance of participating in the screening program (akin to a psychological "unpacking" effect, see Van Boven and Epley 2003 and Angelini *et al*, 2017).

We have also found that our estimated effect is stronger for subjects living farther away from the health care centers. Among other factors, women's participation in the screening program is negatively influenced by the distance having to be traveled for the mammography. In fact, it is likely that the trade-off between the cost of having the mammography done, and its potential benefits, will be more relevant for women who have to travel further to the screening sites. For them, a more effective invitation letter format can make them switch from not participating in the breast cancer screening program to having the mammography.

To appreciate the potential effects of our manipulation on survival rates, we carried out some "back of the envelope" calculations.[29] Assuming that screening means prevent the death of 8 out of 1,000 screened women, as estimated by Lauby-Secretan *et al*. (2015), by increasing the take-up rate from 10 to 12.5%, our manipulation would save 10 instead of 8 lives out of 10,000 invited women, increasing the survival rate by 25% at zero cost. Given that the target population for the Province of Messina program is nearly 90,000 women, we estimate that switching to the "enhanced-loss" letter would prevent the deaths of 18 more women as compared to the current situation.

Recent studies (see e.g. Elmore and Fletcher, 2012) highlight that a higher screening rate may not only reduce mortality, but also lead to more cases of

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[29] For confidentiality reasons we could not have access to data on cancer detection or mortality.

over-diagnosis, that is, to cases where *“breast cancers [...] would never have been diagnosed or never caused harm if women had not been screened”* (Lauby-Secretan *et al*. 2015). The available estimates of the phenomenon vary largely and there is not a consensus yet on the most appropriate methodology to quantify this phenomenon (Carter *et al*. 2015; Nelson *et al*. 2016; Houssami, 2017). Still, to the best of our knowledge, the estimated extent of over-diagnosis in Italy is low, as it ranges between 1 and 4.6 percent (see the review by Puliti *et al*. 2012), leading us to consider the phenomenon as negligible for our population of interest.[30]

All things considered, we believe that our study has great relevance not only for economists and other social scientists interested in understanding the behavioral motives that guide investment in health promoting behaviors, but also, and especially, for policy makers keen to design cost-effective screening programs. In particular, the conclusions of our experiment could help to improve the design of the invitation letters for national breast cancer screening programs in order to increase take-up rates at zero cost. For instance, the “European guidelines for quality assurance in breast cancer screening and diagnosis", published by the European Commission in 2006, on p. 390 advise health policy-makers that the invitations to the screening program should be *“positively framed (e.g. 9 out of 10 recalled women are found to be normal rather than 1 out of 10 recalled women will have cancer)”*. Our experimental findings from the Province of Messina, an area with a very low take-up rate, do not lend empirical support to this advice. To ensure that the highest possible take-up rate is achieved, our findings would call for an update of the guidelines, at least for programs implemented in comparable areas with very low take-up rates, where the need to intervene and improve participation is more pressing.

[30] Beckmann *et al*. (2015), and the Independent UK Panel on Breast Cancer Screening (2012) provide additional comparable international evidence. According to Duffy and Parmar (2013), estimates of higher over-diagnosis rates shall be mostly attributed to a short follow-up period and lack of adjustment for lead time (that is, the time between the detection of a disease under the screening program and its usual clinical presentation).

Needless to say, our analysis could be extended in several directions, for instance by examining a different reference population (e.g. by focusing on an area with a higher baseline take-up rate), by studying long-term effects and by combining different treatments. On this latter point, we believe that "tailoring" – i.e. personalizing messages on the basis of the recipients' characteristics (Kreuter *et al*. 2000, Kreuter and Holt 2001), and "narrative based approaches" – that is, using stories about someone else's experience in order to enhance the understanding of the experience described in the message (Hibbard and Peters 2003, Jensen *et al*. 2012, Jensen *et al*. 2014b, Lipku *et al*. 2003) - are two promising strategies, that we leave for future research.

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Tables

Table 1. Manipulations of the invitation letter content: information and framing

	INFORMATION INCLUDED	INFORMATION EXCLUDED
GAIN FRAMING	Treatment “Enhanced - Gain” On page 1: *“Scientific studies demonstrate that participating in breast cancer screening programs can have relevant positive effects on the treatment of an early diagnosed disease: it reduces the mortality rate, allows for less extensive surgeries, more effective treatments, with higher chances of recovery.”* On page 2: “*Scientific evidence demonstrates that an early diagnosis of this cancer can have relevant positive effects on the treatment of the disease. In particular, it has been documented that an early diagnosis of this cancer reduces the mortality rate, allows for less extensive surgeries, more effective treatments, with higher chances of recovery.”*	Treatment “Restricted - Gain” On page 1: *“Scientific studies demonstrate that participating in breast cancer screening programs can have relevant positive effects on the treatment of an early diagnosed disease.”* On page 2: “*Scientific evidence demonstrates that an early diagnosis of this cancer can have relevant positive effects on the treatment of the disease.”*
LOSS FRAMING	Treatment “Enhanced - Loss” On page 1: *“Scientific studies demonstrate that not participating in breast cancer screening programs can have relevant negative effects on the treatment of a lately diagnosed disease: it increases the mortality rate, implies more extensive surgeries, less effective treatments, with lower chances of recovery.”* On page 2: “*Scientific evidence demonstrates that a late diagnosis of this cancer can have relevant negative effects on the treatment of the disease. In particular, it has been documented that a late diagnosis of this cancer increases the mortality rate, implies more extensive surgeries, less effective treatments, with lower chances of recovery.”*	Treatment “Restricted – Loss” On page 1: *“Scientific studies demonstrate that not participating in breast cancer screening programs can have relevant negative effects on the treatment of a lately diagnosed disease.”* On page 2: “*Scientific evidence demonstrates that a late diagnosis of this cancer can have relevant negative effects on the treatment of the disease.”*

Table 2. Allocation of the sample among treatment groups.

Treatment Group	(1) Observations	(2) Percent
Baseline	1,237	19.97%
Restricted - Gain	1,238	19.99%
Restricted - Loss	1,245	20.10%
Enhanced - Gain	1,238	19.99%
Enhanced - Loss	1,236	19.95%
Total	6,194	100%

Table 3. Descriptive statistics.

Variable	(1) Mean	(2) Std. dev.
Outcome:		
Screened	0.104	0.305
Covariates:		
Screened Jan14 - Jun16	0.136	0.343
Invited to screen in previous years	0.922	0.268
Year of birth	1958.1	6.232
Express mail	0.848	0.359
Home-hospital travel time (minutes)	27.76	28.66
Health care center 2	0.309	0.462
Health care center 3	0.120	0.325
Health care center 4	0.132	0.338
Health care center 5	0.345	0.476

Notes: the table reports descriptive statistics for the outcome and covariates used in the analysis. Health care center names have been anonymized for confidentiality reasons. Health care center 1 is the reference group. Number of observations: 6,194.

Table 4. Balancing tests.

	(1) Baseline	(2) Restricted Gain	(3) Restricted Loss	(4) Enhanced Gain	(5) Enhanced Loss	(6) Joint equality (p-value)
Screened Jan14 - Jun16	0.131	0.128	0.137	0.143	0.142	0.71
Invited to screen in previous years	0.928	0.922	0.925	0.921	0.916	0.86
Year of birth	1958.3	1958.2	1957.9	1958.0	1958.2	0.48
Express mail	0.866	0.855	0.841	0.836	0.844	0.58
Home-hospital travel time (median)	19.95	19.64	21.38	20.80	20.63	0.38
Health care center 2	0.301	0.307	0.311	0.317	0.309	0.96
Health care center 3	0.122	0.120	0.120	0.118	0.121	0.99
Health care center 4	0.133	0.133	0.128	0.131	0.133	0.98
Health care center 5	0.347	0.347	0.349	0.342	0.341	0.97

Notes: the table reports the mean (median for travel time) of each variable by treatment group. Column (6) reports the p-value test for joint equality in means (medians for travel time) among treatments. Health care center names have been anonymized for confidentiality reasons. Health care center 1 is the reference group. Number of observations: 6,194.

Table 5. Main results: the effects of framing and enhancing information on the probability of screening.

	(1) Logit	(2) Logit	(3) Linear Probability Model	(4) Linear Probability Model
Restricted - Gain	-0.009	-0.009	-0.008	-0.007
	(0.013)	(0.012)	(0.012)	(0.011)
Restricted - Loss	-0.001	-0.001	-0.001	-0.002
	(0.012)	(0.012)	(0.012)	(0.012)
Enhanced - Gain	0.004	0.001	0.004	0.001
	(0.012)	(0.012)	(0.012)	(0.012)
Enhanced- Loss	0.026	0.023	0.028	0.025
	(0.012)	(0.011)	(0.013)	(0.012)
Covariates	No	Yes	No	Yes
Mean outcome – Baseline group	0.099	0.099	0.099	0.099

Notes: the table reports the average causal effects of each treatment on the probability of screening. Columns (1) and (2) report average marginal effects from logit models, while Column (3) and (4) report those obtained with linear probability models. The covariates included in Columns (2) and (4) are listed in Table 3. The mean outcome for the baseline group is reported in the last line as a benchmark. Number of observations: 6,194. Standard errors robust to the presence of heteroscedasticity reported in parenthesis.

Table 6. Robustness: testing for seasonality.

	(1) 2015	(2) 2016	(3) 2017
Year Week 8 / Restricted - Gain	-0.028	0.002	-0.009
	(0.021)	(0.014)	(0.013)
Year Week 9 / Restricted - Loss	-0.003	0.015	-0.001
	(0.027)	(0.013)	(0.012)
Year Week 10 / Enhanced - Gain	-0.028	-0.005	0.004
	(0.022)	(0.014)	(0.012)
Year Week 11 / Enhanced - Loss	0.004	0.002	0.026
	(0.021)	(0.013)	(0.012)
Observations	3,484	6,094	6,194

Notes: the table reports the average marginal effects on screening rates by week in 2015, 2016 and 2017. The baseline is Year Week 7. Logit models without covariates. Standard errors robust to the presence of heteroscedasticity reported in parenthesis.

Table 7. Heterogeneous effects of framing and enhancing information on take-up probabilities by home-hospital travel time.

	(1) Above median travel time	(2) Below median travel time	(3) Above median travel time	(4) Below median travel time	(5) Above median travel time	(6) Below median travel time
Restricted - Gain	0.006	-0.021	0.010	-0.026	0.010	-0.025
	(0.019)	(0.017)	(0.018)	(0.016)	(0.018)	(0.016)
Restricted - Loss	0.019	-0.019	0.018	-0.024	0.017	-0.024
	(0.018)	(0.018)	(0.017)	(0.017)	(0.017)	(0.017)
Enhanced - Gain	0.027	-0.017	0.031	-0.029	0.029	-0.030
	(0.018)	(0.017)	(0.017)	(0.016)	(0.017)	(0.016)
Enhanced- Loss	0.035	0.018	0.035	0.008	0.033	0.006
	(0.018)	(0.016)	(0.017)	(0.015)	(0.017)	(0.016)
Observations	3,094	3,100	3,094	3,100	3,094	3,100
Covariates	No	No	Individual	Individual	Individual and municipality	Individual and municipality
Mean outcome – Baseline group	0.088	0.110	0.088	0.110	0.088	0.110

Notes: the table reports the average marginal effects of each treatment on the probability of screening, estimated with logit models. Columns (1), (3) and (5) report estimation outcomes for individuals above median travel time, while Column (2), (4) and (6) report for individuals below median travel time. The covariates included in Columns (3) and (4) are listed in Table 3. Models in Column (5) and (6) include as additional covariates population density and the share of residents with at least high school in each subjects' municipality of residence from the 2011 Italian Population Census. The mean outcome for the baseline group is reported in the last line as a benchmark. Standard errors robust to the presence of heteroscedasticity reported in parenthesis.

Figure 1. Timing of dispatch of the five invitation letter formats

Randomly assigned week of invitation	Week 7: 13/2 – 19/2	Week 8: 20/2 – 26/2	Week 9: 27/2 – 5/3	Week 10: 6/3 – 12/3	Week 11: 13/3 – 19/3
Format of the letter	Baseline	Restricted Info – Gain Frame	Restricted Info – Loss Frame	Enhanced Info – Gain Frame	Enhanced Info – Loss Frame

Notes: “Info” stands for information

Figure 2. Geographic location of the health care centers involved in the screening program in the Province of Messina.

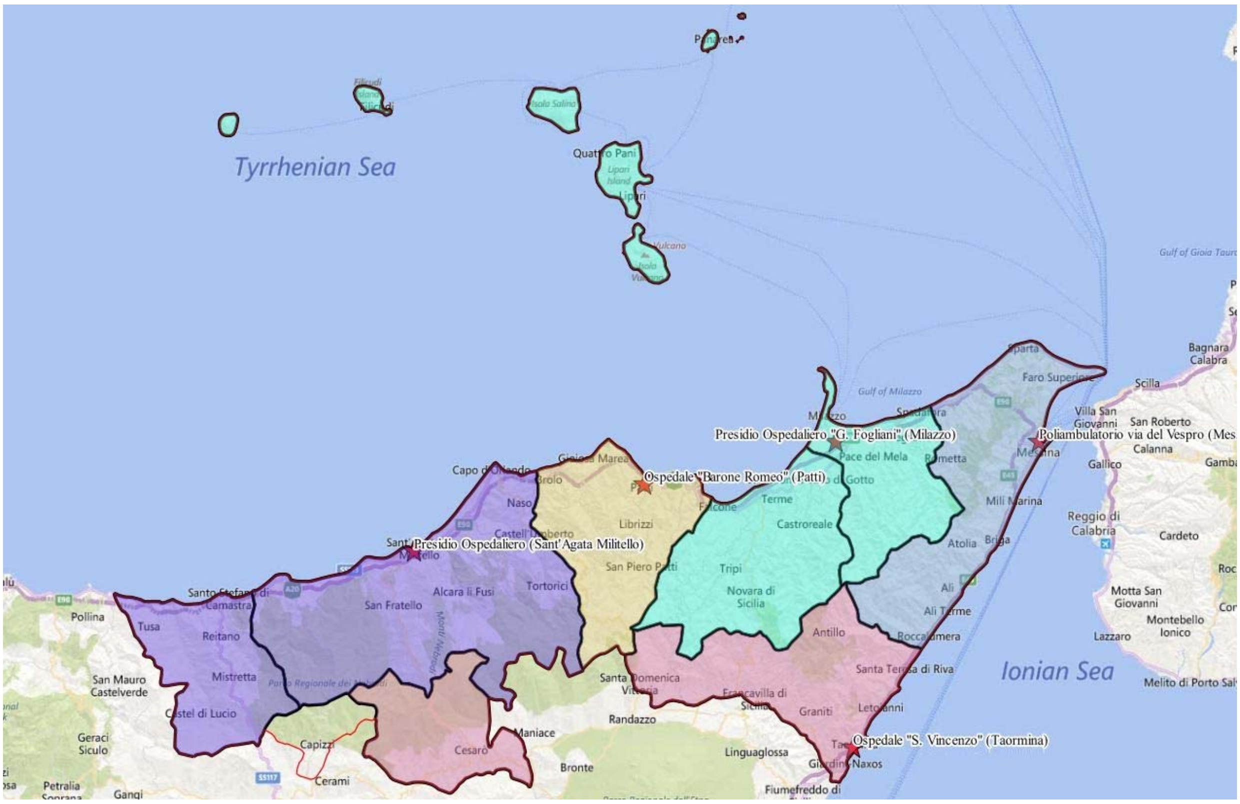
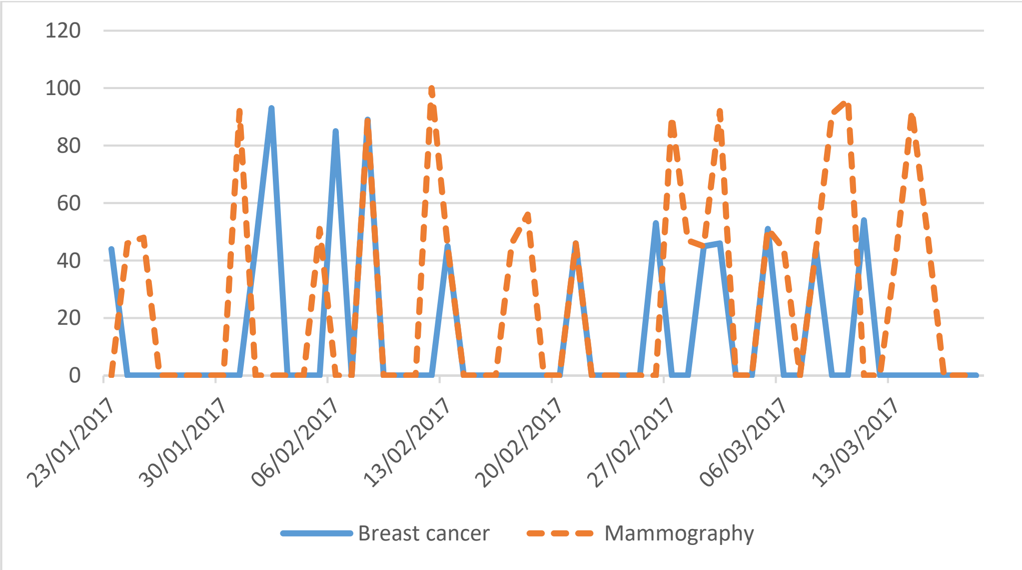


Figure 3. Google trend searches for "breast cancer" and "mammography" in Sicily over the experimental period



Notes: Numbers represent search interest relative to the highest point on the chart. A value of 100 is the peak popularity for the term. A value of 50 means that the term is half as popular. Likewise, a score of zero means the term was less than 1% as popular as the peak.

Appendix – For Online Publication

1. Additional Tables and Figures

Table A1. Differential effects on the probability of screening between the "Enhanced - Loss" and the other treatments. Absolute differences, p-values in brackets.

Enhanced - Loss vs. …	(1) Logit	(2) Logit	(3) Linear Probability Model	(4) Linear Probability Model
Restricted - Gain	0.034 [0.005]	0.032 [0.006]	0.036 [0.004]	0.032 [0.007]
Restricted - Loss	0.026 [0.027]	0.024 [0.037]	0.028 [0.026]	0.026 [0.031]
Enhanced- Gain	0.022 [0.066]	0.022 [0.054]	0.024 [0.066]	0.024 [0.053]
Covariates	No	Yes	No	Yes

Notes: the table reports the difference in average causal effects of the Enhanced – Loss manipulation with respect to each of the other treatments. As in Table 5 in the Main Text, Columns (1) and (2) report average marginal effects from logit models, while Column (3) and (4) report those obtained with linear probability models. The covariates included in Columns (2) and (4) are listed in Table 3. Number of observations: 6,194. Standard errors robust to the presence of heteroscedasticity are not reported. P-values for significance of the differences are instead reported in square brackets.

Table A2. Balancing tests for rainfall

	(1) Baseline	(2) Restricted Gain	(3) Restricted Loss	(4) Enhanced Gain	(5) Enhanced Loss	(6) Joint equality (p-value)
Rainfall (mm/day)	0.000	0.397	0.213	5.283	0.133	0.000

Notes: the table reports the mean by treatment group of rainfall (mm/day) in the municipality where the health care center each woman had to take the mammography at is located, in the day when she was invited to take the mammography. Column (6) reports the p-value test for joint equality in means among treatments. Number of observations: 6,194.

Table A3. Main results including rainfall among the controls

	(1) Logit	(2) Linear Probability Model
Restricted - Gain	-0.009	-0.007
	(0.012)	(0.011)
Restricted - Loss	-0.001	-0.002
	(0.012)	(0.012)
Enhanced - Gain	0.003	0.002
	(0.013)	(0.013)
Enhanced- Loss	0.023	0.025
	(0.011)	(0.012)
Rainfall (mm/day)	-0.000	-0.000
	(0.001)	(0.001)
Other covariates	Yes	Yes
Mean outcome – Baseline group	0.099	0.099

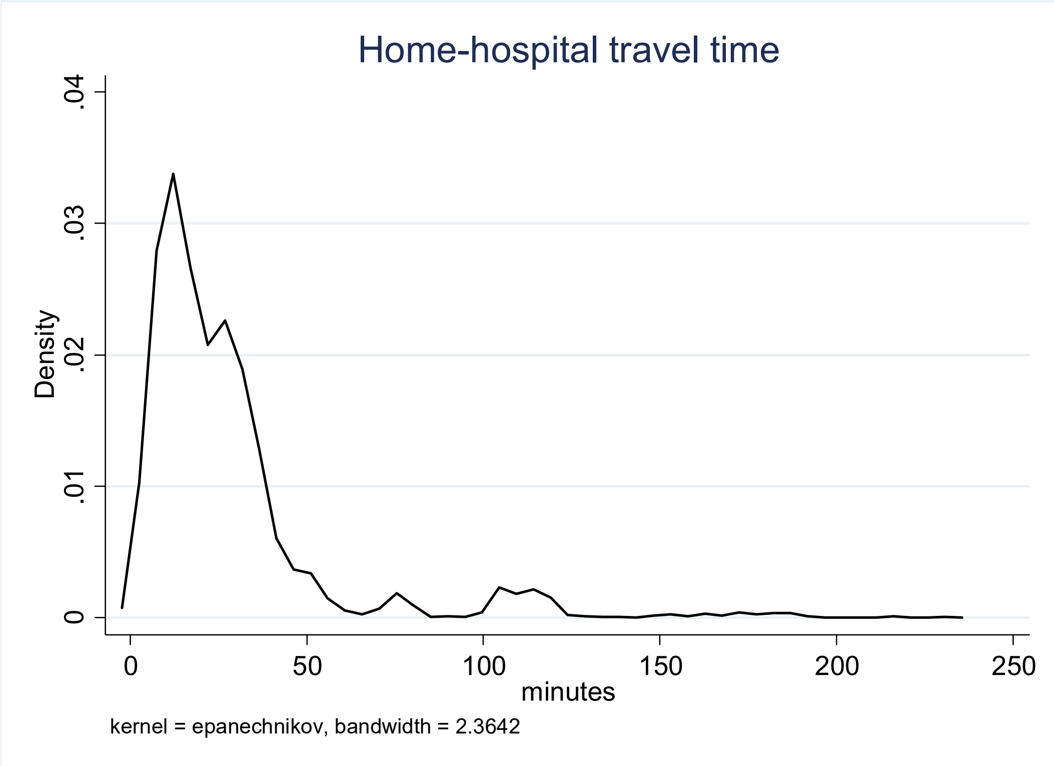
Notes: the table reports the average causal effects of each treatment on the probability of screening. Column (1) reports average marginal effects from a logit model, while Column (2) reports those obtained with a linear probability models. The other covariates included are listed in Table 3. The mean outcome for the baseline group is reported in the last line as a benchmark. Number of observations: 6,194. Standard errors robust to the presence of heteroscedasticity reported in parenthesis.

Table A4. Differences in daily take-up rates during the week of the 8th March strike

	(1) Monday 6-3-2017	(2) Tuesday 7-3-2017	(3) Wednesday 8-3-2017	(4) Thursday 9-3-2017	(5) Friday 10-3-2017	(6) Saturday 10-3-2017	(7) Joint equality (p-value)
Take-up	0.083	0.115	0.074	0.118	0.123	0.088	0.36
N. Obs.	192	296	230	272	203	45	

Notes: the table reports the daily take-up rates in the week of the 8th March strike. Column (7) reports the p-value test for joint equality in take-up rates among treatments. Number of observations: 1,238.

Figure A1. Kernel estimate of home-hospital travel time density



2. The invitation letter format

[The invitation letters were originally written in Italian. The following letter refers to the "enhanced information – loss framing" treatment.]

[PAGE 1]

Azienda Sanitaria Provinciale
Prevention Department

Address: XXXX
Tel. XXXX

LOCAL RADIOLOGY UNIT

Director: Dr. XXXX

Senology unit: Dr. XXXX

Address: XXXX

Dear Madam,

this Azienda Sanitaria Provinciale (ASP), in collaboration with your general practitioner, is promoting a breast cancer prevention campaign, inviting all women between 50 and 69 to have a mammography.

Scientific studies demonstrate that not participating in breast cancer screening programs can have relevant negative effects on the treatment of a lately diagnosed disease: it increases the mortality rate, implies more extensive surgeries, less effective treatments, with lower chances of recovery.

For this reason, we have booked an appointment for you to have the mammography at the following address and date:

Address: XXXX

Date and Time: XXXX

The mammography is free and you do not need a medical prescription. You only need to show your tax code, your identity card and the present letter to the radiologist.

Please, call the following telephone number XXXX from Monday to Friday, from 09.00 to 13.00 if:

- you have already had a mammography in the last 12 months;
- you want to modify date and/or time of the appointment;
- you had a breast surgery.

In case you previously had a mammography, please bring the results with you.

Please read carefully the information reported in the back of the present letter, under the law dated 28th of March, 2001, n.145.

Sincerely yours,

Your General Practitioner,
Dr. XXXX

The Direction of the Local Radiology Unit
Dr. XXXX

[PAGE 2]

In industrialized western countries, due to its incidence, breast cancer represents a concerning social disease. Italian estimates show that every year more than 31,000 women are diagnosed with breast cancer (data from the Italian Association for Cancer Registries).

Scientific evidence demonstrates that a late diagnosis of this cancer can have relevant negative effects on the treatment of the disease. In particular, it has been documented that a late diagnosis of this cancer increases the mortality rate, implies more extensive surgeries, less effective treatments, with lower chances of recovery.

For this reason, in the last 20 years, great attention has been paid to early diagnosis through the promotion of high quality national screening programs by targeting all women between 50 and 69(who represent the age category with higher risk of breast cancer).

The early diagnosis activities involve an integrated approach of different services in senology and will be implemented in collaboration with a network of oncological and epidemiological institutions. This collaboration guarantees monitoring and valuable assistance in case of breast cancer diagnosis.

DO NOT MISS THIS OPPORTUNITY!!!

The responsible of the Breast Cancer Screening Program

Dr. XXXX

CONSENT TO THE PROCESSING OF PERSONAL DATA (Legislative Decree 196/03)

In accordance with the Legislative Decree 196/03, ASP, responsible of the processing of personal data, informs you that your personal and sensitive data will be exclusively used for conducting the screening activities, for research purposes and for ordinary administration, and will be processed by authorized staff, under the limitations of the current law and in accordance with minimal security requirements. At any time, you can contact the secretary of the screening unit to obtain information on how your personal data will be processed as well as on the adopted security procedures adopted by ASP.

DATE____________________________

SIGNATURE___________________________