Mammography Screening Guideline and Screening Behavior

by
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A thesis submitted to the faculty of the Rollins School of Public Health at Emory University in partial fulfillment of the requirements for the Masters of Science in Public Health in the Department of Health Policy and Management.

Atlanta, Georgia
2014

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Abstract

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In November 2009, the US Preventive Services Task Force (USPSTF) revised the 2002 recommendation regarding mammography screening to recommend against routine mammography screening for women aged 40-49 due to considerations of the harm of mammography screening. This revised recommendation is highly controversial, and has led to confusion regarding mammography screening among both physicians and women. To address the controversy and the confusion it caused, this study aims to examine the impact of the revised recommendation on mammography screening rates and the impact of the false-positive mammogram on screening behavior. The private insurance outpatient claims data from 2006 to 2011 were used to establish study samples. A difference-in-difference approach was applied to examine the impact of the revised recommendation on screening rates among women aged 40-49. Survival analyses were conducted to estimate the impact of a false-positive mammogram on screening behavior. Among women aged 40-49, biennial mammography screening rates declined by 1.15 percentage point between 2008-2009 and 2010-2011($P<0.0001$). With women who had enrolled in private insurance programs from 2006 to 2011, false-positive rates were slightly higher among women aged 40-49 than among women aged 50-59 (2.5% vs. 2.3%, $P<0.001$). The likelihood of rescreening among women who had a false-positive mammogram that requires a biopsy was 20.5% lower than that among women who did not have any false-positive mammograms ($P<0.0001$). Findings suggest that the revised recommendation led to a reduction in mammography screening rates, and that false-positive mammograms that require a biopsy have a negative impact on continuing mammography screening.

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Introduction

In November 2009, the United States Preventive Services Task Force (USPSTF) revised its 2002 recommendations on mammography screening [1]. Compared to the 2002 recommendation endorsing annual or biennial mammography screening for women aged 40 and older[2], the USPSTF, in 2009, recommended biennial mammography screening for women aged 50 to 74 and recommended against routine mammography screening for women aged 40 to 49. The term "routine" was further explained by the USPSTF as "the decision to start regular, biennial screening mammography before age 50 years should be an individual one and should take into account patient context, including the patient's values regarding specific benefits and harms."[1]

Misunderstanding the term "routine", the mass media has portrayed the revised recommendation as opposing mammography screening in all women aged 40 to 49 and was critical of this revised recommendation [3]. Breast cancer survivors and advocacy groups were further outraged by the revised recommendation [4]. Radiologists also discredited the revised recommendation for ignoring important scientific evidence and appealed for rescinding the revised recommendation [5, 6]. The American Cancer Society, the American College of Radiology and the Society of Breast Imaging continue to recommend annual mammography screening for women aged 40 and over and strongly criticized the USPSTF revised recommendation [7-10].

Both women and physicians were exposed to the controversy surrounding the 2009 revised

recommendation. This controversy led to the confusion regarding mammography screening among both physicians and women aged 40 to 49 [11, 12]. Also, a study has shown that the majority of women learned the changes of the USPSTF recommendations from the media and thus had negative attitudes about the changes [13]. Considering the confusion and negative attitudes, it is unclear whether patients and physicians will adhere to the 2009 revised recommendations.

Literature Review

Trends of Mammography Screening Rates in the US

In 1987, before the first USPSTF breast cancer screening recommendation was released in 1989, there was only 17% women over the age of 40 reported having had a screening mammography in previous year and there were evident racial disparities in utilization[14, 15]. By 1990, the mammography screening rates among women aged 40 and older doubled , and a continuing trend of increased mammography is shown through the proportion of women aged 40 and older who reported ever having a mammogram that increased from 63.9% in 1989 to 84.8% in 1997[16]. Between 2000 and 2006, mammography screening rates among women aged 40 and older remained stable above 75% according to the Behavioral Risk Factor Surveillance System surveys [17].

Among women aged 40 to 49, mammography rates rose rapidly from 1987 to 1992 and were relatively stable through 2005, followed by a slight decline from 63.8% in 2005 to 65.4% in 2008[18]. Among women aged 50 and older, mammography rates rose rapidly from 1987 to 2000, remained unchanged from 2000 to 2005 and then increased again from 2005 to 2008 [18]. From 2005 to 2008, mammography rates among women aged 50 to 64 increased from 71.8% to 74.2%, and mammography rates among women aged 65 and older increased from 63.8% to 65.4%[18]. As guidelines consistently recommended mammography screening for women aged 50 and older, the

mammography rates among this age group kept increasing.

The Impact of Breast Cancer Screening Guidelines

Practice guidelines could change screening rates in terms of physicians' and patients' adherence to the guidelines.

Physicians' adherence to guidelines depends on their awareness of guidelines, familiarity with guidelines, agreement with guidelines, and motivation to follow guidelines [19]. According to a 1990 survey regarding American Cancer Society and National Cancer Institute recommendations on breast cancer screening, 72% physicians agreed with annual mammography screening for women aged 50 and older, and only 51% of them agreed with mammography screening between 1 and 2 years for women aged 40 to 49 [20]. According to a 1992 survey regarding a variety of preventive care practice guidelines, 69% physicians agreed with USPSTF recommendations, and 78.3% complied with mammography screening guidelines [21].

Patient utilization of mammography screening is strongly related to physicians' recommendations [22]. Also, improved physician-patient communication could increase mammography use [23]. Women who reported participating with their doctor in the decision to be screened were significantly more likely to adhere to mammography screening guidelines. Other characteristics of women related to having a mammogram included age, family size, education, income, a recent Pap smear, breast problems, and whether lived in an area with a higher percentage of

mammography facilities with reminder systems, no shortage of providers, higher HMO market share, and higher screening charges[24].

When breast cancer guidelines were conflicting, patients' anxiety about cancer, patients' expectations of being tested, and a positive family history of cancer significantly increased the chance that mammography would be ordered. In such situations, good quality patient-physician relationship significantly decreased the chance of ordering a mammogram, and physicians' beliefs about benefits and harms of screening and physicians' sensitivity to their colleagues' practice also influenced mammography screening decisions[25].

History of the USPSTF Breast Cancer Screening Recommendations

The US Preventive Services Task Force (USPSTF), an independent panel of experts in primary care and prevention, was established in 1984 by the US Department of Health and Human Services to develop recommendations for clinical preventive services. The panel, usually drawn from academia or public health, is funded by the federal government. Prior to the passage of the Patient Protection and Affordable Care Act, the USPSTF was strictly an advisory body. The Act requires insurers to cover USPSTF-recommended services without cost-sharing. For all services but mammography, the Act specifies that insurers should use the latest version of USPSTF recommendations. For mammography, the Act specifies that insurers should use the 2002 USPSTF recommendations.

The USPSTF released its first breast cancer screening recommendation in 1989, which called for

annual clinical breast examinations for women aged 40 to 49, and mammography every 1 to 2 year for women aged 50 to 75 [26]. Since the evidence regarding the effectiveness of screening women aged 40 to 49 was not as clear as that of screening women aged 50 and older, the USPSTF did not recommend mammography for women aged 40 to 49 [27]. In 1996, the USPSTF updated the breast cancer screening recommendation and again concluded that there was insufficient evidence to recommend for or against routine mammography or clinical breast examination for women aged 40 to 49 or aged 70 and older[28]. In 2002, the USPSTF issued a grade B recommendation[1] endorsing mammography screening for women aged 40 and older every 1 to 2 years, based on the evidence that mammography screening every 12 to 33 months can significantly reduce mortality from breast cancer. The evidence also indicated a mortality benefit for women undergoing mammography at the age of 40 to 49, and the USPSTF concluded that the evidence was also generalizable to women aged 70 and older[2]. In 2009, the USPSTF revised the 2002 breast cancer recommendation, and recommended biennial mammography screening for women aged 50 to 74 and recommended against routine mammography screening for women aged 40 to 49[1].Unlike previous USPSTF breast cancer recommendations, this newest recommendation sparked controversy and intense critical coverage.

Impact of the 2009 Revised USPSTF Breast Cancer Screening Recommendation

The 2009 revised USPSTF breast cancer screening recommendation is highly controversial.

[1] A grade B recommendation means that the USPSTF recommends the service. There is high certainty that the net benefit is moderate or there is moderate certainty that the net benefit is moderate to substantial.

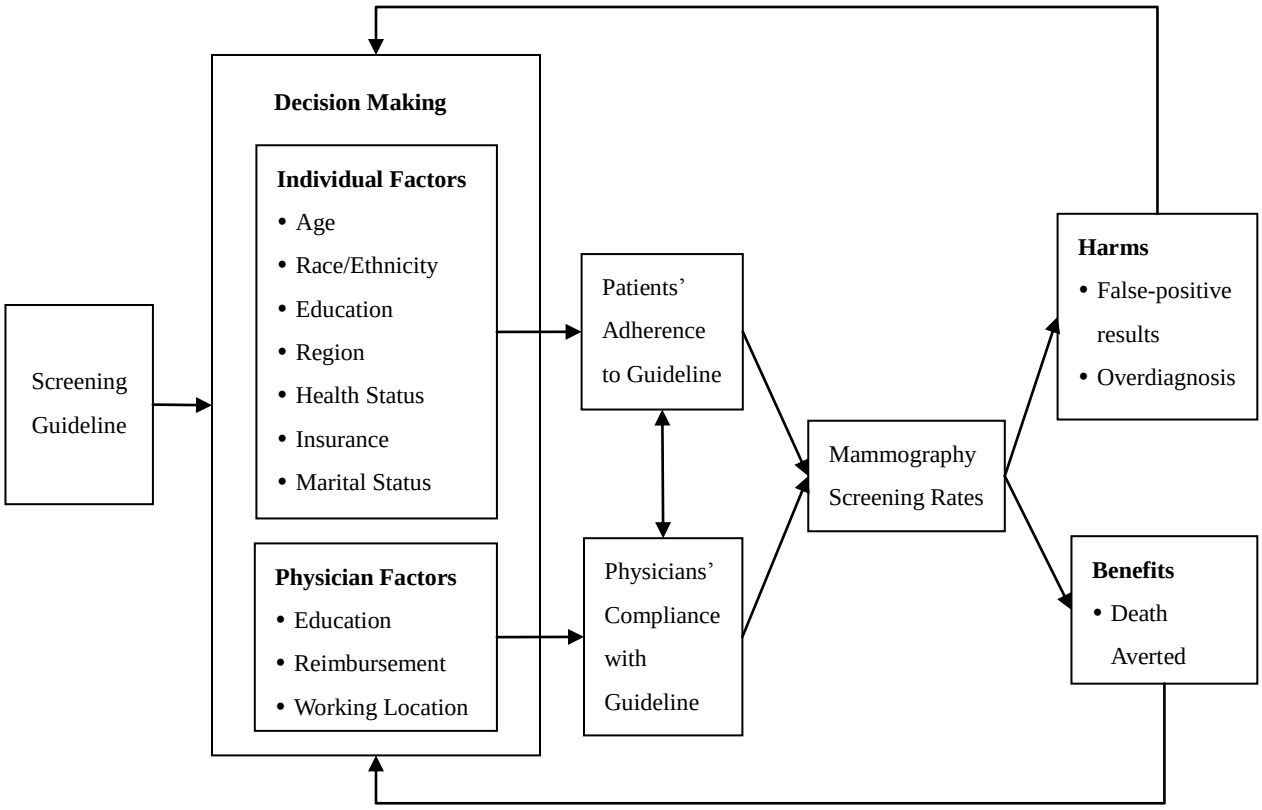
News media was generally critical to this revised recommendation. A survey study conducted in2010 targeting women aged 40 and older has shown that regarding knowledge of the 2009 revised USPSTF recommendation, 29.7% and 36.1% of respondents provided accurate answers regarding the changes to start age and the changes to recommended screening frequency, respectively. 80.6% of the respondents heard about the changes from the news media; in contrast, only 5% of respondents heard about the changes from health care professionals. Among women who were aware of the changes of the revised recommendation, 66% of them had negative attitude about the changes[13]. Another survey study targeting physicians has shown that 92.5% of respondents were aware of the revised guidelines, but only 42.4% of them applied the recommendation to their patient population[12].Patients' awareness of the changes of the revised recommendation was limited, and most physicians did not follow the revised recommendation.

To date, three studies have investigated the impact of the 2009 revised USPSTF recommendation on the mammography use using national datasets and concluded that mammography screening rates did not decrease among women aged 40 to 49 after the release of the 2009 revised recommendation [29-31]. However, survey data with self-reported screening rates are subject to measurement error, which may have made it more difficult to detect small changes in screening rates. The impact of the controversial 2009 USPSTF recommendation on mammography screening practices remains unclear.

Conclusion

Based on the literature, we built a conceptual model, which illustrates how decisions regarding mammography screening are made (Figure 1). The controversy around the 2009 revised USPSTF breast cancer screening recommendation and correspondingly confusion regarding screening among physicians and women this controversy caused may harm the ability of women and physicians to make informed decision on mammography screening. Informed decisions are based on considering the tradeoff between lifesaving benefits and harms of mammography screening. Since the screening rates decide the amount of benefits and harms received by women and the revised recommendation aims to reduce the harms of mammography screening, it is important to know the impact of the revised recommendation on mammography screening rates. If the revised recommendation is followed by some, the mammography screening rates could decline. This decline may be small in magnitude, and cannot be accurately captured by self-report screening measures. Claims data are needed to accurately estimate the impact of the revised recommendation on mammography screening rates. Furthermore, to better understand the impact of the revised recommendation, it is crucial to investigate how the benefits and harms of mammography screening affect the decision regarding mammography screening, such as the impact of the false-positive mammogram on screening behavior.

Figure 1: Conceptual Model



Methodology

This study is guided by a conceptual model that assumes that breast cancer screening decisions are affected by screening guidelines, individual's characteristics, physician's characteristics and perceived benefits and harms of mammography screening. As shown in the Figure 1 in Literature Review, we captured individual factors such as age, region, insurance plan and comorbidities, but were unable to capture some unobservable variables, such as physician's factors and perceived benefits and harms of mammography screening when we examined the impact of the revised recommendation on mammography screening rates. When we examined the impact of false-positive mammogram on screening behavior, we restricted false-positive mammograms to those that requires a biopsy, because biopsies are painful for women and are more likely to be perceived as the harm of mammography screening and have an impact on screening behavior.

Research Questions

Q1: Does the 2009 revised USPSTF breast cancer recommendation lead to a reduction in mammography screening rates among women aged 40 to 49?

Q2: Does a false-positive mammogram requiring a biopsy lower the likelihood of continuing mammography screening?

Hypotheses

H1: The 2009 revised USPSTF breast cancer recommendation led to a reduction in mammography screening rates among women aged 40 to 49.

H2: Women who had a false-positive mammogram that requires a biopsy are less likely to continue mammography screening.

Data

The data were from the Truven Health Analytics MarketScan®Database (previously known as Thomson Reuters MarketScan®Database). This data include private insurance outpatient claims and enrollment records from multiple insurers from 2006 through 2011. These data have several strengths. First, compared to self-reported screenings, insurance claims can measure screening rates more accurately [32, 33]. Second, the claims data allowed us to look at the screening rates by age in years rather than broad age groups as has been done by previous studies. Third, with the large sample size, we can estimate the impact of the recommendation on screening rates and the impact of false-positive mammogram on screening rates more precisely.

Research Question 1

Sample

Our sample consisted of women aged 40 to 59 years who enrolled in private insurance programs for 24 months during either the pre-recommendation period (2008-2009) or the post-recommendation period (2010-2011). We excluded women who had been diagnosed with breast cancer. The final sample included 4,012,292 women for the pre-period and 5,058,953 women for the post-period. There were 2,256,854 women in both pre and post periods. Since the revised recommendation mainly targets women aged 40 to 49, the age group 40 to 49 was the treatment group, and the age group 50 to 59 was the control group. Consequently, we applied a pre-post quasi-experimental study design. Moreover, the size of our sample permitted us to examine screening rates among both broad age categories (eg, 40 to 49) and for each age separately.

Variables

Dependent Variable: Mammography Screening Rate

We used the Healthcare Common Procedure Coding System (HCPCS) codes (76083, 76085, 76092, 77052, 77057, G0202, and G0203) to identify mammography screening. We measured the receipt of mammography screening biennially beginning January 1, 2008. We coded a woman as screened if she had at least one mammography screening during a two-year interval. We measured a woman's age based on the enrollment records and calculated biennial screening rates for each age and by age group (40-49 or 50-59). The dependent variable was a dichotomous variable indicating

whether a woman received at least one mammography screening in pre-period or post-period.

Independent Variables

Age Group (40-49 versus 50-59)—ages were measured based on the first year enrollment records of pre- or post- period. Age group 50-59 was the reference group.

Period (2008-2009 versus 2010-2011)—this dichotomous variable indicates whether the revised recommendation was issued. The period 2008-2009 was the reference group, which means that the revised recommendation had not been issued.

Interaction Term—we included an interaction term for age group and period.

Women's Relation to Employee—this variable included two categories—employee themselves and spouse/other.

Benefit Plan—this variable included three categories HMO/PPO/CDHP, POS and other).

Region—this variable included four categories--northeast, north central, south, and west).

Comorbidity groups—comorbidity groups were grouped to 10 categories based on Elixhauser comorbidity index [34, 35].

We did not include those variables that have large amount of missing values (more than 30%) in our model. However, since those omitted variables were time-invariant, they would not bias our results.

Statistical Analysis

We used two-proportion two-tailed z-tests to compare mammography screening rates, demographic characteristics and comorbidities of each age group in pre period (2008-2009) with that

in post period (2010-2011).

Next, we employed a difference-in-difference approach to estimate the impact of the 2009 revised USPSTF recommendation on mammography screening rates, using a Linear Probability Model (LPM) regression. Because of the large sample size, LPM is more efficient than other models. The difference-in-difference approach compares the change of biennial mammography rates in women aged 40 to 49 (the treatment group) to the change in women aged 50 to 59 (the control group). The difference-in-difference regression equation is as following:

$$\textit{Receipt of Mammography Screening} = b_0 + b_1 \textit{Year10-11(PolicyChange)} + b_2 \textit{Age40-49} + b_3 \textit{Year10-11*Age40-49} + b_4 \textit{Comorbidities} + b_6 \textit{Covariates} + \varepsilon.$$

To examine the bias due to differences in the composition of samples from one year to the next, we used z-tests to compare screening rates in the pre period versus post period by age with the sample that had 2,256,854 women in both pre and post periods. Data were analyzed using SAS version 9.3 (SAS Institute Inc, Cary, NC) and Stata 12 (StataCorp, College Station, Texas).

Research Question 2

Sample

We only included women who were regularly screened, which means they had another mammogram (index screen) within 9 to 15 months after the first negative screen, and there were no

breast cancer diagnoses during this period, and did not have any breast cancer diagnoses within 1 year after the index screen. False-positive mammograms were defined as having a biopsy within 3 months after the index screen. Women who had a mammogram within 3 months after the index screen were excluded. All women had enrolled in private insurance programs from 2006 to 2011, and were followed for at least 2 years, which means that between the date of the index screen and the end of 2011, there were at least 2 years. Our final sample included 578,452 women, in which 13,941 of them had a false-positive mammogram that requires a biopsy (treatment group), and 564,511of them did not have any false-positive mammograms (control group).

Variables

Dependent Variable

In survival analyses, the dependent variable was the time to receive another mammogram from the date of the index screen.

Independent Variables

Age—ages were measured based on the date of the index screen.

False-positive Mammogram—this dichotomous variable indicates whether a woman had a false-positive mammogram that requires a biopsy. Mammograms were identified through the HCPCS codes described in Research Question 1. If a woman had a biopsy within 3 months after the index mammography screen and no breast cancer diagnoses within 1 year after the index screen, we coded this woman as having a false-positive mammogram. We used ICD-9 codes 8511, 8512, 8519, 8521 and HCPCS codes 19120, 19100, 19101, 19102, 19103 to identify biopsies.

Statistical Analysis

We described the characteristics of the treatment group and the control group, and used two-tailed z-test to compare the false-positive rates between women aged 40-49 and women aged 50 to 59. In our survival analyses, women who had a breast cancer diagnosis 1 year after the index screen and women who did not receive a second screen after the index screen by the end of 2011 were censored. Then, we graphed Kaplan-Meier plots of the receipt of a second mammogram to illustrate the differences in the percentage of women who had a second screen between the treatment group and the control group in different time points from the date of the index screen. We ran a Cox proportional hazard regression to estimate the impact of the false-positive mammogram on the likelihood of receiving a second mammogram after the index screen. Data were analyzed using SAS version 9.3 (SAS Institute Inc, Cary, NC) and Stata 12 (StataCorp, College Station, Texas).

Results

Research Question 1

Figure 2 shows pre-recommendation and post-recommendation trend in biennial mammography screening rates from age 35 to 63. The screening rates sharply increased and continued increasing from the age of 40. Compared to the pre period (2008-2009), the biennial screening rates, in the post period (2010-2011), decreased for women aged 40 to 49, and were nearly unchanged for women aged 50 to 59. The differences in screening rates were larger for women right around age 40. The screening rate among women aged 39 was 50.8% and 47.2% in the pre period and the post period, respectively. It was 55.1% and 52.6% respectively among women aged 40, 56.2% and 54.0% among women aged 41, and 57.0% and 55.0% among women aged 42 .

Figure 2: Mammography Screening Rates by Age

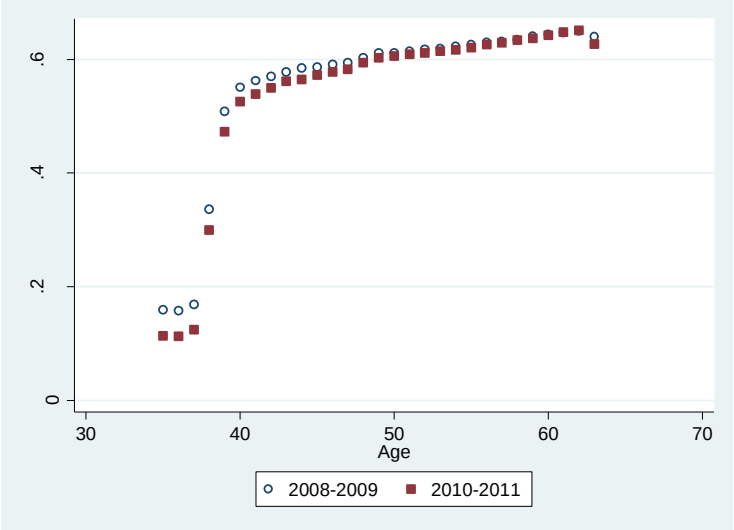


Table 1 displays characteristics of our sample. Between 2008 and 2009, there were 1,947,409 women aged 40 to 49, and 58.48% of them received at least one mammogram; there were 2,064,883 women aged 50 to 59, and 62.46% of them received at least one mammography screening. Between 2010 and 2011, there were 2,451,673 women aged 40 to 49, and 56.90% of them received at least one mammography screening; there were 2,607,280 women aged 50 to 59, and 62.01% of them received at least one mammography screening. Compared to the pre period, the biennial screening rates, in the post period, decreased by 1.58% for the age group of 40-49, and decreased by 0.45% for the age group of 50-59. These differences in biennial screening rates for both age groups were significant ($p<0.001$).

Table 1: Characteristics Summary for Research Question 1

	Age 40-49			**Age 50-59**		
	2008-2009	**2010-2011**	**p-value[a]**	**2008-2009**	**2010-2011**	**p-value[a]**
Sample Size	1,947,409	2,451,673	<0.001	2,064,883	2,607,280	<0.001
Screened	58.5%	56.9%	<0.001	62.5%	62.0%	<0.001
Relation to Employee						
Employee	57.2%	56.6%	<0.001	60.1%	60.7%	<0.001
Spouse /Other	42.8%	43.4%	<0.001	39.9%	39.4%	<0.001
Benefit Plan Link Month 1						
HMO/PPO/CDHP	84.0%	84.0%	0.499	82.0%	81.5%	<0.001
POS	10.6%	7.2%	<0.001	11.3%	8.3%	<0.001
Other/Missing	5.4%	8.9%	<0.001	6.7%	10.2%	<0.001
Region						
Northeast	8.8%	16.1%	<0.001	7.5%	15.6%	<0.001
North Central	24.8%	24.2%	<0.001	26.4%	24.8%	<0.001
South	49.4%	38.9%	<0.001	48.8%	38.3%	<0.001
West	16.7%	20.6%	<0.001	17.0%	21.2%	<0.001
Missing	0.4%	0.2%	<0.001	0.4%	0.2%	<0.001
Comorbidity						
Cardiac Disease	7.13%	6.93%	<0.001	11.09%	10.54%	<0.001
Hypertension	22.18%	20.98%	<0.001	38.18%	35.84%	<0.001

Chronic Pulmonary Disease	10.27%	9.74%	<0.001	11.94%	11.29%	<0.001
Diabetes	7.47%	7.42%	0.059	13.87%	13.34%	<0.001
Cancer	3.49%	3.50%	0.679	6.13%	6.12%	0.874
Rheumatoid Arthritis/collagen	3.49%	3.70%	<0.001	4.74%	4.86%	<0.001
Obesity	5.29%	6.39%	<0.001	4.81%	5.80%	<0.001
Anemia	4.47%	4.71%	<0.001	3.65%	3.71%	<0.001
Alcohol/drug Abuse	0.96%	1.05%	<0.001	0.79%	0.94%	<0.001
Depression	13.01%	13.79%	<0.001	11.79%	12.50%	<0.001

a Two-proportion two tailed z-test

Table 2 displays estimates of the impact of a woman's characteristics on the probability of receiving a mammography screening. For example, women who are covered as employees themselves by private insurance are 3.3% more likely to receive a screening biennially than those who are covered as employees' spouses. The estimate of the interaction term (difference-in-difference estimator) indicates the impact of the revised Task Force recommendation on mammography screening rates, comparing differences in mammography screening rates between 2008 and 2009 for the age group of 40-49 to the differences for the age group of 50-59. The revised recommendation led to a 1.15 percentage point decline in the likelihood of receiving a mammogram among women aged 40 to 49 (P<0.0001).

Table 2: Impact of the Revised Recommendation on the Likelihood of Receiving a Mammogram

	Estimate	**Standard Error**	**p-value**
Age between 40 and 49	-0.0310	0.0005	<.0001
Revised Recommendation Issued	-0.0074	0.0005	<.0001
Interaction Term (age_40_49#1.year_10_11)	-0.0115	0.0007	<.0001
Employee	0.0330	0.0003	<.0001

HMO/PPO/CDHP	-0.0076	0.0006	<.0001
Other Benefit Plans	-0.0228	0.0009	<.0001
North Central	0.0005	0.0005	0.3048
Northeast	0.0306	0.0006	<.0001
South	-0.0166	0.0005	<.0001
Cardiac Disease	0.0334	0.0006	<.0001
Hypertension	0.0620	0.0004	<.0001
Chronic Pulmonary Disease	0.0101	0.0005	<.0001
Diabetes	-0.0187	0.0006	<.0001
Cancer	-0.0680	0.0008	<.0001
Rheumatoid Arthritis/collagen	0.0485	0.0008	<.0001
Obesity	0.0318	0.0007	<.0001
Anemia	0.0557	0.0008	<.0001
Alcohol/drug Abuse	-0.1021	0.0017	<.0001
Depression	0.0446	0.0005	<.0001

Table 3 displays the differences in biennial mammography screening rates between the pre period and the post period by ages from 37 to 61. Compared to the pre period, biennial screening rates decreased significantly in post period for women aged 37 to 47. For women aged 40 who probably hadn't received mammography screening before, the biennial screening rates for this age group decreased by 1.78% in the post period relative to the pre period. For women under 50 who probably have been receiving the screening annually or biennially for years, the biennial screening rates decreased in smaller magnitude or did not change. For women aged 50 to 59 who were less affected by the revised recommendation and probably have been receiving the screening annually or biennially for years, the biennial screening rates were almost unchanged.

Table 3: Mammogram Screening Rates by Age

	Period			
Age	**2008-2009**	**2010-2011**	**Difference**	**p-value[a]**
37	0.175	0.127	-0.048	<0.001

38	0.352	0.315	-0.037	<0.001
39	0.533	0.502	-0.031	<0.001
40	0.577	0.560	-0.018	<0.001
41	0.591	0.573	-0.018	<0.001
42	0.598	0.583	-0.016	<0.001
43	0.606	0.594	-0.012	<0.001
44	0.611	0.597	-0.014	<0.001
45	0.613	0.604	-0.009	<0.001
46	0.616	0.609	-0.007	<0.001
47	0.620	0.613	-0.007	<0.001
48	0.629	0.624	-0.006	0.002
49	0.638	0.633	-0.005	0.007
50	0.636	0.635	-0.001	0.333
51	0.639	0.637	-0.002	0.216
52	0.642	0.638	-0.003	0.446
53	0.645	0.640	-0.005	0.008
54	0.650	0.644	-0.006	<0.001
55	0.651	0.645	-0.006	0.001
56	0.653	0.649	-0.003	0.040
57	0.655	0.652	-0.004	0.037
58	0.661	0.654	-0.007	<0.001
59	0.666	0.659	-0.007	<0.001
60	0.670	0.662	-0.008	<0.001
61	0.657	0.666	0.009	0.938

a Two-proportion right-tailed z-test

Research Question 2

Our study has shown that the false-positive tests rate among women aged 40 to 49 was 0.2 percentage point higher than that among women aged 50 to 59 (2.5% vs. 2.3%, P<0.001).

Table 4 displays characteristics of our sample. There were 13,941 women who had a false-positive mammogram requiring a biopsy (treatment group), and 564,511 women did not have a

false-positive mammogram (control group). The average age of both groups was 51 years old. The percentages of censored observations were similar in two groups.

Table 4: Characteristics Summary for Research Question 2

	Treatment Group	Control Group
Sample size	13,941	562,988
Age	51(36-62)	51(35-63)
End of observation period		
Breast cancer	321(2%)	3,156(1%)
No second screen	3,567(12%)	39,400(7%)
Second screen	11,964(86%)	520,432(92%)

Figure 3 shows the Kplan-Meier plots of receiving a second mammogram (rescreening rates by time), that is, the estimated percentage of women who received another mammogram at a certain time point after the index mammography screen. For women who had a false-positive mammogram that required a biopsy, the estimated rescreening rates in 1, 2, and 3 years after the index screen are 4%, 69% and 85%, respectively. For women who did not have any false-positive mammograms, the estimated rescreening rates in 1, 2, and 3 years after the index screen are 2%, 79% and 91%, respectively. Overall, the estimated rescreening rates are lower among women who had a false-positive mammogram that required a biopsy than among women who did not have any false-positive mammograms, and the effect of a false-positive mammogram is diminishing as time passes.

Figure 3: Kaplan-Meier Plots of Receipt of another Mammogram

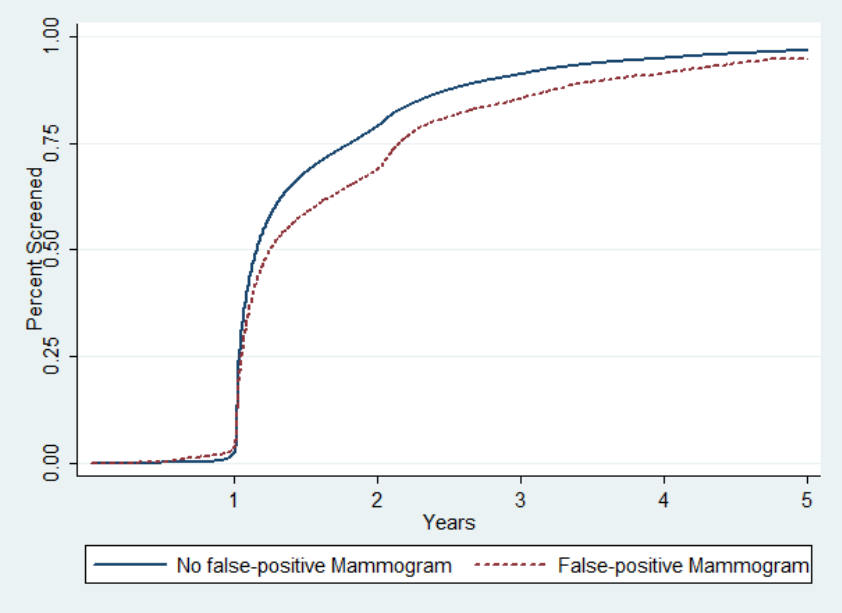


Table 5 displays estimates of the impact of a false-positive mammogram on the likelihood of receiving another mammogram. Women who had a false-positive mammogram that requires a biopsy were 20.5% less likely to receive another mammogram than those who did not have a false-positive mammogram. Also, with 1 year increase in age, the likelihood of receiving another mammogram after the index screen increased by 0.6%.

Table 5: Impact of a False-positive Mammogram on the Likelihood of Receiving another Mammogram

	Mammography Screening	
	Hazard Ratio (95% CI)	P
Age	1.006 (1.005-1.006)	<0.0001
False-positive mammogram	0.797 (0.783-0.811)	<0.0001

Discussion

Summary

Research Question 1

Our study confirmed the hypothesis that the 2009 revised US Preventive Services Task Force breast cancer screening recommendation led to a small decline in the likelihood of receiving a mammogram among women aged 40 to 49. Although a study has shown that American Cancer Society and American College of Obstetricians and Gynecologists guidelines for breast cancer screening were perceived by physicians as more influential than other guidelines[36], our study results suggest that the controversial revised USPSTF recommendation may be followed by some women. The impact of the recommendation was larger among younger women. Women who were about to turn 40 may decide not to begin screening based on the revised USPSTF recommendation. Women aged 40 to 47 may discontinue their routine screening because of the revised recommendation. Our results could help women and physicians to make decisions regarding mammography screening and inform future research.

Research Question 2

The revised USPSTF recommendation aimed to reduce the harm from false-positive mammography tests. As shown in the results chapter, false-positive rates were higher among women

in their 40s than for women in their 50s, and women who had a false-positive test were less likely to receive another mammogram. If we want to reduce the risk of false-positive mammogram among women aged 40 to 49, improving women's knowledge of the harms of false-positive mammogram could be a potential approach. Furthermore, the difference in the false-positive mammogram rates between women aged 40 to 49 and women aged 50 to 59 is consistent with the rationale of the 2009 revised USPSTF breast cancer recommendation that the risk of false-positive mammogram is higher among women aged 40 to 49 than that among women aged 50 and older.

Limitations

Although claims data have some strengths as we discussed in methodology chapter, this data still have some limitations. First, we excluded women who were diagnosed with breast cancer, but it is impossible to know whether other women in our sample had a history of breast cancer diagnosis before study period, which could introduce uncertainty. Second, claims data have limited ability to distinguish mammograms performed for purposes of screening from diagnostic mammograms that are ordered by physicians for symptom,injury,a breast cancer history, the treatment or diagnosis of an illness[37]. However, since the amount of diagnostic mammograms is not influenced by the changes in preventive guidelines and may have not changed during the study period, this limitation of claims data does not severely bias our results. Third, we cannot use claims data to directly identify false-positive mammograms rather, we defined a false-positive mammogram as having a biopsy

within 3 months after the index screen and not having breast cancer diagnoses within 1 year after the index screen. Although this 3-months cut-off could lead to inaccurate false-positive mammogram rates, our conclusion will not be compromised, because the direction of the impact of false-positive mammogram on screening rates, not the magnitude of the impact, is of most interest.

In addition to limitations due to claims data, our study design also has a limitation. For our research question 1, one potential limitation comes from the use of women aged 50-59 as a control group. For this age group, the USPSTF recommended biennial screening in 2009, a change from screening every 1 to 2 years previously. Since the recommended screening frequency decreased, the screening rates among women aged 50 to 59 may decline slightly due to the revised recommendation. This could bias our estimate of the impact of the revised recommendations on the mammography screening rates among women aged 40 to 49, that is, the impact could be underestimated.

Moreover, our estimation of the impact of the revised recommendation is only short-term. While long-term impacts remain to be seen, there is precedent for the idea that immediate impacts are likely to be maintained. For example, after the American Cancer Society and the National Cancer Institute updated their mammography screening guidelines in 1997 to endorse mammography screening among women aged 40 to 49, there was an immediate increase in the receipt of mammography screening[38] and this impact was sustained long-term[39].

Future Research

On one hand, the revised USPSTF breast cancer screening recommendations were intended to reduce the risk of false-positive screening results, overdiagnosis and overuse of mammography screening among women aged 40 to 49, given that breast cancer incidence is relative low in this population[40]. Although the revised USPSTF recommendations led to a decrease in mammography screening rates, and the screening rates may continue to decrease, it is remains to be seen whether this decrease would lead to higher breast cancer mortality in the future. The findings of this study only confirmed 1) that the revised USPSTF recommendations has an impact on mammography screening rates and 2) that false-positive mammograms have a negative impact on screening rates. Whether the risk of mammography screening for women aged 40 to 49 exceeds the benefit of the screening remains to be determined.

On the other hand, the revised USPSTF recommendation emphasized shared decision making between patients and their physicians. Decisions about the starting age for mammography screening depends on the goal of screening, individual objectives, how women balance the benefits and harms of screening and resource considerations [41, 42].However, although women prefer doctor's involvement in their decisions about mammography screening[43, 44], physicians often do not discuss cancer screening tests with their patients[43, 44]. Even for those women who discussed mammography screening with their health care providers, their decision regarding the screening consistently failed to meet criteria for being informed[45], that is, communication with medical

providers of women aged 40 to 49 about the risks and benefits of mammography screening is limited, and thus shared decision making regarding the mammography screening is difficult to achieve[46, 47]. Future research could explore the shared decision making between women and physicians.

Policy Implications

This study has three major policy implications:

1) That the revised recommendation led to decreased screening rates could help policymakers understand how controversial guidelines would affect patients' behavior.

2) The USPSTF and other guideline-writing bodies should work with patient advocacy groups and professional societies to ensure that guidelines are effectively communicated, and reach a consensus, so that the recommendation can have larger impacts.

2) Under the Affordable Care Act, private insurers and Medicare are required to cover preventive services with a US Preventive Services Task Force grade of A or B[48]. Likely because of the controversy around the 2009 revised USPSTF breast cancer screening recommendations, the Affordable Care Act require the Department of Health and Human Services to utilize the 2002 USPSTF breast cancer screening recommendation[49].By confirming the impact of the 2009 revised USPSTF recommendations, this study provides some insights into determining the insurance coverage of mammography screening for women aged 40 to 49.

3) By confirming the negative impact of false-positive mammograms on continuing

mammography screening, this study suggest that the risk of false-positive mammogram could be reduced by improving women's perception of the harm of false-positive mammograms.

Conclusion

Results of this study confirmed the hypotheses stated in the methodology chapter, that is, the 2009 revised USPSTF breast cancer recommendation led to a reduction in mammography screening rates，and women who had a false-positive mammogram that requires a biopsy are less likely to continue mammography screening. This study has demonstrated that even a controversial guideline could affect patients' behavior. This study provides support for the recommendation's rationale that the risk of false-positive mammograms is higher among women ages 40-49 than among women ages 50 and older. Moreover, this study is the first study to examine how false-positive mammograms would affect screening behavior and consequently provides support for the idea that since biopsies are painful, women who had such experience due to false-positive mammograms are more likely to temporarily discontinue mammography screening.

In addition, by confirming our hypotheses, this study provides a roadmap for future research. Policymakers and stakeholders would like to know whether mortality from breast cancer will increase due to the reduction in mammography screening, and whether the harm of mammography screening decreased as the screening use decreased.

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