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Quasi-experimental Evidence on the Effects of Home Invitation on Mammography Uptake

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Vincenzo Carrieri and Ansgar Wuebker[1]

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Abstract

We exploit regional variation in the availability of breast cancer screening policies and variations in age eligibility criteria across European regions to estimate the causal effect of home invitation on mammography uptake. We link administrative public data about regional breast cancer screening policies from various sources to individual Survey of Health Ageing and Retirement in Europe (SHARE) data. We find that home invitation increases mammography uptakes by almost 20 percentage points. At the same time, we find that home invitation reduces education-related inequalities but increases gradient in the use related to cognitive functions. In addition, significant effects on mammography use are found only when at least 50 per cent of the population is reached by the home invitation. Our results suggest that an exogenous informational shock affects preventive decisions especially among less informed individuals but the effectiveness of invitation is strongly reduced for women who are less able to process information.

JEL Classification: C10, I 11, I 14, I 18

Keywords: Home invitation; preventive health care; quasi-experiment

June 2014

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1. Introduction

Breast cancer is one of the most important public health concerns in Europe both because of its high incidence and high mortality risk. On average, one in nine women gets breast cancer and one in thirty dies from this disease (OECD, 2009). Currently, it is the most common cause of cancer death among women (Von Karsa et al., 2008) and, due to demographic ageing, it will be an even more important health issue in the future (Ferlay et al., 2007). Breast cancer also poses real economic concerns. Overall spending for breast cancer typically amounts to about 0.5- 0.6 per cent of the total health care expenditure in developed countries (OECD, 2009). In addition, breast cancer generates significant efficiency losses from a social welfare point of view. It causes not only productivity losses for women due to absence from work, but also leads to an overall decline in well-being of women affected.

Fortunately, mortality risks and health deterioration caused by breast cancer can be substantially reduced if cancer is detected sufficiently early and treated appropriately (World Health Organization, 2011). The overall five-year relative survival rate among US women diagnosed with breast cancer at an early stage is 98.5 per cent, compared with 25 per cent if the disease is detected at a later stage when other organs are attacked (National Cancer Institute, , 2014). At the moment, despite some criticism (see for instance 'Mammography Wars' by Quanstrum and Hayward (2010)), mammography is the best available tool to detect a breast lump before it can be palpated, i.e. in the earliest stage.

This paper aims to provide the first empirical evidence on the causal impact of screening policies on mammography uptake relying on a quasi-experimental setting occurred in local European authorities. In the 1980th European local authorities (typically NUTS-2-regions) started to provide organized screening programs (hereafter OSP) in which eligible women typically get regular (i.e. every two years) personal invitations to participate in free mammography screening at a location nearby. Women living in these regions receive an information booklet, which explains the pros and cons of mammography screening. Most influential international authorities advice that mammography screening should be offered to women aged 50–69 every two years as a public health policy (e.g. the International Agency for Research on Cancer expert working group ((IARC, 2002)). However, up to 2006, only some local authorities in Europe offered an OSP while some others did not implement any program. This pattern occurred even within the same country. In addition, age eligibility criteria for OSP vary across those European regions that implemented local screening programs.

Building on such heterogeneity, in this paper we use a Diff-in-Diff estimator to explore the impact of screening policies on mammography uptake. Under the assumption of a parallel age-increase pattern in mammography use among regions, this estimate allows us to retrieve the causal impact of screening on mammography uptake. Moreover, given that the key distinctive feature of the OSP is the home delivery of comprehensive information around breast cancer, we also investigate whether treatment effect varies according to education - acting as a proxy of the stock of health education - and cognitive functions- which indicate the ability to process information. Empirical Analysis is based on a unique data-set built on epidemiological literature and government reports containing information on characteristics of regional screening programs in Europe (NUTS-2 Level). The data set is then linked to two waves of SHARE data covering information on several individual characteristics.

Our analysis contributes to the literature in several aspects. Firstly, the assessment of the effectiveness of regional screening programs offers an exceptional opportunity to investigate the importance of information on preventive decisions. Since Grossman's model (1972) of health investment and Cropper (1977) and Phelps' (1978) extensions accounting for preventive care as specific input, economic studies of health care demand consider the marginal benefits of consuming health care as the key determinant of the decision to invest in health. Health information plays an important role in such decision, affecting the consumers' perceived marginal benefits of health care (Kenkel, 1990). In our specific case, empirical evidence suggests that women tend to have false perceptions of the risks and seriousness of breast cancer (Wuebker, 2013) and this may reduce dramatically their incentive to demand a mammography. However, identifying the impact of information on preventive decisions is complicated because unobserved individual characteristics affect both the decision to do a mammography and the individual efforts to acquire information. Learning and acquiring new information is costly and may be a time-intensive process, thus the optimal stock of information is likely to vary with the individuals' expected costs and benefits of acquiring such information (Kenkel, 1990). Previous papers that rely on observational data estimate a positive effect of information on preventive decisions (e.g. Hsieh and Lin, 1997; Parente, Salkever and DaVanzo, 2005). Nuscheler and Roeder (2014) recently showed for the case of influenza vaccination that well informed individuals have a much higher propensity to vaccinate than poorly informed individuals, highlighting the importance of information campaigns in public health policy. Maurer (2009) argued that asymmetric information is widespread in health care markets and physicians might act as agents for their less informed patients. Using exclusion restrictions implied by an economic model of physician-patient interactions, he found evidence for the important role of physician agency for the demand of preventive services. All these studies advance our understanding of the potential role of information in preventive care markets. However, to the best of our knowledge, our paper is the only one which exploits an exogenous informational shock introduced by the home delivery of the information. This allows us to retrieve a causal effect of such informational shock on preventive decision. Moreover, we also investigate the differential impact of the delivery of the information upon individuals with a different stock of information (proxied by education level) and with a different ability to process information (proxied by cognitive function). Educational status is highly correlated with the ability to acquire new information (Schultz, 1975), as higher educated individuals are more likely to gather health information from media or other sources (Ippolito and Mathios, 1990). On the other side, individuals with low cognitive functions might be less able to process information received. Previous observational studies asked the respondent questions about the symptoms and the health effects associated with some specific diseases and used the number of correct responses as a measure of information (Kenkel, 1990; Hsieh and Lin, 1997). Since this measure takes into account the effective knowledge of individuals around health issues, it does not allow to separate the role of health information from the ability to process the information. In our setting, the delivery of the information through the invitation letter makes this distinction possible.

Secondly, except for one study estimating the effectiveness of screening policies in Denmark on mammography and mortality (Jorgensen, Zahl and Goetzsche, 2010), our paper is the first attempt to estimate the causal impact of screening programs on preventive care use. Underuse of preventive care is a large concern for European countries. On average, only 50 per cent of women get an appropriate mammography in Europe, besides, many other countries exhibit sensibly lower rates and high intra-country variation (Carrieri and Wuebker, 2013; Wuebker, 2013). While screening programs are often indicated as a good strategy to increase preventive care use (i.e. IARC, 2002 recommendations), evidence on their effectiveness is still missing.

Thirdly, the paper investigates the effect of screening on education and cognitive-related inequalities in preventive care use. Since the last decade, normative health economics is dealing with 'avoidable inequalities', namely inequalities in use depending on non-need factors; i.e. education or social position. Vast empirical evidence shows that health care and preventive care are effectively not fairly distributed across Europeans (see Van Doorslaer et al., 2004; Carrieri and Wuebker, 2013; Jusot and Sirven, 2011; Sirven and Or, 2011; Lorant et al., 2002). Despite that, to the best of our knowledge, there is no evidence on how such inequalities might be reduced. In particular, there is no evidence on the impact of screening policies on inequalities in preventive care use.

Lastly, our data also includes information about the actual invitation rate within each local screening program. This enables us to deeply analyze the relationship between invitation rate and mammography uptake (and inequality in use). A careful analysis of this aspect is likely to be strongly beneficial for the design of screening policies.

This paper is organized as follows. The next section discusses characteristics of organized screening programs in Europe. Section 3 presents the data. In section 4 the empirical strategy is explained. Section 5 presents the results along with robustness checks. The last section summarizes and concludes this paper.

2. Institutional Setting: organized screening programs in Europe.

OSP can be defined as a population based program to which women of defined ages are regularly invited to mammography screenings (e.g. Autier et al. 2011).[1] OSPs are implemented typically at local level (e.g. at NUTS-2-level). They are different from so-called opportunistic screening, which happens when someone asks her doctor or health professional for a mammogram. In all EU-member states women in a target age group may get a mammography with no costs at point of consumption at the General Practitioner, specialist or at healthcare authorities. Thus, opportunistic screening programs exist in virtually all EU countries. Given that in both opportunistic and

[1] According to the IARC (2005) elements of an OSP include 1) an explicit policy with specified age categories, method and interval for screening 2) a defined target population; 3) a management team responsible for implementation; 4) a healthcare team for decisions and care; 5) a quality assurance structure; and 6) a method for identifying cancer occurrence in the target population.

organized program mammography is provided at no cost, the key distinctive feature of OSP is the home delivery of comprehensive information around breast cancer and benefits and risks of mammography screening.

While national opportunistic screening programs are a common practice in EU-member states, there is much more heterogeneity across regional health authorities with respect to OSP. This heterogeneity has three main dimensions: availability of the screening program, target age group and actual invitation rates. In figure 1 we report heterogeneity in the availability of OSP across all EU-NUTS2-regions for which we collected primary data. Information is updated to 2006 (see data section). As figure 1 shows, only 58 per cent of regions implemented an OSP in Europe, while many NUTS-2 regions did not implement any OSP by 2006. Differences exist even within the same country. In particular, Italy, Switzerland, Denmark and Germany display a substantial within-country variation in the availability of regional OSP.

Figure 1 also displays the heterogeneity in the range of age windows for age groups invited. The majority of regions (around 70 per cent) that implemented an OSP use the recommended age group 50 to 69 as a target age group. This is consistent with the guidelines offered by most influential health authorities' (e.g. IARC 2002). However, some other regions chose a smaller age window (around 3 per cent) and some other regions chose a wider age window (around 27 per cent). The minimum age window is 50 to 64 and the maximum age window is 50 to 75.

[Insert figure 1 around here]

As shown by Figure 2, NUTS-2 regions differ also in terms of actual invitation rates. Actual invitation rates indicate the proportion of women in target age group who are effectively reached by the invitation letter. While the theoretical invitation rate should be always 100% in regions where an OSP exists, figure 2 shows that many regions fail to reach the whole target population. When considering the actual invitation rate, 45.02 per cent of the women included in our sample live in NUTS-2-regions where they do not get an invitation letter at all. In contrast, 45.28 per cent of women live in regions with screening rates of 75 per cent and more. Figure 2 demonstrates that high differences also exist within countries and are of substantial relevance in Switzerland, Germany, Denmark and Italy. For example in the North of Italy invitation rates are quite high (i.e. between 75 and 100 per cent), while in southern Italy invitations rates are often below 50 per cent. Overall, 4.19 per cent of women live in regions with positive but low invitation rates (i.e. rates below 25 per cent). Less than 1 per cent (0.89) of women live in regions with invitation rates between 25 and below 50 per cent and 4. 68 per cent of women live in regions with rates between 50 and below 75 per cent and 45.02 live in regions with rates over 75 per cent.

[Insert figure 2 around here]

Heterogeneity in the availability of OSP, in the age windows and in the actual invitation rates may depend on several factors. Local budget constraints, organizational efforts or local preferences for prevention might be the main reasons for such heterogeneity [2]. With respect to the first, implementing an OSP and reaching the whole population is costly and the choice of a finer age eligibility window might be a cost saving solution. Secondly, the implementation of OSP requires high organizational efforts which are likely to increase with the size of the age window chosen and the share of population effectively reached by the letter. Lastly, the choice to implement a program and the age window chosen might depend on the local preferences for prevention. In other words, some regions may prefer to allocate more money for prevention than the others.

In the next pages, we will describe how we exploit all this heterogeneity to retrieve the causal effect of organized screening programs on mammography uptake and on inequalities in mammography use across education and cognitive functions in EU regions.

3. Data and descriptive statistics

Data

Our analysis is based on two sources of data. Firstly, we collect a unique macro data-set containing information on characteristics of local screening programs at NUTS-2 Level in 13 EU countries: Austria, Belgium, Czech Republic, Denmark, France, Germany, Greece, Italy, Netherlands, Poland, Spain, Switzerland and Sweden. The data set includes information with respect to whether a local OSP exists, which age eligibility criteria is chosen in each region and the proportion of eligible women effectively reached by the letter. All data are updated to 2006. Main descriptive statistics around the characteristics of OSP programs have been discussed in the previous section. The data-set has been build relying on various epidemiological studies (i.e. Autier and Quakrim 2008, Biesheuvel et al. 2011, Bastos et al. 2009, Giorgi et al. 2007, Giorgi et al. 2008, Jørgensen et al. 2010Shopper de Wolf (2007) and government and public reports (Kooperationsgemeinschaft Mammographie (2012), National Cancer Institute (2012), von Karsa et al. (2008), European Observatory of Health Sytem and Management (2012). The data set is then linked to the first two waves (2004 and 2006) of individual level data from the Survey of Health, Ageing and Retirement in Europe (SHARE). SHARE is a large representative micro data set providing detailed information on health, health-care use, a variety of other socio-economic characteristics and the region of residence (Nuts-2) of more than 30,000 individuals. The data was collected using a computer assisted personal interviewing (CAPI) program, supplemented by a self-completion paper and pencil questionnaire.

Our main variable of interest is whether a woman got a mammography in the last two years. While SHARE data is in principle a longitudinal data set, information on mammography uptake is collected in the so called drop-off questionnaire, which is a repeated cross section of a sub-sample of interviewed. Considering the non-missing values of our variables of interest, we dispose of about 14,000 individuals living in 173 NUTS-2 regions of 13 countries (see above).

[2] These are factors which influence the implementation and the success of any kind of policy intervention. Moreover, we dispose of some soft information gathered during informal talks with some directors of OSP in Italian and German regions. They list these factors as the main reasons for all such heterogeneity across European regions.

In the analysis of heterogeneous treatment effect, we concentrate on education and cognitive functions. In SHARE data, educational status is measured by standard ISCED-2-code (reference), while cognitive functions are assessed by the interviewer during the interview. Of particular interest is the variable related to verbal fluency, which is the ability to state as many names of different animals as possible within one minute. This variable is identified by cognitive psychology literature (e.g. Richards et al., 2004) as a valid measure of cognitive function and it seems suitable to measure the ability to process the information provided by the invitation letter. The variable ranges from 0 to 100. SHARE data also collects information on other dimensions of cognitive functions such as, numeracy and recall (reference SHARE) that we use later for robustness checks.

Other variables available in SHARE are useful to take into account the determinants of preventive behavior identified by theoretical and empirical scientific literature (see Wübker 2012 for further details). These include factors like age (dummy variable for different age groups), health status (self-assessed health), a history of breast cancer and family structure (having a partner).

Treatment and control groups

Table 1 provides information on how treatment and control groups are defined. Women in regions where an OSP exists are assigned to the treatment group, and women in regions without OSP are assigned to the control group. For each woman we construct a binary indicator whether she belongs to the recommended age group meaning that she is theoretically eligible for an OSP. The variable takes the value 1 if she is in eligible age that is recommended for screening in the region in which she lives (e.g. women age 50 to 69 in Germany), and zero otherwise (e.g. for German women younger than 50 years or older than 69 years). The sample consists of 8,036 women (5,696 in the eligible age group + 2,340 out of the eligible age group) from 97 Nuts-2 regions who live in regions with an OSP and 6,552 (4,244 in the eligible age group + 2,108 out of the eligible age group) women living in 76 Nuts-2 regions without OSP. We observe 9,940 (4,244 in regions without OSP + 5,696 in regions with OSP) women who are in the eligible age group and 4,448 (2,108 in regions without OSP + 2,340 in regions with OSP) women out of the eligible age group.

[Insert Table 1 around here]

Table 1 also presents selected summary statistics for the treatment (D_i = 1) and control (D_i = 0) groups for women in the eligible age group (AgeGroup = 1) and women out of the eligible age group (AgeGroup=0). 78 per cent of women in regions with OSP who belong to the eligible age group did a mammogram in the last two years. In contrast, only 50 per cent of women from OSP regions did a mammogram when they were not in the eligible age group. Thus, the difference between women within and outside the eligible age groups in OSP regions is 28 percentage points. In regions without OSP, 33 per cent of women in the eligible age group and 23 per cent of women out of the eligible age group did a mammogram screening in the previous two years. The difference in non-OSP regions between women within and outside eligible age groups is 10 percentage points. Taking the difference of both differences, we arrive at a Diff-in-Diff value of 18 percentage points, which is our treatment effect of the OSP without covariate adjustment.

Table 1 shows that women in the treatment group have a higher income on average, more often have a partner and a history of breast cancer compared to women in regions without OSP. Other characteristics are similar across treatment and control group. Moreover, women in the eligible age group are considerably younger, have higher income, better cognitive skills, have more often a partner and are much more often in the workforce compared to women out of the eligible age group. Our identification strategy accounts for these possible confounders by using a Diff-in-Diff estimator within a regression framework.

4. Identification Strategy

Our identification strategy exploits regional variation in the availability of local breast cancer screening policies and variations in age eligibility criteria across such policies as a source of exogenous variation in treatment assignment. We estimate the effect of local breast cancer screening programs in a Diff-in-Diff framework built as in equation (1):

$$Y_{ira} = \beta_0 + \beta_1 D_r + \beta_2 A_a + \beta_{12} D_r * A_a + \beta_3 X + \varepsilon_{ira} \quad (1)$$

Where the dependent variable Y_{ira} is a dummy variable that indicates whether a woman i in the recommended age group a got a mammography in the last two years in region r. D_r is a dummy variable equal to one if the woman is living in a region where an OSP is available. This variable captures differences in mammography uptake levels across regions with and without an OSP. A_a is a dummy variable equal to one if the woman fits the OSP-specific age criteria. This variable captures differences in screening uptake between the recommended age groups and the other age groups. β_{12} is our Diff-in-Diff estimator. X is a vector of control variables and ε is the standard disturbance term. In such a kind of Diff-in-Diff specification, β_{12} measures the causal effect of OSP on mammography uptake under the assumption of a parallel age increase in mammography uptake across regions with and without a screening program. This is equivalent to the common trend assumption used in Diff-in-Diff estimators exploiting pre-post variation in policy evaluation. In our case, this assumption requires that variations in mammography uptake between age groups in screening regions are not systematically different to the ones arising in non-screening regions.

Epidemiological evidence suggests that it is a rather weak assumption. One important violation of our assumption may arise if breast cancer risk evolution across ages varies between regions with and without an OSP. Providing that individuals have perfect knowledge around such a risk, this could generate a different incentive to demand mammography across individuals with the same age but living in different regions. At the same time, it could explain heterogeneity across regions in the implementation of OSP and in the choice of the invited age group. This hypothesis does not find any support in the epidemiological literature. Bray, Mc Carron and Pakin (2004) report no differences in the mean age at diagnosis of breast cancer within European populations while some differences exists only in the comparison between developed and developing countries where the risk of breast cancer starts at earlier age. Importantly, this is also consistent with the guidelines of the most influential health authorities (e.g. IARC, 2002), which suggest screening uptake to women aged 50 to 69 in all developed countries.

The existence of OSP and variations in the age eligibility window across OSP could depend principally on budget constraints, organizational efforts of the local authorities or they might just reflect differences in local preferences for prevention, as discussed in the institutional setting paragraph. If all these factors have any effect on the individual decision to uptake mammography they affect differences in mammography levels across screening and non-screening regions (which are controlled for in our specification), but they are unlikely to affect the mammography uptake by age groups across regions. In the robustness check paragraph we also include some additional analysis that empirically supports the plausibility of this identification strategy.

On the basis of the previous arguments, we believe that our specification in equation (1) allows a robust identification of the causal effect of screening programs on mammography uptake. In this paper, we also consider the actual invitation rate within OSP rather than the dichotomous specification (OSP yes or no) shown in equation (1). This leads to an estimation of the following equation:

$$Y_{ira} = \beta_0 + \beta_1 I_r + \beta_2 A_a + \beta_{12} I_r * A_a + \beta_3 X + \varepsilon_{ira} \ (2)$$

Where I_r replaces the D_r dummy shown in equation (1) and indicate the proportion of women effectively reached by the letter within the OSP. In equation (2) the 'continuous treatment effect' is captured by $ß_{12}$ and measures the causal impact of invitation intensity on mammography uptake. All other parameters and coefficients are the same as in equation (1) and identification strategy relies on the similar assumption of a parallel age increase in mammography uptake across regions with different actual invitation rates.

Finally, when turning to the analysis of the effect of OSP on inequalities, we interact β_{12} in equation (1) and (2) with education and cognitive ability variables. This enables us to investigate the causal effect of screening on education and cognitive-related inequalities in mammography use.[3]

5. Results

Table 2 presents the results of the baseline regression. In column 1 we report the estimate of the treatment effect using equation (1) without controls, while in column 2 we report the estimate of the treatment effect with controls. A comparison between columns 1 and 2 easily demonstrates that the estimates of the average treatment effect are substantially unchanged when covariates are included. We find that OSP have a significant and large impact on mammography uptake. OSP causes an increase in mammography uptake by 18.6 percentage points. This value actually underestimates the real effect of OSP, because we consider the theoretical invitation rate, implicitly assuming that all

[3]In all analysis, we use a linear probability model in order to obtain a meaningful interpretation of the interaction effect of our interest, since, as suggested by Ai and Norton (2003), a simple summary measure of the interaction effect is problematic in non-linear models, because the effect and the sign of the interaction effect actually changes for each single observation (being dependent on the different values of the covariates). However, we also experiment using non-linear models that lead to qualitatively equivalent results (results not shown and available upon request).

OSP succeed to reach the 100 per cent of the total population. In the next table, we demonstrate that the effect is even larger when the actual invitation rate is considered.

With respect to the control variables, we find results in line with the main literature. Women with better education and better cognitive abilities (higher verbal fluency score) as well as women with a partner are more likely to get a mammography. Not surprisingly, we find a large increase mammography uptake among women with a history of breast cancer compared with women without breast cancer (40 per cent). This indicates that follow-up remains one of the most important reasons for mammography uptake.

[Insert Table 2 around here]

Table 3 displays the estimates of the treatment effect of the OSP considering the actual invitation rate, as in equation (2). Invitation rate varies between 0 and 100 per cent of the target population, consequently the treatment effect in table 3 can be interpreted as the marginal effect of the invitation rate passing from 0 to 100 per cent on mammography uptake. In column (1) we estimate the treatment effect without controls. Again, column (2) displays that the estimate of the treatment effect remains stable and precise after including controls. We find that OSP increase mammography uptakes by around 21 percentage points. This treatment effect is around 3 percentage points higher than the treatment effect of the OSP when the theoretical instead of the actual invitation rate is considered.

We also investigate whether the effectiveness of invitation remains constant across invitation rounds. Consistently with guidelines, women in the target population are invited every two years within OSP. For instance, considering the most used age eligibility window (50-69), women in the age eligibility group receive first letter at 50, with following invitations every two years. In column 3 we report the estimates of the treatment effect of the first compared to the following invitations. We find that the effect of the first invitation (21.7 percentage points) is about 1.5 percentage points stronger than for the following ones (20.2 percentage points). This suggests that the informational shock produces stronger effect when the information is provided for the first time.

Lastly, in column 4, we report the treatment effect for different levels of regional invitation intensity. This analysis can be useful to better understand the relation between invitation and mammography uptake. The results in column 4 show some interesting patterns. Firstly, we detect a strictly increasing relationship between invitation and mammography uptake. Interestingly, we also find an empirical threshold below which OSP are ineffective: OSP does not affect mammography uptake if less than 25 per cent of women in the region are reached by the invitation letter. With increasing screening intensity, mammography uptake probabilities increase initially progressive going from 6.3 percentage points (inv. intensity up to 50 %) to 14.6 percentage points (inv. intensity up to 75 %). This progressive increase may indicate the existence of some ‘social multiplier’ mechanisms that boost the spreading of the information delivered by the OSP when a consistent share of population is reached by the letter. Then uptake probabilities increase further to 20.2 percentage points (inv. intensity up to 100 %), but with some diminishing marginal returns: the difference between the treatment effect from 50 to 75 is slightly higher than the difference in the treatment effect between 75 to 100 of invitation rate.

[Insert Table 3 around here]

Heterogeneity of the treatment effect

In this section we test whether the effects of OSP on mammography uptake varies according to different levels of education and cognitive abilities. The motivation behind this analysis is that the home delivery of information may have a differential impact upon individual with a different stock of information/health literacy and a different ability to process the information. For this purpose, we analyze whether treatment effects differ with regard to a) the educational background (as measured by ISCED-codes) and b) cognitive functions (as measured by verbal fluency). To make the interpretation easier, we include education as continuous variable so that estimated coefficient measures the differential treatment effect between women with no education (ISCED-code ‘0’) and women with post-secondary education (ISCED-code ‘6’). In robustness check paragraph, we show that results are not driven by this particular specification.

In the first two columns of table 4, we report estimates using the dichotomous OSP variable which refers to theoretical invitation rate, while in columns 3 and 4 we report estimates based on the actual invitation rate. In both cases, we first report estimates where only education is interacted with the treatment effect (columns 1 and 3) and then estimates where both education and verbal fluency are interacted with treatment effect (columns 2 and 4).

[Insert Table 4 around here]

Albeit not statistically significant, estimates reported in columns 1 and 2 show that OSP decreases the educational gradient (i.e. has a lower impact on women with high education compared to women with low education), but increases the gradient with regard to cognitive abilities (i.e. has a higher impact on women with good cognitive abilities compared to women with bad cognitive abilities). The picture is much clearer when actual invitation rate is considered (columns 3 and 4). When using actual invitation rates which take into account the effective delivery of the information, we find a strong and significant negative impact of the invitation intensity on the educational gradient. Considering the full model, we find that the treatment effect of the invitation letter is around 14 percentage points higher for women with no education (ISCED-code ‘0’) compared to women with postsecondary education (ISCED-code ‘6’). In contrast, the treatment effect of the invitation letter is stronger for women with high cognitive abilities compared to women with low cognitive abilities. On the basis of our estimates, the invitation letter increases the use of mammography by almost 30 percentage points among women with the highest verbal fluency score (100) compared with women with the lowest level (0). Moreover, one standard deviation increase in verbal fluency score is associated with an increase of 3 percentage points in use among high-cognitive abilities individuals (compared to low ones).

Robustness checks and sensitivity analysis

In this section, we report several checks to verify the robustness of our results. Firstly, we focus on the plausibility of the parallel age-increase pattern assumption. In table 5 we report the estimates of a number of Diff-in-Diff placebo regressions based on the specification introduced in equation (1), but with two fake eligibility age groups. In column 1, we report estimates based on a fake eligibility group made of women aged 40 to 60, while in column 2 we repeat the exercise assuming women aged from 65 to 80 years as ‘treated’. In both cases, we find no significant placebo treatment effect which provides credence to the common age trend assumption. To give even more credence to our assumption, we also perform a sharp discontinuity test. Basically, we test whether mammography uptake is statistically different among women aged just one year before and one year after the region-specific age eligibility group. Results of this exercise based on a Diff-in-Diff model as in equation (1) are shown in column 3. Again, we find no significant treatment effect which supports the presence of a sharp discontinuity around the age eligibility threshold. The existence of a sharp discontinuity is also illustrated in Figure 1. Without loss of generalization, the figure focuses only on regions with and without the existence of an OSP which recommend screening for women between 50 to 69 years. The graph demonstrates that in regions with OSP the screening participation rate displays a sharp discontinuity at age 50 with a jump in screening rates in OSP regions. A similar discontinuity can also be seen around the age of 71 (recalling that mammography question refers to the last 2 years in the data-set), but the discontinuity here seems to be just a bit less sharp. Indirectly, this also confirms our previous result showing a decreasing effect of invitation across invitation rounds. All in all, robustness checks demonstrate that regions with and without screening do not exhibit any significant difference in the use of mammography across ages out of the age eligibility criteria. This also occurs when ages extremely close to the age eligibility thresholds are considered. This evidence supports our identification strategy of looking at differences observed within age eligibility groups across regions to measure the causal effect of the OSP.

[Insert Figure 1 around here]
[Insert Table 5 around here]

As a second check, we also test the robustness of the estimates of the heterogeneous treatment effects. We mainly focus on equation (2), because we found significant heterogeneous treatment effects when considering the actual invitation rate. In table 6 we test whether heterogeneous treatment effects for educational levels and cognitive functions are sensitive to the choice of the cognitive ability variables available in SHARE. We now consider ‘recall delayed’ (in column 1) and ‘numeracy’ (in column 2) as a measure of cognitive function. ‘Recall delayed’ is a variable counting the number of words read by the interviewer that the women is able to recall, while ‘numeracy’ measures the ability to do some simple calculation. We build a dummy variable equal to one if a woman replies correctly to the following question: ‘In a sale, a shop is selling all items at half price. Before the sale, a sofa costs 300 euro. How much will it cost in the sale?’.

In column 1, we show that the heterogeneous treatment effect for different educational levels remains substantially unchanged compared to the results in column (3) of table 4, when ‘recall’ instead of verbal-fluency is used as a cognitive function variable. The same occurs when 'numeracy' is used (column 2). In column 3, we also show that the heterogeneous treatment effect with respect to verbal fluency levels remains also unaltered when all alternative cognitive functions variables are included in the regression. In all of our regressions, we could not find any significant interaction between the treatment effect and the alternative cognitive function variables. Moreover, we also tried to include alternative cognitive function variable in the main regression (equation 1 and equation 2) without including the interaction terms between treatment effect and the cognitive function variable[4]. We found that only the verbal fluency score variable is always positively associated with mammography uptake, while other cognitive function variables are never statistically significant. From this exercise, we conclude that verbal fluency seems to be the cognitive function variable that is more effectively correlated with the decision to do mammography than any of the others.

As an additional check, we test whether heterogeneous treatment effect at different verbal fluency levels is sensitive to the specification of the education variable. Thus, in column (4) we report estimates of the treatment effect interacted with a dichotomous (instead of a continuous one) education variable (a dummy variable equals to one for women with ICSCED < 3). Results are substantially unchanged for verbal fluency scores compared to the results found in column (4) of table 4 and we confirm the presence of a strong gradient in education. More precisely, we observe that the treatment effect for women with low education is around 8 percentage points higher for women with no education compared to women with higher education (ISCED-code > 2).

As a final check, we test whether heterogeneous treatment effects are sensitive to the inclusion of income in the regression. We did not include income in the main specification because it suffers from many missing values in the SHARE (almost 50% of missing values). However, in column (5) we show that both interactions with education and verbal fluency score are substantially unchanged when income is included in the regression. Moreover, we do not find any significant heterogeneity of the treatment effect with respect to income.

[Insert Table 6 around here]

6. Discussion

In this paper we estimate the impact of organized screening policies on mammography uptakes. We base our analysis on a quasi-experimental setting arising in the implementation of OSP across European regions. We exploit regional variation in the availability of OSP and variations in age eligibility criteria across OSP as a source of exogenous variation in treatment assignment. Empirical Analysis is based on a unique data-set built on epidemiological literature and government reports containing information on characteristics of regional screening programs in Europe (NUTS-2

[4] These results are not shown but are available upon request.

Level). The data set is then linked to two waves of SHARE data covering information on several individual characteristics.

Our analysis leads to a number of findings that substantially increase the knowledge around the impact of information delivery on preventive decisions. Firstly, we find that information delivery within OSP effectively increases the uptake of appropriate mammography by around 20 percentage points, according to our preferred specification. At the same time, we find that the treatment effect is heterogeneous across individuals with a likely different information stock (proxied by education level) and ability to process information (proxied by a cognitive function measure). OSP *reduce* education-related inequalities by up to 13 percentage points (no education versus post-secondary gradient). In contrast, OSP *increase* inequalities related to cognitive functions: one standard deviation increase in verbal fluency score is associated with an increase of 3 percentage points in use among high-cognitive abilities individuals (compared to low ones). Put it differently, OSP increase cognitive-related inequalities in mammography use by 30 percentage points if one compares women with the highest fluency score compared to women with the lowest verbal fluency score. Thirdly, we find that the beneficial effect of invitation is not constant across invitation rounds, but it is stronger when information is delivered for the first time. Lastly, when analyzing the intensity of invitation we find a strictly increasing relationship between invitation and mammography uptake. However, we find an empirical threshold below which OSP are ineffective: OSP does not affect mammography uptake when less than the 25 per cent of the target group is reached by the invitation letter. Moreover, we find a sizeable effect on mammography use only when at least 75 per cent of the target group is reached by the invitation letter and we also find some diminishing marginal returns from invitation above such threshold.

These results may have some important practical implication on the design of screening policies across Europe. Firstly, despite some isolated attempts to estimate the effectiveness of screening policies in Denmark (Jorgensen, Zahl and Goetzsche, 2010), this paper is, to our knowledge, the first study that estimates the causal effect of OSP on mammography uptake on a bigger scale across European regions. We find a sizeable effect of home invitation on mammography uptake. On the basis of several randomized clinical trials, the World Health Organization concluded in 2002 that in areas with screening attendance of at least 70 per cent, a reduction in breast cancer mortality by about 25 per cent may be expected in screened women (IARC, 2002). Actually, the average screening rate across EU-countries is almost 50 per cent. We found that screening programs cause an increase of around 20 percentage points in mammography uptake on average. This implies that increasing the implementation of OSPs across regions could be virtually sufficient to reach the target fixed by the WHO. We are aware of the intense debate around the effectiveness of mammography in reducing mortality risk (e.g. Gøtzsche and Nielsen, 2011; Gigerenzer et al., 2009; Quanstrum and Hayward 2010; Raftery and Chorozoglou, 2011) and we do not aim to take a view on this debate. However, insofar as early diagnosis is useful to reduce mortality, our results suggest some important health benefits from the implementation of OSPs in all European regions.

Secondly, our results reveal some consequences of OSPs on the distribution of mammography across individuals with different education and cognitive function. We find that OSPs might be an effective tool to reduce education-related inequalities in mammography uptake found in several previous descriptive studies (e.g. Pacelli et al. 2014; Damiani et al. 2012). This is likely to be due to the fact that the delivery of information around benefits and consequences of mammography is useful to reduce the informational gap around health and prevention between individuals with a different level of education. At the same time, we realize that OSPs generate some perhaps unintended consequences on people with different cognitive functions. One might speculate that information provided by the invitation letter is less effective among individuals who are less able to process such information, i.e. women with low cognitive functions. This aspect is relevant considering that women in the target age are in a lifetime period in which cognitive function starts to decline (e.g. Skirbekk, 2004). Thus, our results may suggest that an alternative to the letter or a different kind of letter could be beneficial to increase mammography uptake of individuals with low cognitive functions. To this respect, a higher involvement of the GP may be beneficial. Expert GPs might act as agents for their less informed patients and they might play an important role in determining mammography screening uptake in particular for cognitive impaired women. Empirical evidence clearly indicates that women follow physician advice for different preventive decisions (e.g. Wübker, 2012; Schmitz and Wübker, 2011 or Maurer, 2009). This is true in particular for socially deprived women (Uscher-Pines, Maurer and Harris, 2011) but evidence is missing for cognitive impaired women. This would be a fruitful area for future research.

Lastly, our results indicate that the effective delivery of the information is the main aspect to be considered in the implementation of OSPs. We found that the home delivery of the information to less than the 25% of the population does not generate any significant effect on preventive decision. However, with increasing screening intensity, mammography uptake probabilities increase progressive going from 6.3 percentage points (inv. intensity up to 50 %) to 14.6 percentage points (inv. intensity up to 75 %). This progressive increase may indicate the existence of some 'social multiplier' mechanisms that boost the spreading of the information delivered by the OSP when a consistent share of population is reached by the letter.

Our study suffers from some shortcomings. First, we only have self-reported information on mammography uptake. Different US studies reveal that women tend to over report their mammography use in self-reports (Caplan et al. 2003; Cronin et al. 2009). E.g. Caplan et al. 2003 found that self-reported mammography rates exceeded record rates by 8.2 per cent. This over report could lead to an upward bias of our treatment effect. Second, while response rates in the SHARE are high (over 55 per cent) and very similar across the entire age range, the data does not include the institutionalized population (Börsch-Supan and Jürges, 2005) Therefore, it is only possible to generalize the results to a limited extent. Third, our design exploits regional variation in the availability of an OSP and variations in age eligibility criteria across OSPs in a cross-sectional setting. Further research might also try to explore the time dimension in analyzing the treatment effect of organized screening programs to provide additional credence in the results found here. This was not possible with our data.

Despite these limitations, our paper represents the first attempt of estimating the role of information on preventive decision in a quasi-experimental setting. In line with a number of previous papers relying on observational data (Kenkel, 1990; Hsieh and Lin, 1997; Parente, Salkever and DaVanzo, 2005; Nuscheler and Roeder 2014; Maurer, 2009), our results stress the high relevance of information for preventive decisions. More precisely, our results suggest that an exogenous informational shock induced by home delivery of the letter strongly affects preventive decisions.

We also find that the benefits from the exposure to this information are particularly high for less informed individuals. On the contrary, we document that the effectiveness of invitation is strongly reduced for women who are less able to process information. This implies that the simple delivery of information via a letter is not always sufficient and an alternative communication strategy addressed to people with low cognitive functions might be considered in the design of public health information campaigns.

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Figure 1: Screening Uptake by NUTS-2 regions

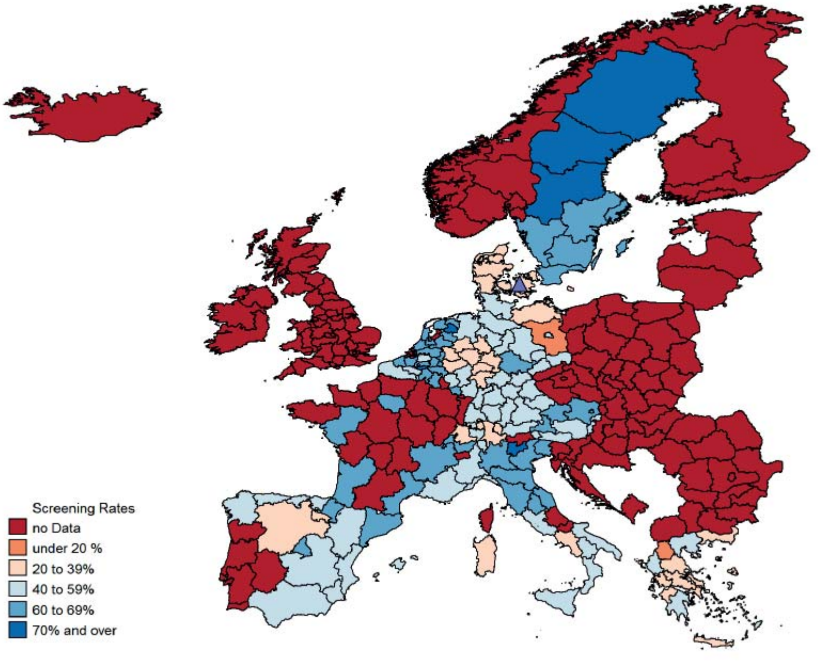

Figure 2: Age Eligibility criteria for OSP at NUTS-2 level

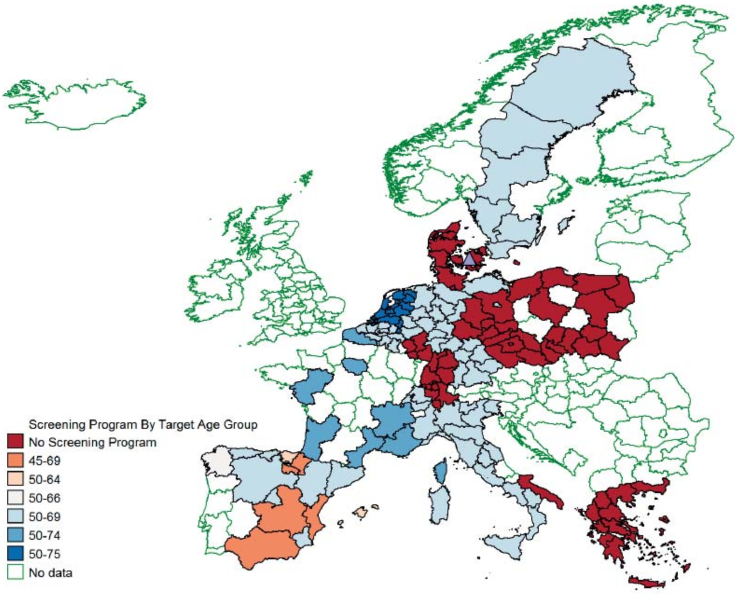

Figure 3: Invitation rates in OSP at NUTS-2 level

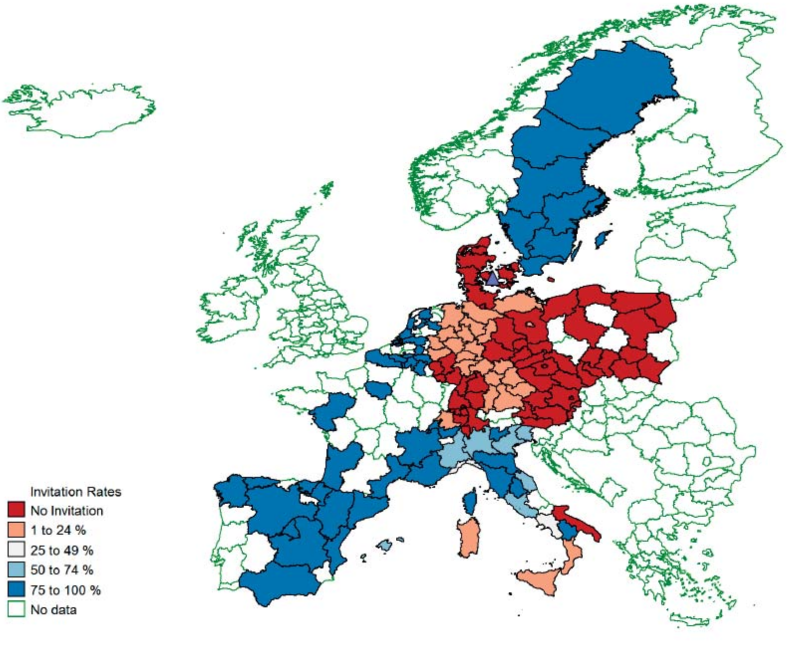

Figure 4: Mammography uptake and OSP

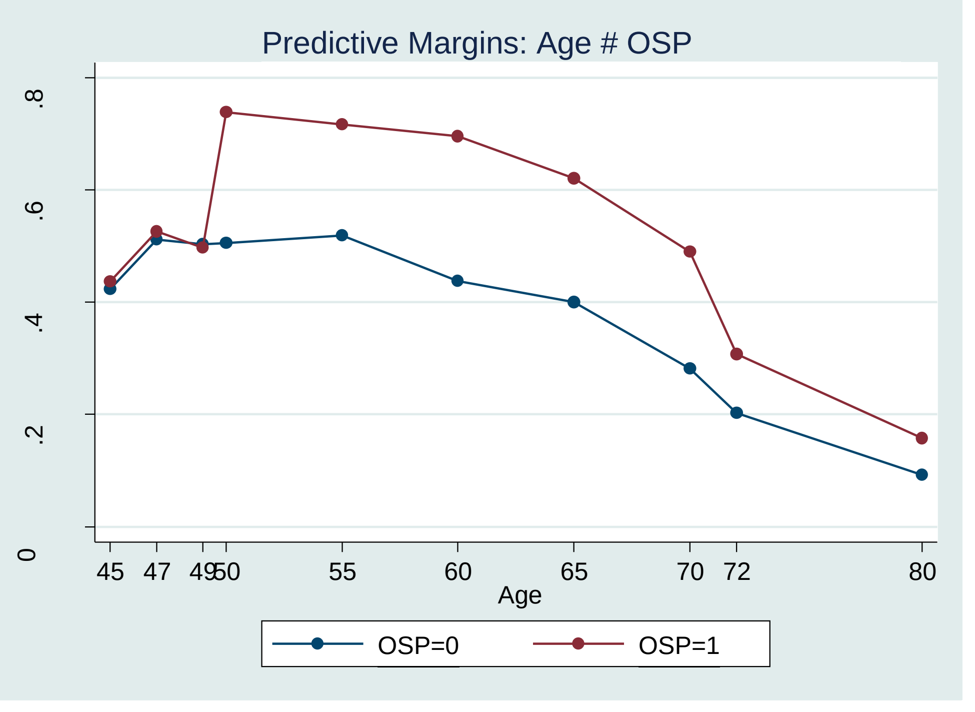

Table 1: Means (standard deviations) of sample characteristics

	In Eligible Age Group AgeGroup **= 1**			**Out of Eligible Age Group** AgeGroup **= 0**		
Treatment status (i.e. in Screening region)	$D_i = 0$	$D_i = 1$	delta	$D_i = 0$	$D_i = 1$	delta
Dependent variable						
Mammogram in previous 2 years in %	50.37	78.17	27.80	23.33	33.46	10.13
Inequalities related variables						
Education (ISCED-code)	2.75 (1.29)	2.83 (1.06)	0.08	2.13 (1.33)	3.20 (1.03)	1.07
Verbal fluency	19.97 (7.39)	20.15 (6.92)	0.18	16.11 (7.72)	16.58 (6.88)	0.47
Equiv. household income (gross in 1000 €)	24.50 (112.75)	37.30 (167.91)	12.80	18.22 (25.52)	24.03 (92.34)	5.81
Control variables						
Age	58.70 (5.86)	59.23 (6.28)	0.53	71.58 (12.93)	71.80 (13.21)	0.22
Self-Assessed Health	3.00 (1.05)	2.83 (1.06)	-0.17	3.36 (1.10)	3.20 (1.03)	-0.16
Working at least 35 hours in %	20.47	18.94	1.53	7.73	7.22	-0.51
History of breast cancer in %	1.65	3.26	1.61	2.22	3.46	1.24
Having a partner in %	70.26	76.59	6.33	47.01	56.32	9.31
No of observation	4244	5696		2108	2340	
No of Nuts-2 regions	76	97		76	97	

Abbreviations: ISCED-International Standard Classification of Education; Nuts - Nomenclature des unités territoriales statistiques
Notes: AgeGroup – Women belongs to the recommended age group; standard deviations in brackets

Table 2: Treatment effect OSP

	mammogram	mammogram
Screening region	0.085**	0.089**
	(0.038)	(0.030)
Eligible age group	0.269***	0.062**
	(0.019)	(0.022)
Treatment effect OSP	**0.180*** **	**0.186*** **
	(0.032)	**(0.029)**
Education		0.017***
		(0.005)
Cognition (Verbal fluency)		0.003**
		(0.001)
Self-assessed health		-0.010
		(0.008)
Having a partner		0.052***
		(0.009)
Having a full time job		0.030
		(0.019)
History of breast cancer		0.402***
		(0.052)
Controls	No	Yes
Age polynomials (age, age^2, age^3, age^4)	No	Yes
Observations	14185	14185

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3: Treatment effect invitation letter

	mammogram	mammogram	mammogram	mammogram
Treatment effect inv. letter	0.208***	0.210***		
	(0.032)	(0.025)		
Treatment effect first invitation			0.217***	
			(0.053)	
Treatment effect following invitations			0.202***	
			(0.036)	
Treatment effect inv. intensity 25 %				-0.019
				(0.040)
Treatment effect inv. intensity 50 %				0.063**
				(0.021)
Treatment effect inv. intensity 75 %				0.146***
				(0.014)
Treatment effect inv. intensity 100 %				0.202***
				(0.025)
Controls	No	Yes	Yes	Yes
Age polynomials (age, age^2, age^3, age^4)	No	Yes	Yes	Yes
Observations	14185	14185	14185	14185

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Heterogeneous treatment effect

	mammogram	mammogram	mammogram	mammogram
Treatment effect OSP	0.219***	0.189**		
	(0.053)	(0.070)		
Treatment effect inv. letter			0.249***	0.206***
			(0.031)	(0.034)
Treatment effect OSP # Education	-0.014	-0.018		
	(0.014)	(0.012)		
Treatment effect OSP # Cognition		0.002		
		(0.002)		
Treatment effect inv. letter # Education			-0.017***	-0.023***
			(0.006)	(0.005)
Treatment effect inv. letter # Cognition				0.003***
				(0.001)
Education	0.023***	0.025***	0.026***	0.028***
	(0.006)	(0.005)	(0.004)	(0.004)
Cognition (Verbal fluency)	0.003**	0.002**	0.002***	0.002**
	(0.001)	(0.001)	(0.001)	(0.001)
Controls	Yes	Yes	Yes	Yes
Age polynomials (age, age^2, age^3, age^4)	Yes	Yes	Yes	Yes
Observations	14185	14185	14185	14185

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Robustness checks – Placebo regression Diff-in-Diff

	mammogram	mammogram	mammogram
Treatment effect (Placebo Inv. 65 to 80)	-0.002		
	(0.061)		
Treatment effect (Placebo Inv. 40 to 60)		0.049	
		(0.039)	
Treatment effect inv. just after eligible age			0.085
			(0.106)
Treatment effect inv. just before eligible age			0.036
			(0.030)
Controls	Yes	Yes	Yes
Age polynomials (age, age^2, age^3, age^4)	Yes	Yes	Yes
Observations	14185	14185	14185

Table 6: Robustness checks – Heterogeneous treatment effect

	mammogram	mammogram	mammogram	mammogram	mammogram
Treatment effect inv. letter # Education	-0.016**	-0.018***	-0.019***		-0.033***
	(0.007)	(0.005)	(0.006)		(0.006)
Treatment effect inv. letter # Educ. low				0.082***	
				(0.017)	
Treatment effect inv. letter # Verb.flu.			0.004***	0.003***	0.004***
			(0.001)	(0.001)	(0.001)
Treatment effect inv. letter # Rec.del.	-0.006		-0.008		
	(0.006)		(0.007)		
Treatment effect inv. letter # Numeracy		0.000	-0.005		
		(0.014)	(0.014)		
Treatment effect inv. letter # Income					-0.000
					(0.000)
Controls	Yes	Yes	Yes	Yes	Yes
Age polynomials (age, age^2, age^3, age^4)	Yes	Yes	Yes	Yes	Yes
Observations	14185	14185	14180	14185	7447

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$