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Information Shocks and Health Behaviors: Evidence from Breast Cancer Screening Recommendations

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Abstract

We provide novel evidence on how health care decision-making responds to changes in information by studying the effects of the United States Preventive Services Task Force's 2009 decision to stop recommending mammogram screenings for women aged 40-49. Using a difference-in-differences identification strategy, we find that after the update women aged 40-49 were 1.4-4.9 percentage points less likely to report ever receiving a mammogram than their 50-59-year-old counterparts. We also identify large spillovers onto women aged 35-39: post-2009 they were significantly less likely to receive a mammogram recommendation or a mammogram. Additional analyses suggest the revision reduced overdiagnosis of early-stage tumors.

JEL Codes: I18; I12
Key words: mammography; recommendation; cancer

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1. Introduction

The United States is routinely ranked last when comparing health care system performance among high-income countries (Commonwealth Fund 2021). It spends more on health care than any other OECD country yet ranks 30 out of 38 for life expectancy at birth (OECD 2019, 2022). Though many factors contribute to this dubious distinction, policymakers have long argued that preventive care may be a health care silver bullet; by detecting and treating disease in its early stages, the hope is that preventive care can save both lives and money (White House 2012; White House 2022). As a result, public officials have sought to increase preventive care take-up by reducing the costs of these services and increasing knowledge about the associated benefits. While researchers have devoted considerable attention to understanding the effects of prices on health care utilization (Finkelstein et al. 2012; Kolstad and Kowalski 2012; Antwi et al. 2015; Barbaresco et al. 2015; Brot-Goldberg et al. 2017), relatively less is known about how government-induced information shocks affect patient and physician decision-making. Nevertheless, these policies can be found throughout the health care system, including recommended practice guidelines for a variety of preventive care services.[1]

In this paper, we study the impact of the 2009 update to the United States Preventive Services Task Force (USPTF) mammogram recommendations. The USPSTF is an independent panel of medical experts appointed by the Department of Health and Human Services with the goal of making evidence-based recommendations about preventive services. While the task force has long recommended mammography for breast cancer prevention (USPSTF 1989; Woolf 1992), over the past several decades there have been multiple revisions to the age

[1] For example, the United States Preventive Services Task Force currently has 52 recommendations related to diseases including cancer, diabetes, obesity, and mental health disorders, among others. The Advisory Committee on Immunization Practices has recommendations for 26 vaccine preventable diseases, including hepatitis A and B, influenza, shingles, and COVID-19.

at which these screenings are first recommended and the suggested interval between screenings.

Prior to 2009, USPSTF recommended that all women aged 40 or older receive a mammogram every 1-2 years;[2] in 2009 they issued a revision recommending biennial mammograms for women aged 50 to 74, with no routine mammography recommended for women under the age of 50.[3] This revision was motivated by updated randomized clinical evidence that failed to detect any reduction in breast cancer mortality attributable to mammography in younger women (Nelson et al. 2009; Moss et al. 2006; Bjurstam et al. 2003), as well as concerns that younger women were being harmed due to the high rate of false positives for this group and the treatment of tumors that would have otherwise remained harmless (Elmore et al. 1998; Armstrong et al. 2007; Hubbard et al. 2011; Welch et al. 2016; Einav et al. 2020; Ryser et al. 2022). The revised recommendations were disseminated through publication on the USPSTF website and in a peer-reviewed medical journals (USPSTF 2022a), and we document widespread mammogram-related newspaper coverage, concentrated in the week the recommendation was issued. Thus, this recommendation change, by synthesizing and publicizing the most up-to-date clinical findings, represents a shock to both physician and patient information on the benefits of mammography.[4]

We first evaluate how the 2009 USPSTF guideline revision affected mammogram screenings and related health behaviors using data from the 2002-2019 Behavioral Risk Factor Surveillance System, the 2003-2018 National Health Interview Surveys, and the 2003-2019 National Cancer Institute's Health

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[2] This recommendation had been in place since 2002. We provide a detailed timeline regarding the evolution of mammogram recommendations in Section 2.1.
[3] Throughout the text, we follow USPSTF's language and discuss mammography recommendations for women. Yet it is important to acknowledge that there are women who do not have breasts and that not everyone with breasts identifies as a woman.
[4] Notably, this recommendation change did not impact health insurance coverage of mammograms. See Section 2 for more details.

Information National Trends Surveys. To identify these effects, we use a difference-in-differences strategy comparing changes in the probability that women aged 40-49 reported ever receiving a mammogram screening to the concurrent changes for women aged 50-59. Our results show that the 2009 USPSTF guideline revision reduced mammography among 40-49-year-old women by 1.4-4.9 percentage points. While prior work has shown that compliers with new recommendations to receive health screenings are healthier than average (Einav et al. 2020; Oster 2020; Kowalski *forthcoming*), in heterogeneity analyses we find that it was the *least healthy* women who responded to the recommendation to delay screening.

We also find evidence of sizable reductions in mammography among women aged 35-39, who were never recommended to receive routine mammograms and thus were not directly affected by the updated guidelines. We provide suggestive evidence that these spillovers to younger women were driven by changes in physician behavior. Our results show that the guideline change reduced the probability that women aged 35-39 reported receiving a mammogram recommendation from their doctor by over 12 percentage points. Yet the revised guideline also seemingly generated confusion about the benefit of health care screenings – targeted women were 7-percentage points more likely to report feeling that they did not know which cancer prevention recommendations to follow in the post-revision period. Overall, our estimates imply approximately 1.8 million fewer initial mammogram screenings each year for women aged 30-49 and over $381 million in annual health care savings (O'Donoghue et al. 2014).

Next, we use a similar difference-in-differences model and the 2002-2019 Surveillance, Epidemiology, and End Results (SEER) Program data to examine the effects of the guideline revision and subsequent change in mammography on breast cancer diagnoses. After the 2009 update, we find no change in breast cancer diagnoses for women aged 40-49 relative to the concurrent changes for older women. We do, however, find that diagnoses of non-invasive precancer ("in situ") breast tumors fell by approximately 16 percent for women aged 35-39 (the group with the largest change in mammography). Some cancer experts have argued that excessive screening has resulted in an overdiagnosis of these in situ precancers (Marmot et al. 2012; Francis et al. 2015; Worni et al. 2015; Benson et al. 2016; Co 2020), given that less than a quarter progress to life-threatening disease (Rosen et al. 1980). Indeed, we do not detect significant changes in diagnoses of later-stage malignant tumors for any age group, consistent with existing evidence that physicians over-test predictably low risk patients (Mullainathan and Obermeyer 2022). Overall, we estimate that the reduction in precancer diagnoses resulted in nearly $11 million in annual health care savings.

Our findings contribute to several notable literatures. First, by showing that women responded to the recommendation change by delaying when they received their first mammogram, we contribute new evidence to a literature exploring how non-binding recommendations affect health behaviors. Understanding the impacts of these types of recommendations is important given how widespread they are in health care. Notably, our results run counter to a large public health literature which failed to detect discernable changes in mammography among younger women following the 2009 USPSTF guideline revision (Hinz et al. 2011; Howard and Adams 2012; Block et al. 2013; Pace et al. 2013; Wang et al. 2014; Fedewa et al. 2016; Rajan et al. 2017; Wernli et al. 2017; Brown et al. 2018). However, many of these papers did not utilize a comparison group, while those that did often only examined changes in the very short run (e.g., only examined changes in the year following the revision). Related to this work, Kadiyala and Strumpf (2016) show using a regression discontinuity framework that 41-year-old women were 23 percentage points more likely to have had a recent mammogram compared to 39-

year-old women prior to the updated guidelines.[5] More broadly, several recent papers have found mixed evidence of whether age-targeted vaccine recommendations increase vaccine take-up (Lawler 2017; Lawler 2020; Churchill and Henkhaus *forthcoming*).

By documenting the reduction in physician mammogram recommendations following the guideline change, we also offer new evidence on a relatively unexplored economic determinant of physician behavior. Prior work has explored the roles of financial incentives (Gaynor and Pauly 1990; Gruber et al. 1999; Rizzo and Zeckhauser 2003; Clemens and Gottlieb 2014; Brekke et al. 2017; Alexander and Schnell 2021; Schnell 2022), legal liability (Baicker and Chandra 2005; Currie and MacLeod 2008; Frakes 2013; Shurtz 2013), and professional norms (Chandra and Staiger 2007; Kesternich et al. 2015; Currie and MacLeod 2020) in shaping physician behavior. Yet there has been comparably less work on the role of information shocks. While a few papers have found that individually targeted information shocks can sway behavior (Kolstad 2013; Singh 2021),[6] there is mixed evidence on the role of information shocks generated by government-endorsed practice recommendations (Alalouf et al. 2018; Buchmueller and Carey 2018; Dubois and Tunçel 2021; Cuddy and Currie 2022). Most recently, Wu and David (2022) showed that an unexpected FDA safety communication regarding the risk of minimally invasive hysterectomies shifted physicians away from the procedure, especially among those physicians least skilled at performing it.

[5] Because their data predated the 2009 policy change, Kadiyala and Strumpf (2016) could not leverage the temporal variation in the recommended starting age for mammography and necessarily assumed that women did not otherwise discontinuously change their health behaviors when turning 40 – a focal age signaling the start of being ‘middle aged.’

[6] Studying surgeon ‘report cards’ containing information on individual and peer performance that was unrelated to patient demand, Kolstad (2013) documented improvements in surgeon quality. Likewise, Singh (2021) found that physicians were responsive to information shocks obtained through personal experience – physicians whose patients experienced complications with a particular delivery mode (i.e., vaginal or Cesarean) were more likely to switch delivery modes for the subsequent patient.

Through analyzing changes in both mammogram screenings and breast cancer diagnoses, we add to work analyzing the efficacy of health screenings (Stewart and Mumpower 2003; Hackl et al. 2015; Abaluck et al. 2016; Welch et al. 2016; Kim et al. 2017; Glewwe et al. 2018; Conner et al. 2022). Kowalski (2021) reviewed the existing evidence on the efficacy of mammograms and provides new evidence that a large, randomized mammography trial had no mortality benefits up to 20 years after enrollment. Also, closely related to our study, Einav et al. (2020) showed that women receiving mammograms at the recommended age of 40 were less likely to have cancer than younger women who selected into screening or women who never screened.

Finally, by detailing how a government-induced information shock affected women's decisions to undergo breast cancer screenings, we add to a broader literature documenting the economic determinants of cancer screenings. Much of the literature to date has focused on the impact of health insurance coverage and cost-sharing (Busch and Duchovny 2005; Finkelstein et al. 2012; Kolstad and Kowalski 2012; Bitler and Carpenter 2016; Bitler and Carpenter 2017; Kim and Lee 2017; Sabik and Bradley 2016; Myerson et al. 2020). Other studies have considered the role of retirement (Coe and Zamarro 2015; Frimmel and Pruckner 2020; Eibich and Goldzahl 2021), access to health clinics (Lu and Slusky 2016), awareness campaigns (Jacobsen and Jacobsen 2011), unemployment rates (Ruhm 2000), and targeted screening programs (Pletscher 2017; Buchmueller and Goldzahl 2018; Bitler and Carpenter 2019).

The rest of the paper proceeds as follows: Section 2 describes the clinical evidence regarding mammography and cancer detection, as well as the policy history of age-targeted recommendations. Section 3 explains the data that we use and our difference-in-differences identification strategy. Section 4 presents our results on mammography, breast cancer diagnoses, and the potential underlying mechanisms. Based on these results, Section 5 provides back-of-the envelope calculations of the estimated cost savings from the recommendation change. Finally, Section 6 discusses the policy implications and limitations of our results.

2. Clinical Evidence and Policy History

Cancer is the second leading cause of death in the United States (CDC 2022), and – except for some skin cancers – breast cancer is the most diagnosed cancer, with over 280,000 expected new cases in 2022 (NCI 2022a).[7] Approximately 30 percent of all female cancers are breast cancers, and 1 in 8 US women will develop breast cancer during their lives. As the second leading cause of cancer death in women, breast cancer kills over 40,000 women each year (ACS 2022a). Moreover, with total medical costs exceeding $16.5 billion each year, breast cancer has a higher economic burden than all other cancers (Mariotto et al. 2011).[8] Reducing the female breast cancer mortality rate has been an explicit goal of the US Department of Health and Human Services for the past several decades (US DHHS 2021, 2014, 2012). Because treatment costs and mortality are higher for more advanced breast cancers, increasing early detection through routine screenings known as mammograms is also a US public health priority (US DHSS 2021; Cutler 2008).[9]

A mammogram is an X-ray examination of the breast used to detect potentially cancerous abnormalities. Mammograms are very effective at detecting breast cancer, in the sense that they have low rates of false negatives; however, they also have high rates of false positives. False positives are particularly common for younger women and may cause unnecessary distress and follow-up procedures

[7] The National Cancer Institute excludes nonmelanoma skin cancers from the list of the most common cancer types.
[8] Mariotto et al. (2011) estimated the total annual medical cost of breast cancer to be $16.5 billion in 2010. They projected this value would range from $18.9-$25.6 billion in 2020.
[9] The 5-year relative survival rate is 99 percent for localized breast cancer that has not spread, 86 percent for regional breast cancer that has spread to nearby structures or lymph nodes, and 20 percent for distance breast cancer that has spread to other parts of the body (ACS 2022b).

(e.g., biopsies).[10] Additionally, there is a growing body of evidence that mammography results in the detection and treatment of early-stage tumors that would have remained harmless (Elmore et al. 1998; Armstrong et al. 2007; Hubbard et al. 2011; Einav et al. 2020; Welch et al. 2016; Ryser et al. 2022).

The out-of-pocket monetary costs for screening mammograms are likely to be low during our sample period, due to widespread adoption of insurance coverage mandates. At the start of our sample period, almost every state mandated mammography benefits for qualified health insurance plans, including baseline mammogram screenings for 35-39-year-old women, biennial mammograms for women aged 40-49, and annual mammograms for women aged 50 or older (Bitler and Carpenter 2016). Additionally, under the Affordable Care Act, private insurers are required to cover mammogram screenings without cost-sharing for women aged 40 or older, effective for plan years beginning on or after August 1, 2012 (USPSTF 2019). For physicians, reimbursement is also relatively low: in 2022, physicians received approximately $40 per mammogram under the Medicare Physician Fee Schedule and the facility received $90.67 (CMS 2022).

The USPSTF issued their first set of mammogram recommendations in 1996, initially recommending that women aged 50-69 receive a mammogram every 1-2 years.[11] At that time, they did not recommend routine screening for women aged 40-49, stating that there was "conflicting evidence…regarding clinical benefit from mammography" for women in that age group (USPSTF 1996). After

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[10] For example, Ho et al. (2022) estimate the average false positive rate of digital mammography to be 9 percent. Rates are significantly higher for women aged 40-49 (10.8%) versus women aged 50-59 (8.2%) and 60-69 (5.7%). This gradient is explained in part by the fact that denser breasts result in higher rates of false positives, and younger women have denser breast tissue (Sprague et al. 2014; Mandelson et al. 2000; Kerikowske et al. 2015).

[11] The USPSTF mammography recommendations do not apply to women who have a genetic risk for breast cancer (i.e., to women who have one of the two genes, *BRCA1* and *BRCA2*, associated with breast cancer). However, the USPSTF only recommends *BRCA* screening for women with a known history of breast, ovarian, tubal, or peritoneal cancer, and less than 10 percent of women with breast cancer have a *BRCA* mutation (Long and Ganz 2015).

conducting a meta-analysis of the existing evidence, in 2002 USPSTF reversed course and recommended routine mammography every 1-2 years for women aged 40 or older (USPSTF 2002).

In 2009, USPSTF updated their 2002 meta-analysis to incorporate new clinical evidence from two more recent trials (Bjurstam et al. 2003; Moss et al. 2006). Based on this evidence USPSTF stopped recommending routine screening for women aged 40-49, concluding that the cost of "false-positive results and unnecessary biopsies is larger" than the benefits of averted breast cancer deaths attributable to mammogram screenings for these younger women. They also noted that these women would be at heightened risk for "treatment of noninvasive and invasive breast cancer that would otherwise not have become a threat to their health, or even apparent, during their lifetime." At the same time, USPSTF also reduced the frequency of its recommendation for women aged 50-74 to biennial screening (USPSTF 2009). Finally, in 2016, USPSTF again updated their meta-analysis and then reaffirmed their 2009 recommendations (Nelson et al. 2016; USPSTF 2016).[12] Table 1 summarizes these recommendation changes.

At the time of the USPSTF 2009 guideline revision, there was not a clear consensus among medical professionals about the appropriate age to begin mammogram screenings.[13] The American Cancer Society (ACS) contradicted the USPSTF recommendation, releasing a 2009 statement affirming routine breast cancer screenings for women aged 40-49, with ACS's chief medical officer Dr. Otis W. Brawley stating, "[t]his is one screening test I recommend unequivocally, and

[12] The 2016 USPSTF mammogram recommendation also acknowledged that women aged 40-49 with a familial history of breast cancer "may benefit more than average-risk women from beginning screening their 40s." Yet USPSTF did not issue a recommendation in favor of screening these women.

[13] There was, however, longstanding public support for mammogram screenings. For example, a nationally representative survey found that over 40 percent of adults would consider it irresponsible for an 80-year-old to forgo mammography (Schwartz et al. 2004), and a separate study found that over half of adults would undergo a cancer screening that did not reduce the chance of cancer death or extend the length of life (Scherer et al. 2019).

would recommend to any woman 40 and over, be she a patient, a stranger, or a family member" (ACS 2009).[14] The American College of Radiology (2009) called the updated guidelines "ill-advised and dangerous," and a survey found that nearly 60 percent of physicians reported that the revised guidelines were not applicable to their patients (Hinz et al. 2011).

As previously noted, the explicit audience for USPSTF guidelines are primary care physicians (USPSTF 2022a), with official dissemination occurring via publication online and in a peer-reviewed medical journal. Descriptive evidence presented in Figure 1, however, suggests that the 2009 update to the USPSTF mammography guidelines was disseminated much more broadly. Panel A shows that there was an intense (though short lived) spike in mammogram-related newspaper coverage coinciding with the timing of the recommendation;[15] Panel B shows a similarly timed spike in internet search activity for the term 'mammogram.'

3. Data and Methodology

3.1 Mammography Data: Behavioral Risk Factor Surveillance System

We obtain information on mammography screening from the Centers for Disease Control and Prevention's 2002-2019 Behavioral Risk Factor Surveillance System (BRFSS). The BRFSS is a state representative phone survey tracking health behaviors and outcomes for more than 400,000 adults each year. Questions on mammogram screenings were asked of all women in even-numbered survey years and of a more limited set of women during every odd-numbered year except 2017. In these data, women were asked, "[a] mammogram is an X-ray of each breast to look for breast cancer. Have you ever had a mammogram?" If they answered yes, they were then asked, "[h]ow long has it been since you had your last

[14] Notably, however, in 2016 the American Cancer Society raised their recommended starting age for mammography from 40 to 45 years old (ACS 2015).
[15] We separately denote mammogram-related newspaper articles during the month of October because it is National Breast Cancer Awareness Month.

mammogram?" From these questions, we construct several dichotomous outcomes. First, we create *Ever Had a Mammogram*, which is equal to 1 if the woman reported ever receiving a mammogram and 0 if not. We also create *Mammogram in Past Year*, which is equal to 1 if the woman reported receiving a mammogram within the last year and 0 if her most recent mammogram was more than a year ago or she reported never receiving a mammogram. We similarly construct indicators for *Mammogram in Past Three Years* and *Mammogram in Past Five Years*.

Figure 2 shows that prior to the updated USPSTF guidelines, the share of women reporting having ever received a mammogram was trending similarly for women aged 40-49 and 50-59, though older women were consistently 10 percentage points more likely to have ever had a mammogram (Panel A). After USPSTF revised their mammography guidelines in 2009, the share of targeted 40-49-year-old women reporting ever receiving a mammogram began falling while mammography was essentially unchanged for women aged 50-59.[16] Indeed, the unadjusted 2 × 2 difference-in-differences comparison in Appendix Table 2 shows that women aged 40-49 were 2.7 percentage points less likely to report ever having had a mammogram in the post-period relative to those aged 50-59.

While the BRFSS data contain mammography measures, they also have several notable limitations. For one, the BRFSS underwent a survey redesign in 2011 that included a change in weighting methodology and the addition of cell phone-only respondents, and the CDC explicitly warned researchers that these changes would affect the share of respondents reporting various risky health behaviors. As such, these changes pose a challenge for comparing pre-redesign survey data with data from the later waves. Thus, for our baseline estimates, we adopt the sample weight adjustment proposed by Simon et al. (2017), though we also show that our results are robust to excluding sample weights. Additionally,

[16] We report additional summary statistics in Appendix Table 1.

during our sample period, the BRFSS data only include age in 5-year intervals. As such, we are unable to account for the fact that women who turned 40 following the 2009 USPSTF recommendation change were likely differentially affected compared to 44-year-old treated women in that same year.

3.2 Mammography Data: National Health Interview Surveys

We further explore the relationship between the 2009 USPSTF recommendations and mammography using the 2003-2018 National Health Interview Surveys (NHIS). The NHIS collect detailed information from face-to-face interviews of approximately 87,500 persons each year. Though the surveys only ask breast cancer screening questions in select years,[17] a key strength of these data is that (i) they contain each respondent's age in years, instead of the 5-year intervals available in the BRFSS data, and (ii) are directly comparable across years. Figure 3 shows that the trends in mammography for those aged 40-49 and 50-59 match the BRFSS data (Panel A). Using the more granular age information available in the NHIS, Panel B shows that women younger than 50 years old were less likely to report ever receiving a mammogram during the post-period.[18] We report additional summary statistics for the NHIS data in Appendix Table 3.

3.3 Opinions on Health Care: Health Information National Trends Survey

We explore how the 2009 USPSTF mammogram recommendation affected targeted women's views on cancer recommendations, satisfaction with their input into health care decision making, and trust in the health care system using the 2003-2019 Health Information National Trends Survey (HINTS). These nationally representative data are collected by the National Cancer Institute to measure cancer-related knowledge and attitudes among adults aged 18 or older and include

[17] Breast cancer screening information is available in 2003, 2005, 2008, 2010, 2013, 2015, and 2018.
[18] Appendix Figure 1 separately plots the share of each age reporting that they had ever received a mammogram during the pre-period (Panel A) and post-period (Panel B). The reduction in mammography for women younger than 50-years-old seemingly grew over time.

demographic characteristics such as age, race/ethnicity, educational attainment, marital status, and health insurance coverage. Thus, we can separately examine changes in outcomes for targeted women (aged 40-49) compared to the associated changes experienced by their older counterparts (aged 50-59).

As with the BRFSS and NHIS data, the HINTS data contain information on whether women reported ever receiving a mammogram. For our purposes, a key advantage of these surveys is that they also asked whether women felt that there were "so many recommendations about preventing cancer" that it made it difficult to know which ones to follow, whether they felt that their doctor always involved them in their health care decision-making, and whether they trusted health information from doctors and government agencies. Although these questions allow us to explore potentially important consequences of the 2009 USPSTF recommendation, they contain a relatively small sample; for women aged 40-59, the HINTS mammography sample is 1 percent (21 percent) of the size of our BRFSS (NHIS) sample. We report the summary statistics from these data in Appendix Table 4.[19]

3.4 Cancer Data: Surveillance, Epidemiology, and End Results Program

We obtain information on breast cancer diagnoses from the 2002-2019 National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER) Program. Our data include the universe of breast cancer diagnoses for women collected from 17 cancer registries in 12 states, covering nearly 27 percent of the US population (NCI 2022b). These data include information on age at diagnosis, state of residence, and diagnosis year. They also include detailed information on tumor location, size,

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[19] There are also several other notable limitations of the HINTS data. First, the set of survey questions varies across survey waves, so the underlying sample varies slightly across outcomes. We show in Appendix Table 5 the set of years each question is included. Second, the survey does not consistently include geographic variables across waves, and so we are unable to include region-by-time fixed effects in our specification. Third, the mammography questions are only asked of women aged 35 and older, and so we are unable to examine effects for women aged 30-34, unlike in the BRFSS and NHIS.

and behavior (e.g., in situ, malignant), and months of survival following diagnosis (measured as of 2019). For our analyses we differentiate between in situ and malignant tumors, given evidence that many in situ precancers do not progress or become malignant (invasive) tumors (Rosen et al. 1980; Marmot et al. 2012; Francis et al. 2015; Worni et al. 2015; Benson et al. 2016; Co 2020). Summary statistics are provided in Appendix Table 6; trends in breast cancer incidence are presented in Appendix Figure 2.

3.5 Empirical Strategy: Difference-in-Differences

While the trends offer descriptive evidence that the 2009 USPSTF mammography recommendation reduced mammography among women aged 40-49, we empirically test this relationship using the following event study specification:

$$M_{iast} = \alpha + \sum_{j=2002,\, j\neq 2009}^{2019} \beta^{j} \cdot \mathbf{1}\{40 \leq \text{Age} \leq 49\}_{ia} \times \mathbf{1}\{\text{Year} = j\}_{t} + X_{iast}'\gamma + \theta_{a} + \tau_{st} + \varepsilon_{iast} \quad (1)$$

where the dependent variable, M, is the mammogram-related outcome of interest for respondent *i*, age *a*, in geographic area *s*, and year-month *t*. The independent variables of interest are the interactions between an indicator variable capturing whether a woman was between 40 and 49 years old at the time of the survey and a set of indicators for each year around the recommendation change (omitting 2009). This setup allows us to assess whether mammography rates of women aged 40-49 were differentially trending relative to those of women aged 50-59 in the pre-period, as well as to allow for potential dynamic treatment effects in the post-period. We also estimate the following specification which summarizes the effect of the 2009 USPSTF guidelines on mammography in a single static difference-in-differences coefficient:

$$M_{iast} = \alpha + \beta \cdot \mathbf{1}\{40 \leq \text{Age} \leq 49\}_{ia} \times \mathbf{1}\{2009\ \text{USPSTF}\}_{t} + X_{iast}'\gamma + \theta_{a} + \tau_{st} + \varepsilon_{iast} \quad (2)$$

We include a vector of individual-level characteristics, X, to account for demographic traits potentially related to the decision to receive a mammogram, including indicators for race/ethnicity (white, Black, Hispanic, and Asian with 'other' omitted), educational attainment (less than high school, high school graduate, and some college with college graduate omitted), marital status (married, divorced, widowed, and separated with never married omitted), and health insurance coverage (any coverage with no coverage omitted). We also include an indicator for whether the American Cancer Society recommended that the woman receive a mammogram screening based on her age. This variable takes on the value of 1 for all women aged 45 or older throughout the full sample period. For women aged 40-44, it takes on the value of 1 until October of 2015 and a 0 thereafter (ACS 2015).

The vector of age fixed effects, θ, accounts for time-invariant age-specific attitudes toward mammography. In the BRFSS data, age is reported in 5-year intervals, so we include three age-identifying indicators (40-44, 45-49, and 55-59 with 50-54 omitted). However, in the NHIS and HINTS data this vector includes the respondents exact age in years (40-59 with 50 omitted). We account for secular changes in mammography by including a vector of area-year-month fixed effects, τ. For regressions using the BRFSS data, this latter vector is comprised of state-year-month fixed effects to account for all state-level economic and policy changes occurring at the year-month level (e.g., ACA Medicaid expansion or state breast cancer awareness campaigns). Because the publicly available NHIS data do not contain state identifiers, regressions using NHIS data include Census region-year-month fixed effects. We report heteroskedastic robust standard errors, as well as wild bootstrapped p-values (Cameron et al. 2008; Cameron and Miller 2015) after clustering standard errors at the treatment group-time level (Abadie et al. 2017).

4. Results

4.1 Effects on Mammography

We begin by assessing the relationship between the 2009 USPSTF recommendation and the likelihood that women aged 40-49 reported ever receiving a mammogram. The dependent variable in Table 2 is an indicator for whether the woman reported ever receiving a mammogram, and the sample is women aged 40-59 in the BRFSS data. Panel A reports the dynamic event study estimates from equation (1) and Panel B the static difference-in-differences estimates from equation (2). Column 1 only controls for age group and year-month fixed effects, and Figure 4 plots these estimates to visually inspect whether mammography was differentially trending for women aged 40-49 relative to those aged 50-59 in the pre-period. Column 2 then augments this sparse specification with the individual-level demographic controls, and column 3 additionally includes state-year-month fixed effects.

Across all specifications, there is no evidence in Panel A that extensive margin mammography was differentially trending during the pre-period for women who were bound by the updated 2009 USPSTF recommendation. Indeed, the point estimates are small in magnitude, flat, and jointly statistically insignificant ($p^{Pre=0}$ = 0.624, 0.745, and 0.640). In contrast, the post-recommendation coefficients trended downward in the years following the 2009 guideline revision, and we can uniformly reject the null hypotheses that the pre- and post-period coefficients are equal ($p^{Pre=Post}$ = 0.000, 0.002, 0.001).[20] By differencing the average of the post-recommendation coefficients and the average of the pre-recommendation coefficients, we find that the 2009 USPSTF guidelines reduced the likelihood that women aged 40-49 reported ever receiving a mammogram by 1.3-2.9 percentage points – values which are consistent with the static difference-in-differences

[20] We note that the post-recommendation coefficients are less precisely estimated in odd-numbered years, and this is likely because, as previously mentioned, the BRFSS data only include information on breast cancer screening for a subset of women during these years.

estimates shown in Panel B.[21] Overall, Table 2 provides compelling evidence that – counter to prior findings (Hinz et al. 2011; Howard and Adams 2012; Block et al. 2013; Pace et al. 2013; Wang et al. 2014; Fedewa et al. 2016; Rajan et al. 2017; Wernli et al. 2017; Brown et al. 2018) – the 2009 USPSTF guidelines did reduce mammography among targeted women.[22]

In Table 3, we test the robustness of this finding to using a second independent dataset (NHIS) and alternative specifications. Reassuringly, regardless of whether we use the BRFSS data (Panel A) or the NHIS data (Panel B), column 1 shows that the 2009 USPSTF guidelines reduced mammography in targeted women by 1.4-2.0 percentage points. As previously noted, the BRFSS underwent a redesign in 2011, and our BRFSS analyses employ Simon et al.'s (2017) sample weight procedure. While this redesign would not affect our NHIS estimates, column 2 transparently shows that our results are not driven by the sample weights (Carpenter and Dobkin 2009; Solon et al. 2015). We also verify that our results are not being driven by the American Cancer Society's 2015 recommendation change which increased the age at which they recommend women begin mammogram screenings from age 40 to 45. While we control for this recommendation change in our baseline specification, in column 3 we limit the sample to periods prior to this policy change. We continue to find a 1.4-1.8 percentage point decrease in mammography for women aged 40-49.

The remaining three columns in Table 3 explore whether our estimates are sensitive to the ages included in the treatment and comparison groups. Compared to our baseline sample of women aged 40-59, column 4 shows that the results grow more pronounced if we expand the comparison group to also include women aged

[21] The difference in the effect size between columns 1 and 2 is almost entirely driven by our control for whether the woman was recommended by the American Cancer Society to receive a mammogram screening.

[22] Appendix Figure 3 separately plots the event study estimates for various age groups (30-34, 35-39, 40-44, 45-49, and 55-59) relative to those aged 50-54.

60-85+: we estimate a 2.3-3.1 percentage point reduction in mammography for women aged 40-49 relative to those 50-85+. We find a similar pattern in column 5 when we include younger women aged 30-39 in the treatment group. Finally, the sample in column 5 includes all women aged 30-85+, and we find that the 2009 USPSTF guidelines reduced the likelihood of mammography by 2.9-3.5 percentage points.

Why might we find larger effects in samples that include younger women? One possibility is that patients under 40 years old and their health care providers may have used the 40-year-old threshold as an anchor when making health care decisions. By updating the starting age to 50, the 2009 USPSTF guidelines would have increased the gap between a younger woman's age and the threshold, generating spillovers onto these 30-39-year-old women. Indeed, we show descriptively in Figure 2 that mammography rates were flat for women aged 35-39 during the pre-period and began trending down concurrent with the 2009 USPSTF guidelines change (Panel B). We test for these spillovers using the NHIS data – where we know the respondent's exact age – and a modified version of equation (2) that interacts the post-period indicator with indicators for each age (omitting age 50). Figure 5 shows large, statistically significant 8.8-16.7 percentage point reductions in extensive margin mammography among women aged 36-39, as well as less-precisely estimated reductions for women aged 40-49. The point estimates for women aged 51-59, whose decision to ever receive a mammogram should not have been affected, are smaller in magnitude and statistically insignificant. Overall, Figure 5 shows that the 2009 USPSTF recommendation reduced mammography rates among both the targeted women (40-49-year-old women newly recommended to delay until age 50) and younger women who were never recommended to receive a mammogram.

4.2 Heterogeneity

We next explore potential heterogeneity in the effects of the 2009 USPSTF recommendation change along several dimensions. For expositional simplicity and due to data limitations of the BRFSS regarding the respondents' exact ages, variable availability, and comparability across sample waves, for these analyses we present results using only data from the NHIS.[23] These heterogeneity results are presented in Table 4; the column headers indicate the sample restriction.[24]

We first examine heterogeneity in the impacts of the recommendation change based on age at the time of the update (2009). One concern about focusing on extensive margin mammography (i.e., 'Ever Received a Mammogram') is that we will be unable to detect mammography changes for women aged 40-49 who had already received a mammogram at the time of the recommendation change.[25] To examine the extent to which this impacts our results, we separately estimate the effect of the recommendation change for women who turned 40 following the 2009 recommendation (column 1) and those who had already turned 40 at the time of the update (column 2). As expected, we find larger reductions in mammography for women who turned 40 following the recommendation change relative to our baseline results.

We next consider whether the effect of the 2009 USPSTF recommendations on mammography varied by health insurance status, race/ethnicity, or educational

[23] In this section, we characterize the health status of women who complied with the 2009 USPSTF guidelines by exploring heterogeneity by health behaviors. Because the CDC explicitly warned that the 2011 survey redesign would increase the occurrence of certain risky behaviors, including "tobacco use, obesity…, and health status," we are unable to credibly stratify the sample by these characteristics. In results available upon request, we confirm that the BRFSS sample did in fact change along these dimensions during our sample period.
[24] The sample in this analysis is women aged 40-59. Appendix Table 7 shows that results are similar if we include women aged 30-39.
[25] Later in the paper, we further address this question by examining higher frequency outcomes, including whether the woman received a mammogram during the prior year, the prior three years, and the prior five years.

attainment.[26] First, we note that insured women were approximately 20 percentage points more likely to report ever having had a mammogram in the pre-recommendation period compared to uninsured women, and column 3 shows that the 2009 recommendation change reduced the probability that insured women aged 40-49 reported ever receiving a mammogram by 2.0 percentage points. Column 4 does not show any evidence of a significant change in mammography among uninsured women, although the point estimate is comparable in magnitude across insurance statuses. Columns 5 and 6 indicate that white and non-white women responded differently to the 2009 USPSTF guidelines. While we find that white women aged 40-49 were 2.9 percentage points less likely to report ever having had a mammogram, the estimates for age-targeted non-white women are less than a third of the magnitude and are statistically insignificant. Finally, columns 7 and 8 show similar estimates for higher and lower educated women.

In Table 5, we characterize the health status of women who complied with the 2009 USPSTF recommendation by exploring heterogeneity across four dimensions – receipt of the flu vaccine, BMI, smoking history, and self-reported health.[27] Prior work found that women who comply with health recommendations are typically healthier than average (Oster 2020; Kowalski *forthcoming*). Indeed, Einav et al. (2020) found that women who began mammography at age 40 were

[26] Appendix Table 8 reports estimates whereby the group indicators (insured vs. uninsured, white vs. nonwhite, and more than a high school degree vs. at most a high school degree) are fully interacted with the right-hand side variables. Using this specification, we find no evidence of significant differences between the examined groups. In Appendix Table 9, we explore changing demographic composition during our sample period by placing the demographic characteristics on the lefthand side of our regression equation. Only one estimate is even marginally significant (probability of being white). Because white women are more likely to report mammography relative to their non-white counterparts, it is possible that these demographic changes would bias us toward finding a reduction in mammography in the full sample. However, Table 4 shows robust reductions in mammography using a sample of white women, indicating that this composition change is unlikely to explain our effects.

[27] Appendix Table 10 documents a similar pattern of results when examining women aged 30-59 rather than those aged 40-59.

less likely to have breast cancer than women who (i) never began mammogram screenings or (ii) began mammogram screenings prior to age 40.

Consistent with prior work, the sub-sample means indicate that healthier women were generally more likely to have received a mammogram in the pre-period relative to their less-healthy counterparts. Yet, surprisingly, we find larger reductions in mammography among less-healthy women following the 2009 USPSTF recommendation. While we do not detect any statistical change in mammography among women who reported receiving a flu shot during the prior 12 months (column 1), we find that women who did not receive a flu shot were 3.7 percentage points less likely to report mammography following the revision (column 2). Similarly, we do not detect any change for women who were not classified as overweight or obese; the point estimate is very small in magnitude and statistically insignificant (column 3). In contrast, we find a statistically significant 3-percentage point reduction in the likelihood of ever receiving a mammogram for overweight or obese women (column 4). We likewise find a marginally significant 1.6 percentage point reduction among non-smokers (column 5) and a statistically significant 2.9 percentage point reduction among smokers (column 6). Finally, while the coefficient indicates a 1.2 percentage point reduction in mammography for women who self-reported being in at least very good health, the estimate is not statistically distinguishable from zero (column 5). For targeted women who reported being in worse health, we find a 3.3 percentage point reduction in mammography (column 6).[28] Thus, while prior work has found that healthier women were more likely to comply with recommendations to receive a screening,

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[28] Appendix Table 11 shows that targeted women were no more likely to report having a recent flu shot or describe themselves as being in at least very good health in the post-period. We find some evidence that these women were more likely to be classified as overweight or obese (less healthy) and simultaneously less likely to be smokers (healthier). Yet Appendix Figure 4 indicates that these composition changes were driven by pre-existing trends. Importantly, despite some evidence of countervailing composition changes, we uniformly find larger effects for less healthy women, regardless of the characteristic examined.

our estimates indicate that it was the less-healthy women who complied with the recommendation to delay mammography. Overall, these findings suggest that the difference in the baseline characteristics between compliers and the general population may vary based on whether the recommendation is to receive or forgo an additional procedure.[29]

4.3 Additional Results

In this section we conduct several additional analyses to understand broader impacts and potential mechanisms through which the 2009 recommendation change may have impacted mammography. First, we examine relative changes in the probability that younger women report having received a mammogram in the past year, past 3 years, or past 5 years. Second, we examine the impacts of the recommendation revision on physician mammography recommendations and on the doctor-going behavior of women. Finally, using data from the HINTS, we consider the effects on women's opinions regarding health care decision-making and the trust they have in their doctor and government health agencies.

We present in Table 6 the results from examining the impact of the 2009 recommendation change on relative changes in the frequency of receiving a mammogram. For these analyses, the dependent variables are indicators for whether the woman reported receiving a mammogram during the prior year, prior three years, or prior five years.[30] Accordingly, we lag our independent variable of

[29] In Appendix Table 12, we examine changes in mammography separately for women with and without a maternal history of breast cancer following the 2009 USPSTF recommendation. We are unable to reject that the estimated effects for these two groups differ from one other, likely due to the small number of women in our sample with maternal history of breast cancer (1,518 women). Appendix Figure 5 also descriptively shows similar reductions in mammography among women with and without a history of maternal breast cancer, though the former group had higher baseline rates.

[30]The results in this table rely on NHIS data as the BRFSS data do not contain information on whether women reported receiving a mammogram recommendation. We report results for changes in recent mammography using BRFSS data in Appendix Table 13. The results are consistent across datasets.

interest by one year, three years, and five years, respectively.[31] Consistent with the fact that 50-59-year-old women were also recommended to receive less frequent mammograms following the 2009 revision, we do not detect any differential change in the probability that women aged 40-49 reported receiving a mammogram during the prior year compared to the change for the older women.[32] However, as we increase the reporting interval to mammography during the prior three years and the prior five years, the point estimate becomes negative, increases in magnitude, and becomes statistically significant.[33] Appendix Figure 9 examines these effects for women aged 30-59 separately by five-year age group and shows significant reductions in mammography for women aged 35-39 and women aged 40-44 as we increase the time horizon.

The 2009 USPSTF guidelines were primarily intended to guide physician behavior regarding mammogram screenings. However, given how broadly the recommendation change was disseminated (see Figure 1), the update may have also made the targeted women aged 40-49 less likely to engage with the health care system. We test these pathways in the final two columns of Table 6. Column 4 shows that women aged 40-49 were 1.2 percentage points less likely to have had a health care visit during the prior year.[34] Appendix Figure 11 shows that the change in health care utilization was unique to women – there was no change in health care utilization among their similarly aged male counterparts. Finally, column 5 shows

[31] In results available upon request, we verified that the relationship is robust to alternatively using a 1-year lagged independent variable to examine the likelihood of mammography during the past three and past five years.

[32] Appendix Figure 6 descriptively shows that women aged 40-49 and women aged 50-59 were less likely to report having a mammogram during the prior year. Appendix Figure 7 plots the event study estimates for past year mammography for each age group (30-34, 35-39, 40-44, 45-49, and 55-59) relative to those aged 50-54.

[33] We also explored a NHIS question about how many mammograms a woman reported receiving during the prior six years. Appendix Figure 8 shows that women aged 40-49 were descriptively more likely to report having zero mammograms relative to those aged 50-59.

[34] We show in Appendix Figure 10 that this change was driven by women aged 40-44 in the NHIS data (Panel A). However, we do not detect any change using the BRFSS data (Panel B).

that women aged 40-49 were 2.2 percentage points less likely to report having been recommended a mammogram screening in the past year. Figure 6 shows that when we expand the sample to include younger women, women aged 35-39 were 11.1 percentage points less likely to report having been recommended a mammogram by a health care professional.[35] This is consistent with the USPSTF guidelines being intended to shape primary care physicians' practicing behaviors (USPSTF 2022b) and may explain the large mammography spillovers we documented for younger women.

By changing the age at which women were recommended to begin mammogram screenings, the information-shock generated by the 2009 USPSTF recommendation may have affected women's perceptions of their health care quality and their view of government health recommendations. On one hand, women near the threshold may have felt confused by the decision to raise the recommended starting age and, subsequently, lost faith in government health recommendations more broadly. On the other hand, it is possible that this change might have signaled to women that the recommendations were based on the best available clinical evidence. We test these possibilities in Table 7 using the 2003-2019 HINTS data.

Consistent with the patterns from both the BRFSS and NHIS estimates, column 1 shows that women aged 40-49 in the HINTS data were 4.9 percentage points less likely to report ever having had a mammogram than their 50-59-year-old counterparts following the 2009 revision.[36] In column 2, we find suggestive evidence that targeted women were less likely to report that they were always involved as much as they would like in their health care decision-making process,

[35] Appendix Figure 12 plots the effects by individual age. The pattern is qualitatively similar, though the effects are less precisely estimated.
[36] Appendix Table 14 shows the same pattern of results using a sample of women aged 35-59. Women under the age of 35 were not asked mammogram-related questions in the HINTS.

though the results are not statistically significant. Meanwhile, column 3 shows that targeted women were nearly 7-percentage points more likely to report that there were so many cancer recommendations that it made it difficult to know which ones to follow, and this increase is statistically significant regardless of our inference method. Columns 4 and 5 show no significant changes in the probability that women aged 40-49 reported trusting health information from doctors or from government health agencies relative to 50-59-year-olds. However, the confidence intervals are wide, and we are unable to rule out sizable effects.

4.4 Effects on Breast Cancer Incidence

With the prior evidence indicating that the 2009 USPSTF mammography recommendations were successful in reducing the likelihood that women younger than 50 years old began mammogram screening, we now test whether this recommendation affected subsequent breast cancer diagnoses. For these analyses, we use SEER data collapsed to the age group level, such that each observation contains the count of cases diagnosed in a given year for a 5-year age group.[37] Our results are presented in Figure 7: the blue triangles plot the estimates from a regression where the dependent variable is the natural log of the number of in situ precancerous cases; the red circles plot the estimates where the dependent variable is the natural log of the number of malignant cases. Consistent with Figure 5, which showed the largest reductions in extensive margin mammography occurred for women aged 35-39, Figure 7 shows a 16 percent reduction in the number of in situ precancerous cases for 35-39-year-old women.[38]

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[37] For completeness, we verify that we continue to find a reduction in mammography using the BRFSS data when we limit the sample to states that are found in the SEER dataset. Our coefficient is -0.014 with a standard error of 0.006. For reference, our full sample coefficient is -0.014 with a standard error of 0.003.

[38] Appendix Figure 13 plots the event study estimates for in situ and malignant breast cancer diagnoses for each age group (30-34, 35-39, 40-44, 45-49, and 55-59) relative to those aged 50-54.

We conduct several supplemental analyses to further characterize the impact of the 2009 recommendation change on breast cancer outcomes. Analyses examining tumor size suggest that tumors were somewhat larger at diagnosis: Appendix Figure 14 shows a reduction in the share of diagnosed breast cancers that were less than 2 centimeters, driven primarily by changes for women aged 40-44. In Appendix Figure 15 we present results for analyses examining the impact on mortality within 5 years of diagnosis. Across all age groups we find no statistically significant changes in the 5-year mortality rate.[39,40] Overall, these results suggest that the 2009 USPSTF recommendations reduced the overdiagnosis of in situ precancers which would likely have otherwise remained harmless (Welch et al. 2016; Einav et al. 2020; Ryser et al. 2022), and are consistent with the USPSTF's review of clinical evidence which failed to find a statistically significant reduction in breast cancer mortality in younger women attributable to mammography (USPSTF 2009).

5. Estimated Cost Savings

The US spends nearly $8 billion annually on mammogram screenings, and O'Donoghue et al. (2014) estimated that full compliance with the 2009 USPSTF guidelines would save an estimated $4.4 billion. While the US has not achieved full compliance – over three quarters of women aged 40-49 reported having ever received a mammogram in the most recent survey year – we now adopt O'Donoghue et al.'s (2014) framework to estimate the realized health care savings from the 2009 USPSTF recommendation. First, we multiply the age-specific

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[39] Appendix Table 15 reports the estimates, standard errors, and wild bootstrapped p-values for every evaluated outcome (ln(in situ cases+1), ln(malignant cases+1), 5-year mortality rate, share <2cm, share 2-5 cm, share 5+cm). Appendix Table 16 then shows the robustness of our main in situ estimate to alternative samples and specifications.

[40] The breast cancer cases and breast cancer mortality results are both robust to alternatively omitting 30-34 year old women, as opposed to 50-54 year old women. These results are available upon request.

estimated mammography impacts from Figure 5 by the total number of women of that age in 2010. This linear combination of parameters implies 1,816,673 fewer initial mammogram screenings for women aged 30-49 following the 2009 USPSTF recommendation.[41] To place a dollar value on mammogram screenings, we follow O'Donoghue et al. (2014) and assume that 81.7 percent of these screenings would have been digital mammograms, 18.3 percent would have been film mammograms, and 27.8 percent of all mammograms would have included computer-aided detection (CAD).[42] We also assume that 16.8 percent of these initial mammograms would have resulted in recall follow-up evaluations.[43] Multiplying these figures by their associated costs at the time of the recommendation change yields a total savings estimate of over $381 million dollars annually.[44]

We also estimated significant reductions in non-invasive precancer (in situ) diagnoses for women aged 35-39. Siegel et al. (2022) estimated that there will be 51,400 in situ cases in 2022, and in our data 2.3 percent of cases are for women aged 35-39. We estimate a 16 percent reduction for these women, yielding 177 fewer diagnoses of in situ precancer (51,400 × 0.023 × 0.16). At an average cost of $60,000 during the year following diagnosis (Blumen et al. 2016), this implies nearly $11 million in additional health care savings (177 × $60,000).

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[41] The 95 percent confidence interval indicates that there were between 265,905 and 3,367,442 fewer mammograms. These figures imply estimated cost savings ranging from $5 million to over $707 million.

[42] Mammogram results are first reviewed by radiologists. Then, the CAD software reviews the mammogram to highlight any areas that the radiologist might have missed on the first review (Baker et al. 2003).

[43] O'Donoghue et al. (2014) estimated a recall rate of 16.8-20.1 percent for initial mammograms. We use the smaller number to generate conservative cost saving estimates.

[44] Specifically, we estimate 1,484,222 fewer digital mammograms, 332,451 fewer film mammograms, 505,035 fewer instances of CAD, 249,249 fewer digital recalls, and 55,852 fewer film recalls. O'Donoghue et al. (2014) estimated the cost of a digital mammogram to be $137.24, a film mammogram to be $86.09, and CAD to be $17.93. They also estimated digital recall to cost $467.93 and film recall costing $421.97.

6. Conclusion

While mammogram screenings are generally viewed as effective tools for detecting breast cancer in its early stages – thereby increasing the chance of survival – there is considerable controversy surrounding the appropriate age at which to begin these screenings. As a result, the United States Preventive Services Task Force has altered their mammography guidelines multiples times over the last several decades, first recommending that women aged 40-49 receive mammogram screenings in 2002 and then dropping that recommendation in 2009.

In this paper, we provide evidence that the 2009 USPSTF recommendation significantly reduced the likelihood that targeted women aged 40-49 ever received a mammogram by 1.4-4.9 percentage points. Our results show that the recommendation change also had important spillovers onto younger women aged 35-39, who were up to 16.7 percentage points less likely to begin mammogram screenings after the revision. Heterogeneity analyses show that the compliers with the recommendation change were *less* healthy women, in contrast with prior work showing that women who comply with recommendations to receive health screenings are healthier than average (Einav et al. 2020; Oster 2020; Kowalski *forthcoming*). This result highlights that the set of compliers may not be symmetric in response to the addition versus removal of a health screening recommendation.

We also provide evidence on the mechanisms underlying these effects. Our results show that, following the recommendation change, physicians were 2 percentage points less likely to recommend mammography to the targeted women, with even larger reductions for younger women. Women aged 40-44 also responded to the guideline revision by modestly decreasing health care visits. Interestingly, we further document a 7-percentage point increase in the probability that women in the targeted age group felt that there are ‘so many recommendations about preventing cancer,’ that it is hard to know what to follow. We hypothesize that this confusion was driven both by the numerous revisions to the USPSTF cancer screening guidelines, as well as the fact that the 2009 revision created inconsistencies in the recommendations across major medical organizations.

Finally, using data from National Cancer Institute's Surveillance, Epidemiology, and End Results Program 2002-2019, we find a 16 percent reduction in the number of in situ precancerous diagnoses among women aged 35-39, without any detected change in malignant cancer diagnoses. These findings are consistent with the arguments made by some cancer experts that in situ precancerous growths are over-diagnosed and over-treated (Marmot et al. 2012; Francis et al. 2015; Worni et al. 2015; Benson et al. 2016; Co 2020) and that increasing the recommended age to begin mammography would help reduce the unnecessary diagnosis of these cancers (Elmore et al. 1998; Armstrong et al. 2007; Hubbard et al. 2011; Einav et al. 2020; Welch et al. 2016; Ryser et al. 2022). Overall, we estimate that the 2009 USPSTF recommendations have generated approximately $392 million in annual health care savings.

In contrast with our findings, prior public health literature has largely concluded that the 2009 USPSTF recommendation change had no effect on mammogram screening rates (Hinz et al. 2011; Howard and Adams 2012; Block et al. 2013; Pace et al. 2013; Wang et al. 2014; Fedewa et al. 2016; Rajan et al. 2017; Wernli et al. 2017; Brown et al. 2018), suggesting that public health officials may be limited in their ability to influence health behaviors through non-binding recommendations. One explanation for the difference between our results and the prior literature is that prior papers examined changes in the likelihood that women aged 40-49 reported having a *recent* mammogram compared to their 50-59-year-old counterparts – in contrast to our measure examining whether women reported *ever* receiving a mammogram – even though the 2009 USPSTF recommendation also reduced the frequency with which these older women were recommended to receive mammogram screenings. This additional dimension of policy change prevents these older women from serving as a ‘clean’ comparison group when examining changes in recent mammography. In contrast, we use three separate nationally representative data sets (NHIS, BRFSS, and HINTS) and a difference-in-differences identification strategy to examine the probability that women report *ever* having a mammogram – an outcome that was not affected by the updated guidelines for older women.

This study is subject to some important limitations. For one, our mammography measures are self-reported, and prior research has shown that women underestimate how long it has been since their prior mammogram (Warnecke et al. 1997). Analyses focusing on the extensive margin, however, are unlikely to be impacted by this bias. Moreover, there is no reason to suspect that women’s reporting behavior changed differentially across age groups concurrent with the updated guidelines; if anything, the media coverage surrounding the updated guidelines would likely have made women more likely to remember that they had received a mammogram. Another limitation is that we are unable to disentangle whether the reduction in mammography was due to the 2009 USPSTF recommendations or the subsequent media coverage. Yet we show that the reduction has persisted over many years, while the media coverage surrounding the guidelines was relatively short lived. Nevertheless, identifying methods to isolate these mechanisms remains an important area for future research. Finally, while we found a reduction in in situ precancer diagnoses among the targeted women, the relative recency of the policy change prohibits us from examining longer run outcomes that are important considerations for drawing conclusions about how the updated guidelines will affect welfare. Despite these limitations, our study highlights the important and previously overlooked relationship between the 2009 USPSTF recommendations and mammography screening rates.

7. References

Abadie, Alberto, Susan Athey, Guido W. Imbens, and Jeffrey Wooldridge (2017). "When Should You Adjust Standard Errors for Clustering," NBER Working Paper No. 24003.

Abaluck, Jason, Leila Agha, Chris Kabrhel, Ali Raja, and Arjun Venkatesh (2016). "The Determinants of Productivity in Medical Testing: Intensity and Allocation of Care," *American Economic Review*, 106(12): 3730-3764.

Alalouf, Mattan, Sarah Miller, and Laura Wherry (2019). "What Difference Does a Diagnosis Make? Evidence from Marginal Patients," NBER Working Paper No. 26363.

Alexander, Diane and Molly Schnell (2021). "The Impacts of Physician Payments on Patient Access, Use, and Health," Working Paper. Accessed at: https://static1.squarespace.com/static/572372e7c2ea51b309e9991a/t/600b52a025e873435ec8cac3/1611354805361/Alexander_Schnell_012021.pdf (October 4, 2022).

American Cancer Society (2022a). "Key Statistics for Breast Cancer: How Common is Breast Cancer?" Accessed at: https://www.cancer.org/cancer/breast-cancer/about/how-common-is-breast-cancer.html (March 17th, 2022).

American Cancer Society (2022b). "Survival Rates for Breast Cancer," Accessed at: https://www.cancer.org/cancer/breast-cancer/understanding-a-breast-cancer-diagnosis/breast-cancer-survival-rates.html (March 18th, 2022).

American Cancer Society (2015). "American Cancer Society Updates Breast Cancer Screening Guideline," Accessed at: https://pressroom.cancer.org/2015BrCaGuideline (December 3rd, 2022).

American Cancer Society (2009). "American Cancer Society Responds to Changes to USPSTF Mammography Guidelines," Accessed at: http://pressroom.cancer.org/releases?item=201 (March 18th, 2022).

American College of Radiology (2009). "Detailed ACR Statement on Ill-Advised and Dangerous USPSTF Mammography Recommendations," Accessed at: https://www.acr.org/Advocacy-and-Economics/ACR-Position-Statements/Ill-Advised-and-Dangerous-USPSTF-Mammography-Recommendations.

Antwi, Yaa Akosa, Asako S. Moriya, and Kosali I. Simon (2015). "Access to Health Insurance and the Use of Inpatient Medical Care: Evidence from the Affordable Care Act Young Adult Mandate," *Journal of Health Economics*, 39: 171-187.

Armstrong, Katrina, Elizabeth Moye, Sankey Williams, Jesse A. Berlin, and Eileen E. Reynolds (2007). "Screening Mammography in Women 40 to 49 Years of Age: A Systematic Review for the American College of Physicians," *Annals of Internal Medicine*, 146(7): 516-526.

Barbaresco, Silvia, Charles J. Courtemanche, and Yanglin Qi. (2015). “Impacts of the Affordable Care Act Dependent Coverage Provision on Health-Related Outcomes of Young Adults,” *Journal of Health Economics*, 40: 54-68.

Baicker, Katherine and Amitabh Chandra (2005). “The Effect of Malpractice Liability on the Delivery of Health Care,” *Forum for Health Economics & Policy*, 8(1): doi: 10.2202/1558-9544.1010.

Baker, Jay A., Eric L. Rosen, Joseph Y. Lo, Edgardo I. Gimenez, Ruth Walsh, and Mary Scott Soo (2003). “Computer-Aided Detection (CAD) in Screening Mammography: Sensitivity of Commercial CAD Systems for Detecting Architectural Distrotion,” *American Journal of Roentgenology*, 181: 1083-1088.

Benson, John R., Ismail Jatoi, and Masakazu Toi (2016). “Treatment of Low-Risk Ductal Carcinoma In Situ: Is Nothing Better than Something?” *Lancet: Oncology*, 17(10): e442-e451.

Bitler, Marianne P. and Christopher S. Carpenter (2019). “Effects of Direct Provision to the Uninsured: Evidence from Federal Breast and Cervical Cancer Screening Programs,” NBER Working Paper No. 26140.

Bitler, Marianne P. and Christopher S. Carpenter (2017). “Effects of State Cervical Cancer Insurance Mandates on Pap Test Rates,” *Health Services Research*, 52(1): 156-175.

Bitler, Marianne P. and Christopher S. Carpenter (2016). “Health Insurance Mandates, Mammography, and Breast Cancer Diagnoses,” *American Economic Journal: Economic Policy*, 8(3): 39-68.

Bjurstam, Niels, Lena Bjöneld, Jane Warwick, Evis Sala, Stephen W. Duffy, Lennarth Nyström, Neil Walker, Erling Cahlin, Olof Eriksson, Lars-Olof Hafström, Halvard Lingaas, Jan Mattsson, Stellan Persson, Carl-Magnus Rudenstam, Håkan Salander, Johan Säve-Söderbergh, and Torkel Wahlin (2003). “The Gothenburg Breast Screening Trial,” *Cancer*, 97(10): 2387-2396.

Block, Lauren D., Marian P. Jarlenski, Albert W. Wu, and Wendy L. Bennett (2013). “Mammography Use Among Women Ages 40-49 After the 2009 U.S. Preventive Services Task Force Recommendation,” *Journal of General Internal Medicine*, 28(11): 1447-1453.

Blumen, Helen, Kathryn Fitch, and Vincent Polkus (2016). “Comparison of Treatment Costs for Breast Cancer, by Tumor Stage and Type of Service,” *American Health & Drug Benefits*, 9(1): 23-31.

Brekke, Kurt R., Tor Helge Holmås, Karin Monstad, and Odd Rune Straume (2017). “Do Treatment Decisions Depend on Physicians’ Financial Incentives?” *Journal of Public Economics*, 155: 71-92. Doi: 10.1016/j.jpubeco.2017.09.012.

Brot-Goldberg, Zarek C., Amitabh Chandra, Benjamin R. Handel, and Jonathan T. Kolstad (2017). "What Does a Deductible Do? The Impact of Cost-Sharing on Health Care Prices, Quantities, and Spending Dynamics," *Quarterly Journal of Economics*, 132(3): 1261-1318.

Brown, Clare, Adrienne Nevola, and Bradley C. Martin (2018). "Lack of Impact of the 2009 USPSTF Guidelines on Rates of Mammography Screening," *Journal of Women's Health*, 27(7): https://doi.org/10.1089/jwh.2017.6425.

Buchmueller, Thomas C. and Léontine Goldzahl (2018). "The Effect of Organized Breast Cancer Screening on Mammography Use: Evidence from France," *Health Economics*, 27: 1963-1980.

Buchmueller, Thomas C. and Colleen Carey (2018). "The Effect of Prescription Drug Monitoring Programs on Opioid Utilization in Medicare," *American Economic Journal: Economic Policy*, 10(1): 77-112.

Busch, Susan H. and Noelia Duchovny (2005). "Family Coverage Expansions: Impact on Insurance Coverage and Health Care Utilization of Parents," *Journal of Health Economics*, 24(5): 876-890.

Cameron, A. Colin and Douglas L. Miller (2015). "A practitioner's guide to cluster-robust inference," *The Journal of Human Resources*, 50(2): 317-372.

Cameron, A. Colin, Jonah B. Gelbach, and Douglas L. Miller (2008). "Bootstrap-based improvements for inference with clustered errors," *The Review of Economics and Statistics*, 90(3): 414-427.

Carpenter, Christopher S. and Carlos Dobkin (2009). "The Effect of Alcohol Consumption on Mortality: Regression Discontinuity Evidence from the Minimum Drinking Age," *American Economic Journal: Applied*, 1(1): 164-182.

Centers for Disease Control and Prevention (2022). "Leadings Causes of Death," Accessed at: https://www.cdc.gov/nchs/fastats/leading-causes-of-death.htm (March 24, 2022).

Centers for Medicare & Medicaid Service (2022). "Medicare Physicians Fee Schedule," Accessed at: https://www.cms.gov/medicare/physician-fee-schedule/search/overview (October 27th, 2022).

Chandra, Amitabh and Douglas O. Staiger (2007). "Productivity Spillovers in Health Care: Evidence from the Treatment of Heart Attacks," *Journal of Political Economy*, 115(1): 103-140. Doi: 10.1086/512249.

Churchill, Brandyn F. and Laura E. Henkhaus (forthcoming). "The Roles of Cost and Recommendations in Driving Vaccination: Evidence from the Herpes Zoster Vaccine for Shingles Prevention," *American Journal of Health Economics*, forthcoming.

Clemens, Jeffrey and Joshua D. Gottlieb (2014). "Do Physicians' Financial Incentives Affect Medical Treatment and Patient Health?" *American Economic Review*, 104(4): 1320-1349. Doi: 10.1257/aer.104.4.1320.

Co, Michael (2020). "Ductal Carcinoma In Situ of the Breasts: Over-Diagnosis, Over-Treatment and a Decade of Lost Direction," *Precision Medical Sciences*, 9(1): 4-8.

Coe, Norma B. and Gema Zamarro (2015). "Does Retirement Impact Health Care Utilization?" CESR-Schaeffer Working Paper Series No. 2015-032.

Commonwealth Fund (2021). "Mirror, Mirror 2021: Reflecting Poorly – Health Care in the U.S. Compared to Other High-Income Countries," Accessed at: https://www.commonwealthfund.org/publications/fund-reports/2021/aug/mirror-mirror-2021-reflecting-poorly (October 2nd, 2022).

Conner, Peter, Liran Einav, Amy Finkelstein, Petra Persson, and Heidi L. Williams (2022). "Targeting Precision Medicine: Evidence from Prenatal Screening," NBER Working Paper No. 30669.

Cuddy, Emily, and Currie, Janet. (2022). "Rules vs. discretion: Treatment of Mental Illness in US Adolescents." NBER Working Paper Working Paper No. 27890

Currie, Janet M. and W. Bentley MacLeod (2020). "Understanding Doctor Decision Making: The Case of Depression Treatment," *Econometrica*, 88(3): 847-878. Doi: 10.3982/ECTA16591.

Currie, Janet M. and W. Bentley MacLeod (2008). "First Do No Harm? Tort Reform and Birth Outcomes," *Quarterly Journal of Economics*, 123(2): 795-830. Doi: 10.1162/qjec.2008.123.2.795.

Cutler, David M. (2008). "Are We Finally Winning the War on Cancer?" *Journal of Economic Perspectives*, 22(4): 3-26.

Dobois, Pierre and Tuba Tunçel (2021). "Identifying the Effects of Scientific Information and Recommendations on Physicians' Prescribing Behavior," *Journal of Health Economics*, 78: 102461. Doi: 10.1016/j.jhealeco.2021.102461.

Eibich, Peter and Léontine Goldzahl (2021). "Does Retirement Affect Secondary Preventive Care Use? Evidence from Breast Cancer Screening," *Economics and Human Biology*, 43: 101061.

Einav, Liran, Amy Finkelstein, Tamar Oostrom, Abigail Ostriker, and Heidi Williams (2020). "Screening and Selection: The Case of Mammograms," *American Economic Review*, 110(12): 3836-3870.

Elmore, Joann G., Mary B. Barton, Victoria M. Moceri, Sarah Polk, Philip J. Arena, and Suzanne W. Fletcher (1998). "Ten-Year Risk of False Positive Screening Mammograms and Clinical Breast Examinations," *New England Journal of Medicine*, 338(16): 1089-1096.

Fedewa, Stacey A., Janet S. de Moor, Elizabeth M. Ward, Carol E. DeSantis, Ann Goding Sauer, Robert A. Smith, and Ahmedin Jemal (2016). "Mammography Use and Physician Recommendation After the 2009 U.S. Preventive Services Task Force Breast Cancer Screening Recommendation," *American Journal of Preventive Medicine*, 50(5): e123-e131.

Finkelstein, Amy, Sarah Taubman, Bill Wright, Mira Bernstein, Jonathan Gruber, Joseph P. Newhouse, Heidi Allen, Katherine Baicker, and the Oregon Health Study Group (2012). "The Oregon Health Insurance Experiment: Evidence from the First Year," *Quarterly Journal of Economics*, 127(3): 1057-1106.

Frakes, Michael (2013). "The Impact of Medical Liability Standards on Regional Variations in Physician Behavior: Evidence from the Adoption of National-Standard Rules," *American Economic Review*, 103(1): 257-276.

Francis, Adele, Jeremy Thomas, Lesley Fallowfield, Matthew Wallis, John M. S. Bartlett, Cassandra Brookes, Tracy Roberts, Sarah Pirrie, Claire Gaunt, Jennie Young, Lucinda Billingham, David Dowell, Andrew Hanby, Sarah E. Pinder, Andrew Evans, Malcom Reed, Valerie Jenkins, Lucy Matthews, Maggie Wilcox, Patricia Fairbrother, Sarah Bowden, and Daniel Rea (2015). "Addressing Overtreatment of Screen Detected DCIS; The LORIS Trial," *European Journal of Cancer*, 51(16): 2296-2303.

Frimmel, Wolfgang and Gerald J. Pruckner (2020). "Retirement and Healthcare Utilization," *Journal of Public Economics*, 184: 104146.

Gaynor, Martin and Mark V. Pauly (1990). "Compensation and Productive Efficiency in Partnerships: Evidence from Medical Groups Practice," *Journal of Political Economy*, 98(3): 544-573. Doi: 10.1086/261694

Glewwe, Paul, Kristine L. West, and Jongwook Lee (2018). "The Impact of Providing Vision Screening and Free Eyeglasses on Academic Outcomes: Evidence from a Randomized Trial in Title I Elementary Schools," *Journal of Policy Analysis and Management*, 37(2): 265-300.

Gruber, Jonathan, John Kim, and Dina Mayzlin (1999). "Physician Fees and Procedure Intensity: The Case of Cesarean Delivery," *Journal of Health Economics*, 18(4): 473-490.

Hackl, Franz, Martin Halla, Michael Hummer, and Gerald J. Pruckner (2015). "The Effectiveness of Health Screening," *Health Economics*, 24(8): 913-935.

Hinz, Erica K., Rashmi Kudesia, Renee Rolston, Thomas A. Caputo, and Michael J. Worley Jr. (2011). "Physician Knowledge of and Adherence to the Revised Breast Cancer Screening

Guidelines by the United States Preventive Services Task Force," *American Journal of Obstetrics and Gynecology*, 205(3): 201.e1-201.e5

Ho, Thao-Quyen H., Michael CS Bissell, Karla Kerlikowske, Rebecca A. Hubbard, Brian L. Sprague, Christoph I. Lee, Jeffrey A. Tice, Anna NA Tosteson, and Diana L. Miglioretti. (2022) "Cumulative probability of false-positive results after 10 years of screening with digital breast tomosynthesis vs digital mammography." *JAMA Network Open,* 5(3): e222440-e222440.

Howard, David H. and E. Kathleen Adams (2012). "Mammography Rates after the 2009 US Preventive Services Task Force Breast Cancer Screening Recommendation," *Preventive Medicine*, 55: 485-487.

Hubbard, Rebecca A., Karla Kerlikowske, Chris I. Flowers, Bonnie C. Yankaskas, Weiwei Zhu, and Diana L. Miglioretti (2011). "Cumulative Probability of False-Positive Recall or Biopsy Recommendation After 10 Years of Screening Mammography," *Annals of Internal Medicine*, 155: 481-492.

Jacobsen, Grant D., and Kathryn H. Jacobsen (2011). "Health Awareness Campaigns and diagnosis rates: Evidence from National Breast Cancer Awareness Month," *Journal of Health Economics*, 30:55-61.

Kadiyala, Srikanth and Erin Strumpf (2016). "How Effective is Population-Based Cancer Screening? Regression Discontinuity Estimates from the US Guideline Screening Initiation Ages," *Forum for Health Economics and Policy*, 19(1): 87-139.

Kerlikowske, Karla, Weiwei Zhu, Anna N.A. Tosteson, Brian L. Sprague, effrey A. Tice, Constance D. Lehman, Diana L. Migloiretti (2015). "Identifying Women with Dense Breasts at High Risk for Interval Cancer: A Cohort Study," *Annals of Internal Medicine,* 162(10): 673-681.

Kesternich, Iris, Heiner Schumacher, and Joachim Winter (2015). "Professional Norms and Physician Behavior: *Homo Oeconomicus* or *Homo Hippocraticus*?" *Journal of Public Economics*, 131: 1-11. Doi: 10.1016/j.jpubeco.2015.08.009.

Kim, Hyuncheol Bryant and Sun-mi Lee (2017). "When Public Health Intervention is Not Successful: Cost Sharing, Crowd-Out, and Selection in Korea's National Cancer Screening Program," *Journal of Health Economics*: 53:100-116.

Kolstad, Jonathan T. (2013). "Information and Quality: When Motivation is Intrinsic: Evidence from Surgeon Report Cards," *American Economic Review*, 103(7): 2875-2910.

Kolstad, Jonathan T. and Amanda E. Kowalski (2012). "The Impact of Health Care Reform on Hospital and Preventive Care: Evidence from Massachusetts," *Journal of Public Economics*, 96: 909-929.

Kowalski, Amanda E. (*forthcoming*). “Behavior Within a Clinical Trial and Implications for Mammography Guidelines,” *Review of Economic Studies,* forthcoming.

Kowalski, Amanda E. (2021). “Mammograms and Mortality: How Has the Evidence Evolved?” *Journal of Economic Perspectives,* 35(2): 119-140.

Lawler, Emily C. (2017). “Effectiveness of Vaccination Recommendations versus Mandates: Evidence from the Hepatitis A Vaccine,” *Journal of Health Economics*, 52: 45-62.

Lawler, Emily C. (2020). “Giving Teens a Boost? Effects of Adolescent Meningococcal Vaccine Recommendations,” *American Journal of Health Economics,* 6 (2): 251-287.

Long, Elisa F. and Patricia A. Ganz (2015). “Cost-Effectiveness of Universal *BRCA1/2* Screening,” *Journal of the American Medical Association: Oncology*, 1(9): 1217-1218.

Lu, Yao and David J. G. Slusky (2016). “The Impact of Women’s Health Clinic Closures on Preventive Care,” *American Economic Journal: Applied Economics*, 8(3): 100-124.

Mandelson, Margaret T., Nina Oestreicher, Peggy L. Porter, Donna White, Charles A. Finder, Stephen H. Taplin, and Emily White (2000). “Breast Density as a Predictor of Mammographic Detection: Comparison of Interval- and Screen-Detected Cancers,” *Journal of the National Cancer Institute*, 92(13): 1081-1087.

Mariotto, Angela B., K. Robin Yabroff, Yongwu Shao, Eric J. Feuer, and Martin L. Brown (2011). “Projects of the Cost of Cancer Care in the United States: 2010-2020,” *Journal of the National Cancer Institute,* 103(2): 117-128.

Marmot, M.G., D.G. Altman, D.A. Cameron, J.A. Dewar, S.G. Thompson, and Maggie Wilcox (2012). “The Benefits and Harms of Breast Cancer Screening: An Independent Review,” *Lancet*, 17(380): 1778-1786, doi: 10.1016/S0140-6736(12)61611-0.

Moss, Sue M., Howard Cuckle, Andy Evans, Louise Johns, Michael Waller, Lynda Bobrow (2006). “Effects of Mammographic Screening from Age 40 Years on Breast Cancer Mortality at 10 Years’ Follow-Up: A Randomised Controlled Trial,” *The Lancet*, 368(9552): 2053-2060.

Mullainathan, Sendhil and Ziad Obermeyer (2022). “Diagnosing Physician Error: A Machine Learning Approach to Low-Value Health Care,” *Quarterly Journal of Economics*, 137(2): 679-727.

Myerson, Rebecca M., Reginald D. Tucker-Seeley, Dana P. Goldman, and Darius N. Lakdawalla (2020). “Does Medicare Coverage Improve Cancer Detection and Mortality Outcomes?” *Journal of Policy Analysis and Management,* 39(3): 577-604.

National Cancer Institute (2022a). “Common Cancer Types,” Accessed at: https://www.cancer.gov/types/common-cancers (March 17th, 2022).

National Cancer Institute (2022b) "Number of Persons by Race and Hispanic Ethnicity for SEER Participants (2020 Census Data)," Accessed at: https://seer.cancer.gov/registries/data.html (July 21st, 2022)

Nelson, Heidi D., Rochelle Fu, Amy Cantor, Miranda Pappas, Monica Daeges, and Linda Humphrey (2016). "Effectiveness of Breast Cancer Screening: Systematic Review and Meta-Analysis to Update the 2009 U.S. Preventive Services Task Force Recommendation," *Annals of Internal Medicine*, 164(4): 244-255.

Nelson, Heidi D., Kari Tyne, Arpana Naik, Christina Bougatsos, Benjamin K. Chan, and Linda Humphrey (2009). "Screening for Breast Cancer: An Update for the U.S. Preventive Services Task Force," *Annals of Internal Medicine*, 151(10): 727-737.

O'Donoghue, Cristina, Martin Eklund, Elissa M. Ozanne, and Laura J. Esserman (2014). "Aggregate Cost of Mammography Screening in the United States: Comparison of Current Practice and Advocated Guidelines," *Annals of Internal Medicine*, 160: 145-153.

OECD (2022). "Life Expectancy at Birth," Accessed at: https://data.oecd.org/healthstat/life-expectancy-at-birth.htm#indicator-chart (October 2, 2022).

OECD (2019). "Health at a Glance 2019: United States," Accessed at: https://www.oecd.org/unitedstates/health-at-a-glance-united-states-EN.pdf (October 2, 2022).

Oster, Emily (2020). "Health Recommendations and Selection in Health Behaviors," *American Economic Review: Insights*, 2(2): 143-160.

Pace, Lydia E., Yulei He, and Nancy L. Keating (2013). "Trends in Mammography Screening Rates After Publication of the 2009 US Preventive Services Task Force Recommendations," *Cancer*, 119(14): 2518-2523.

Pletscher, Mark (2017). "The Effects of Organized Screening Programs on the Demand for Mammography in Switzerland," *European Journal of Health Economics*, 18: 649-665.

Rajan, Suja S., Manasi S. Suryavanshi, Siddharth Karanth, and David R. Lairson (2017). "The Immediate Impact of the 2009 USPSTF Screening Guideline Change on Physician Recommendation of a Screening Mammogram: Findings from a National Ambulatory and Medical Care Survey-Based Study," *Population Health Management*, 20(2): https://doi.org/10.1089/pop.2015.0180.

Rizzo, John A. and Richard J. Zeckhauser (2003). "Reference Incomes, Loss Aversion, and Physician Behavior," *Review of Economics and Statistics*, 85(4): 909-922. Doi: 10.1162/003465303772815817.

Rosen, Paul P., David W. Braun Jr., and David E. Kinne (1980). "The Clinical Significance of Pre-Invasive Breast Carcinoma," *Cancer*, 46(S4): 919-925.

Ruhm, Christopher J. (2000). "Are Recessions Good for Your Health?" *Quarterly Journal of Economics*, 115(2): 617-650.

Ryser, Marc D., Jane Lange, Lurdes Y.T. Inoue, Ellen S. O'Meara, Charlotte Gard, Diana L. Miglioretti, Jean-Luc Bulliard, Andrew F. Brouwer, E. Shelley Hwang, and Ruth B. Etzioni (2022). "Estimation of Breast Cancer Overdiagnosis in a U.S. Breast Screening Cohort," *Annals of Internal Medicine*, doi:10.7326/M21-3577.

Sabik, Lindsay M. and Cathy J. Bradley (2016). "The Impact of Near Universal Insurance Coverage on Breast and Cervical Cancer Screening: Evidence from Massachusetts," *Health Economics*, 25(4): 391-407.

Scherer, Laura D., K. D. Valentine, Niraj Patel, S. Glenn Baker, and Angela Fagerlin (2019). "A Bias for Action in Cancer Screening?" *Journal of Experimental Psychology: Applied*, 25(2): 149-161.

Schnell, Molly (2022). "Physician Behavior in the Presence of a Secondary Market: The Case of Prescription Opioids," Working Paper. Accessed at: https://static1.squarespace.com/static/572372e7c2ea51b309e9991a/t/62a361101fa2c47a22943335/1654874393320/Schnell_06102022.pdf (October 4, 2022).

Schwartz, Lisa M., Steven Woloshin, Floyd J. Fowler Jr., and H. Gilbert Welch (2004). "Enthusiasm for Cancer Screening in the United States," *Journal of the American Medical Association*, 291(1): 71-78. Doi:10.1001/jama.291.1.71.

Shurtz, Ity (2013). "The Impact of Medical Errors on Physician Behavior: Evidence from Malpractice Litigation," *Journal of Health Economics*,32(3): 331-340.

Siegel, Rebecca L., Kimberly D. Miller, Hannah E. Fuchs, and Ahmedin Jemal (2022). "Cancer Statistics, 2022," *CA: A Cancer Journal for Clinicians*, 72(1): 7-33.

Simon, Kosali, Aparna Soni, and John Cawley (2017). "The Impact of Health Insurance on Preventive Care and Health Behaviors: Evidence from the First Two Years of the ACA Medicaid Expansions," *Journal of Policy Analysis and Management*, 36(2): 390-417.

Singh, Manasvini (2021). "Heuristics in the Delivery Room," *Science*, 374 (6565): 324-329.

Solon, Gary, Steven J. Haider, and Jeffrey M. Wooldridge (2015). "What Are We Weighting For?" *Journal of Human Resources*, 50(2): 301-316.

Sprague, Brian L., Ronald E. Gangon, Veronica Burt, Amy Trentham-Dietz, John M. Hampton, Robert D. Wellman, Karla Kerlikowske, and Diana L. Miglioretti (2014). "Prevalence of Mammographically Dense Breasts in the United States," *Journal of the National Cancer Institute*, 106(10): dju255.

Stewart, Thomas R. and Jeryl L. Mumpower (2003). "Detection and Selection in the Practice of Screening Mammography," *Journal of Policy Analysis and Management*, 23(4): 908-920

United States Department of Health and Human Services (2021). "Healthy People 2030: Cancer," Accessed at https://health.gov/healthypeople/objectives-and-data/browse-objectives/cancer (November 4th, 2022).

United States Department of Health and Human Services (2014). "Healthy People 2020: Cancer," https://wayback.archiveit.org/5774/20220414131934/https://www.healthypeople.gov/2020/topics-objectives/topic/cancer/objectives (November 4th, 2022).

United States Department of Health and Human Services (2012). "Healthy People 2010 Final Review," Accessed at www.cdc.gov/nchs/data/hpdata2010/hp2010_final_review.pdf (November 4th, 2022).

United States Preventive Services Task Force (1989). "Guide to Clinical Preventive Services: An Assessments of the Effectiveness of 169 Interventions," Baltimore: Williams and Wilkins.

United States Preventive Services Task Force (2016). "Breast Cancer: Screening," Accessed at: https://www.uspreventiveservicestaskforce.org/uspstf/recommendation/breast-cancer-screening (October 27th, 2022).

United States Preventive Services Task Force (2022a). "About the USPSTF," Accessed at: https://www.uspreventiveservicestaskforce.org/uspstf/about-uspstf (August 16th, 2022).

United States Preventive Services Task Force (2022b). "Current Processes: Refining Evidence-Based Recommendation Development," Accessed at: https://www.uspreventiveservicestaskforce.org/uspstf/about-uspstf/methods-and-processes/current-processes-refining-evidence-based-recommendation-development (August 29th, 2022).

United States Preventive Services Task Force (2019). "Appendix I. Congressional Mandate Establishing the U.S. Preventive Services Task Force," Accessed at: https://uspreventiveservicestaskforce.org/uspstf/about-uspstf/methods-and-processes/procedure-manual/procedure-manual-appendix-i (March 18th, 2022).

United States Preventive Services Task Force (2016). "Breast Cancer: Screening," Accessed at: https://www.uspreventiveservicestaskforce.org/uspstf/recommendation/breast-cancer-screening (December 3rd, 2022).

United States Preventive Services Task Force (2009). "Breast Cancer: Screening," Accessed at: https://www.uspreventiveservicestaskforce.org/uspstf/recommendation/breast-cancer-screening-2009 (December 3rd, 2022).

United States Preventive Services Task Force (2002). "Breast Cancer: Screening, 2002," Accessed at: https://www.uspreventiveservicestaskforce.org/uspstf/recommendation/breast-cancer-screening-2002 (December 3rd, 2022).

United State Preventive Services Task Force (1996). "Breast Cancer: Screening, 1996," Accessed at: https://www.uspreventiveservicestaskforce.org/uspstf/recommendation/breast-cancer-screening-1996 (December 3rd, 2022).

Wang, Amy T., Jiaquan Fan, Holly K. Van Houten, Jon C. Tilburt, Natasha K. Stout, Victor M. Montori, and Nilay D. Shah (2014). "Impact of the 2009 US Preventive Services Task Force Guidelines on Screening Mammography Rates on Women in Their 40s," *PloS ONE*, 9(3): e91399.

Warnecke, Richard B., Seymour Sudman, Timothy P. Johnson, Diane O'Rourke, Andrew M. Davis, and Jared B. Jobe (1997). "Cognitive Aspects of Recalling and Reporting Health-Related Events: Papanicolaou Smears, Clinical Breast Examinations, and Mammograms," *American Journal of Epidemiology*, 146(11): 982-992.

Welch, H. Gilbert, Philip C. Prorok, A. James O'Malley, and Barnett S. Kramer (2016). "Breast-Cancer Tumor Size, Overdiagnosis, and Mammography Screening Effectiveness," *New England Journal of Medicine*, 375(15): 1439-1447.

Wernli, Karen J., Robert F. Arao, Rebecca A. Hubbard, Brian L. Sprague, Jennifer Alford-Teaster, Jennifer S. Haas, Louise Henderson, Deidre Hill, Christoph I. Lee, Anna N. Tosteson, and Tracy Onega (2017). "Change in Breast Cancer Screening Intervals since the 2009 USPSTF Guideline," *Journal of Women's Health*, 26(8): 820-827.

White House (2012). "Remarks by the President on Preventive Care on February 10th, 2012," Accessed at: https://obamawhitehouse.archives.gov/the-press-office/2012/02/10/remarks-president-preventive-care (March 24th, 2022).

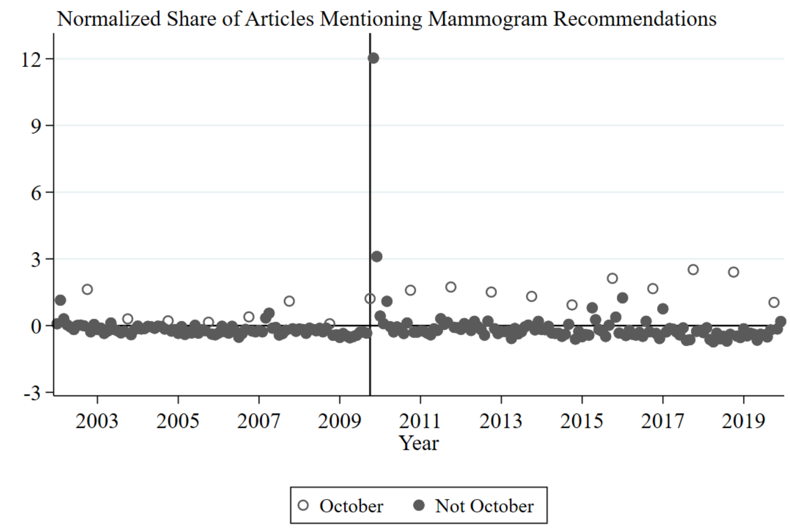
White House (2022). "Statement by President Joe Biden on the 12th Anniversary of the Affordable Care Act," Accessed at: https://www.whitehouse.gov/briefing-room/statements-releases/2022/03/23/statement-by-president-joe-biden-on-the-12th-anniversary-of-the-affordable-care-act/ (July 7th, 2022).

Woolf, Steven H. (1992). "United States Preventive Service Task Force Recommendations on Breast Cancer Screening," *Cancer*, 69(S7): 1913-1918.

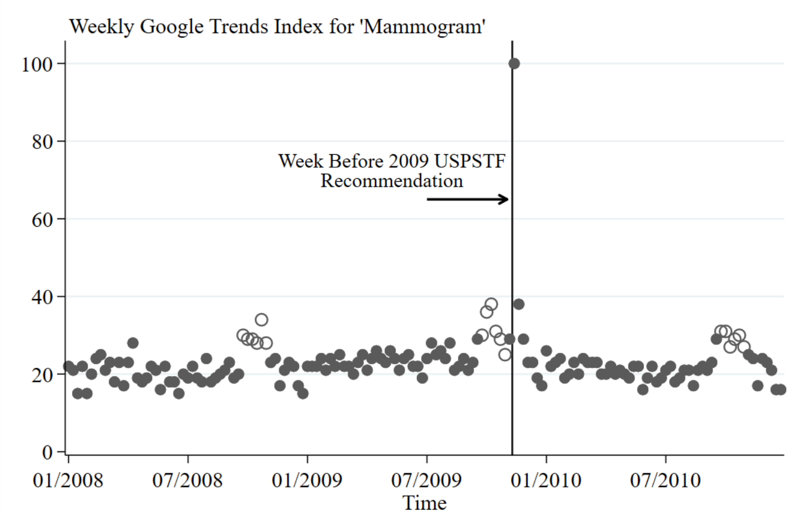
Worni, Mathias, Igor Akushevich, Rachel Greenup, Deba Sarma, Marc D. Ryser, Evan R. Myers, and E. Shelley Hwang (2015). "Trends in Treatment Patterns and Outcomes for Ductal Carcinoma In Situ," *Journal of the National Cancer Institute*, 107(12), doi: 10.1093/jnci/djv263.

Wu, Bingxiao and Guy David (2022). "Information, Relative Skill, and Technology Abandonment," *Journal of Health Economics*, 83: 102596. Doi: 10.1016/j.jhealeco.2022.102596.

Figure 1: Trends in Media Coverage and Internet Search Activity



(A)

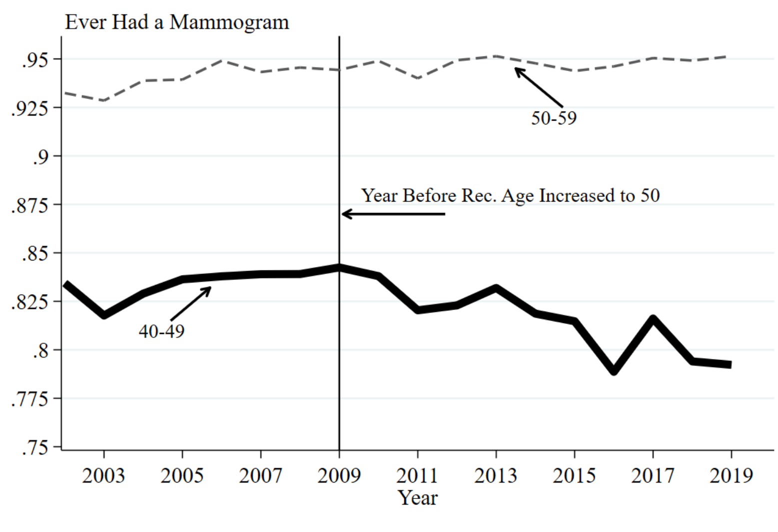


(B)

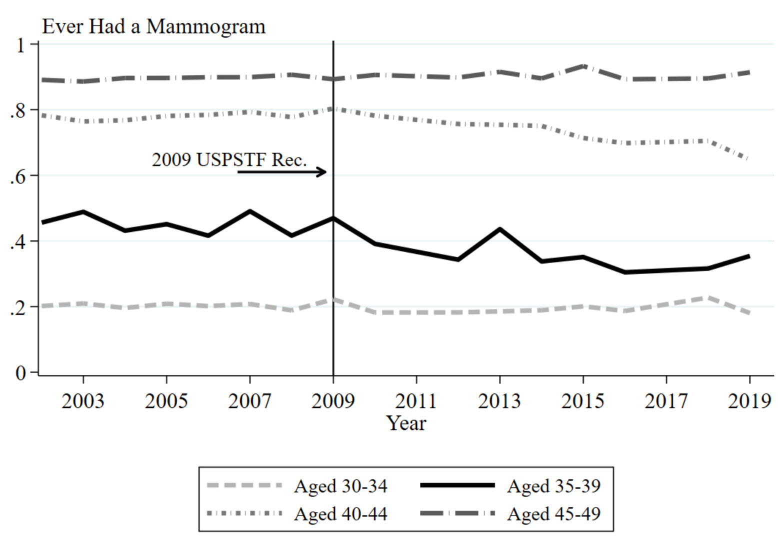
Source: ProQuest U.S. Newsstream 2002-2019; Google Trends 2008-2010

Note: Panel A plots the share of articles mentioning 'mammogram recommendation' or 'mammogram guideline.' For ease of interpretation, the share has been normalized to be mean 0 with a standard deviation of 1. The grey circles plot the value for every month and the open circles for the months of October (National Breast Cancer Awareness Month). Panel B plots the weekly Google Trends Index for the term 'mammogram' from January 1st, 2008, through December 31st, 2010. The grey circles plot the value for every non-October week and the open circles plot the values during the month of October. To construct the index, Google takes a random sample of all searches. From this sample, Google divides the number of searches for the word 'mammogram' by the total number of searches. The week when this value is maximized is set equal to 100, and the remaining values are determined by taking the ratio of the weekly search ratio to the maximum search ratio. The index does not contain information on the age of the individuals performing the searches.

Figure 2: Mammography Trends in the BRFSS Data



(A)

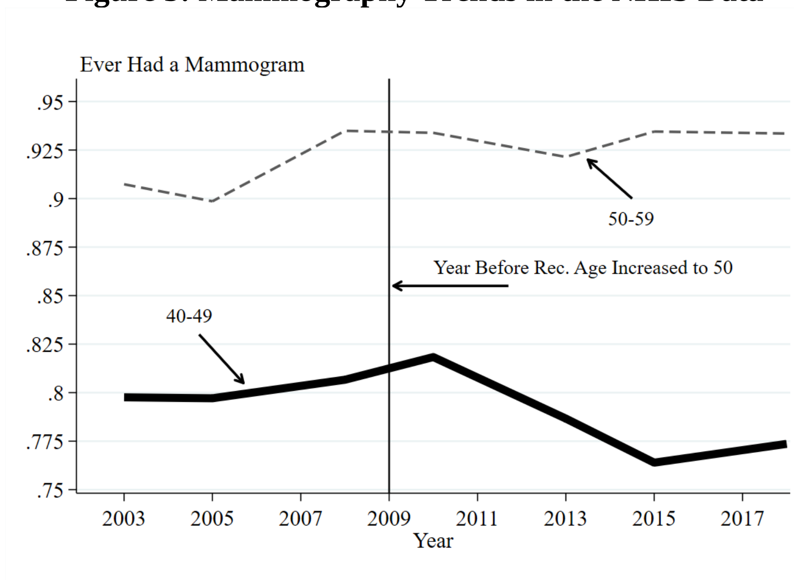


(B)

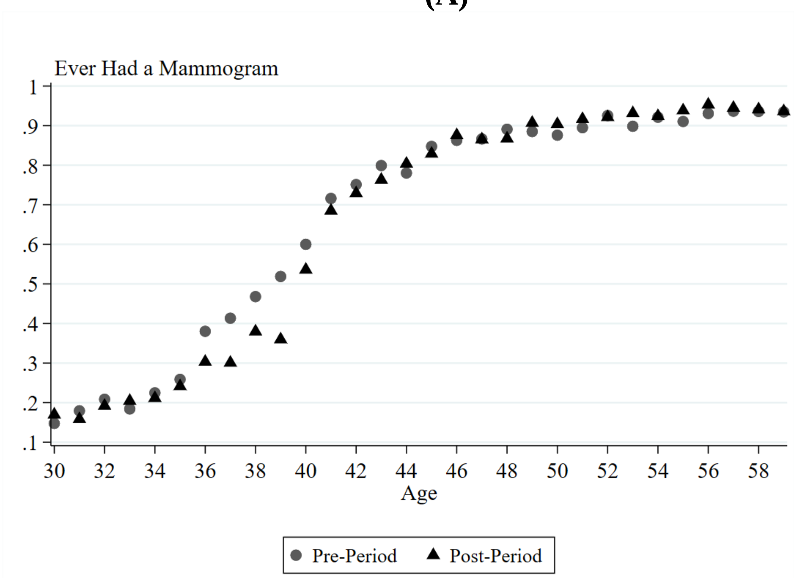
Source: Behavioral Risk Factor Surveillance System 2002-2019

Note: Panel A examines trends in mammography among women aged 40-49 (solid black line) and those aged 50-59 (dashed grey line). Panel B more granularly presents the trends for women aged 30-49. The descriptive statistics utilize the sample weights.

Figure 3: Mammography Trends in the NHIS Data



(A)

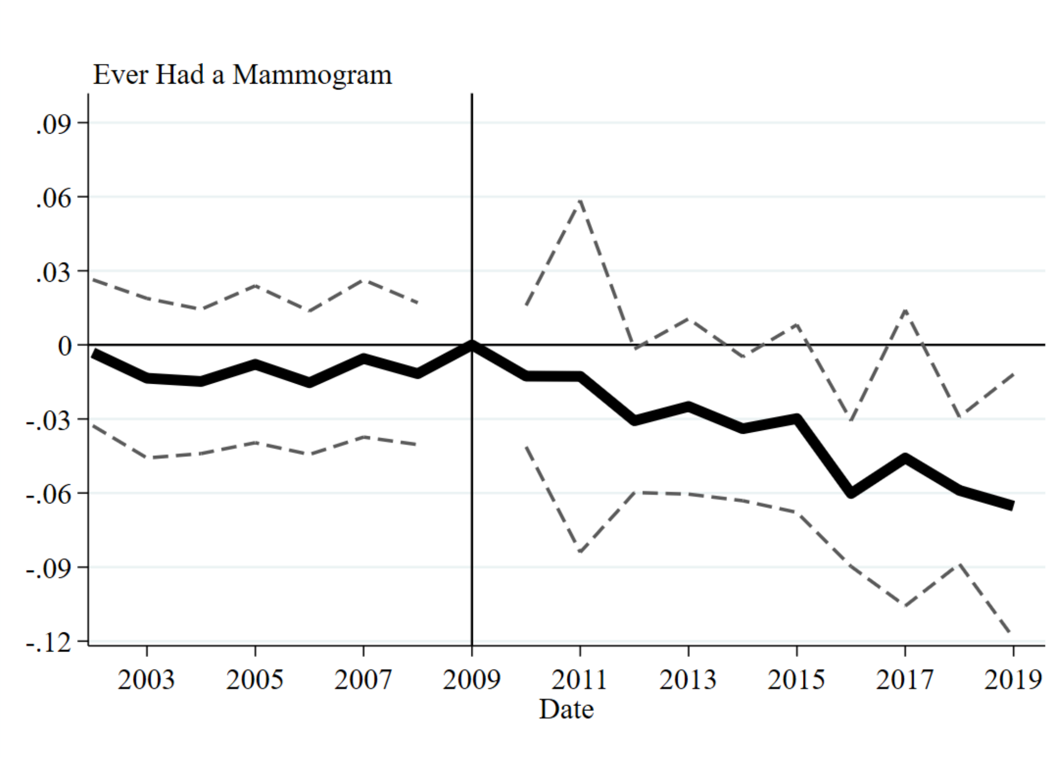


(B)

Source: National Health Interview Survey 2003-2018

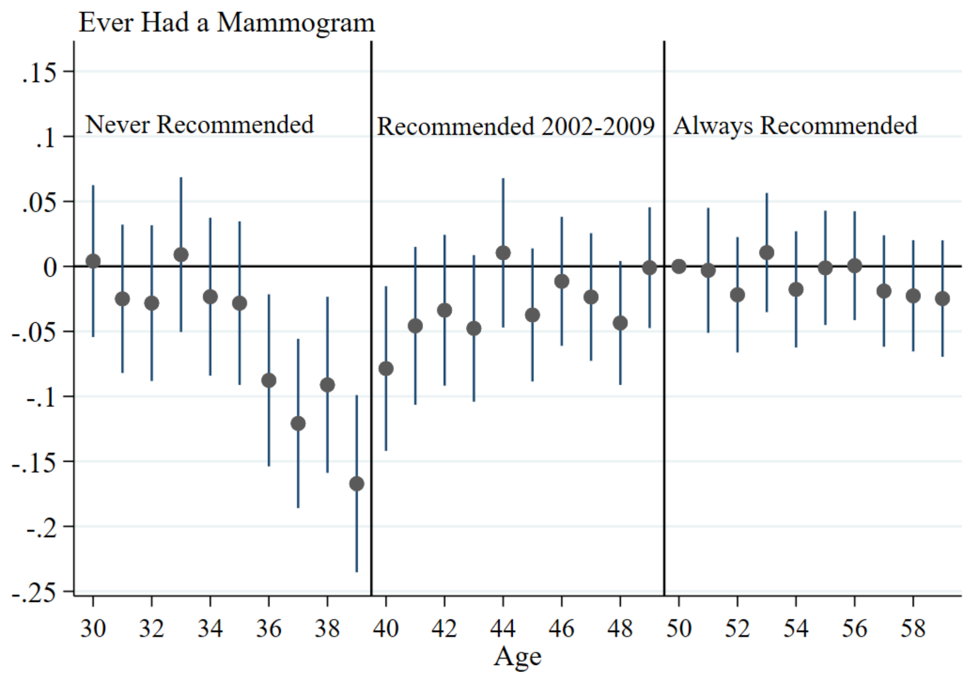
Note: In Panel A, the solid black line plots the share of women aged 40-49 who reported ever receiving a mammogram. The dashed grey line plots the share of women aged 50-59 who ever reported receiving a mammogram. Panel B plots the share of women of each individual age who reported ever receiving a mammogram at the time of survey. Pre-period observations (gray circles) are from the 2003, 2005, and 2008 survey waves; post-period observations (black triangles) are from the 2010, 2013, 2015, and 2018 survey waves. The descriptive statistics utilize the sample weights.

Figure 4: Event Study Estimates from the BRFSS Data



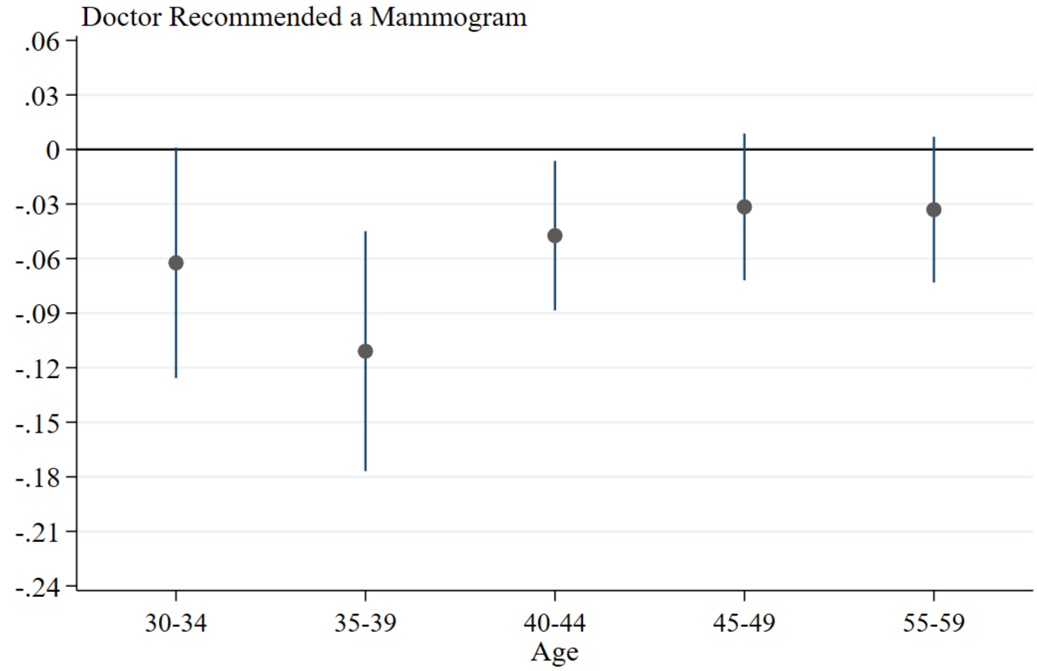
Source: Behavioral Risk Factor Surveillance System 2002-2019
Note: The solid black line plots event study coefficients from Table 2 column 1 Panel A, while the dashed grey lines plot the associated 95 percent confidence intervals. The dependent variable is an indicator for whether the woman reported ever receiving a mammogram. The estimates utilize the sample weights.

Figure 5: Evidence of Spillovers onto Younger Women



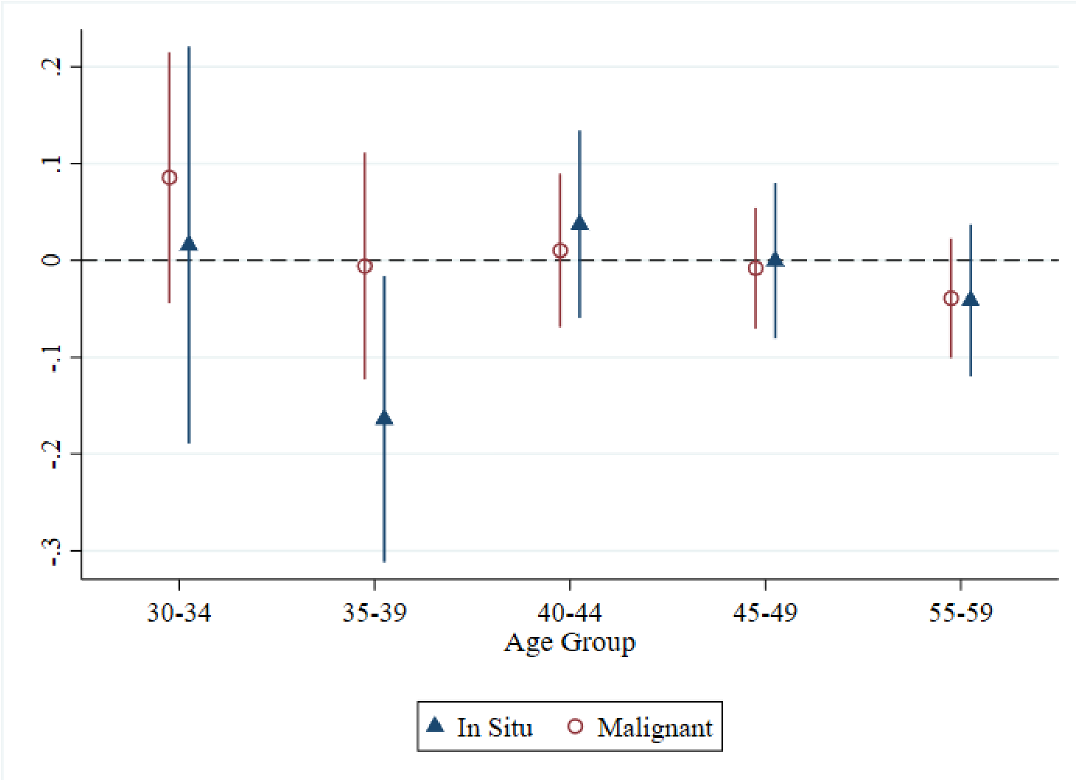
Source: National Health Interview Survey 2003-2018
Note: The grey circles plot the point estimates and the lines represent the corresponding 95 percent confidence intervals obtained from a modified version of equation (2). First, the sample is expanded to include adults aged 30-59. Next, rather than include an indicator for being in the treated group, each age variable is interacted with the post-period indicator (with age 50 omitted for reference). The estimates utilize the sample weights.

Figure 6: Effects on Mammogram Recommendations



Source: National Health Interview Survey 2003-2018
Note: The grey circles plot the point estimates and the lines the corresponding 95 percent confidence intervals obtained from a modified version of equation (2). First, the sample is expanded to include adults aged 30-59. Next, rather than include an indicator for being in the treated group, five age group indicators (30-34, 35-39, 40-44, 45-49, 55-59, with 50-54 omitted for reference) are interacted with the post-period indicator. More granular age-specific estimates are presented in Appendix Figure 12 Panel B. The estimates utilize the sample weights.

Figure 7: Effects on Breast Cancer Diagnoses



Source: National Cancer Institute's Surveillance, Epidemiology, and End Results Program 2002-2019
Note: The solid triangles and hollow circles plot the point estimates and the lines the corresponding 95 percent confidence intervals obtained from a modified version of equation (2), for the outcome variables ln(in situ cases +1) and ln(malignant cases +1), respectively. First, the sample is expanded to include adults aged 30-59. Next, rather than include an indicator for being in the treated group, five age group indicators (30-34, 35-39, 40-44, 45-49, 55-59, with 50-54 omitted for reference) are interacted with the post-period indicator. Each regression includes fixed effects for state, diagnosis year, five-year age group, and race, as well as time-varying controls (see text for details). Regressions are weighted by population, and heteroskedastic robust standard errors are reported.

Table 1: USPSTF Recommendations Over Time

	(1)	(2)	(3)	(4)
Age →	40-49	50-69	70-74	75 +
1996				
Rating	C	A	C	
Frequency		Every 1-2 Years		
2002				
Rating	B	B	B	B
Frequency	Every 1-2 Years	Every 1-2 Years	Every 1-2 Years	Every 1-2 Years
2009				
Rating	C	B	B	I
Frequency		Biennial Screening	Biennial Screening	
2016				
Rating	C	B	B	I
Frequency		Biennial Screening	Biennial Screening	

Source: USPSTF Recommendations in 1996, 2002, 2009, and 2016

Note: Grade A indicates 'strongly recommend,' grade B indicates 'recommend,' grade C indicates 'no recommendation,' grade D indicates 'not recommended,' and grade I indicates 'insufficient evidence to make a recommendation.' The 1996 USPSTF guidelines did not explicitly mention a recommendation for women aged 75 or older. The 2009 guidelines gave a C rating to routine screening for all women under the age of 50. The 2009 and 2016 recommendations did not explicitly mention women under the age of 40.

Table 2: Event Study and Difference-in-Differences Results

	(1)		(2)		(3)	
Panel A: Event Study						
Pre-Period						
2002	-0.003	(0.015)	-0.002	(0.015)	-0.000	(0.015)
2003	-0.014	(0.016)	-0.013	(0.016)	-0.012	(0.016)
2004	-0.015	(0.015)	-0.010	(0.015)	-0.009	(0.015)
2005	-0.008	(0.016)	-0.006	(0.016)	-0.005	(0.016)
2006	-0.015	(0.015)	-0.013	(0.015)	-0.014	(0.015)
2007	-0.006	(0.016)	-0.007	(0.016)	-0.007	(0.016)
2008	-0.012	(0.015)	-0.012	(0.015)	-0.011	(0.015)
Post-Period						
2010	-0.013	(0.015)	-0.012	(0.015)	-0.012	(0.015)
2011	-0.013	(0.036)	-0.007	(0.037)	-0.005	(0.034)
2012	-0.031**	(0.015)	-0.028*	(0.015)	-0.027*	(0.015)
2013	-0.025	(0.018)	-0.020	(0.018)	-0.020	(0.018)
2014	-0.034**	(0.015)	-0.030**	(0.015)	-0.030**	(0.015)
2015	-0.030	(0.019)	-0.027	(0.019)	-0.026	(0.019)
2016	-0.060***	(0.015)	-0.024*	(0.015)	-0.022*	(0.015)
2017	-0.046	(0.031)	-0.015	(0.030)	-0.012	(0.030)
2018	-0.059***	(0.015)	-0.022	(0.015)	-0.021	(0.015)
2019	-0.065***	(0.027)	-0.026	(0.026)	-0.035	(0.025)
p-value for Pre = 0	0.624		0.745		0.640	
p-value for Post = 0	0.000		0.105		0.084	
p-value for Pre = Post	0.000		0.002		0.001	
Avg. Post – Avg. Pre	-0.029***		-0.013***		-0.014***	
Panel B: Static DD						
$\mathbf{1}\{40 \leq \text{Age} \leq 49\} \times$	-0.027***		-0.015***		-0.014***	
$\mathbf{1}\{\text{2009 USPSTF}\}$	(0.002)		(0.003)		(0.003)	
	[0.000]		[0.000]		[0.000]	
Treated Mean in 2008	0.839		0.839		0.839	
Observations	780,659		780,659		780,659	
Age and Time FE?	Y		Y		Y	
Demographics ?			Y		Y	
State-Year-Month FE?					Y	

Source: Behavioral Risk Factor Surveillance System 2002-2019

Note: The dependent variable is an indicator for whether the woman reported ever receiving a mammogram. Panel A reports the event study estimates from equation (1) and Panel B the static difference-in-differences estimates from equation (2). The sample is women aged 40-59. Column 1 uses a sparse specification controlling for only age and year-month fixed effects. Column 2 augments this specification with individual demographic characteristics, including indicators for race/ethnicity, educational attainment, marital status, health insurance coverage, and whether the women was recommended by the American Cancer Society to undergo a mammogram screening. Column 3 then adds on state-year-month fixed effects. The estimates utilize the sample weights. Heteroskedastic robust standard errors are shown in parentheses. In Panel B, wild bootstrapped p-values from clustering standard errors at the treatment group-time level are shown in brackets.

*** p < 0.01, ** p < 0.05, * p < 0.10

Table 3: Alternative Samples and Specifications

	(1)	(2)	(3)	(4)	(5)	(6)
Specification →	Baseline	(1) but No Sample Weights	(1) but before 2015 ACS Rec. Change	(1) but Include Older Adults as Controls	(1) but Include Younger Treated Adults	(1) but Include All Women Aged 30-85+
Panel A: BRFSS						
$\mathbf{1}\{40 \leq \text{Age} \leq 49\} \times$ $\mathbf{1}\{\text{2009 USPSTF Rec.}\}$	-0.014***	-0.018***	-0.014***	-0.023***	-0.018***	-0.029***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.002)
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
R^2	0.109	0.100	0.101	0.096	0.491	0.539
Treated Mean in 2008	0.839	0.846	0.846	0.839	0.525	0.525
Observations	780,659	780,659	637,311	1,717,733	1,248,216	2,185,280
Panel B: NHIS						
$\mathbf{1}\{40 \leq \text{Age} \leq 49\} \times$ $\mathbf{1}\{\text{2009 USPSTF Rec.}\}$	-0.020**	-0.022***	-0.018**	-0.031***	-0.026***	-0.035***
	(0.008)	(0.007)	(0.009)	(0.008)	(0.008)	(0.007)
	[0.004]	[0.000]	[0.026]	[0.000]	[0.000]	[0.000]
R^2	0.142	0.139	0.137	0.123	0.404	0.410
Treated Mean in 2008	0.807	0.796	0.807	0.807	0.548	0.569
Observations	35,892	35,892	35,892	69,241	54,922	88,271

Source: Behavioral Risk Factor Surveillance System 2002-2019; National Health Interview Survey 2003-2018

Note: The dependent variable is an indicator for whether the woman reported that she ever received a mammogram. Panel A uses the BRFSS data and Panel B the NHIS data. The baseline sample is women aged 40-59. Column 1 reprints the baseline estimate from Table 2 column 3. Column 2 estimates the baseline specification but does not utilize the sample weights. Column 3 restricts the sample to the periods prior to the American Cancer Society's decision to raise its recommended mammography age from 40 to 45-years-old. Column 4 estimates the baseline specification but expands the sample to include adults aged 40-85+, while column 5 expands the sample to include women aged 30-59. Finally, column 6 estimates the baseline specification but expands the sample to include all women aged 30-85+. Except for column 2, the estimates utilize the sample weights. Heteroskedastic robust standard errors are shown in parentheses. Wild bootstrapped p-values from clustering standard errors at the treatment group-time level are shown in brackets.

*** p < 0.01, ** p < 0.05, * p < 0.10

Table 4: Heterogeneity by Age at Time of the Recommendation, Health Insurance Status, Race/Ethnicity, and Educational Attainment

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sample →	Women Aged 40-49 Who Turned 40 After the Rec. Change and Women Aged 50-59	Women Aged 40-49 Who Turned 40 Before the Rec. Change and Women Aged 50-59	Women with Health Insurance Coverage	Women without Health Insurance Coverage	White Women	Non-White Women	Women with at Most a High School Degree	Women with More than a High School Degree
1{40 ≤ Age ≤ 49}× **1**{2009 USPSTF}	-0.039***	-0.003	-0.020***	-0.026	-0.029***	-0.009	-0.021	-0.020**
	(0.008)	(0.009)	(0.008)	(0.031)	(0.010)	(0.016)	(0.016)	(0.010)
	[0.001]	0.700	[0.006]	[0.352]	[0.000]	[0.560]	[0.120]	[0.027]
R^2	0.151	0.121	0.111	0.171	0.133	0.177	0.161	0.136
Treated Mean in 2008	0.807	0.449	0.844	0.627	0.838	0.747	0.756	0.841
Observations	30,804	31,132	30,442	5,450	22,465	13,427	13,749	22,143

Source: National Health Interview Survey 2003-2018

Note: The dependent variable an indicator for whether the woman reported ever receiving a mammogram. The sample is women aged 40-59. Column 1 limits the sample to women aged 40-49 who turned 40 after the recommendation and to the 50-59-year-old comparison women. Column 2 limits the sample to women aged 40-49 who turned 40 prior to the 2009 recommendation change and to the 50-59-year-old comparison women. Column 3 limits the sample to those with health insurance coverage and column 4 to those without health insurance coverage. Column 5 restricts the sample to white women, column 6 to non-white women, column 7 to women with at most a high school degree, and column 8 to women with more than a high school degree. Because all the women in column 2 turned 40 after 2008, the sample mean is for 39-year-old women. Heteroskedastic robust standard errors are shown in parentheses. Wild bootstrapped p-values from clustering standard errors at the treatment group-time level are shown in brackets. The estimates utilize the sample weights.

*** p < 0.01, ** p < 0.05, * p < 0.10

Table 5: Characterizing the Compliers

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sample →	Flu Shot During Prior 12 Months	No Flu Shot During Prior 12 Months	BMI < 25	BMI ≥ 25	Non-Smoker	Smoker	Health ≥ 'Very Good'	Health < 'Very Good'
1{40 ≤ Age ≤ 49}× **1**{2009 USPSTF Rec.}	0.007	-0.037***	0.000	-0.030***	-0.016*	-0.029**	-0.012	-0.033**
	(0.013)	(0.013)	(0.013)	(0.011)	(0.011)	(0.014)	(0.011)	(0.014)
	[0.546]	[0.002]	[0.977]	[0.002]	[0.089]	[0.041]	[0.167]	[0.015]
R^2	0.153	0.151	0.163	0.153	0.155	0.155	0.154	0.159
Treated Mean in 2008	0.881	0.779	0.823	0.794	0.808	0.810	0.827	0.779
Observations	10,772	19,253	12,966	21,166	21,599	14,225	19,926	15,937

Source: National Health Interview Survey 2003-2018

Note: The dependent variable is an indicator for whether the woman reported ever receiving a mammogram. The sample is women aged 40-59. In column 1, the sample is restricted to women who reported receiving a flu vaccine during the prior 12 months, while column 2 limits the sample to those who did not report receiving a flu vaccine. Column 3 limits the sample to women who were not classified as overweight or obese (BMI < 25) and column 4 to those women classified as overweight or obese (BMI ≥ 25). Column 5 limits the sample to women who did not report smoking at least 100 cigarettes during their lifetime and column 6 to women with a history of smoking cigarettes. Column 7 limits the sample to women who reported being in at least very good health (very good, or excellent) and column 8 to women who reported being in less than very good health (good, fair, or poor). The estimates include the full set of controls from equation (2). Heteroskedastic robust standard errors are shown in parentheses. Wild bootstrapped p-values from clustering standard errors at the treatment group-time level are shown in brackets. The estimates utilize the sample weights.

*** p < 0.01, ** p < 0.05, * p < 0.10

Table 6: Additional Outcomes and Potential Mechanisms

	(1)	(2)	(3)	(4)	(5)
	Mammogram in Past			Health Care Visit in Past Year	Doctor Recommended Mammogram in Past Year
Outcome →	One Year	Three Years	Five Years		
1{40 ≤ Age ≤ 49}× **1**{2009 USPSTF Rec.}	0.006	-0.011	-0.020**	-0.012**	-0.022*
	(0.013)	(0.011)	(0.010)	(0.005)	(0.015)
	[0.655]	[0.363]	[0.019]	[0.017]	[0.052]
R^2	0.094	0.138	0.137	0.097	0.085
Treated Mean in 2008	0.494	0.694	0.778	0.887	0.652
Observations	34,900	34,900	34,900	91,465	25,878

Source: National Health Interview Survey 2003-2018

Note: The dependent variable in column 1 is an indicator for whether the woman reported receiving a mammogram during the prior year, column 2 during the prior three years, and column 3 during the prior five years. The dependent variable in column 4 is an indicator for whether the respondent had a recent health care visit, and in column 5 for whether a physician recommended a mammogram during the prior year. The sample is women aged 40-59. The estimates include the full set of controls from equation (2). Because the outcomes in columns 1, 4, and 5 have a 1-year look back window, the recommendation indicator turns on one year after the formal recommendation (December 2010 instead of December 2009). The recommendation indicator turns on three years after the recommendation in column 2 and five years after the recommendation in column 3. Heteroskedastic robust standard errors are shown in parentheses. Wild bootstrapped p-values from clustering standard errors at the treatment group-time level are shown in brackets. The estimates utilize the sample weights.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Table 7: Trust, Complexity, and Involvement with the Health Care Process

	(1)	(2)	(3)	(4)	(5)
Outcome →	Ever Had Mammogram	Doctor always involved you in care decisions as much as you wanted	Hard to know which recommendations to follow for preventing cancer	Highly trust health information from a doctor	Highly trust health information from government health agency
1{40 ≤ Age ≤ 49}×	-0.049*	-0.045	0.069**	0.028	-0.020
1{2009 USPSTF Rec.}	(0.021)	(0.036)	(0.034)	(0.037)	(0.049)
	[0.063]	[0.141]	[0.045]	[0.670]	[0.670]
R^2	0.141	0.028	0.033	0.032	0.058
Mean	0.879	0.559	0.269	0.692	0.297
Observations	7,645	6,269	8,210	6,001	4,654

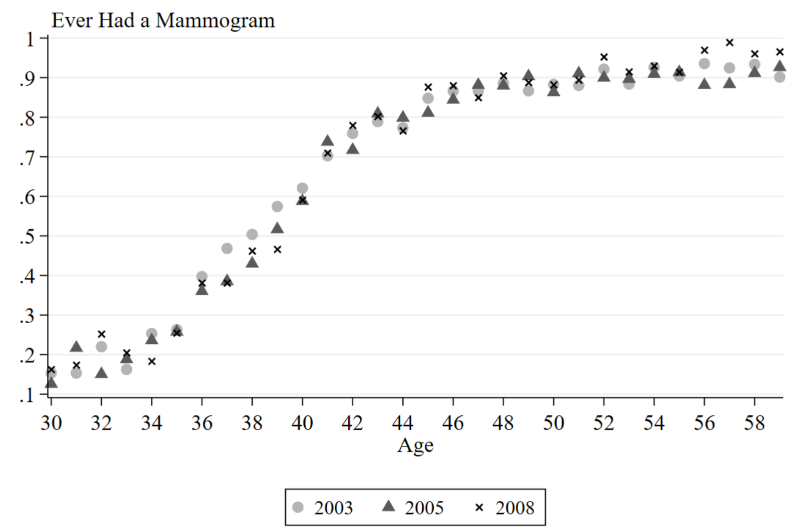
Source: Health Information National Trends Survey 2003-2019.

Note: The sample is women aged 40-59. All columns include age and year fixed effects, as well as demographic controls (marital status, race/ethnicity, health insurance status, and educational attainment) and controls for changes to the ACS mammogram recommendation and the ACA preventive services provision. The dependent variable in column 1 is an indicator for whether the woman reported ever receiving a mammogram. The dependent variable in column 2 is an indicator for whether the woman reported that during the past 12 months her health care professionals always involved her as much as she wanted in her health care decisions and in column 3 an indicator for whether the woman strongly agreed that there were so many recommendations for preventing cancer that it was difficult to know which ones to follow. The dependent variable in column 4 is an indicator for whether the woman reported high trust about health or medical topics from doctors and medical professionals and in column 5 an indicator for whether the woman reported high trust about these topics from government health agencies. Heteroskedastic robust standard errors are shown in parentheses, p-values from wild cluster bootstrap procedure are reported in brackets. The estimates utilize the survey weights.

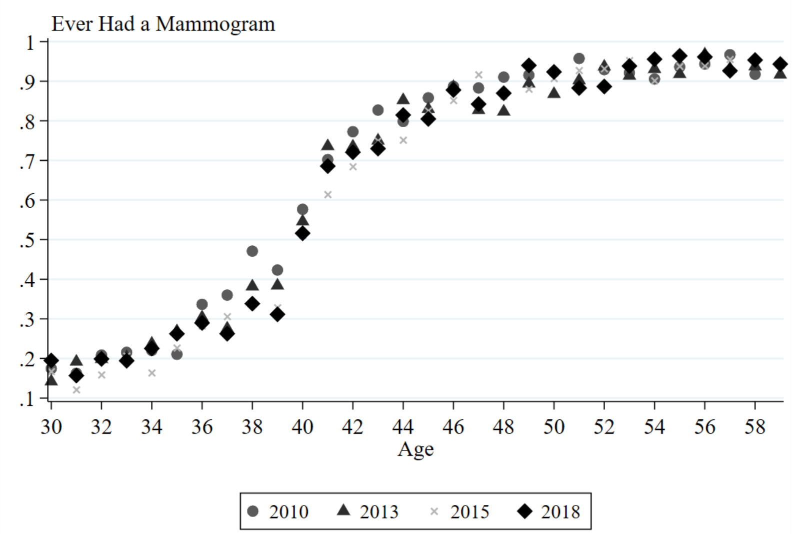
*** p < 0.01, ** p < 0.05, * p < 0.10

8. Appendix

Appendix Figure 1: Mammography by Individual Age Over Time



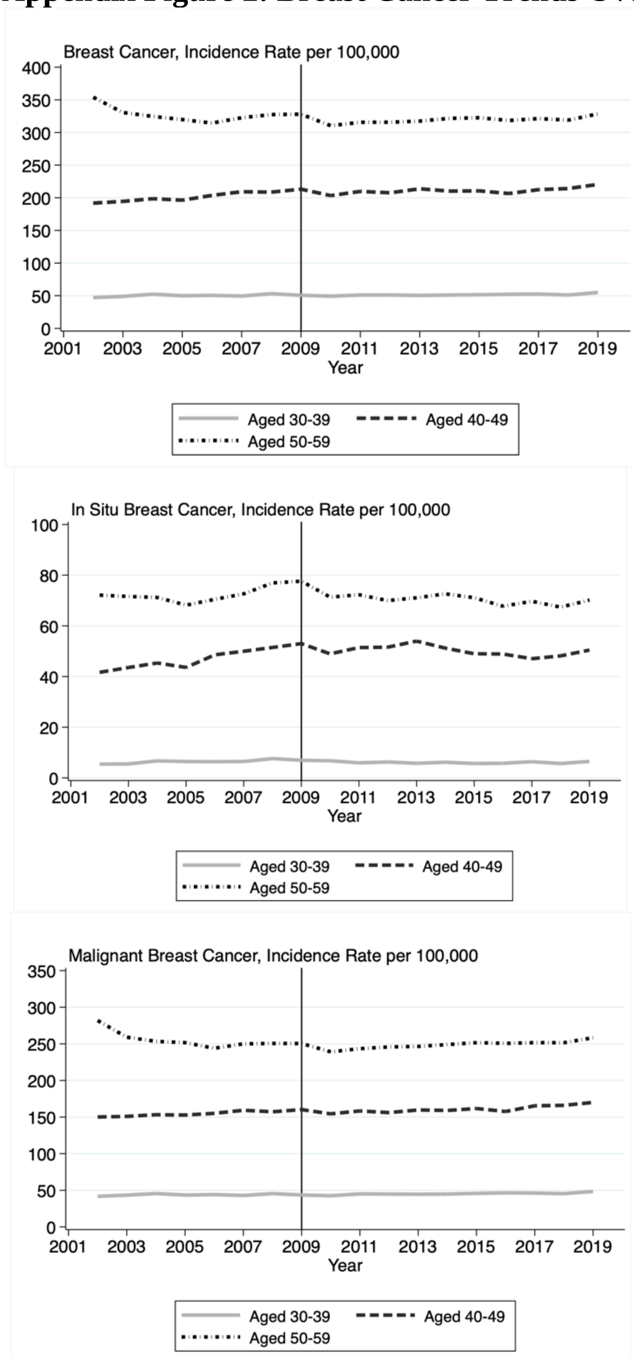
(A)



(B)

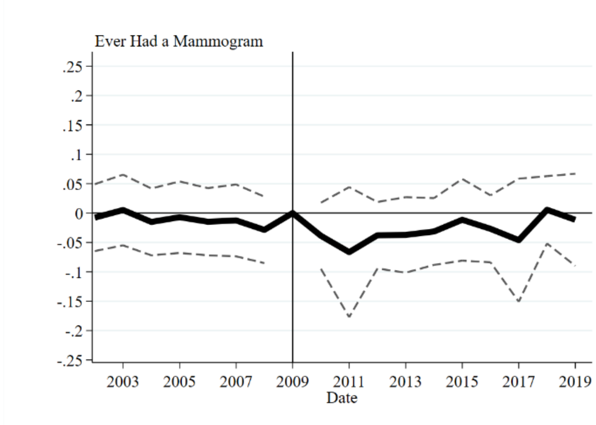
Source: National Health Interview Survey 2003-2018
Note: Panel A plots the share of women of each individual age who reported ever receiving a mammogram at the time of survey in sample waves conducted prior to the 2009 USPSTF guidelines (2003, 2005, 2008). Panel B plots the shares during the post-period (2010, 2013, 2015, 2018). The descriptive statistics utilize the survey weights.

Appendix Figure 2: Breast Cancer Trends Over Time

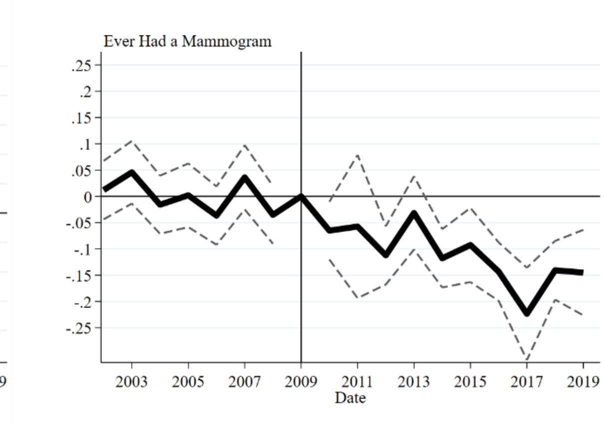


Source: National Cancer Institute's Surveillance, Epidemiology, and End Results Program 2002-2019
Note: Each panel plots trends in the number of diagnosed breast cancers per 100,000 women by 10-year age group. The solid black vertical line indicates the year of the USPSTF mammogram guidelines revision.

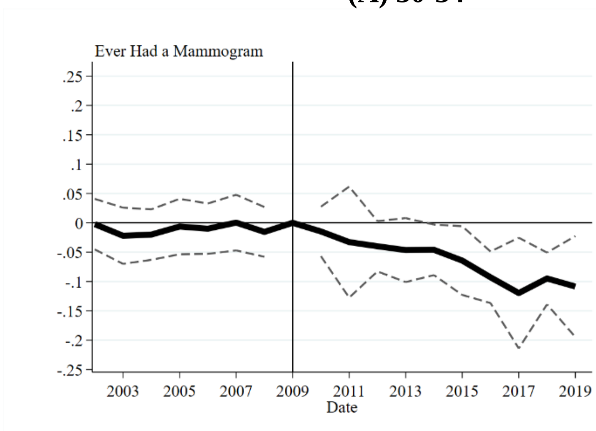
Appendix Figure 3: Event Study Estimates for Any Mammography



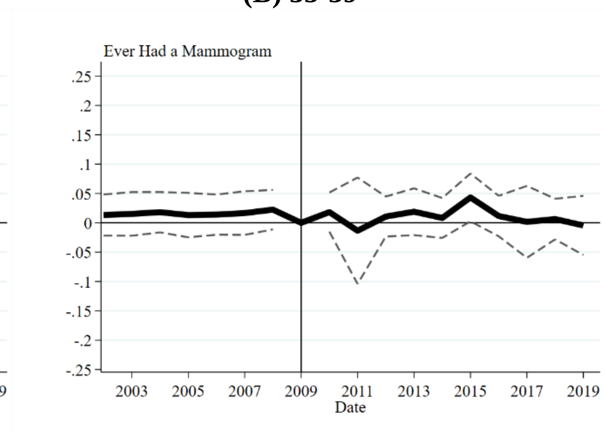
(A) 30-34



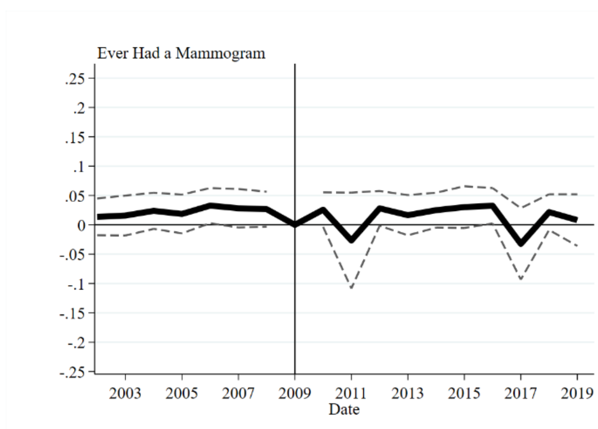
(B) 35-39



(C) 40-44



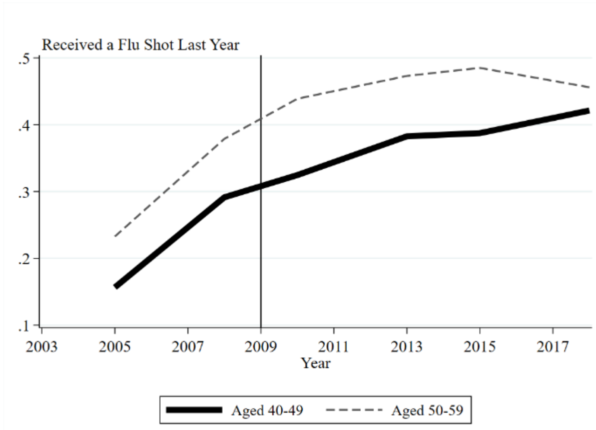
(D) 45-49



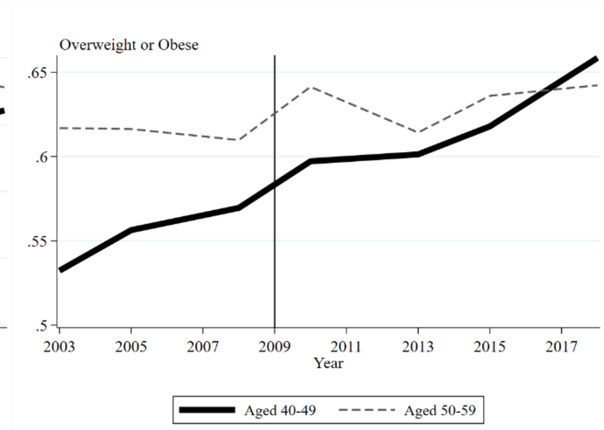
(E) 55-59

Source: Behavioral Risk Factor Surveillance System 2002-2019
Note: The figures plot the event study estimates comparing changes in the likelihood that women of the indicated age ever had a mammogram to the associated changes for women aged 50-54. The estimates utilize the sample weights.

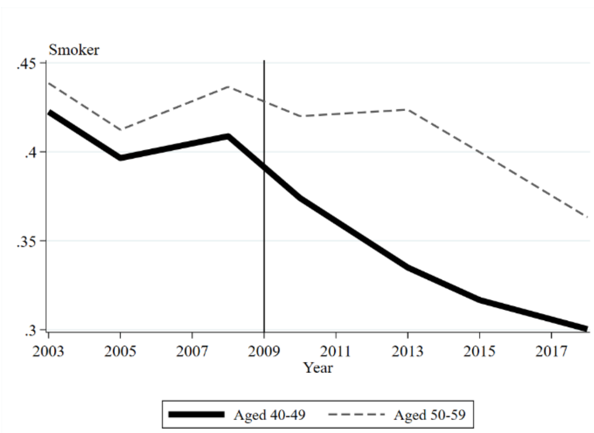
Appendix Figure 4: Trends in Complier Characteristics



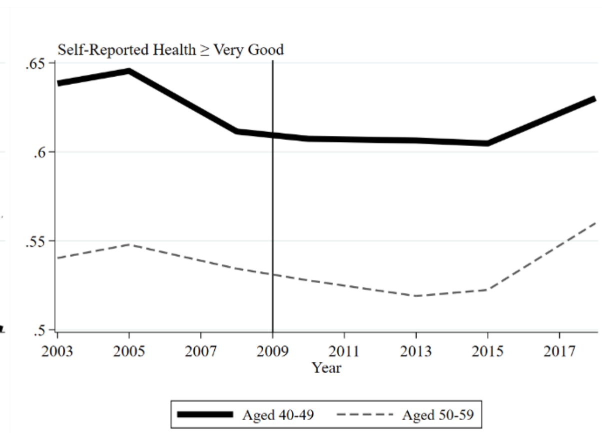
(A)



(B)



(C)

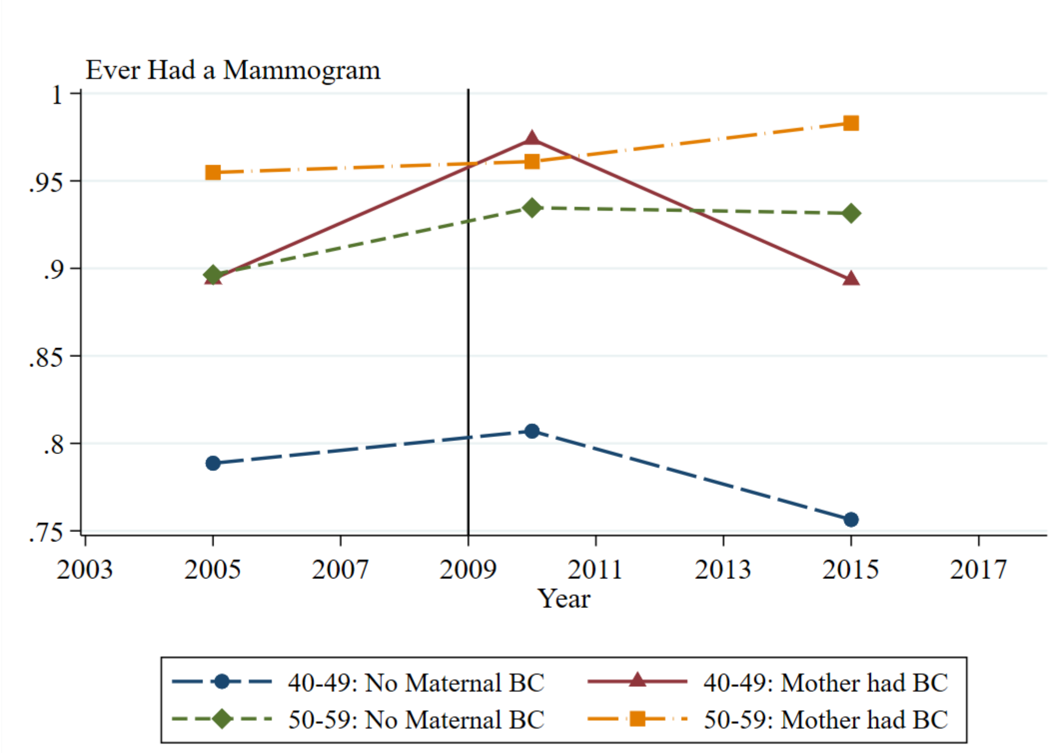


(D)

Source: National Health Interview Survey 2003-2018

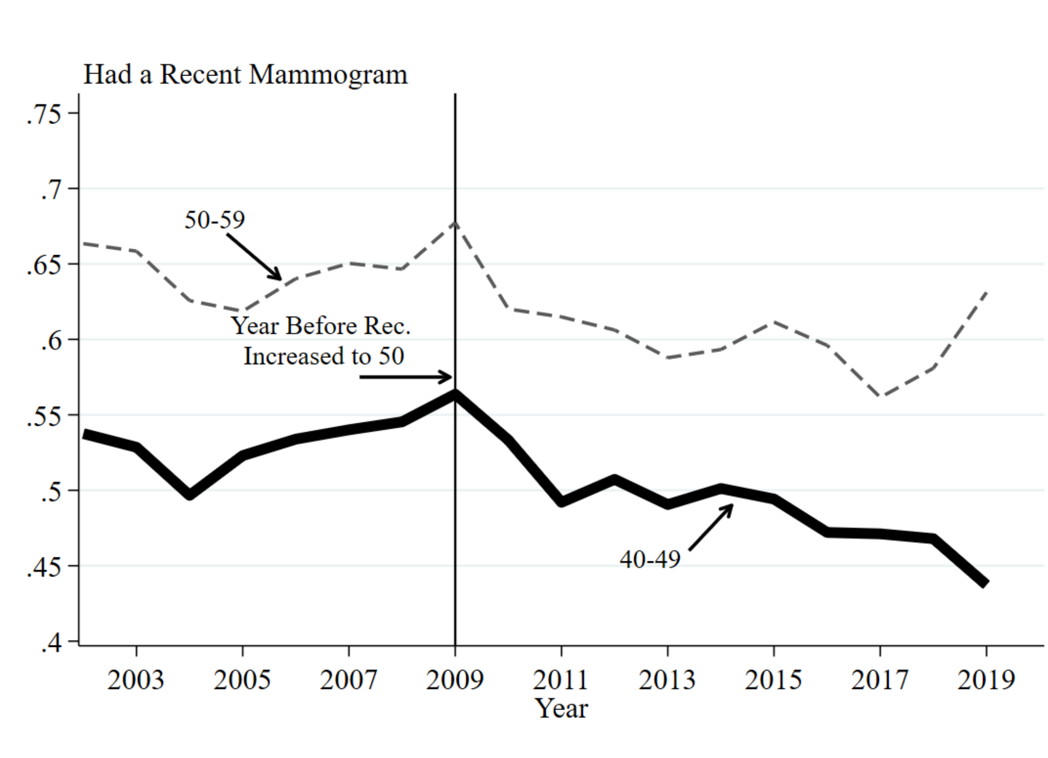
Note: The figures plot the share of women aged 40-49 (solid black line) and the share of women aged 50-59 (dashed grey line) who have various characteristics. Panel A explores the share of women who reported receiving a flu shot during the prior year, Panel B the share who were classified as overweight or obese, Panel C the share who had smoked 100 cigarettes during their lifetime, and Panel D the share who reported being in very good or excellent health. The summary statistics utilize the sample weights.

Appendix Figure 5: Mammography Trends by Maternal Breast Cancer History



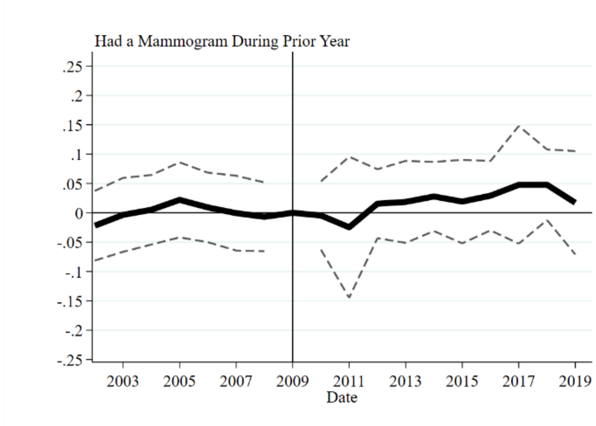
Source: National Health Interview Survey 2003-2018
Note: The figure plots the share of women of each individual age who reported ever receiving a mammogram at the time of survey by age group and maternal breast cancer history. The descriptive statistics utilize the sample weights.

Appendix Figure 6: Trends in Past Year Mammography

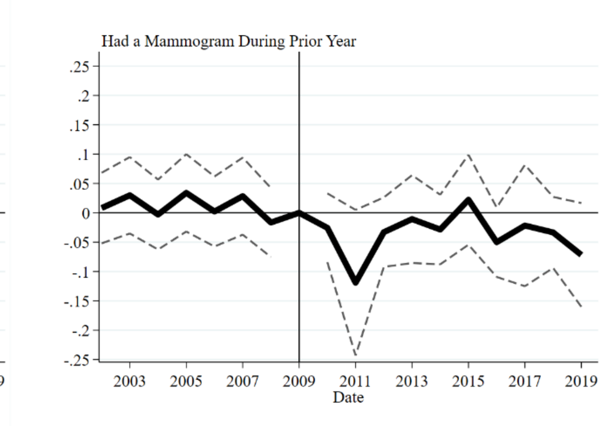


Source: Behavioral Risk Factor Surveillance System 2002-2019
Note: The figure plots the share of women reporting that they had received a mammogram during the prior year in the BRFSS data. The solid black line plots the share for women aged 40-49 and the light dashed line the share for women aged 50-59. The descriptive statistics utilize the sample weights.

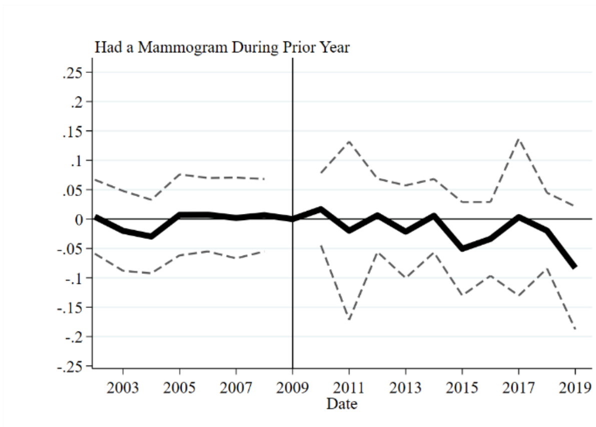
Appendix Figure 7: Event Study Estimates for Past Year Mammography



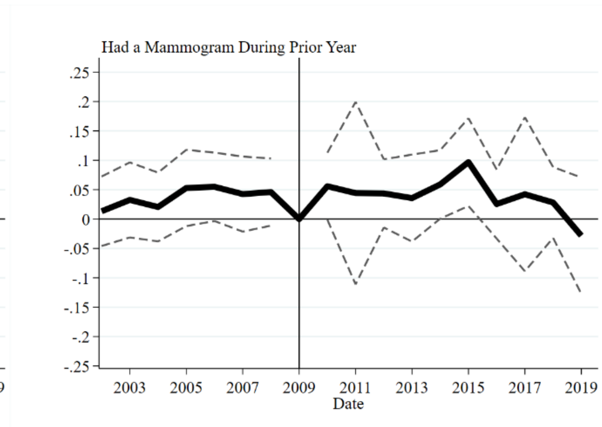
(A) 30-34



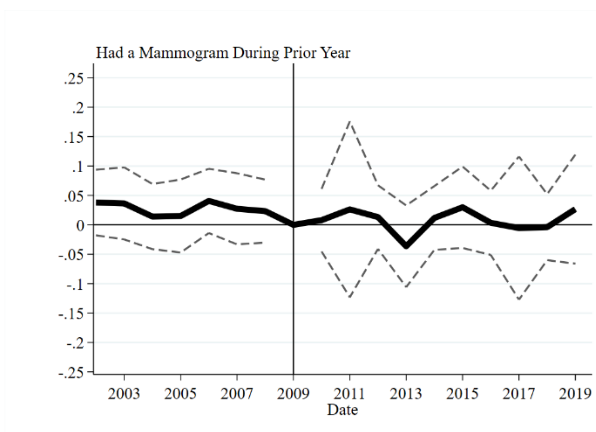
(B) 35-39



(C) 40-44



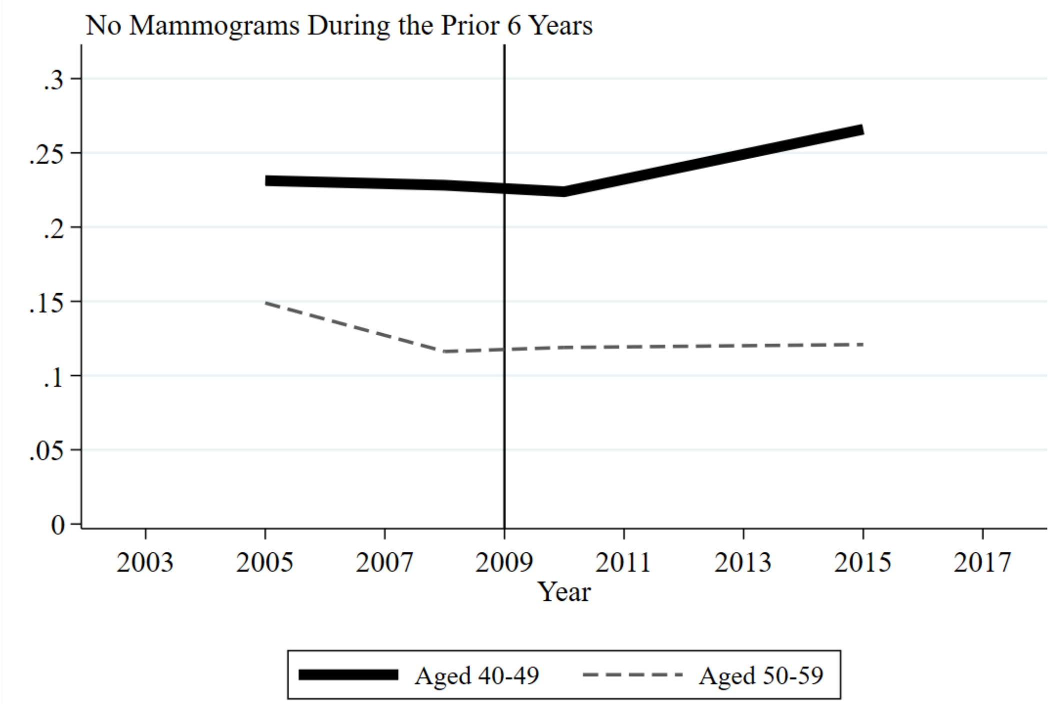
(D) 45-49



(E) 55-59

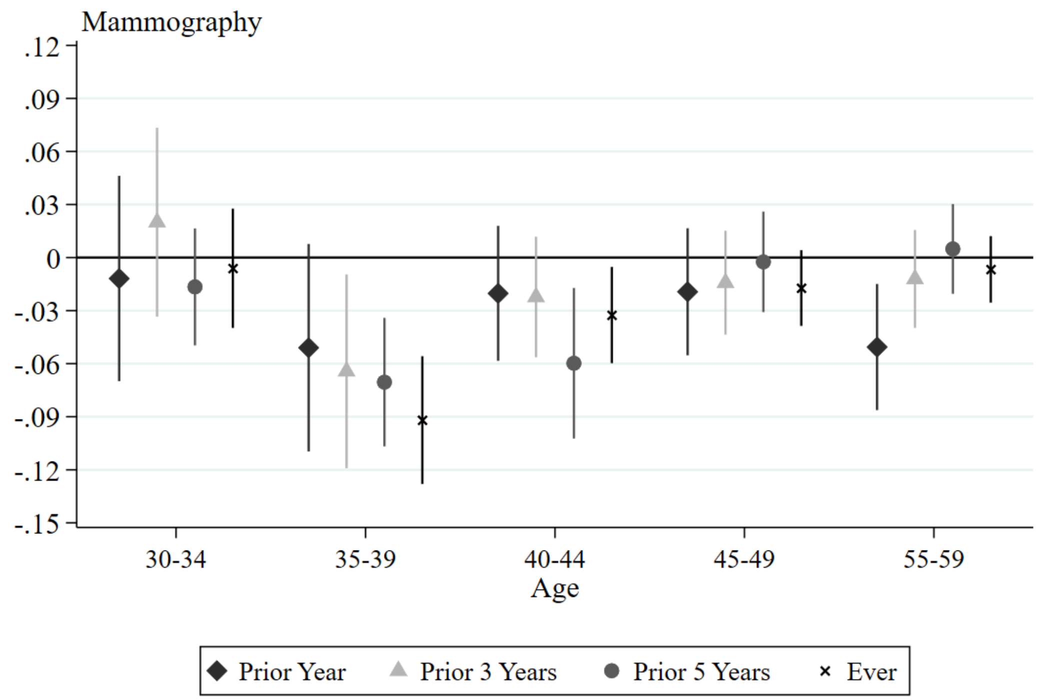
Source: Behavioral Risk Factor Surveillance System 2002-2019
Note: The figures plot the event study estimates comparing changes in the likelihood that women of the indicated age had a mammogram during the prior year to the associated change for women aged 50-54. The estimates utilize the sample weights.

Appendix Figure 8: Trends in Share of Women Reporting No Mammograms During the Prior Six Years



Source: National Health Interview Surveys 2005-2015
Note: The solid black line plots the share of women aged 40-49 who reported that they had received 0 mammograms during the prior six years. The dashed grey line plots the share for women aged 50-59. The estimates utilize the sample weights.

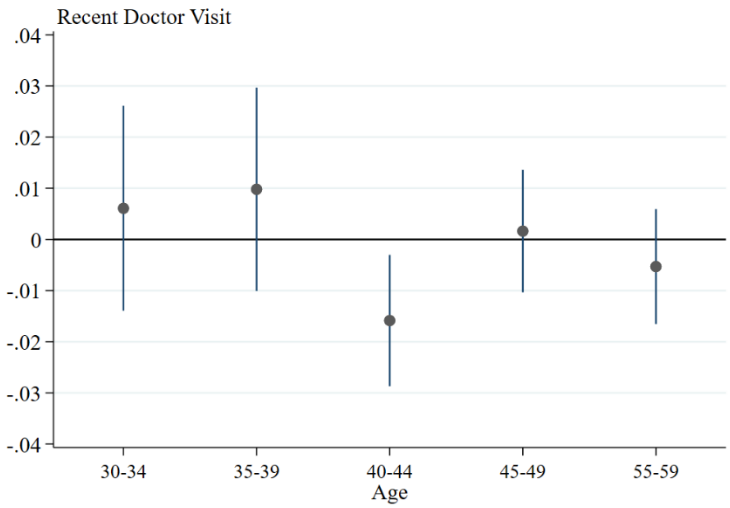
Appendix Figure 9: Effects on Mammogram Receipt



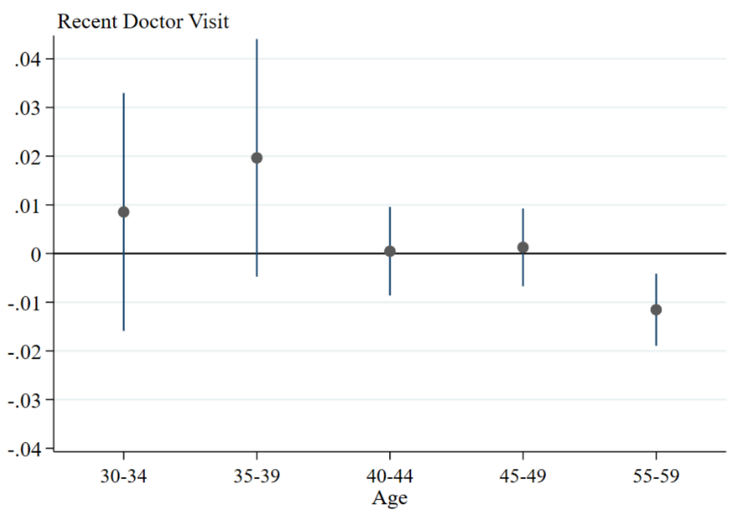
Source: National Health Interview Survey 2003-2018

Note: The markers plot the point estimates and the lines represent the corresponding 95 percent confidence intervals obtained from a modified version of equation (2). The black diamonds denote the results from a regression where the dependent variable is an indicator for having had a mammogram during the prior year, the grey triangles during the prior three years, the grey circles during the prior five years, and the black x for ever receiving a mammogram. The sample is expanded to include adults aged 30-59. Next, rather than include an indicator for being in the treated group, five age group indicators (30-34, 35-39, 40-44, 45-49, 55-59, with 50-54 omitted for reference) are interacted with the post-period indicator. The post-period indicator is lagged to match the timing of the independent variable (one year, three years, five years, or not at all). The estimates utilize the sample weights.

Appendix Figure 10: Effects on Recent Doctor Visits



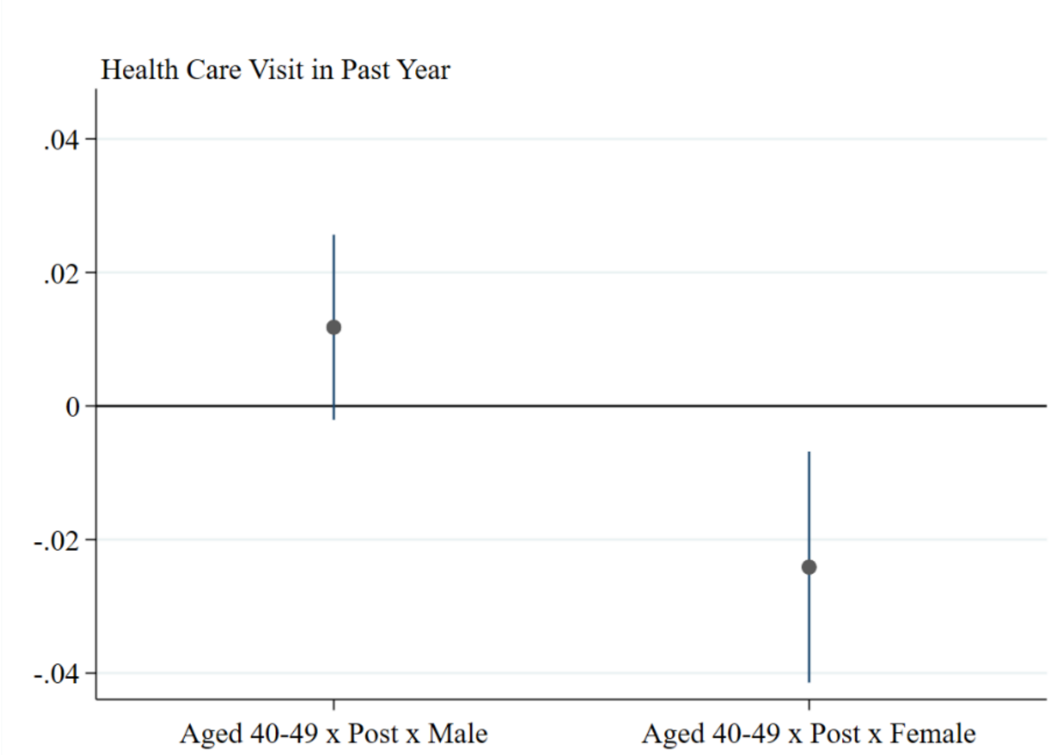
(A) NHIS Data



(B) BRFSS Data

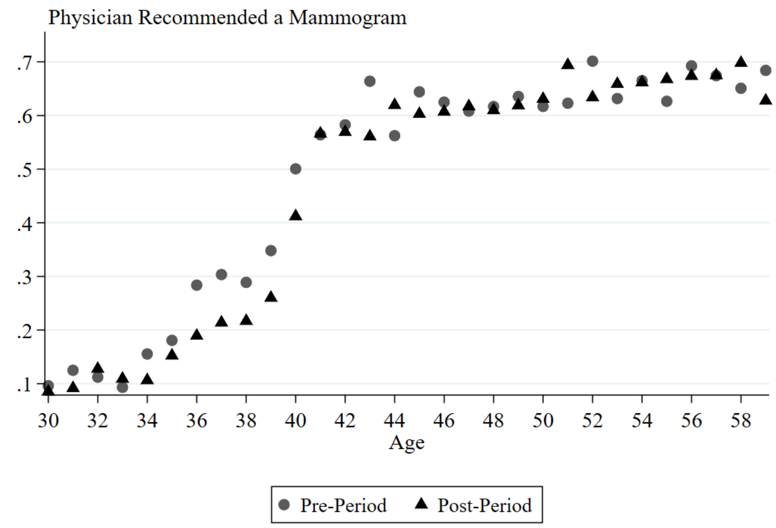
Source: National Health Interview Survey 2003-2018; Behavioral Risk Factor Surveillance System 2002-2019
Note: The dependent variable is an indicator for whether the respondent reported having a health care visit during the prior 12 months. The grey circles plot the point estimates and the lines represent the corresponding 95 percent confidence intervals obtained from a modified version of equation (2). First, the sample is expanded to include adults aged 30-59. Next, rather than include an indicator for being in the treated group, five age group indicators (30-34, 35-39, 40-44, 45-49, 55-59, with 50-54 omitted for reference) are interacted with the post-period indicator. Panel A uses the NHIS data and Panel B the BRFSS data. The estimates utilize the sample weights.

Appendix Figure 11: Effects on Health Care Visits for Women and Similarly Aged Men

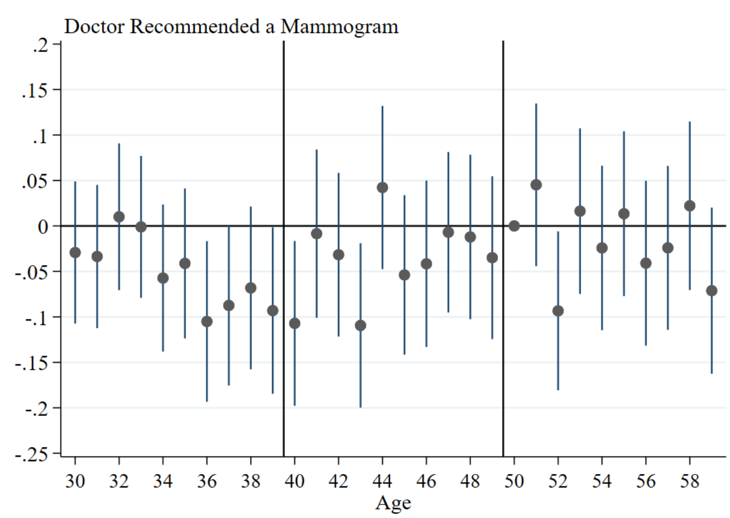


Source: National Health Interview Survey 2003-2018
Note: The figure plots the percentage point change in the share of men and women aged 40-49 reporting that they had a health care visit in the past year following the 2009 USPSTF recommendation. The regression includes the full set of control from equation (2) fully interacted with an indicator for being female. The estimates utilize the sample weights.

Appendix Figure 12: Individual Age Effects on Mammogram Recommendations



(A)

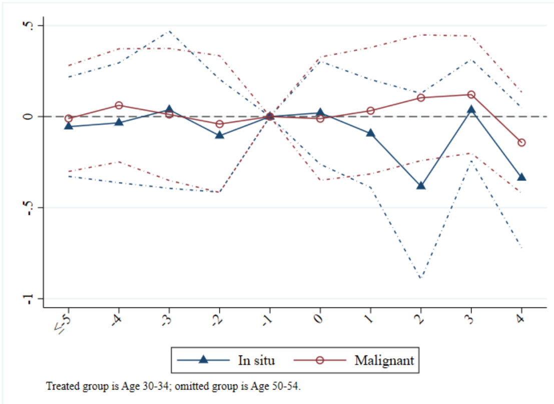


(B)

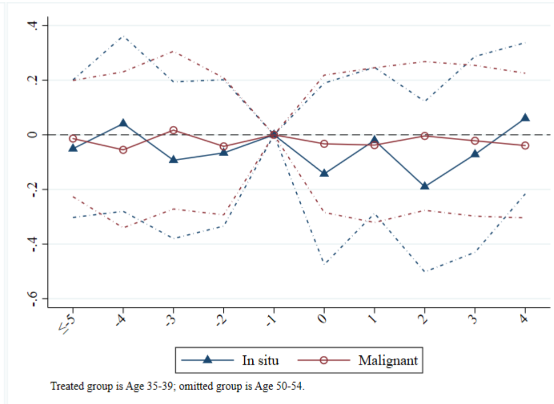
Source: National Health Interview Survey 2003-2018

Note: In Panel A, the grey circles plot the share of each age that reported a physician mammogram recommendation during the pre-period, while the black triangles denote the corresponding share in the post-period. In Panel B, the grey circles plot the point estimates and the lines represent the corresponding 95 percent confidence intervals obtained from a modified version of equation (2). First, the sample is expanded to include adults aged 30-59. Next, rather than include an indicator for being in the treated group, each age variable is interacted with the post-period indicator (with age 50 omitted for reference). The estimates and descriptive statistics utilize the sample weights.

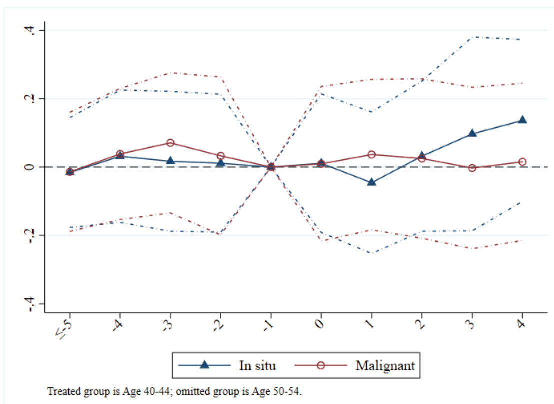
Appendix Figure 13: Event Study Estimates for Breast Cancer Effects



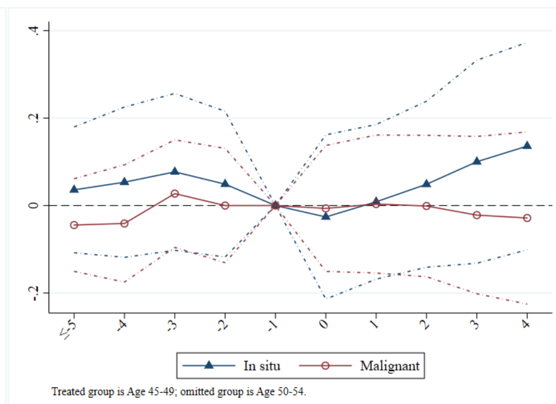
(A) 30-34



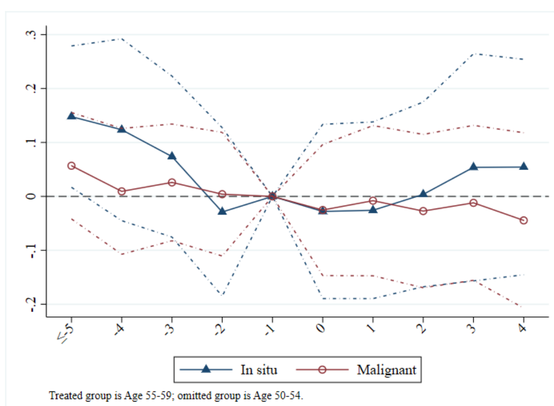
(B) 35-39



(C) 40-44



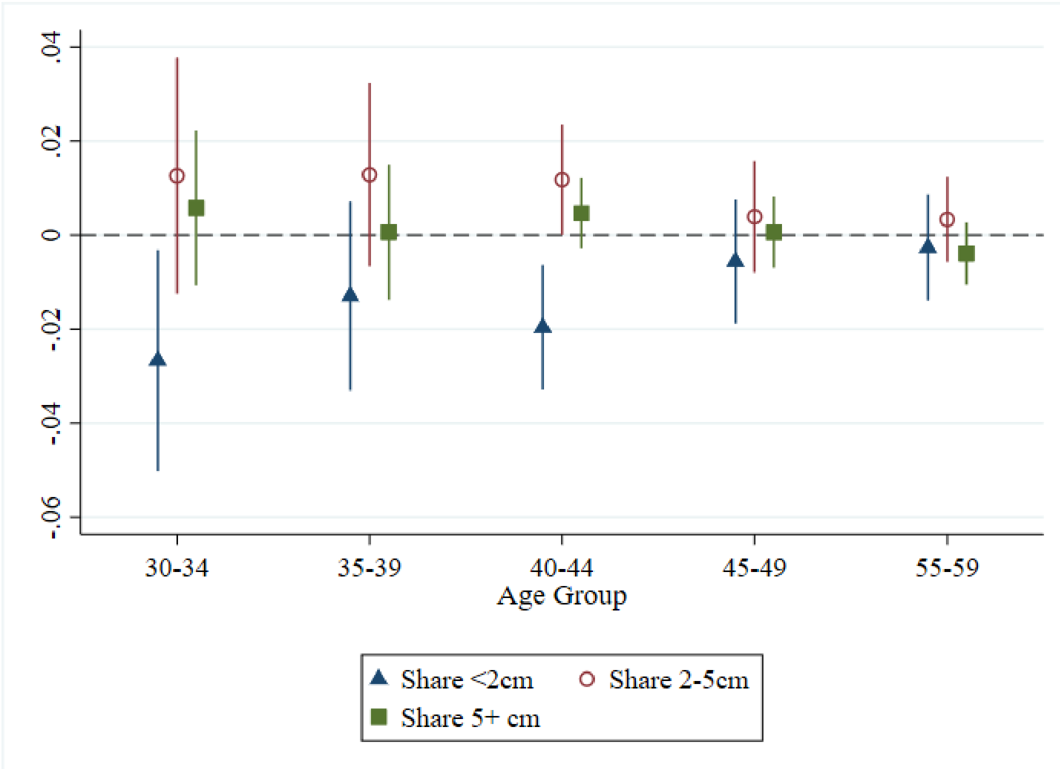
(D) 45-49



(E) 55-59

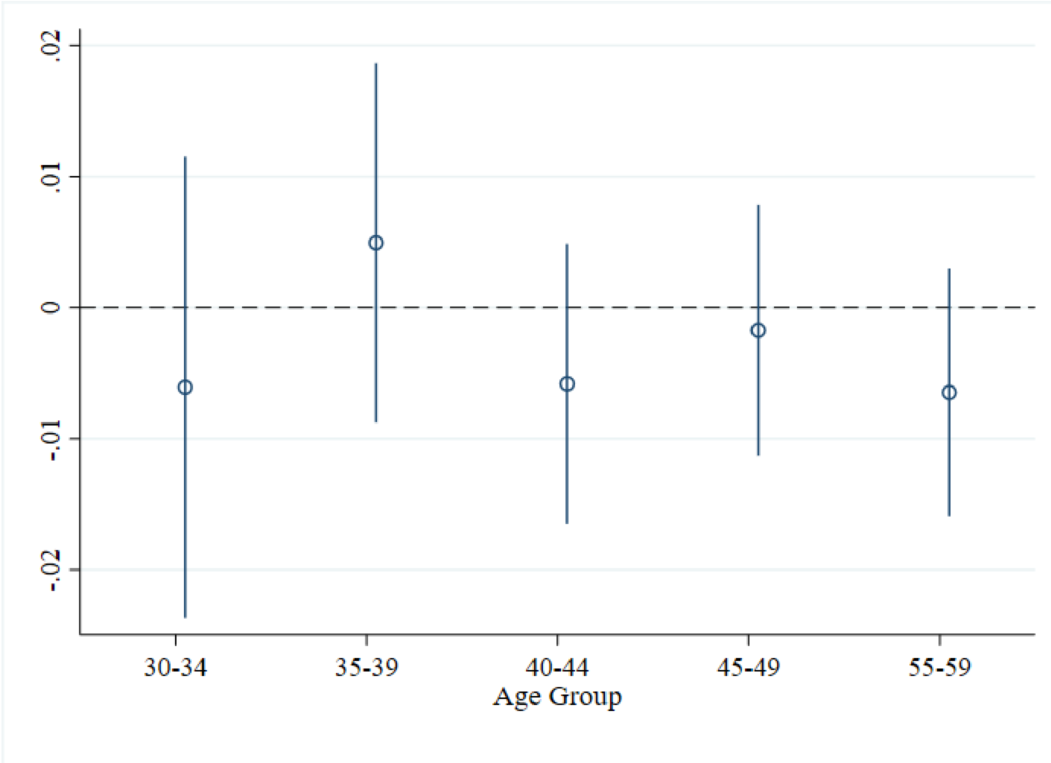
Source: National Cancer Institute's Surveillance, Epidemiology, and End Results Program 2002-2019
Note: The figures plot the event study estimates comparing changes in the natural log of in Situ (blue triangles) and malignant (red circle) breast cancer diagnoses for each group relative to the changes for women aged 50-54. Regressions are weighted by population, and heteroskedastic robust standard errors are reported.

Appendix Figure 14: Effects on Tumor Size



Source: National Cancer Institute's Surveillance, Epidemiology, and End Results Program 2002-2019
Note: The figure plots the difference-in-differences estimates examining how the 2009 USPSTF's mammography recommendations affected the share of tumors less than 2 centimeters in size (blue triangles), the share between 2 and 5 centimeters (red circle), and the share greater than 5 centimeters (green square). The lines show the corresponding 95 percent confidence intervals obtained from a modified version of equation (2) whereby five age group indicators (30-34, 35-39, 40-44, 45-49, 55-59, with 50-54 omitted for reference) are interacted with the post-period indicator. Regressions are weighted by population, and heteroskedastic robust standard errors are reported.

Appendix Figure 15: Effects on 5-Year Breast Cancer Mortality



Source: National Cancer Institute's Surveillance, Epidemiology, and End Results Program 2002-2019
Note: Panel A plots the difference-in-differences estimates examining how the 2009 USPSTF's mammography recommendations affected the 5-year mortality rate for women diagnosed with breast cancer from 2002-2014 (the last year for which there is 5 years of post-diagnosis data). The circles plot the point estimates and the lines represent the corresponding 95 percent confidence intervals from a modified version of equation (2) whereby five age group indicators (30-34, 35-39, 40-44, 45-49, 55-59, with 50-54 omitted for reference) are interacted with the post-period indicator. Regressions are weighted by population, and heteroskedastic robust standard errors are reported.

Appendix Table 1: BRFSS Summary Statistics

	(1)	(2)	(3)	(4)
Age Group →	Full Sample	Women Aged 30-39	Women Aged 40-49	Women Aged 50-59
Ever Had a Mammogram	0.684	0.288	0.825	0.945
	(0.465)	(0.453)	(0.380)	(0.227)
White	0.672	0.614	0.674	0.731
	(0.470)	(0.489)	(0.469)	(0.444)
Black	0.120	0.127	0.120	0.113
	(0.325)	(0.333)	(0.325)	(0.317)
Asian	0.016	0.019	0.017	0.013
	(0.126)	(0.136)	(0.129)	(0.111)
Hispanic	0.141	0.182	0.139	0.099
	(0.348)	(0.386)	(0.346)	(0.299)
Other	0.051	0.058	0.050	0.045
	(0.220)	(0.233)	(0.219)	(0.207)
Less than High School	0.104	0.109	0.103	0.100
	(0.305)	(0.312)	(0.304)	(0.300)
High School Diploma	0.249	0.217	0.252	0.880
	(0.433)	(0.412)	(0.434)	(0.325)
Some College	0.291	0.285	0.288	0.301
	(0.454)	(0.451)	(0.453)	(0.459)
College Degree	0.355	0.389	0.356	0.320
	(0.479)	(0.487)	(0.479)	(0.466)
Health Insurance Coverage	0.853	0.828	0.853	0.880
	(0.354)	(0.378)	(0.355)	(0.325)
Married	0.659	0.649	0.676	0.650
	(0.474)	(0.477)	(0.468)	(0.477)
Divorced	0.130	0.086	0.136	0.169
	(0.336)	(0.280)	(0.343)	(0.374)
Widowed	0.027	0.006	0.018	0.056
	(0.160)	(0.079)	(0.134)	(0.229)
Separated	0.036	0.037	0.038	0.031
	(0.189)	(0.190)	(0.192)	(0.172)
Never Married	0.150	0.222	0.131	0.095
	(0.357)	(0.416)	(0.337)	(0.293)
ACS Recommended	0.634	0.000	0.911	1.000
	(0.482)	-	(0.284)	-
ACA Coverage	0.285	0.000	0.399	0.462
	(0.452)	-	(0.490)	(0.499)
Observations	1,054,754	274,095	344,678	435,981

Source: Behavioral Risk Factor Surveillance System 2002-2019

Note: Column 1 reports the mean and standard deviation for the entire sample. Column 2 reports the statistics for those aged 30-39, column 3 for those aged 40-49 and column 4 for those aged 50-59. The sample is women aged 30-59. The summary statistics utilize the sample weights.

Appendix Table 2: Simple 2 × 2 Difference-in-Differences Comparisons

	(1)	(2)	(3)	(4)	(5)	(6)
	Ever Had a Mammogram			Mammogram in Past Year		
	2002-2009	2009-2019	(2) – (1)	2002-2009	2009-2019	(5) – (4)
A. BRFSS						
T: Aged 40-49	0.835	0.815	-0.020	0.529	0.498	-0.031
C: Aged 50-59	0.942	0.949	0.007	0.644	0.600	-0.044
T - C	-0.107	-0.134	**-0.027**	-0.115	-0.102	**0.013**
B. NHIS						
T: Aged 40-49	0.800	0.786	-0.014	0.497	0.475	-0.022
C: Aged 50-59	0.914	0.931	0.017	0.592	0.568	-0.024
T - C	-0.114	-0.145	**-0.031**	-0.095	-0.093	**0.002**

Source: Behavioral Risk Factor Surveillance System 2002-2019; National Health Interview Survey 2003-2018
Note: Panel A uses the BRFSS data and Panel B the NHIS data. Columns 1-3 examine how the share of women aged 40-49 and aged 50-59 ever receiving a mammogram evolved around the 2009 USPSTF recommendation. Column 1 presents the summary statistics prior to the policy change, column 2 after the policy change, and column 3 takes the difference of columns 2 and 1. The bolded value is the unadjusted difference-in-differences value. Columns 4-6 examine how the share of women aged 40-49 and aged 50-59 receiving a mammogram during the prior year changed around the 2009 USPSTF recommendation. Column 4 presents the summary statistics prior to the policy change, column 5 after the policy change, and column 6 takes the difference of columns 5 and 4. The bolded value is the unadjusted difference-in-differences value. The summary statistics utilize the sample weights.

Appendix Table 3: NHIS Summary Statistics

	(1)	(2)	(3)	(4)
Age Group →	Full Sample	Women Aged 30-39	Women Aged 40-49	Women Aged 50-59
Mammogram	0.664	0.271	0.792	0.924
	(0.472)	(0.444)	(0.406)	(0.265)
White	0.662	0.603	0.664	0.720
	(0.473)	(0.489)	(0.472)	(0.449)
Black	0.128	0.137	0.125	0.121
	(0.334)	(0.344)	(0.330)	(0.326)
Asian	0.053	0.063	0.055	0.042
	(0.225)	(0.243)	(0.227)	(0.201)
Hispanic	0.146	0.185	0.146	0.106
	(0.353)	(0.388)	(0.353)	(0.308)
Other	0.009	0.009	0.009	0.010
	(0.096)	(0.097)	(0.095)	(0.097)
Less than High School	0.114	0.116	0.110	0.116
	(0.318)	(0.320)	(0.313)	(0.320)
High School Diploma	0.237	0.202	0.243	0.267
	(0.425)	(0.401)	(0.429)	(0.442)
Some College	0.309	0.306	0.310	0.312
	(0.462)	(0.461)	(0.462)	(0.463)
College Degree	0.340	0.376	0.338	0.305
	(0.474)	(0.484)	(0.473)	(0.461)
Health Insurance Coverage	0.853	0.825	0.853	0.883
	(0.354)	(0.380)	(0.355)	(0.322)
Married	0.646	0.638	0.655	0.644
	(0.478)	(0.481)	(0.475)	(0.479)
Widowed	0.024	0.005	0.017	0.049
	(0.152)	(0.072)	(0.130)	(0.216)
Divorced	0.149	0.094	0.160	0.191
	(0.356)	(0.292)	(0.367)	(0.393)
Separated	0.035	0.036	0.039	0.031
	(0.184)	(0.186)	(0.193)	(0.174)
Never Married	0.147	0.227	0.129	0.085
	(0.354)	(0.419)	(0.335)	(0.279)
ACS Recommended	0.643	0.000	0.917	1.000
	(0.479)	-	(0.275)	-
ACA Coverage	0.320	0.000	0.434	0.500
	(0.466)	-	(0.498)	(0.500)
Observations	54,922	19,030	18,167	17,725

Source: National Health Interview Survey 2003-2018

Note: Column 1 reports the mean and standard deviation for the entire sample. Column 2 reports the statistics for those aged 30-39, column 3 for those aged 40-49, and column 4 for those aged 50-59. The sample is women aged 30-59. The summary statistics utilize the sample weights.

Appendix Table 4: HINTS Summary Statistics

	(1)	(2)	(3)	(4)
Age Group →	Full Sample	Women Aged 35-39	Women Aged 40-49	Women Aged 50-59
Ever Had Mammogram	0.794	0.385	0.811	0.945
	(0.405)	(0.487)	(0.391)	(0.228)
Involved in Care Decisions	0.555	0.530	0.556	0.563
	(0.497)	(0.499)	(0.497)	(0.496)
Too Many Recs.	0.278	0.287	0.283	0.270
	(0.448)	(0.452)	(0.451)	0.444)
Trust Doctor	0.686	0.695	0.691	0.677
	(0.464)	(0.461)	(0.462)	(0.468)
Trust Gov. Health Agency	0.307	0.367	0.276	0.313
	(0.461)	(0.482)	(0.447)	(0.464)
Non-Hispanic White	0.642	0.613	0.604	0.694
	(0.479)	(0.487)	(0.489)	(0.461)
Black	0.145	0.133	0.154	0.140
	(0.352)	(0.340)	(0.361)	(0.347)
Asian	0.041	0.052	0.042	0.036
	(0.199)	(0.222)	(0.202)	(0.186)
Hispanic	0.143	0.165	0.169	0.107
	(0.350)	(0.372)	(0.375)	(0.309)
Other	0.029	0.036	0.031	0.024
	(0.167)	(0.187)	(0.172)	(0.152)
Less than High School	0.086	0.090	0.091	0.080
	(0.281)	(0.286)	(0.288)	(0.272)
High School Diploma	0.226	0.198	0.207	0.257
	(0.418)	(0.399)	(0.405)	(0.437)
Some College	0.333	0.291	0.347	0.336
	(0.471)	(0.455)	(0.476)	(0.472)
College Graduate	0.355	0.421	0.355	0.327
	(0.478)	(0.494)	(0.479)	(0.469)
Health Insurance	0.868	0.848	0.863	0.881
	(0.339)	(0.359)	(0.344)	(0.324)
Married	0.625	0.615	0.632	0.621
	(0.484)	(0.487)	(0.482)	(0.485)
ACS Recommended	0.762	0.000	0.851	1.000
	(0.426)	-	(0.356)	-
ACA Coverage	0.511	0.000	0.599	0.643
	(0.500)	-	(0.490)	(0.479)
Observations	10,497	1,718	3,888	4,891

Source: Health Information National Trends Survey 2003-2019.

Note: Column 1 reports the mean and standard deviation for the entire sample (ages 35-59). Column 2 reports the statistics for those aged 35-39, column 3 for those aged 40-49, and column 4 for those aged 50-59. Summary statistics utilize the sample weights.

Appendix Table 5: HINTS Survey Question Availability Across Sample Waves

	2003	2005	2007	2011	2012	2013	2014	2015	2017	2018	2019
Ever Had Mammogram	●	●		●	●	●	●		●	●	●
Involved in Care Decisions	●		●	●	●	●	●		●	●	●
Too Many Recs.	●		●	●	●	●	●	●	●	●	●
Trust Doctor		●	●	●		●		●	●		●
Trust Gov. Health Agency			●	●		●		●	●		●

Source: Health Information National Trends Survey 2003-2019.

Note: A black dot indicates that the survey question was asked in a given sample wave. A year is omitted from the table if nationally representative surveys were not conducted in that year.

Appendix Table 6: SEER Summary Statistics

	(1)	(2)	(3)	(4)
Age Group →	Full Sample	Women Aged 30-39	Women Aged 40-49	Women Aged 50-59
Breast Cancer Cases	234.3	62.7	260.4	379.8
	(389.2)	(94.0)	(361.7)	(513.7)
In Situ Cases	51.0	7.7	61.4	84.0
	(87.1)	(12.0)	(84.0)	(111.8)
Malignant Cases	183.3	55.0	199.1	295.8
	(304.0)	(82.9)	(279.5)	(403.8)
Population (000s)	122.3	123.1	126.0	117.8
	(193.3)	(196.7)	(198.6)	(184.3)
5-Year Mortality Rate	0.145	0.168	0.127	0.141
	(0.089)	(0.118)	(0.070)	(0.065)
Share of Tumors ≤ 2 cm	0.441	0.344	0.462	0.516
	(0.139)	(0.156)	(0.103)	(0.088)
Share of Tumors 2 cm – 5 cm	0.378	0.443	0.364	0.326
	(0.123)	(0.157)	(0.095)	(0.070)
Share of Tumors 5+ cm	0.111	0.143	0.103	0.085
	(0.081)	(0.116)	(0.056)	(0.039)
Observations	2,484	828	828	828

Source: National Cancer Institute's Surveillance, Epidemiology, and End Results Program 2002-2019
Note: Column 1 reports the mean and standard deviation for the entire sample. Column 2 reports the statistics for those aged 30-39, column 3 for those aged 40-49, and column 4 for those aged 50-59. The full sample is women aged 40-59. Observations are at the registry-5-year age group-race-year level. Registries included are from AK, CA, CT, GA, HI, IA, KY, LA, NJ, NM, UT, and WA.

Appendix Table 7: Heterogeneity When Including Younger Women

	(1)	(2)	(3)	(4)	(5)	(6)
Sample →	Women with Health Insurance Coverage	Women without Health Insurance Coverage	White Women	Non-White Women	Women with at Most a High School Degree	Women with More than a High School Degree
$\mathbf{1}\{30 \leq \text{Age} \leq 49\}\times$ $\mathbf{1}\{\text{2009 USPSTF}\}$	-0.027***	-0.026	-0.030***	-0.024	-0.023	-0.027***
	(0.008)	(0.028)	(0.010)	(0.015)	(0.015)	(0.009)
	[0.001]	[0.285]	[0.003]	[0.085]	[0.103]	[0.001]
R^2	0.427	0.281	0.429	0.367	0.350	0.448
Treated Mean in 2008	0.594	0.437	0.597	0.514	0.547	0.581
Observations	45,666	9,249	32,456	22,461	20,429	34,487

Source: National Health Interview Survey 2003-2018

Note: The dependent variable an indicator for whether the woman reported ever receiving a mammogram. Column 1 limits the sample to those with health insurance coverage and column 2 to those without health insurance coverage. Column 3 restricts the sample to white women, column 4 to non-white women, column 5 to women with at most a high school degree, and column 6 to women with more than a high school degree. Heteroskedastic robust standard errors are shown in parentheses. Wild bootstrapped p-values from clustering standard errors at the treatment group-time level are shown in brackets. The estimates utilize the sample weights.

*** p < 0.01, ** p < 0.05, * p < 0.10

Appendix Table 8: Fully Interacted Heterogeneity Results

	(1)	(2)	(3)
Group →	Health Insurance Coverage	White	More than a High School Degree
$\mathbf{1}\{40 \leq \text{Age} \leq 49\}\times$ $\mathbf{1}\{\text{2009 USPSTF}\}$	-0.026	-0.009	-0.021
	(0.030)	(0.016)	(0.016)
$\mathbf{1}\{40 \leq \text{Age} \leq 49\}\times$ $\mathbf{1}\{\text{2009 USPSTF}\}\times$ $\mathbf{1}\{\text{Group} = j\}$	0.006	-0.020	0.002
	(0.031)	(0.019)	(0.018)
R^2	0.162	0.157	0.157
Treated Mean in 2008	0.809	0.809	0.809
Observations	35,892	35,892	35,892

Source: National Health Interview Survey 2003-2018

Note: The dependent variable an indicator for whether the woman reported ever receiving a mammogram. The sample is women aged 40-59. Each column reports the coefficient from a modified version of equation (2) where all the righthand side variables are interacted with an indicator for being a member of a particular group. The group variable in column 1 is an indicator variable for having health insurance, in column 2 for being white, and in column 3 for having more than a high school degree. Heteroskedastic robust standard errors are shown in parentheses. The estimates utilize the sample weights.

*** p < 0.01, ** p < 0.05, * p < 0.10

Appendix Table 9: Sample Demographics

	(1)	(2)	(3)
Outcome →	Health Insurance Coverage	White	More than a High School Degree
1{40 ≤ Age ≤ 49}× **1**{2009 USPSTF}	-0.010	-0.016*	-0.011
	(0.009)	(0.011)	(0.013)
	[0.192]	[0.068]	[0.370]
R^2	0.032	0.066	0.029
Treated Mean in 2008	0.838	0.683	0.621
Observations	35,890	35,890	35,890

Source: National Health Interview Survey 2003-2018

Note: The dependent variable is the indicator variable listed in the column header. The sample is women aged 40-59. Heteroskedastic robust standard errors are shown in parentheses. Wild bootstrapped p-values from clustering standard errors at the treatment group-time level are shown in brackets. The estimates utilize the sample weights.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Appendix Table 10: Characterizing the Compliers Including Younger Women

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sample →	Flu Shot During Prior 12 Months	No Flu Shot During Prior 12 Months	BMI < 25	BMI ≥ 25	Non-Smoker	Smoker	Health ≥ 'Very Good'	Health < 'Very Good'
1{30 ≤ Age ≤ 49}× **1**{2009 USPSTF Rec.}	0.002	-0.038***	-0.000	-0.040***	-0.022**	-0.033**	-0.023**	-0.032**
	(0.013)	(0.012)	(0.012)	(0.011)	(0.010)	(0.013)	(0.010)	(0.013)
	[0.895]	[0.000]	[0.980]	[0.000]	[0.018]	[0.017]	[0.014]	[0.010]
R^2	0.500	0.376	0.421	0.408	0.422	0.387	0.426	0.377
Treated Mean in 2008	0.655	0.536	0.579	0.556	0.544	0.609	0.569	0.567
Observations	15,390	30,343	20,989	31,474	34,557	20,278	32,555	22,336

Source: National Health Interview Survey 2003-2018

Note: The dependent variable is an indicator for whether the woman reported ever receiving a mammogram. The sample is women aged 30-59. In column 1, the sample is restricted to women who reported receiving a flu vaccine during the prior 12 months, while column 2 limits the sample to those who did not report receive a flu vaccine. Column 3 limits the sample to women who were not classified as overweight or obese (BMI < 25) and column 4 to those women classified as overweight or obese (BMI ≥ 25). Column 5 limits the sample to women who did not report smoking at least 100 cigarettes during their lifetime and column 6 to women with a history of smoking cigarettes. Column 6 limits the sample to women who reported being in at least very good health (very good, or excellent) and column 7 to women who reported being in less than very good health (good, fair, or poor). The estimates include the full set of controls from equation (2). Heteroskedastic robust standard errors are shown in parentheses. Wild bootstrapped p-values from clustering standard errors at the treatment group-time level are shown in brackets. The estimates utilize the sample weights.

*** p < 0.01, ** p < 0.05, * p < 0.10

Appendix Table 11: Complier Characteristics Sample Composition

	(1)	(2)	(3)	(4)
Sample →	Flu Shot During Prior 12 Months	BMI ≥ 25	Smoker	Health ≥ 'Very Good'
1{40 ≤ Age ≤ 49}× **1**{2009 USPSTF Rec.}	0.006	0.041***	-0.049***	-0.009
	(0.013)	(0.012)	(0.012)	(0.012)
	[0.628]	[0.000]	[0.000]	[0.459]
R^2	0.096	0.086	0.163	0.154
Observations	45,739	52,470	54,837	54,897

Source: National Health Interview Survey 2003-2018

Note: The dependent variable in column 1 is an indicator for whether a woman reported receiving a flu shot during the prior 12 months, in column 2 for whether she was classified as overweight or obese, in column 3 for if she reported smoking more than 100 cigarettes during her lifetime, and in column 4 if she reported being in very good or excellent health. The sample is women aged 40-59. The estimates include the full set of controls from equation (2). Heteroskedastic robust standard errors are shown in parentheses. Wild bootstrapped p-values from clustering standard errors at the treatment group-time level are shown in brackets. The estimates utilize the sample weights.

*** p < 0.01, ** p < 0.05, * p < 0.10

Appendix Table 12: Effects by Maternal Breast Cancer History

	(1)	(2)	(3)
Sample →	Women Aged 30-59	Women Aged 30-59 Without a Maternal History of Breast Cancer	Women Aged 30-59 With a Maternal History of Breast Cancer
$\mathbf{1}\{40 \leq \text{Age} \leq 49\} \times$ $\mathbf{1}\{\text{2009 USPSTF Rec.}\}$	-0.038***	-0.036***	-0.028
	(0.012)	(0.012)	(0.039)
	[0.003]	[0.000]	[0.399]
R^2	0.420	0.424	0.410
Observations	23,472	21,949	1,518

Source: National Health Interview Survey 2003-2018

Note: The dependent variable is an indicator for whether the woman reported ever receiving a mammogram. The sample is women aged 30-59 with data on maternal breast cancer history. The estimates include the full set of controls from equation (2). Column 1 uses the full sample, column 2 restricts the sample to those without a maternal history of breast cancer, and column 3 restricts the sample to those with a maternal history of breast cancer. Heteroskedastic robust standard errors are shown in parentheses. Wild bootstrapped p-values from clustering standard errors at the treatment group-time level are shown in brackets. The estimates utilize the sample weights.

*** p < 0.01, ** p < 0.05, * p < 0.10

Appendix Table 13: Additional Outcomes and Mechanisms in the BRFSS Data

	(1)	(2)	(3)
Outcome →	Mammogram in Past Year	Mammogram in Past 3 Years	Mammogram in Past 5 Years
1{40 ≤ Age ≤ 49}× **1**{2009 USPSTF Rec.}	0.010**	-0.005	-0.009***
	(0.005)	(0.004)	(0.003)
	[0.045]	[0.170]	[0.006]
R^2	0.084	0.110	0.109
Mean for Treated in 2008	0.545	0.753	0.793
Observations	777,634	777,634	777,634

Source: Behavioral Risk Factor Surveillance System 2002-2019

Note: The dependent variable in column 1 is an indicator for whether the woman reported receiving a mammogram during the prior year, in column 2 during the prior three years, and in column 3 during the prior five years. The sample is women aged 40-59. The estimates include the full set of controls from equation (2). Because the outcome in column 1 has a 1-year look back window, the recommendation indicator turns on one year after the formal recommendation (December 2010 instead of December 2009). Similarly, the indicator turns on after three years in column 2 and five years in column 3. Heteroskedastic robust standard errors are shown in parentheses. Wild bootstrapped p-values from clustering standard errors at the treatment group-time level are shown in brackets. The estimates utilize the sample weights.

*** p < 0.01, ** p < 0.05, * p < 0.10

Appendix Table 14: Robustness of HINTS Estimates to Including Younger Treated Women

	(1)	(2)	(3)	(4)	(5)
Outcome →	Ever Had Mammogram	Doctor always involved you in care decisions as much as you wanted	Hard to know which recommendations to follow for preventing cancer	Highly trust health information from a doctor	Highly trust health information from government health agency
1{35 ≤ Age ≤ 49}× **1**{2009 USPSTF Rec.}	-0.047**	-0.037	0.079**	0.011	-0.020
	(0.021)	(0.035)	(0.032)	(0.035)	(0.047)
	[0.026]	[0.161]	[0.014]	[0.832]	[0.661]
R^2	0.301	0.0262	0.0311	0.0273	0.0538
Mean	0.792	0.553	0.273	0.693	0.308
Observations	9272	7497	9850	7205	5542

Source: Health Information National Trends Survey, 2003-2019.

Note: The sample is women aged 35-59. All columns include age and year fixed effects, as well as demographic controls (marital status, race/ethnicity, health insurance status, and educational attainment) and controls for changes to the ACS mammogram recommendation and the ACA preventive services provision. The dependent variable in column 1 is an indicator for whether the woman reported ever receiving a mammogram. The dependent variable in column 2 is an indicator for whether the woman reported that during the past 12 months her health care professionals always involved her as much as she wanted in her health care decisions and in column 3 an indicator for whether the woman strongly agreed that there were so many recommendations for preventing cancer that it was difficult to know which ones to follow. The dependent variable in column 4 is an indicator for whether the woman reported high trust about health or medical topics from doctors and medical professionals and in column 5 an indicator for whether the woman reported high trust about these topics from government health agencies. Heteroskedastic robust standard errors are shown in parentheses, p-values from wild cluster bootstrap procedure are reported in brackets. The estimates utilize the survey weights.

*** p < 0.01, ** p < 0.05, * p < 0.10

Appendix Table 15: SEER Estimates

	(1)	(2)	(3)	(4)	(5)	(6)
Specification →	Ln(In situ cases+1)	Ln(Malignant cases+1)	5-year Mortality Rate	Share 5+cm	Share 2-5cm	Share <2cm
$\mathbf{1}\{30 \leq \text{Age} \leq 34\} \times$ $\mathbf{1}\{\text{2009 USPSTF Rec.}\}$	0.0157	0.0854***	-0.00607	0.00576	0.0126	-0.0267***
	(0.105)	(0.0661)	(0.00897)	(0.00837)	(0.0128)	(0.0120)
	[0.905]	[0.002]	[0.398]	[0.424]	[0.312]	[0.009]
$\mathbf{1}\{35 \leq \text{Age} \leq 39\} \times$ $\mathbf{1}\{\text{2009 USPSTF Rec.}\}$	-0.164*	-0.00591	0.00495	0.000609	0.0128	-0.0130
	(0.0753)	(0.0598)	(0.00699)	(0.00732)	(0.00994)	(0.0102)
	[0.051]	[0.777]	[0.541]	[0.943]	[0.191]	[0.278]
$\mathbf{1}\{40 \leq \text{Age} \leq 44\} \times$ $\mathbf{1}\{\text{2009 USPSTF Rec.}\}$	0.0371	0.0101	-0.00581	0.00462	0.0118*	-0.0196**
	(0.0494)	(0.0404)	(0.00545)	(0.00382)	(0.00597)	(0.00676)
	[0.294]	[0.540]	[0.344]	[0.345]	[0.078]	[0.016]
$\mathbf{1}\{45 \leq \text{Age} \leq 49\} \times$ $\mathbf{1}\{\text{2009 USPSTF Rec.}\}$	-0.000574	-0.00811	-0.00172	0.000585	0.00389	-0.00563
	(0.0410)	(0.0319)	(0.00489)	(0.00386)	(0.00605)	(0.00671)
	[0.986]	[0.586]	[0.690]	[0.893]	[0.567]	[0.468]
$\mathbf{1}\{55 \leq \text{Age} \leq 59\} \times$ $\mathbf{1}\{\text{2009 USPSTF Rec.}\}$	-0.0415	-0.0392*	-0.00647	-0.00394	0.00331	-0.00266
	(0.0400)	(0.0314)	(0.00482)	(0.00337)	(0.00460)	(0.00574)
	[0.196]	[0.055]	[0.159]	[0.258]	[0.429]	[0.537]
R^2	0.958	0.968	0.596	0.470	0.557	0.757
Mean	4.126	5.617	0.134	0.108	0.369	0.458
Observations	2484	2484	1786	1650	1650	1650

Source: SEER data, 2002-2019.

Note: The dependent variable in column 1 is the natural log + 1 of in situ precancer diagnoses, in column 2 the natural log + 1 of malignant diagnoses, in column 3 the 5-year mortality rate (measured 2002-2014), in column 4 the share of tumors larger than 5 cm, in column 5 the share 2-5 cm, and in column 6 the share less than 2 cm. The estimates utilize population weights. Heteroskedastic robust standard errors are shown in parentheses and wild bootstrap p-values are reported in brackets.

*** p < 0.01, ** p < 0.05, * p < 0.10

Appendix Table 16: Robustness of Reduction in In Situ Cases

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Specification →	Baseline	(1) but No Sample Weights	(1) but No Time-Varying Controls	(1) but before 2015 ACS Rec. Change	(1) but include registry-by-year fixed effects	(1) but Include All Women Aged 30-85+	(1) but Outcome is IHS(In situ cases)
Outcome: Ln(In situ cases +1)							
$\mathbf{1}\{30 \leq \text{Age} \leq 34\} \times$ $\mathbf{1}\{\text{2009 USPSTF Rec.}\}$	0.0157 (0.105)	-0.0470 (0.0872)	0.0772 (0.0764)	-0.0572 (0.116)	0.0160 (0.106)	0.00953 (0.109)	0.0178 (0.104)
$\mathbf{1}\{35 \leq \text{Age} \leq 39\} \times$ $\mathbf{1}\{\text{2009 USPSTF Rec.}\}$	-0.164** (0.0753)	-0.150** (0.0721)	-0.178*** (0.0552)	-0.0813 (0.0756)	-0.163** (0.0770)	-0.162** (0.0764)	-0.172** (0.0767)
$\mathbf{1}\{40 \leq \text{Age} \leq 44\} \times$ $\mathbf{1}\{\text{2009 USPSTF Rec.}\}$	0.0371 (0.0494)	0.0970* (0.0578)	-0.0893* (0.0496)	0.0411 (0.0516)	0.0388 (0.0512)	0.0331 (0.0474)	0.0500 (0.0510)
$\mathbf{1}\{45 \leq \text{Age} \leq 49\} \times$ $\mathbf{1}\{\text{2009 USPSTF Rec.}\}$	-0.000574 (0.0410)	-0.0420 (0.0515)	-0.0885* (0.0523)	0.0141 (0.0448)	0.000822 (0.0428)	-0.00517 (0.0346)	0.00734 (0.0407)
$\mathbf{1}\{55 \leq \text{Age} \leq 59\} \times$ $\mathbf{1}\{\text{2009 USPSTF Rec.}\}$	-0.0415 (0.0400)	-0.0445 (0.0519)	0.0422 (0.0540)	-0.0437 (0.0419)	-0.0428 (0.0412)	-0.0648** (0.0283)	-0.0502 (0.0384)
R^2	0.958	0.926	0.938	0.962	0.960	0.959	0.956
Mean	4.126	2.824	4.126	4.143	4.126	4.295	4.764
Observations	2484	2484	2484	1794	2484	4968	2484

Source: SEER data, 2002-2019.

Note: The dependent variable is ln(in situ cases +1), except in column 7, in which the outcome variable is the inverse hyperbolic sine of the count of in situ cases. The baseline sample is women aged 30-59. Column 1 reprints the baseline estimate from Figure 7. Column 2 estimates the baseline specification but does not utilize the population weights. Column 3 omits the time-varying controls; column 4 restricts the sample to the periods prior to the American Cancer Society's decision to raise its recommended mammography age from 40 to 45-years-old, and column 5 includes registry-by-year fixed effects. Column 6 estimates the baseline specification but expands the sample to include adults aged 30-85+. Finally, column 7 estimates the specification but expands the sample to include all women aged 30-85+. Except for column 2, the estimates utilize population weights. Heteroskedastic robust standard errors are shown in parentheses.