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The effect of organized breast cancer screening on mammography use: Evidence from France

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Abstract

In 2004, France introduced a national program of organized breast cancer screening. The national program built on preexisting local programs in some, but not all, *départements*. Using data from multiple waves of a nationally representative biennial survey of the French population, we estimate the effect of organized screening on the percentage of women obtaining a mammogram. The analysis uses difference-in-differences methods to exploit the fact that the program was targeted at women in a specific age group: 50 to 74 years old. We find that organized screening significantly raised mammography rates among women in the target age range. Just above the lower age threshold, the percentage of women reporting that they had a mammogram in the past 2 years increased by over 10 percentage points after the national program went into effect. Mammography rates increased even more among women in their 60s. Estimated effects are particularly large for women with less education and lower incomes, suggesting that France's organized screening program has reduced socioeconomic disparities in access to mammography.

KEYWORDS

cancer, disparities, France, mammography, preventive health

1 | INTRODUCTION

Breast cancer is the most frequently diagnosed cancer and the leading cause of death from cancer among women worldwide, accounting for one quarter of all new cancer cases and roughly 15% of cancer deaths (Torre et al., 2015). In 2015, roughly 154,400 women in the 28 countries of the European Union and 46,400 women in the United States died of breast cancer (Ferlay et al., 2015). If detected early, breast cancer is highly treatable, with very high rates of survival. Survival rates depend importantly on the stage at which breast cancer is detected. Five-year relative survival rates for breast cancer are 99% for localized cancers, 85% for regional cancers, and 26% for metastatic cancers (Siegel et al., 2016). Early screening increases the likelihood of detecting a cancer at a more local stage, thereby improving survival.

The most common method of early detection is mammography, a low-dose X-ray imaging of the breasts used to identify abnormalities. In light of evidence from clinical trials indicating that screening mammography reduces mortality by detecting tumors at an earlier stage (Duffy & Paci, 2012), expert organizations, including the World Health Organization's International Agency for Research on Cancer and the American Cancer Society, recommend regular, biennial screening mammograms starting at age 50 (Perry et al., 2008). Nearly every European country has established a national breast cancer screening program that makes mammograms available free of charge for women in the recommended age range (Altobelli & Lattanzi, 2014).

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Despite the central role that organized screening programs play in national cancer prevention strategies, there is surprising little research evidence on their impact. A basic question is whether organized programs are effective in increasing the number of women who receive mammograms. We examine this question using data from France. The first organized programs in the country were introduced in the late 1980s and early 1990s at the level of the *département*.[1] In 2004, France established a national program that built on and strengthened the early local programs in several ways. In particular, the target age range was expanded slightly, and the recommended frequency for mammography screening was increased to once every 2 years from once every 3 years. By 2009, France's organized breast cancer screening program was the largest in the European Union in terms of the number of mammogram performed each year (Séradour, 2010). We evaluate the impact of both the national program and the earlier local programs using data from a nationally representative survey of the French population spanning the period 2000 to 2010 and difference-in-differences models that exploit variation in exposure to organized screening related to age, geography, and time.

Numerous studies from multiple countries have documented significant disparities related to socioeconomic status in the use of a wide range of preventive health services, including cancer screening (Carrieri & Wubker, 2013; Devaux, 2015; Jusot et al., 2012; Pruitt et al., 2009; Schueler et al., 2008). An important objective of population-based screening programs is to reduce such disparities in utilization, thereby reducing disparities in cancer detection and survival. We consider whether France's organized screening program has reduced disparities in screening by testing for heterogeneous treatment effects related to education and income.

Our results indicate that the early local programs increased the percentage of women who had a mammogram in the past 2 years by roughly six percentage points, a 14% effect relative to the rate in areas without an organized program. We estimate that the effect of the national program that went into effect in 2004 was nearly twice as large. Although the percentage of women reporting a recent mammogram increased for all ages within the target range, the change was greatest among women in their 60s. This result combined with the fact that we find a weaker effect of the program on the probability of *ever* having had a mammogram suggests that the program has increased not only initiation to mammogram use but also the regularity with which women obtain screening. Because we find that France's organized screening program had a larger effect on mammography rates for women with lower socioeconomic status, gradients with respect to education and income have declined since the national program has been in place.

2 | BACKGROUND AND PREVIOUS LITERATURE

2.1 | Breast cancer screening

Breast cancer screening typically includes a clinical breast exam, a physical examination of the breast by a physician or nurse, and a mammogram, which is an X-ray of the breast tissue that provides detailed images of the breast from two angles (frontal and profile). The mammogram is performed and analyzed by a radiologist. Screening mammograms are given to asymptomatic women to look for suspicious markers. Diagnostic mammograms are typically given to women who have had a previous abnormal screening mammogram, have a family history of breast cancer, or have certain symptoms, such as the presence of lumps.

The accuracy of a mammogram depends on the density of the breast tissue, which tends to decline with age. For women over age 50, the sensitivity of the test (the probability of detecting an existing cancer) ranges between 66% and 90%, and specificity (the probability that the test is negative for someone without the disease) reaches 95% (Smith, 2003). Thus, mammography is seen as an effective means of detecting breast tumor for women older than 50 years. It is considered less appropriate for younger women whose breast tissue tends to be denser.

Several studies based on randomized controlled trials have concluded that mammography screening leads to a significant reduction in breast cancer mortality (Duffy & Paci, 2012). These results led to recommendations by medical societies and public agencies that women receive regular mammograms. Reviewing evidence from a number of microsimulation studies, Cutler (2008) concludes that nearly half of the reduction in breast cancer mortality in the United States between 1990 and 2004 can be attributed to increased screening. Recently, however, there has been some debate about how the benefits of mammography related to reduced mortality should be weighed against the cost associated with false-positive results and overdiagnosis possibly leading to overtreatment (Gøtzsche & Nielsen, 2009). In 2009, the U.S. Preventive Ser-

[1]The *département* is the fundamental administrative and political jurisdiction in France. There are 95 *départements* in "metropolitan France," with an average land area of 5,666 km^2 (3.5 times the median land area of U.S. counties). In terms of population, in 2015, *départements* varied in size from 76,000 to 2.6 million, with an average population of 670,000.

vices Task Force generated some controversy when it revised its guidelines to recommend that women begin to receive regular mammograms starting at age 50, rather than 40 as it had previously recommended. The U.S. Preventive Services Task Force also revised its recommendation regarding the frequency of screening mammograms from annual to biennial. In 2012, a U.K. expert panel conducted a meta-analysis of the randomized trial evidence and concluded that screening mammograms reduced the relative risk of mortality by 20%, while acknowledging the problem of overdiagnosis (Marmot et al., 2012). The panel's conclusions supported the National Health Service policy of organized breast cancer screening beginning at age 50.

2.2 | The effect of public policies on screening

Most countries have policies aimed at increasing the number of women who receive a regular mammogram. In the United States, with its fragmented system of health-care financing, different strategies have been targeted at women with different types of insurance coverage. Between the late 1980s and early 2000s, nearly every state enacted laws requiring private health insurance plans to include screening mammograms as a covered benefit. Recent research indicates that these benefit mandates significantly increased the percentage of women obtaining a mammogram, with especially large effects occurring when plans were prohibited from charging cost sharing for the service (Bitler & Carpenter, 2016a).[2] The requirement that private insurance plans provide first-dollar coverage for screening mammograms became national policy as a result of the Affordable Care Act. A different U.S. policy, the National Breast and Cervical Cancer Early Detection Program (NBCCEDP), aims to increase cancer screening among uninsured low-income women. Although it is a Federal program, the NBCCEDP was rolled out incrementally by different states throughout the 1990s. Research exploiting that implementation pattern finds that this program also significantly increased the percentage of women obtaining mammograms (Adams et al., 2003; Bitler & Carpenter, 2016b).

In Europe, breast cancer prevention strategies have centered on organized screening programs (Altobelli & Lattanzi, 2014). The earliest programs, established at the local level, date to the 1980s. Finland, Luxembourg, the United Kingdom, and Sweden expanded their programs to the national level in the early 1990s. In 2003, the European Commission formally recommended population-based screening for women between the ages of 50 and 69. Soon thereafter, nearly every European country had established a national organized breast cancer screening program. Although the exact details vary, these national programs share several common elements. The modal program targets 50- to 69-year-olds.[3] Every 2 (or in a few countries 3) years, women in the target age range receive a letter inviting them to receive a free mammogram. The standard protocol involves two images per breast and double reading of normal mammograms.

Two recent studies evaluate the effect of organized breast cancer screening programs on the utilization of mammography, using difference-in-differences research designs. Pletscher (2017) analyzes the case of Switzerland, where a program targeted at women between the ages of 50 and 69 was rolled out over several years at the level of the canton. This pattern of implementation provides variation related to geography, age, and time. However, it is not clear that this variation is orthogonal to other factors affecting cancer screening. According to Pletscher (2017), cantons that did and did not implement screening programs differed in terms of breast cancer incidence, treatment patterns, the supply of radiologists, and patient preferences. In addition, the survey data he uses have an important limitation: The only question related to mammography use asks if female respondents had *ever* had a mammogram. Thus, to the extent that organized screening affects not only initiation to mammography but also the regularity of screening, his analysis will understate the impact of the policy. Pletscher (2017) finds that organized screening is associated with a 4.6-percentage-point increase in the probability of ever having had a mammogram.

Carrieri and Wuebker (2016) use data from the Survey of Health, Ageing and Retirement in Europe (SHARE) to estimate cross-sectional difference-in-differences models that compare women from 13 different countries who were exposed to organized screening with those who were not exposed because of their age or geographic location. Their dependent variable is an indicator for whether a woman had a mammogram in the past 2 years. One limitation of their research design is that the geographic variation is measured at the level of the NUTS-2 region, a statistical unit that does not map directly to political or administrative divisions and therefore does not necessarily correspond to the geographic area cov-

[2] A related literature from the United States examines the effect of insurance coverage on mammography use. Busch and Duchovny (2005) and Finkelstein et al. (2012) find a positive effect of Medicaid. Several recent studies examine the effect of Massachusetts's 2006 health reform on mammography use and obtain mixed results (Keating et al., 2013; Kolstad & Kowalski, 2012; Sabik & Bradley, 2016).

[3] In addition to France, the Netherlands extends the target age range to 74. In Ireland and Estonia, the upper age limit is 64 and 65, respectively. In the Czech Republic, Hungary, and Portugal, organized screening begins at age 45. Eligibility for the national program of Austria and Sweden start at 40 years old.

ered by an organized screening program.[4] For example, NUTS-2 regions in Switzerland are larger than cantons, the level at where the organized screening programs analyzed by Pletscher (2017) were implemented. Similarly, the NUTS-2 regions for France encompass multiple *départements*. Thus, it is likely that some women in the treatment group were not actually exposed to an eligible screening program, whereas some women in their control group were. And even more than in the case of Switzerland's cantons, differences in health-care financing and delivery among European countries raise concerns about the comparability of this study's treatments and controls. Their main estimates imply that organized screening programs raise the probability that a woman in the target age range has had a mammogram in the past 2 years by roughly 17 percentage points.

Numerous studies document significant socioeconomic disparities in breast cancer screening. Jusot et al. (2012) and Carrieri and Wubker (2013) use SHARE data to examine the socioeconomic correlates of several types of preventive care. Both studies find that, controlling for other factors, screening rates increase significantly with education and income. Significant disparities in mammography use have also been documented in the United States (Lantz et al., 2006; McMorrow et al., 2014; Sabatino et al., 2008) and Canada (Katz & Hofer, 1994; Katz et al., 2000). In a comparative study of 19 Organisation for Economic Co-operation and Development countries, France ranked fourth in terms of income-related inequalities in mammography use (Devaux, 2015).

If cost is an important reason that lower income women make less use of preventive care, organized programs that make mammograms available free of charge should reduce disparities in utilization. Similarly, to the extent that disadvantaged women have low rates of breast cancer screening because they are not well informed about the benefits of mammography, the information that is provided as part of an organized program can also reduce disparities. On the other hand, more educated, higher income women may be more efficient users of health inputs and, therefore, may be more responsive to the reduced cost and informational intervention associated with an organized screening program. Thus, it is possible that an organized program could amplify rather than reduce disparities in mammography use related to socioeconomic status (Goldman & Lakdawalla, 2001).

The existing evidence on the effect of public policies on disparities in mammography utilization is limited and mixed. Adams et al. (2007) find that although the NBCCEDP increased breast and cervical cancer screening in the United States, the program did not reduce disparities in screening outcomes related to race or ethnicity. Similarly, in his analysis of organized screening in Switzerland, Pletscher (2017) tests for heterogeneous effects related to education and income and finds no clear pattern with respect to either. In contrast, Carrieri and Wuebker (2016) find that organized programs have a larger effect on women with the lowest levels of education compared with those with medium or high levels of education.

2.3 | Organized breast cancer screening in France

As in other European countries, organized screening in France began in the 1980s at the local level. Between 1989 and 1998, programs were launched in 27 *départements*; by 2000, there were 32 local programs. These *départements*, which are shown as the darkest ones on the map (Figure 1), are scattered throughout the country. This effectively random geographic dispersion of local programs and the fact that France's health-care system is highly centralized, with uniform benefits and reimbursement policies nationwide, minimize the concern that the distribution of these local programs was correlated with other factors that likely influenced the demand for or supply of mammography.

The national program was announced in 2003 and was operational throughout France by 2004. The current system is financed at the national level by the public health insurance funds and is overseen by the National Cancer Institute, though the operation of the program is still managed at the level of the *département*, typically by a nonprofit organization.

The protocol for the early programs involved a single image, which was read by two radiologists. The national program is based on a new protocol, which includes two images per breast and a clinical breast exam. Whereas the local programs sent invitation letters every 3 years to women between the ages of 50 and 69, under the national program, women between the ages of 50 and 74 receive an invitation letter every 2 years. This letter provides information on the benefits of mammography in general as well as the specific advantages of the organized program, such as the second reading, and a list of radiologists participating in the program. Participating radiologists must undergo a specific training, perform a minimum of 500 mammograms per year, and agree to have their equipment inspected by a national agency. The goal of these requirements is to assure a standard level of quality throughout the country. For women who accept the invitation to the

[4]NUTS stands for Nomenclature of Territorial Units for Statistics. The system was developed by Eurostat for developing, collecting, and analyzing harmonized statistics at the subnational level.

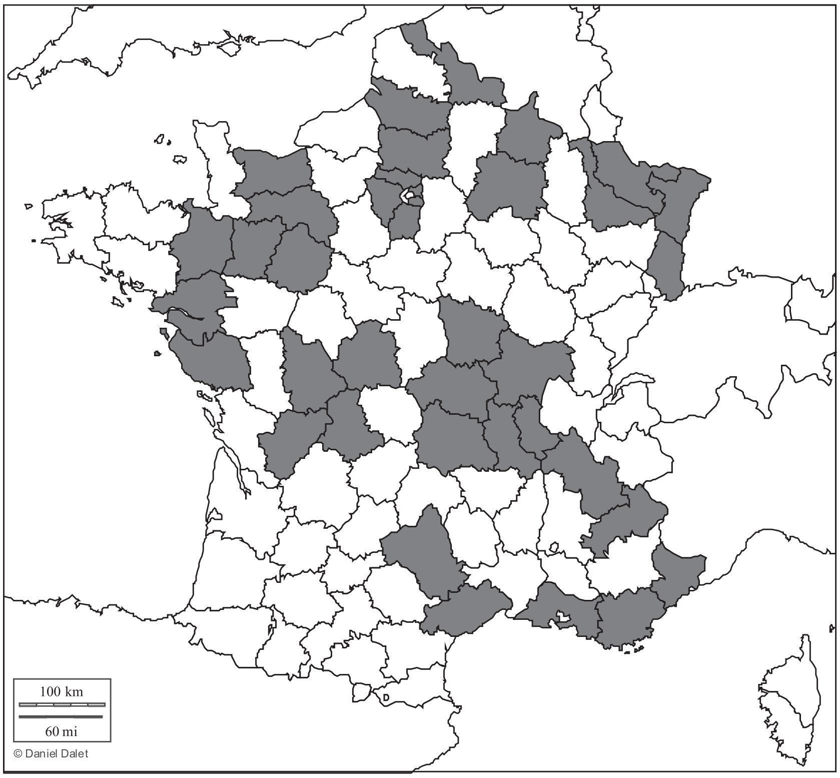

FIGURE 1 Implementation of the local and national programs. The gray areas represent the *départements* that adopted a local program before 2004.

organized program, there is no charge for the mammogram. Currently, the amount that the public insurance system pays to the radiologists for a mammogram (the "standard tariff") is 66.42 euros.

Whether or not a woman receives a letter of invitation, she can screen "opportunistically" by obtaining a prescription from a physician (usually a gynecologist or a general practitioner). In that case, she would face some out-of-pocket expenses. Women screening opportunistically would need to pay the standard tariff upfront, though 70% of it would be reimbursed by the public health insurance system and part or all of the remaining 30% would be reimbursed by private complementary insurance. Some radiologists are allowed to charge more than the standard tariff. It is estimated that in 2008 the physician's fee exceeded the standard tariff for over 80% of the mammograms performed outside of the national program, with an average extra-billing amount of 6 euros (Haute Autorité de Santé, 2011). This extra billing is not reimbursed by the public system, though part may be reimbursed by private complementary insurance, depending on the contract. Mammograms done outside the organized program are not necessarily read by two radiologists and need not be combined with a clinical breast exam.

Thus, there are multiple channels by which the organized program may increase screening. First, there may be an educational or informational effect: The letter informs women about the benefits of mammography and provides information about where they can obtain a mammogram. Second, the program lowers the financial cost of screening. Third, the program may also increase utilization by affecting perceptions of the quality of the program relative to opportunistic screening.[5]

With the program's 2-year invitation cycle, women in the target age range receive an invitation letter 20–22 months after their last mammogram received through the program (if they took up the previous offer) or their last invitation letter (if they did not). In the absence of an organized program, there would be no such follow-up for women who had obtained a mammogram by getting a prescription from their doctor. Thus, an organized screening program may affect not only the likelihood that a woman ever receives a mammogram but also the regularity with which she does. A recent study by

[5] A number of studies find a positive relationship between the volume of mammograms that a physician interprets and accuracy, in terms of both sensitivity and specificity (Esserman et al., 2002; Smith-Bindman et al., 2005). Other research finds that double reading of mammograms significantly increases cancer detection rates (Kopans, 2000; Thurfjell et al., 1994). A qualitative study of target-age women in France found that those who had participated in the organized program viewed the second reading as an indicator of quality (Kalecinski et al., 2015).

Goldzahl and Jusot (2017) is suggestive of such an effect. They find that women who participate in the organized program are more likely than women who obtained a mammogram outside the program to receive a second mammogram within 2 years.

3 | DATA AND METHODS

3.1 | Data: The Enquête Santé et Protection Sociale

Our analysis is based on data from the *Enquête Santé et Protection Sociale* (ESPS), a representative population-based survey that has been conducted biennially since 1988 by the *Institut de Recherche et Documentation en Economie de la Santé*. The ESPS is administered to a sample of French households randomly drawn from public health insurance files. The survey provides information on both the household and its members collected using both interviews (telephone or face to face) and self-administered questionnaires.[6] We use data from the 2000, 2002, 2006, 2008, and 2010 surveys, which are the only years in which the survey includes questions on mammography. The ESPS has a longitudinal component, whereby half of the sample is interviewed every 4 years. Thus, some respondents were interviewed two or three times in the five survey waves that we analyze. In our main analysis, we treat the sample as a repeated cross-section. As a sensitivity check, we also use the panel dimension to estimate models with individual fixed effects.

The timing of the surveys is well suited for our study for several reasons. First, we have two periods of data before and three periods after the implementation of the national screening program in 2004. Second, all but one of the local programs that predated the national program were in place by 2000.[7] This facilitates clear cross-sectional comparisons during the "pre" period and simplifies the implementation of the difference-in-differences model to estimate the effect of the national program. Third, the fact that our first year of "post" data is 2 years after the program was put in place nationally means that nearly all women in the target age group should have received a letter of invitation by the time they responded to the survey. Fourth, the 4-year gap between our last year of data predating the national program and our first year of "post" data means that our estimates should not be affected by short-run dynamic effects around the implementation year. That is, our estimates should not be subject to an upward bias caused by women delaying a mammogram they otherwise would have had in 2003 in order to benefit from the program or by a downward bias from a "learning curve" in the initial year of the program.

There are two timing issues that could potentially cause the effect of the local program to be different in 2000 and 2002. The first is that eight of the 32 early local programs were started in 1998 or later. So while the program was in place by 2000, some eligible women may not have received their invitation letter by the time they completed the 2000 ESPS. Second, some *départements* with local programs began transitioning to the new protocol in 2001 and 2002. Both of these factors could result in the program having a larger impact in 2002 than in 2000. However, we find no evidence of such a difference (as shown in Table SA.1). Therefore, we pool the data from 2000 and 2002, treating them as a single "pre" period relative to the introduction of the national program.

As in previous studies on mammography use (Bitler & Carpenter, 2016a, 2016b; Carrieri & Wuebker, 2016; Pletscher, 2017; Sabik & Bradley, 2016) our dependent variables are based on self-reports. In the first two waves, the ESPS asks women whether they ever had a mammogram. Possible answers are yes, in the past 2 years; yes, between 2 and 3 years ago; yes, more than 3 years ago; and no, never. We create a binary variable that equals 1 for women who screened in the past 2 years. In the next three waves, the ESPS asks women whether they have ever had a mammogram. Those answering yes are then asked to give the date of their last mammogram. On the basis of these responses, we create a binary variable that equals one for women who have had a mammogram in the past 2 years and zero for all others (including both women who have never had a mammogram and women whose last mammogram was more than 2 years earlier). Although the mammography question is asked of all female respondents over age 15, mammography rates for younger women are extremely low. Therefore, we limit our main analysis to women age 35 and older.

Table 1 presents summary statistics for the full sample and for women living in *départements* with and without a local organized screening program respectively in the preperiod and postperiod. As we describe below, our estimate of the effect of the local program relies on a cross-sectional comparison of women in *départements* with and without such programs. Thus, the validity of our research design relies on the assumption that women in *départements* without a local program

[6]More information on the ESPS, including questionnaires for every year, is available at http://www.irdes.fr/recherche/enquetes/esps-enquete-sur-la-sante-et-la-protection-sociale/actualites.html

[7]The exception was the Essonne, a *département* in the greater Paris region, which established its program in January 2000.

TABLE 1 Summary statistics: Full ESPS sample, 2000–2010

	All		*Départements* without a local program		*Départements* with a local program		*p* value of the diff.
Mammogram in the past 2 years	0.378	0.487	0.372	0.483	0.385	0.487	0.032
Ever had a mammogram	0.531	0.499	0.526	0.499	0.537	0.499	0.006
Poor health	0.046	0.194	0.045	0.207	0.048	0.213	0.218
Fair health	0.168	0.362	0.167	0.373	0.169	0.375	0.537
Good health	0.310	0.462	0.308	0.462	0.313	0.464	0.456
Excellent health	0.160	0.382	0.163	0.369	0.157	0.364	0.161
Health unknown	0.297	0.454	0.298	0.457	0.295	0.456	0.519
Private compl. insurance	0.877	0.328	0.882	0.323	0.871	0.335	0.005
Public compl. insurance	0.054	0.226	0.051	0.219	0.058	0.235	0.003
No compl. insurance	0.008	0.091	0.009	0.097	0.010	0.097	0.979
Unknown	0.009	0.097	0.008	0.091	0.008	0.091	0.866
Has long-term condition	0.157	0.363	0.156	0.363	0.157	0.364	0.963
Smoker	0.137	0.344	0.140	0.347	0.134	0.341	0.155
Education: Primary or less	0.303	0.459	0.301	0.459	0.305	0.461	0.391
Education: Middle school	0.271	0.444	0.267	0.442	0.276	0.447	0.083
Education: High school	0.192	0.394	0.196	0.397	0.188	0.391	0.111
Education: University	0.194	0.396	0.200	0.400	0.188	0.391	0.012
Education: Other	0.040	0.195	0.037	0.189	0.043	0.202	0.018
Occupation: Farmer	0.047	0.212	0.057	0.231	0.035	0.185	0.000
Occupation: Craftsman	0.048	0.214	0.053	0.223	0.043	0.202	0.000
Occupation: Executive	0.082	0.274	0.083	0.276	0.080	0.271	0.350
Occupation: Intermediate occup.	0.176	0.381	0.181	0.385	0.170	0.376	0.024
Occupation: Employees	0.431	0.495	0.416	0.493	0.449	0.497	0.000
Occupation: Workers	0.163	0.369	0.162	0.368	0.165	0.371	0.544
Occupation: Other/unknown	0.053	0.224	0.049	0.215	0.058	0.234	0.001
Income: 1st quintile	0.106	0.308	0.108	0.311	0.104	0.305	0.229
Income: 2nd quintile	0.123	0.329	0.125	0.331	0.121	0.327	0.313
Income: 3rd quintile	0.132	0.338	0.134	0.341	0.129	0.335	0.156
Income: 4th quintile	0.171	0.376	0.167	0.373	0.176	0.381	0.027
Income: 5th quintile	0.182	0.386	0.179	0.384	0.185	0.389	0.168
Income: Refused to answer	0.286	0.452	0.287	0.452	0.285	0.451	0.689
Rural	0.293	0.455	0.347	0.476	0.227	0.419	0.000
Paris	0.124	0.330	0.113	0.317	0.137	0.344	0.000
Age	54.779	13.600	55.095	13.805	54.395	13.337	0.000
Radiologist density	9.053	2.362	8.900	2.450	9.239	2.238	0.000
GP density	85.202	11.480	85.374	12.190	84.990	10.560	0.004
Mortality rate 1980–1988	16.96	2.192	17.30	2.099	16.54	2.23	0.000
Year: 2000	0.179	0.384	0.180	0.384	0.178	0.383	0.670
Year: 2002	0.184	0.387	0.184	0.388	0.184	0.387	0.846
Year: 2006	0.204	0.403	0.207	0.405	0.202	0.401	0.299
Year: 2008	0.213	0.410	0.215	0.411	0.211	0.408	0.372
Year: 2010	0.219	0.414	0.214	0.410	0.226	0.418	0.013
Observations	29,296		16,059		13,237		

Note. ESPS: Enquête Santé et Protection Sociale; GP, general practitioner.

are good controls for women in *départements* with a program. The summary statistics support this assumption. In the preperiod, the two subsamples are remarkably similar in terms of observable characteristics. The mean age is 54.4 years in *départements* that had an organized screening program and 55.1 years in those that did not. In each group, just under 5% of women report their health as poor, 17% of women report their health as fair, and 16% say they are in excellent health. Between 13% and 14% of women in each type of *département* are current smokers. The percentage with private complementary health insurance—which has been shown to be positively correlated with the utilization of outpatient care (Buchmueller et al., 2004)—is very similar (87.1% in *départements* with a local program, 88.2% in those without) as is the distribution of income. The one notable difference is that *départements* with local programs tend to be less rural. Despite this, there is no meaningful difference in the supply of services, as measured by the density of radiologists per capita. The two groups were also quite similar in terms of the breast cancer mortality rate for the years 1980 to 1988: In the average *département* with a local program, the rate was 17.3 deaths per 100,000 population compared with 16.5 per 100,000 in the average *département* without a local program.[8]

3.2 Empirical strategy

The quasi-experimental variation in our data allows for several different estimates of the effect of organized breast cancer screening programs on mammography use. Let T_t^k be the screening rate for women in the target age range (50 to 74) and C_t^k be the screening rate for women outside this age range, that is, the "control" group. The superscript k indexes two types of *départements*: those with (L) and without (N) local screening programs. The subscript t indexes two time periods. The "pre" period ($t = 0$) consists of the years 2000 and 2002, before the national program was established; the "post" period ($t = 1$) consists of data from 2006 to 2010, when the national program was in place in all *départements*.

With the use of this notation, a simple cross-sectional estimate of the average effect of the preexisting local programs can be obtained by comparing the screening rates for the target age group in the two types of *départements*:

$$\Delta_{\mathrm{L}} = T_0^{\mathrm{L}} - T_0^{\mathrm{N}}. \tag{1}$$

As just noted, *départements* with and without local programs are quite similar in terms of observable characteristics. However, unobserved factors remain a potential source of bias. One can imagine the bias going in either direction. On the one hand, the "first mover" *départements* may be those with good referral networks and radiologists with a strong orientation toward population screening. On the other hand, some *départements* may have established organized programs in response to low rates of opportunistic screening. If these other factors have the same effect on women within and outside the target age range, this potential bias can be eliminated by using a cross-sectional difference-in-differences estimator:

$$\Delta\Delta_{\mathrm{L}} = (T_0^{\mathrm{L}} - T_0^{\mathrm{N}}) - (C_0^{\mathrm{L}} - C_0^{\mathrm{N}}). \tag{2}$$

The effect of the national program can be estimated by calculating changes in screening rates for target group women who were not exposed to the earlier local programs, using changes for control group women in the same *département* to account for the effect of other factors that may have caused screening rates to change over time. This difference-in-difference estimate can be calculated as

$$\Delta\Delta_{\mathrm{N}} = (T_1^{\mathrm{N}} - T_0^{\mathrm{N}}) - (C_1^{\mathrm{N}} - C_0^{\mathrm{N}}). \tag{3}$$

Given that the national program put in place in 2004 is stronger in several respects than are the preexisting local programs, it is of interest to test whether screening rates increased in those areas that had local programs in place in the "pre" period. The difference-in-difference estimate

$$\Delta\Delta_{\mathrm{LN}} = (T_1^{\mathrm{L}} - T_0^{\mathrm{L}}) - (C_1^{\mathrm{L}} - C_0^{\mathrm{L}}) \tag{4}$$

captures the combined effect of those specific elements of the national program that differ from the local programs: the use of a 2-year rather than 3-year invitation cycle, the extension of program eligibility to age 74 rather than 69, two images per breast are taken instead of one, and the fact that women receive a clinical exam in addition to a mammogram.

Because we have no data from years before the local programs were established, we cannot directly estimate the full effect of the national program in these *départements*. However, we can construct an estimate of that effect by summing the cross-sectional estimate of the effect of the local program, Δ_{L}, with our estimate of the effect of moving from the local program to the national program $\Delta\Delta_{\mathrm{LN}}$. Note that comparing this measure with our direct estimate of the effect of the national program, Δ_{N}, provides a useful test of the assumption that the two types of *départements* are similar, apart from when they implemented their programs. If this assumption holds, the two estimates of the effect of the national program should be similar.

These various estimates can be obtained from the following regression estimated on pooled data:

$$\begin{aligned} y = \alpha_1 Local + \alpha_2 Target + \alpha_3 Post + \beta_1 Local \times Target + \beta_2 Local \times Post + \beta_3 Target \times Post \\ + \gamma Local \times Target \times Post + X'\theta + \epsilon. \end{aligned} \tag{5}$$

[8] We use an averaged mortality rate data from the year 1980 to 1988. This is before local programs implementation. The reason is that we wanted to control for potential prelocal program implementation mortality differences between *départements* in case those differences explain why some *départements* launched a local program or not. General practitioner and radiologist density rates were collected for the years 1998 to 2008, which is contemporaneous with surveys. The data come from the Eco-Santé website.

In this equation, *Local* is an indicator variable that equals one for women who live in a *département* that had a local screening program before 2004, *Target* is an indicator for women between the ages of 50 and 74, the indicator *Post* equals one for years after 2004, and X is a vector of control variables. The various estimates are then as follows.

Effect of local program:	$\Delta\Delta_L =$	β_1
Effect of national program:	$\Delta\Delta_N =$	β_3
Effect of transition from local to national program:	$\Delta\Delta_{LN} =$	$\beta_3 + \gamma$

3.3 | Testing for parallel trends

Our strategy for estimating the effect of the national program relies on the assumption that the post-2004 experience of women outside the target age range represents an appropriate counterfactual for women that were targeted by the program. A standard way to test that assumption is to examine whether outcomes for the two groups were trending similarly before the policy was put in place. The fact that we have only 2 years of data from the preperiod limits our ability to analyze pre-trends. Nonetheless, it is informative to test for differences in changes in mammography utilization between 2000 and 2002. A finding that utilization among target age women was already increasing relative to the control group before the national program was in place would suggest that our difference-in-differences estimates may overstate the program's effect.

Table SA.1 presents the change in mammography utilization between 2000 and 2002 for the four categories of women defined by target group status and *département* type. We see that for each category, there was no significant change in utilization over this period. The most important comparison is between treatments and controls in *départements* without a preexisting program, because these are the observations upon which our main estimates of the national program are based. Within these *départements*, the screening rate fell by a statistically insignificant one percentage point for women in the target age range (p value = 0.535) and increased by a statistically insignificant 0.3 percentage points for the control group (p value = 0.881). The difference between these two estimates is also not significantly different from zero (p value = 0.741). Whereas estimates based on only 2 years of data from the “pre” period do not provide definitive evidence of parallel trends, these null results, along with several other findings discussed below, provide support for our empirical strategy.

4 | RESULTS

4.1 | Unadjusted difference-in-differences estimates

Table 2 presents the percentage of women who had a mammogram in the past 2 years tabulated by membership to the target age group of 50 to 74 years, residence in a *département* with a local program, and the years before or after the implementation of the national program. These figures can be used to calculate the various estimates just described.

TABLE 2 Unadjusted difference-in-differences estimates

Time Period	Age Group	*Département* has a preexisting program? No [1]	Yes [2]	Difference [2] − [1]
A. Prenational program (2000 and 2002)	Outside of target age range	0.250	0.254	0.004
		(0.008)	(0.009)	(0.012)
	In target age range	0.427	0.490	0.063***
		(0.009)	(0.011)	(0.014)
B. Postnational program (2006 to 2010)	Outside of target age range	0.235	0.248	0.012
		(0.006)	(0.008)	(0.009)
	In target age range	0.565	0.553	−0.012
		(0.007)	(0.008)	(0.010)
C. Change over time (B − A)	Outside of target age range	−0.014	−0.006	
		(0.010)	(0.011)	
	In target age range	0.138***	0.063***	
		(0.012)	(0.013)	

Note. $^{*}p < 0.10$. $^{**}p < 0.05$. $^{***}p < 0.01$.

Panel A reports data from the "pre" period (2000 and 2002). The first row pertains to women who are outside the target age range and therefore not eligible for organized screening regardless of where they live. A comparison of mammography rates for this group in the two types of *départements* provides information on whether there are other factors affecting mammography that are correlated with the existence of a program. The fact that the difference is not statistically significant, suggests that other confounding factors are not a concern. As a result, when we compare mammography rates across *département* types for women in the target group, the simple difference, Δ_L, and the difference-in-differences estimate of the program effect, $\Delta\Delta_L$ are essentially identical. Both imply that the local programs raised mammography rates among women in the target age range by roughly six percentage points, or by about 14% of the rate in *départements* without an organized screening program.

Panel B presents screening rates after the national program was in effect. The comparisons across *département* types again suggest a strong similarity between those with and without an organized screening program in place before 2004. As in the earlier period, there is no statistically significant difference between the two types of *départements* among women outside of target age range. The results for women in the target age range indicate that the implementation of the national screening program eliminated the gap in screening rates between *départements* with and without local program. In the "post" period, 55.3% of women in *départements* with an already established local program and 56.5 of women who were not exposed to organized screening prior to 2004. The 1.2 percentage point difference between these two rates is not statistically significant. The fact that screening rates for target group women were essentially identical when the policy environment was the same provides additional support for interpreting the cross-sectional difference in the preperiod as representing the effect of the local programs.

The effect of the national program can be estimated based on changes over time, which are reported in Panel C of the table. Again, it is informative to note the differences that are not statistically significant. In both types of *départements* there was no significant change for women outside the targeted age range, suggesting that there were no other contemporaneous factors, such as a general increase in breast cancer awareness or a change in clinical guidelines that might have caused screening to increase over time. In contrast, we see significant changes for women who were eligible. For women in the target group who were not previously exposed to a local organized screening program (Column [1]), the percentage with a mammogram in the past 2 years increased by 13.8 percentage points, a 32% effect relative to the baseline rate. Since there was no significant change for women outside the target group, the difference-in-differences estimate of the effect of the program is essentially identical. The fact that this estimated effect is substantially larger than the estimated effect of the local programs suggests that the ways in which the national program strengthened the local programs had a meaningful effect. This conclusion is reinforced by the finding that screening rates increased over time in *départements* where there was already a local organized screening program in place. The difference-in-differences estimate of the effect of this change is 6.9 percentage points ($\Delta\Delta_{LN} = 0.063 + 0.006 = 0.069$).

4.2 | Basic regression results

In Table 3 we report key results from linear probability regressions that generate the same set of estimates. In the upper panel of the table we report estimated coefficients and robust standard errors (clustered by *département*). In the lower part of the table, we present the three difference-in-differences estimates of interest. The model reported in Column (1) includes no covariates and therefore corresponds directly to the results in Table 2. The specifications in Column (2) adds the following covariates: age, age squared, age cubed, quintiles of household income, self-reported health status (5 categories), education (5 categories), current or former occupation (7 categories), complementary health insurance status (3 categories) and indicator variables for smoking, having at least one chronic health condition, living in a rural area and living in the greater Paris region. We also control for radiologist density, general practitioner density and the rate of mortality from breast cancer by *département*.

For the most part, including covariates does not have a major impact on the coefficients on the variables of interest. One important exception is the coefficient on the indicator for being in the target group, which is large and statistically significant in Column (1) (0.177, $p = 0.000$) and is a precisely estimated zero in the adjusted model ($p = 0.999$). This result provides support for our difference-in-differences approach as it indicates that in the absence of an organized program there is not a discrete change in the probability of having a recent mammogram associated with turning 50. In other words, our estimates of the effect of organized screening are not capturing the effect of other factors, such as age-based clinical guidelines.

The full regression results are reported in Table SA.2. In addition to the positive effect of age, the estimated coefficients on the other control variables are consistent with results from previous studies on the determinants of mammography

TABLE 3 Basic regression results

	Mammogram last 2 years?		Mammogram ever?	
	(1)	(2)	(3)	(4)
Local (α_1)	0.004	−0.011	0.007	−0.006
	(0.015)	(0.012)	(0.015)	(0.012)
Target (α_2)	0.177***	−0.002	0.186***	−0.043***
	(0.013)	(0.012)	(0.015)	(0.013)
Post (α_3)	−0.014	−0.026***	0.064***	0.035***
	(0.009)	(0.009)	(0.010)	(0.008)
Local × Target ($\beta 1$)	0.059***	0.066***	0.031	0.037**
	(0.021)	(0.018)	(0.022)	(0.017)
Post × Local ($\beta 2$)	0.009	0.012	0.012	0.017
	(0.013)	(0.014)	(0.014)	(0.013)
Post × Target ($\beta 3$)	0.153***	0.122***	0.065***	0.037***
	(0.015)	(0.014)	(0.017)	(0.012)
Post × Local × Target (γ)	−0.084***	−0.080***	−0.061**	−0.058***
	(0.019)	(0.017)	(0.023)	(0.018)
$\Delta\Delta_L$ ($\beta 1$)	0.059***	0.066***	0.031	0.037**
	(0.021)	(0.018)	(0.022)	(0.017)
$\Delta\Delta_N$ ($\beta 3$)	0.153***	0.122***	0.065***	0.037***
	(0.015)	(0.014)	(0.017)	(0.012)
$\Delta\Delta_{LN}$ ($\beta 3 + \gamma$)	0.069***	0.042***	0.004	−0.021
	(0.015)	(0.011)	(0.016)	(0.013)
N	29,296	29,296	29,296	29,296
Covariates?	No	Yes	No	Yes

Note. The models in Columns (2) and (4) include the following covariates: age, age squared, age cubed, the number of radiologists, and general practitioner per capita in the *département*; indicators for smokers, individuals with long-standing chronic conditions, living in a rural area, living in the greater Paris region; and categorical variables for self-reported health, complementary health insurance coverage, education, current or former occupation, income quintile and breast cancer mortality rate. See Table SA.2 for results corresponding to the model in Column (2). $^{*}p < 0.10$. $^{**}p < 0.05$. $^{***}p < 0.01$.

use.[9] Women with private complementary insurance are more likely to have a recent mammogram than are women who either have no complementary coverage or are covered by means-tested public insurance. Current smokers are significantly less likely than nonsmokers to have had a recent mammogram, a result that may reflect preferences regarding risk and preventive medical care. There appears to be an inverse-U-shaped relationship with self-reported health. The probability of having a mammogram in the past 2 years is highest for women who report their health as good and lower for those who say it is fair, poor, or excellent. The results for education and income indicate a positive gradient with respect to socioeconomic status, an issue to which we return below.

Turning to the coefficients that represent the effect of organized screening program, we see that the adjusted differences-in-differences estimates are qualitatively similar to those from the unadjusted model. According to the model reported in Column (2), the local programs raised the percentage of target aged women having a mammogram in the past 2 years by 6.6 percentage points. Modifying those programs to conform with the new national protocols and standards raised the 2-year mammography rate by an additional 4.2 percentage points. Combining these two estimates implies that the national program had the effect of raising the mammography rate by 10.8 percentage points. This is only slightly smaller than the difference-in-differences estimate of the effect of the national program that is identified by changes in *départements* that did not previously have an organized program ($\Delta\Delta_N = 0.122$).

Columns (3) and (4) report results of a different outcome: a binary variable that equals one if a woman has ever had a mammogram and zero otherwise. The results from the model with covariates (Column (4)) imply that both the local and national programs raised the probability of every having a mammogram by between three and four percentage points. These estimates are similar to the effects that Pletscher (2017) finds for Switzerland. The comparison between the two outcomes is informative as to the margins on which organized screening programs operate. The fact that we find a significant

[9]Schueler et al. (2008) provide a comprehensive review of studies using data from the United States. For a recent analysis of the correlates of mammography use in France, see Sicsic and Franc (2014) and Goldzahl and Jusot (2017).

TABLE 4 Regression results of robustness check specifications

	$\Delta\Delta_L$	$\Delta\Delta_N$	$\Delta\Delta_{LN}$
1. Full sample ($N = 29,296$)	0.066***	0.122***	0.042***
	(0.018)	(0.014)	(0.011)
2. Panel analysis ($N = 17,960$)	0.054***	0.128***	0.062***
	(0.018)	(0.018)	(0.014)
3. Ages 40 to 80 ($N = 24,305$)	0.064***	0.116***	0.041**
	(0.020)	(0.014)	(0.012)
4. Drop 50- and 51-year-olds ($N = 27,586$)	0.067***	0.125***	0.049***
	(0.019)	(0.015)	(0.012)
5. Control group 49 and younger ($N = 26,207$)	0.079***	0.137***	0.039**
	(0.019)	(0.014)	(0.011)

Note. Covariates are included in each specification. *$p < 0.10$. **$p < 0.05$. ***$p < 0.01$.

effect on ever having a mammogram but larger effects on the probability of screening in the past 2 years suggests that these programs have important effects on both initiation and the regularity with which women screen.

4.3 | Alternative samples

Table 4 reports key results from models using alternative estimation samples. For ease of comparison, the covariate-adjusted results from Column (2) of Table 3 are presented in the first row. In Row 2, we exploit the limited longitudinal feature of the ESPS data by limiting the sample to respondents who appear more than once in the data and estimating a model with individual fixed effects. The estimated program effects from this model are comparable to our main estimates.

The next three rows illustrate the impact of changing the age criteria for the estimation sample or the target group. Because very young and very old women may not be good controls for women in the target age range, in Row 3, we limit the sample to women between the ages of 40 and 80. In Row 4, the sample includes all women 35 and older with the exception of those who are 50 or 51 at the time of the survey. Although these women were eligible for the program, some may have not yet received an invitation letter. These modifications also do not have a material impact on the estimates.

A particular feature of our research design is that the control group combines women who are too young to participate in the program and women who are too old. Women under the age of 50 are a "cleaner" control group as they should have never received a letter inviting them to have a mammogram through the program. In contrast, some women above the age of 74 will have participated in the program, especially in the later years. Additionally, to the extent that their recall is not perfect, some women who received a mammogram through the program, say, 3 or 4 years ago, may mistakenly say that they had one in the past 2 years. Thus, we would expect to find stronger effects of the program if we compare the target group only to women under age 50. Consistent with this expectation, our estimates of $\Delta\Delta_L$ and $\Delta\Delta_N$ are slightly larger than the corresponding estimates for the full sample, though again the difference is small.

4.4 | Accounting for heterogeneous effects by age

Even though the covariate-adjusted models reported in Table 3 control flexibly for age, they restrict the impact of organized screening to be the same for all women in the target groups. In Figure 2 and Table 5, we allow the effect of the program to vary with age, stratifying by *département* type to account for baseline differences in policy. The figure uses 2-year age bins; in the regression, we interact the "post" variable with indicators for 5-year age categories.

The results for *départements* without a preexisting local program (panel (a) of the figure and Column (1) of the table) provide the clearest evidence of the impact of the national program. When there was no organized screening program in place, mammography rates increased with age up to age 60 and declined thereafter. A comparison of the age profiles for the "pre" and "post" periods confirms that the implementation of the national program had no effect on mammography rates for women under the age of 50. This is visually apparent from the figure and can be seen by the fact that the coefficient on "post" (which represents the change over time for 35 to 40 year olds) and the interaction of that variable and indicators for the next two age categories (40–45, 45–49) are all insignificantly different from zero.

Mammography rates increased for all age groups within the 50- to 74-year-old target range, but the effect was not uniform. The percentage of 50- to 54-year-olds having a recent mammogram increased by just under nine percentage

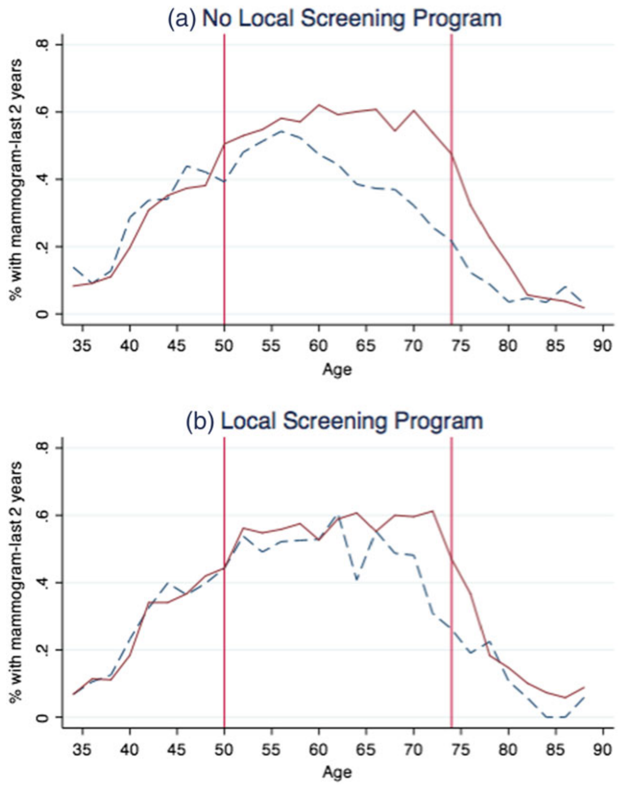

FIGURE 2 The percentage of women with a mammogram in the past 2 years by age. (a) No local screening program. (b) Local screening program. The dashed line represents the pre-2004 period. The solid line represents the post-2004 period [Colour figure can be viewed at wileyonlinelibrary.com]

points. After the national program was in place, mammography rates increased slightly with age up until around age 70 and then began to decline thereafter. Because mammography rates peaked at an earlier age during the "pre" period, the implied effect of the program is larger for women in their 60s and 70s than for women in their 50s. The screening rate increased by roughly 20 percentage points for women in their 60s and by 29 percentage points for women between 70 and 74.

There was also a statistically significant increase among women between the ages of 75 and 79, who are just outside the target age range. Given that the dependent variable equals one for women who had a mammogram in the past 2 years, many of these women may have participated in the national screening program just before aging out of the target group. Indeed, a supplementary analysis suggests that this is the case. We ran separate regressions for 75- to 79-year-olds, allowing the effect to differ between 75- and 76-year-olds, who would have been eligible for the organized program during the 2-year look-back period, and 77- to 79-year-olds, who would not have been. For the younger group, the probability of having a recent mammogram increased by 25 percentage points, which is comparable with the effect for 70- to 74-year-olds. The increase was roughly half as large for 77- to 79-year-olds, though it was still statistically significant ($p = 0.005$). This effect for women just above the upper age threshold may reflect a true spillover effect. For example, after being exposed to the organized program, women may continue to have a strong demand for screening even after they age out of the program. Alternatively, it could reflect measurement error: Women may be understating the time since their last mammogram.

In *départements* with preexisting local programs, the largest changes were for women between the ages of 70 and 74, who are covered by the new protocol but were outside the old protocol's target age range. For women in their 50s and early 60s, the change over time is much smaller and is not statistically significant. This suggests that the expansion of the target range is a major reason for the observed difference between the national program and the earlier local programs.

4.5 | Impacts on disparities in screening

Having established that France's organized breast cancer screening increased mammography use, we now turn to the question of whether it also reduced socioeconomic disparities in screening. Table 6 presents screening rates tabulated by

TABLE 5 Regression results by age

	Départements without local program		*Départements* with local program	
	Coefficient	***SE***	**Coefficient**	***SE***
Age (ref: 35–39)				
Age 40 to 44	0.203***	(0.022)	0.200***	(0.020)
Age 45 to 49	0.308***	(0.020)	0.279***	(0.025)
Age 50 to 54	0.345***	(0.023)	0.386***	(0.020)
Age 55 to 59	0.408***	(0.023)	0.405***	(0.028)
Age 60 to 64	0.320***	(0.025)	0.424***	(0.030)
Age 65 to 69	0.272***	(0.025)	0.401***	(0.030)
Age 70 to 74	0.174***	(0.021)	0.257***	(0.041)
Age 75 to 79	−0.007	(0.019)	0.110***	(0.038)
Age 80 to 84	−0.072***	(0.019)	−0.029	(0.027)
Age 85+	−0.064***	(0.021)	−0.095***	(0.017)
Post	−0.015	(0.015)	−0.001	(0.015)
Post × 40 to 44	−0.024	(0.027)	−0.029	(0.023)
Post × 45 to 49	−0.031	(0.026)	0.002	(0.031)
Post × 50 to 54	0.088***	(0.026)	0.027	(0.023)
Post × 55 to 59	0.057**	(0.027)	0.042	(0.031)
Post × 60 to 64	0.192***	(0.030)	0.034	(0.040)
Post × 65 to 69	0.204***	(0.035)	0.079*	(0.040)
Post × 70 to 74	0.289***	(0.035)	0.219***	(0.041)
Post × 75 to 79	0.205***	(0.031)	0.081*	(0.045)
Post × 80 to 84	0.069**	(0.027)	0.041	(0.035)
Post × 85+	−0.009	(0.024)	0.038	(0.026)
Constant	0.113***	(0.011)	0.107***	(0.016)
N	16,059		13,237	

Note. $^{*}p < 0.10$. $^{**}p < 0.05$. $^{***}p < 0.01$.

TABLE 6 Percentage of women receiving a mammogram in past 2 years by income and education categories

	Départements without local program			*Départements* with local program			% screened via organized program
	Pre-2004	**Post-2004**	**Change**	**Pre-2004**	**Post-2004**	**Change**	**Post-2004**
A. Differences by education							
	($N = 2,562$)	($N = 4,806$)		($N = 2,072$)	($N = 3,994$)		($N = 3464$)
Primary or less	31.8%	50.1%	18.3%***	42.8%	50.3%	7.5%***	70.3%
Middle school	47.8%	57.7%	9.9%***	50.0%	58.4%	8.4%**	59.6%
High school	53.8%	63.6%	9.8 %**	56.7%	59.3%	2.6%	61.7%
University or higher	56.8%	63.1%	6.3 %**	63.1%	62.2%	−0.9%	53.0%
University/primary or less	1.79	1.26		1.47	1.24		
B. Differences by income							
	($N = 1,856$)	($N = 3,535$)		($N = 1,492$)	($N = 2,954$)		($N = 3464$)
1st quintile	33.6%	54.5%	20.9%***	50.2%	55.2%	4.9%	71.5%
2nd quintile	42.1%	61.4%	19.3%***	54.5%	63.1%	8.6%**	66.0%
3rd quintile	53.7%	66.9%	13.2%***	60.3%	62.9%	2.6%	67.0%
4th quintile	61.6%	67.9%	6.3%**	66.2%	68.9%	2.8%	61.3%
5th quintile	66.7%	73.3%	6.5%**	66.3%	67.9%	1.7%	55.8%
5th quintile/1st quintile	1.99	1.35		1.32	1.23		

Note. We assess if the change is statistically significant using t tests. Screened via organized program is only available for the years 2006 and 2008. $^{*}p < 0.10$. $^{**}p < 0.05$. $^{***}p < 0.01$.

education and income categories. Because we are interested in how screening changed among affected women after the national program was implemented, we focus on women in the target age range. To account for differences in baseline conditions, we present separate results by *départements* type.[10]

[10]Some studies in the literature on health disparities focus on unadjusted differences among groups, whereas others condition on proxies for health need and preferences as well as, in some cases, other observable characteristics. Because we are interested in overall differences in mammography use

Looking first at *départements* without preexisting local programs, we see that before the national program was established, there were strong gradients with respect to education and income. Women with a middle school education were 16 percentage points more likely to report having had a mammogram in the past 2 years than were women with a primary school education or less. The rate was higher still for women with a high school education and those with university degrees. The ratio of the rate for the highest education category to the rate for the lowest category was 1.79. The percentage of women with a recent mammogram also increased monotonically with income, with a slightly larger ratio between the highest and lowest quintiles. After the national program was in place, mammography rates increased for all education and income categories, though the change was generally larger at the lower ends of each distribution. The changes were 18.3 and 20.9 percentage points for the lowest education and income categories, compared with just over six percentage points for the highest categories. As a result of this differential effect, the ratio between the top and bottom income quintiles fell from 1.99 to 1.35.

In *départements* with preexisting programs, the baseline gradients were less steep, which suggests that organized screening had already reduced socioeconomic disparities there. Here, we also see greater increases for women in lower education categories, though the differences were less pronounced than in *départements* without preexisting programs. In the "post" period, the ratio of the mammography rates for the top and bottom education and income categories was similar in the two types of *départements*.

The 2006 and 2008 ESPS surveys asked whether a woman had a mammogram in recent years, and those who had a mammogram were asked whether or not they received it through the organized program. In the last column of Table 6, we present the percentage of women in each education or income category that participated in the program. For these calculations, the sample is limited to women who had a mammogram in the past 2 years. Because the overall utilization rate and the gradients are so similar across *département* types, we pool them. The results indicate a negative relationship between socioeconomic status and participation in the organized program. Seventy percent of women with a primary education or less who had a mammogram in the past 2 years received it through the program, compared with 53% of women with at least a university degree. Similarly, the percentage using the program ranged from 71.5% in the lowest income quintile to 55.8% in the highest. Multiplying these percentages by the mammography rates for the postperiod gives the percentage of women in each group participating in the program. This calculation indicates that participation was quite similar across groups and that the gradients that remain are driven by the fact that higher SES women are more likely to go outside the program to receive a mammogram.

The finding that the organized program had a larger impact on lower SES women is consistent with results found by Carrieri and Wuebker (2016) and not with those of Pletscher (2017). One possible explanation is that Pletscher (2017) tests for effects on the probability of ever having a mammogram, which we know is less sensitive to the policy. When we replicate the analysis of Table 6 using this outcome, we see that screening increased most for women in the lowest education and income categories, causing the ratio of screening rates for the highest and lowest categories to decline (results available upon request). Thus, it appears that France's organized screening program reduced socioeconomic disparities in mammography initiation.

5 | DISCUSSION AND CONCLUSION

Our results provide strong evidence that French women who were eligible for a publicly funded organized screening program were significantly more likely to have had a recent mammogram than women who were not eligible. The fact that our estimates of the impact of the French program are similar to those found for other European countries (Carrieri & Wuebker, 2016; Pletscher, 2017) strengthens the conclusion that organized screening programs are successful in increasing the percentage of women obtaining a mammogram.

As with any difference-in-differences analysis, the interpretation of our results as causal effects depends importantly on untestable assumptions about the comparability of treatment and control groups. In our case, there are two critical comparisons, one that is cross-sectional and one related to changes over time.

Our cross-sectional estimates of the effect of the local programs that existed before 2004 relies on the assumption that women in *départements* without local programs are good controls for women in *départements* with such programs. Several results support this assumption. First, women in the two types of *départements* are quite similar in observable demo-

among targeted women, we focus on unadjusted differences across education and income groups. For a useful discussion of methodological issues concerning the measurement and analysis of health-related disparities, see Cook et al. (2012).

graphic, economic, and health characteristics. Second, in the years 2000 and 2002, differences in mammography use are observed *only* for women in the target age range. Outside this age group, we observe no significant difference in screening rates. Third, after 2004, when a uniform policy was in place throughout France, we see no difference in mammography utilization between *départements* that did and did not have local programs prior to 2004. Taken together, these factors suggest that the roughly six-percentage-point difference in screening rates that we observe in that earlier period represents the causal effect of the local programs that existed in some *départements* but not others.

Our estimate of the effect of the national program is identified by comparing changes over time for women within and outside the target age range. Several factors support the validity of this identification strategy as well. We see no trend in mammography rates for women in either the target or control group between 2000 and 2002. Moreover, after 2004, screening rates remained constant for the control group, suggesting the nonimportance of secular trends in breast cancer awareness, technology diffusion, or other factors affecting clinical practice. For the target group, however, there is a large and significant increase in screening after the national program was put in place. Our preferred estimate, based on a regression model that conditions on individual demographic, economic, and health characteristics, implies that the national program led to a 12-percentage-point increase in the screening rate, a 29% effect relative to the baseline mean. Regression models that allow for heterogeneous effects related to age provide further evidence that the increases in mammography utilization occurred only for women age 50 or older.

One important difference between our study and that earlier research is that we test for heterogeneous effects related to age. Interestingly, we find the largest effects for women in their mid-60s, who are in the middle of the target age range. This result combined with the fact that we find weaker effects on the probability on the probability of *ever* having a mammogram suggests that the most important effect of the program may not be on mammography initiation but rather on the regularity of screening.

By eliminating financial barriers and increasing awareness of the importance of screening, organized programs have the potential to reduce socioeconomic disparities in cancer screening. The implementation of the national program increased mammography rates for women of all education and income levels. However, because the increases were greater for women of lower socioeconomic status, the policy had the effect of reducing disparities in mammography utilization.

Although our results suggest that France's organized breast cancer screening program was successful at increasing mammography use, the ultimate goal of any such program is to reduce mortality through the timely detection of treatable tumors. Although the benefits of mammography have long been taken as given, the strongest empirical evidence comes from randomized clinical trials, not population-based screening programs. The extent to which the higher rates of mammography use generated by this program led to reductions in mortality is an empirical question that merits further research.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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