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Breast Cancer Surveillance Practices Among Women Previously Treated With Chest Radiation for a Childhood Cancer

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Abstract

Context—Women treated with chest radiation for a pediatric malignancy have a significantly increased risk of breast cancer at a young age and are recommended to have an annual screening mammogram starting at age 25 or 8 years after radiation, whichever occurs last.

Objective—Characterize the breast cancer surveillance practices among female pediatric cancer survivors who were treated with chest radiation and identify correlates of screening.

Design, Setting, Participants—Between June 2005 and August 2006, a 114-item questionnaire was administered to a random sample of 625 female pediatric cancer survivors who had been treated

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The **Childhood Cancer Survivor Study (CCSS)** is a collaborative, multi-institutional project, funded as a resource by the National Cancer Institute. The cohort was assembled through the efforts of 26 participating clinical research centers in the United States and Canada. The study is currently funded by a U24 resource grant awarded to St. Jude Children's Research Hospital. For information on contributing centers and how to access and utilize the CCSS resource, visit www.stjude.org/ccss.

with chest radiation and were age 25–50 and participating in the Childhood Cancer Survivor Study (CCSS), a North American cohort of long-term survivors diagnosed from 1970–1986. Comparisons were made with similarly aged pediatric cancer survivors not treated with chest radiation (N=639) and the CCSS siblings cohort (N=712).

Main Outcome Measure—Screening mammogram within the previous two years.

Results—Of 1976 cancer survivors and siblings who were contacted, 87.9% participated. Among the 551 women with a history of chest radiation, 55% reported a screening mammogram in the past two years (ages 25–39, 36.5%; 95% confidence interval [CI], 31.0%–42.0%; ages 40–50, 76.5%; 95% CI, 71.3%–81.7%). In comparison, 40.5% of survivors without chest radiation and 37.0% of CCSS siblings reported a screening mammogram in the same time interval. Notably, among women with a history of chest radiation, 47.3% (95% CI, 41.6%–53.0%) of those under age 40 had never had a mammogram and only 52.6% (95% CI, 46.4%–58.8%) of women ages 40–50 were being regularly screened (two mammograms within four years). Screening rates were higher among women who reported a physician recommendation compared to those who did not (ages 25–39, 76.0% vs. 17.6%; ages 40–50, 87.3% vs. 58.3%). In multivariable models, the association was particularly strong for younger women (ages 25–39, prevalence ratio [PR] = 3.0, 95% CI, 2.0–4.0; ages 40–50, PR = 1.3, 95% CI, 1.1–1.6).

Conclusions—In this study cohort of women who had childhood cancer treated with chest radiation, 63.5% of those aged 25–39 years and 23.5% of those aged 40–50 years had not undergone mammography screening for breast cancer, as recommended by current guidelines for survivors of childhood cancer.

INTRODUCTION

Women treated with chest radiation for a pediatric malignancy face a significantly increased risk of breast cancer at a young age.[1–6] The risk of breast cancer begins to increase by eight years following radiation and the median age of breast cancer diagnosis ranges from 32 to 35 years.[1, 2, 4] Risk of breast cancer is greatest among women who were treated for Hodgkin lymphoma with high dose mantle radiation.[2] By age 45, it is estimated that 12–20% of women treated with moderate to high dose chest radiation will be diagnosed with breast cancer.[1, 2, 4] For perspective, among women with a *BRCA* gene mutation, the estimated cumulative incidence of breast cancer ranges from 1–5% at age 30 and from 10–19% at age 40.[7–11] As in the general population, breast cancer outcomes among childhood cancer survivors are strongly associated with stage at diagnosis.[12–14] Notably, treatment options for these women are often limited due to previous chest radiation and possible exposure to anthracycline chemotherapy.

For the past decade, experts have recommended that women in this risk group initiate breast cancer surveillance with annual screening mammography at age 25.[1–6, 13–19] In 2003, the Children's Oncology Group (COG) developed the *Long-Term Follow-Up Guidelines for Survivors of Childhood, Adolescent, and Young Adult Cancer*.[20, 21] At that time, the COG recommended annual screening mammography for women exposed to moderate to high dose chest radiation (≥ 20 Gy), starting at 25 years of age or 8 years after radiation, whichever occurs last. Recently (2008), the COG updated the guidelines to include an adjunct breast MRI with annual screening mammography. These recommendations are consistent with those of the American Cancer Society and the United Kingdom Department of Health.[22, 23]

To date, there is limited published information describing the breast cancer surveillance practices of women who were treated with chest radiation for a pediatric malignancy.[24–28] The aims of this study were to determine the prevalence of screening mammography and other methods of breast cancer surveillance and to identify predictors of screening in a large and geographically diverse population of young adult women who were treated with chest radiation for a childhood cancer. Breast cancer surveillance practices were compared with two groups: female childhood cancer survivors not exposed to chest radiation and siblings of childhood cancer survivors.

PATIENTS AND METHODS

Childhood Cancer Survivor Study

The methodology of the CCSS and a description of the study participants have been previously published.[29, 30] Briefly, the CCSS cohort consists of survivors of specific childhood cancers (leukemia, brain tumors, Hodgkin lymphoma, non-Hodgkin lymphoma, renal tumors, neuroblastoma, soft tissue sarcomas or bone tumors) who were diagnosed before 21 years of age at one of 26 participating centers between 1970 and 1986, and who were alive at least five years from their original diagnosis, and a comparison cohort of their siblings. The current analysis is based upon 9307 survivors and 2951 siblings who participated in the 2003 CCSS Follow-up Survey (Figure 1). The study was approved by the Institutional Review Board at each participating institution and written informed consent was obtained from each participant.

Target and Comparison Populations

From the CCSS cohort, a random sample of 625 eligible female survivors who were age 25–50 and were treated with ≥ 20 Gy chest radiation (hereafter referred to as "chest RT") were contacted for this study. The upper age limit (50 years) reflected the oldest women with this exposure in the CCSS cohort.

We were interested in comparing the breast cancer surveillance practices of survivors exposed to chest RT with the breast cancer surveillance practices of two groups of women matched on age but without this exposure. To assess the influence of having childhood cancer on screening practices, the first comparison group consisted of female survivors who were not treated with chest radiation ("no chest RT"). The second comparison group represented a non-cancer population and consisted of women who were siblings of survivors in the full CCSS cohort ("CCSS siblings").

Study Design

A 114-item cross-sectional survey was administered by mail and telephone interview between June 6, 2005 and August 24, 2006. The survey can be downloaded from www.stjude.org/ccss.

Primary Outcome

The primary outcome was a screening mammogram within the previous two years. Breast cancer surveillance practices, including screening and diagnostic mammograms, were characterized using twenty-five questions adapted from the *National Health Interview Survey (NHIS) 2000 Cancer Control Module* (http://www.cdc.gov/nchs/nhis.htm).

Independent Variables

The following independent variables were assessed: race and ethnicity, self-described living area (rural, urban, suburban), having a primary care physician or usual source of care, having a written cancer treatment summary, last Pap smear, general preventive health beliefs, survivor-related health beliefs and psychological factors, breast cancer knowledge and breast cancer risk perception. Self-reported race and ethnicity was included because mammography screening rates in the general population vary among racial and ethnic groups.[31, 32]

General preventive health beliefs were measured by four validated *Health Belief Model* items with 5-point Likert style responses. The first two items assessed participants' concern with their general health and interest in routine medical check-ups. The second two items focused on cancer-related concerns: susceptibility to serious health problems related to cancer therapy and importance of a routine check-up to look for these problems. Each pair of items was averaged to give two composite measures (general health and cancer health), ranging from 1 (not at all concerned) to 5 (extremely concerned).[33–35] To assess survivor-related psychological factors that may be associated with health care utilization, 7 items previously developed through a four-step iterative process (unpublished CCSS data) were used. Each was ranked from 1 to 5, with higher scores representing more psychological distress.

Participants were considered to have correct breast cancer knowledge if they responded "true" to the statement: "Women who were treated with radiation to the chest or breast area for childhood cancer are more likely to get breast cancer." Participants who responded "false" or "not sure" were considered to have incorrect knowledge. Perceived risk of breast cancer was assessed using a previously reported 5-point Likert style item asking participants to estimate their chance of developing breast cancer compared to other women.[36, 37] Scores ranged from 1 to 5, with high scores indicating higher perceived risk.

Lastly, the survey included the 13-item *Pros and Cons of Mammography*, a validated instrument developed by Rakowski and colleagues that elicits positive opinions/facilitators and negative opinions/barriers of screening mammography.[38–40] Participants rated their agreement with 6 pros and 7 cons items using a 5-point Likert scale; thus, high pros or cons indicated strong agreement with positive or negative perceptions of screening, respectively.

In this particular survey, we did not ask about health insurance or education. However, from the previous 2003 CCSS Follow-Up Survey administered to the entire CCSS survivor and sibling cohorts, 85.8% of eligible women in our study had health insurance and 80.5% were high school graduates with some college or vocational training.

Statistical Analysis

In the general population, women age 40 and older are recommended to have a screening mammogram every 1–2 years.[41] For this reason, we analyzed data separately for two age groups: 25–39 and 40–50 years. Characteristics of chest RT women and the two comparison groups were assessed and the frequency of mammography, clinical breast examination, breast self-examination, and Pap smear testing were determined. To explore potential differences between non-participants and participants, Fisher's exact test was used.

To evaluate differences in screening mammography between women who received chest RT and the two comparison groups, Poisson regression with robust variance estimates was used to directly estimate prevalence ratios (PRs).[42, 43] Akin to the relative risk, the PR is defined as the ratio of the probability of a screening mammogram in the past 2 years among participants with a particular characteristic relative to the probability of a screening mammogram in the past 2 years among participants without this characteristic. Poisson regression models were used to directly model the PR since the odds ratio from a logistic regression model would not be a good approximation of the PR in this setting with a fairly common outcome. Analyses were adjusted for race/ethnicity and age at study in five-year increments.

Poisson regression was also used to evaluate associations among each independent variable and having a screening mammogram within the past two years. Variables that were potentially associated with the outcome ($p < 0.1$) at the univariate level were assessed by multivariable model. In all analyses, PR and 95% confidence intervals (CI) are reported.

Prior to the study, sample size calculations were carried out to ensure at least 90% power to detect PR of reasonable magnitude for each planned comparison and for a range of assumed outcome prevalences. Corresponding to the reference group prevalences that were subsequently observed in the analyses, we had anticipated sufficient power to detect PR of 1.7 or higher for any proposed comparison.

In this descriptive paper, the two comparison groups were used primarily to provide a background rate of screening mammography for the two age categories. However, the same univariate and multivariable assessment of factors associated with screening mammography was applied to both comparison groups for women ages 40–50 (available at www.stjude.org/ccss).

All statistical analyses were performed with SAS Version 9.1 (SAS Institute Inc., Cary, NC, USA), using two-sided statistical inferences and a significance level of $P \leq 0.05$.

RESULTS

Of 625 women in the chest RT group who were contacted, 551 participated in the study (response rate 88.2%; Figure 1). Table 1 reports selected characteristics of study participants. Participants and non-participants did not differ by age at time of study, age at childhood cancer diagnosis, interval from cancer to time of study, history of Hodgkin lymphoma, or exposure to anthracyclines or alkylating agents. Non-participants were more likely to be racial/ethnic minorities than participants (17.8% vs 7.7%; $P = 0.007$).

Of 639 women in the no chest RT group who were contacted, 561 participated (response rate 87.8%). Participants and non-participants in this comparison group did not differ by age at time of study, age at childhood cancer diagnosis, interval from cancer to time of study, or exposure to anthracyclines or alkylating agents. Non-participants were more likely to be racial/ethnic minorities than participants (19.4% vs 6.8%; $P < 0.001$). Of 712 women in the CCSS siblings group who were contacted, 622 participated (response rate 87.4%). As with the other groups, non-participants were more likely to be racial/ethnic minorities than participants (13.6% vs 5.4%; $P = 0.008$).

Table 2 reports the breast cancer screening practices of women in the study. Among chest RT women ages 25–39, only 36.5% (95% CI, 31.0%–42.0%) reported a screening mammogram within the past two years. While the percent of screening mammograms among chest RT women was much lower than expected, the rate was still higher than among women in the general population (CCSS siblings; 10.6% [95% CI, 7.3%–13.9%]) and women who had a childhood cancer but were not at increased risk of breast cancer (no chest RT; 15.5% [95% CI, 11.4%–19.6%]). However, 47.3% (95% CI, 41.6%–53.0%) of women in the target population, ages 25–39, had never had a mammogram and only 23.3% (95% CI, 18.5%–28.1%) had a screening or diagnostic mammogram within the previous year.

Chest RT women, ages 40–50, were more likely to report mammography than their younger chest RT counterparts, with 76.5% (71.3%–81.7%) reporting a screening mammogram within the past two years compared to 70.0% (95% CI, 64.4%–75.6%) for the no chest RT group ($P = 0.10$) and 67.0% (95% CI, 61.6%–72.4%) for the CCSS sibling group ($P = 0.02$). Importantly, only 52.6% (95% CI, 46.4%–58.8%) of chest RT women, ages 40–50, engaged in regular screening (at least two mammograms within four years). This was not significantly higher than the no chest RT women (48.8%; 95% CI, 42.5%–55.1%; $P = 0.39$) and only modestly higher than the CCSS siblings (41.5%; 95% CI, 39.5%–43.5%; $P < 0.01$). In all groups, women who were older were more likely to have been screened in the prior 2 years or to receive regular screening (Figure 2).

In Table 3, the percent of women who reported a screening mammogram within the past two years, by key characteristics, is provided for the 3 study groups. Table 4 provides univariate and multivariable associations between characteristics of women in the chest RT group, ages 25–39, and the likelihood of reporting a screening mammogram within the preceding two years. As illustrated in Figure 2, age is an important predictor of screening mammography. For each five year incremental increase in age, the likelihood of reporting a mammogram increased nearly twofold (PR = 1.8; 95% CI, 1.5–2.2). However, the strongest predictor of mammography in women ages 25–39 was having a physician recommend the test. The likelihood of reporting a mammogram was 3.0 (95% CI, 2.0–4.0) times higher in women who reported a physician recommendation compared with women who did not report a physician recommendation. Perception of breast cancer risk also predicted screening mammography (PR = 1.3; 95% CI, 1.1–1.5). Lastly, women who felt that the pros of mammography outweighed the cons (positive decisional balance) were more likely to report a screening mammogram (PR = 1.1; 95% CI, 1.0–1.2). The two most commonly mentioned barriers to screening mammography among women 25–39 years of age who did not have a mammogram in the previous two years were “Doctor didn’t order it” (31%) and “I’m too young” (30%).

Table 5 provides univariate and multivariable associations between characteristics of women in the chest RT group, ages 40–50, and the likelihood of reporting a screening mammogram. In the final multivariable model, the significant predictors of reporting at least one screening mammogram in the previous two years (versus none), in addition to older age, were: having a primary care physician (PR = 1.5; 95% CI, 1.1–2.3), physician recommendation (PR = 1.3; 95% CI, 1.1–1.6), awareness of increased risk of breast cancer associated with chest radiation (PR = 1.2; 95% CI, 1.1–1.4), increased general health concerns (PR = 1.2; 95% CI, 1.1–1.3), and positive decisional balance in pros and cons of mammography (PR = 1.1; 95% CI, 1.0–1.1). The two most important barriers ranked by women in this age group who did not have a mammogram in the previous two years were “Put it off/didn’t get around to it” (27%) and “Too expensive/no insurance/cost” (17%).

DISCUSSION

We estimate that in the United States, there are approximately 20–25,000 women who are 25 years or older and were treated for a pediatric malignancy with moderate to high dose chest radiation.[44, 45] Worldwide, about 18–20% of female adult survivors of childhood cancer have been exposed to chest radiation. In the past fifteen years, numerous studies have reported on the risk of breast cancer among young women treated with chest radiation for a pediatric malignancy.[1–6, 12–19, 24, 25] Based upon these studies, breast cancer screening with annual mammography has been recommended, starting around the age of 25.[1–6, 13–19] Importantly, most women in this risk group are not followed at a cancer center and they and their clinician may not be aware of this risk or the screening recommendations.[46]

This is the first large study that we are aware of to provide a detailed assessment of the breast cancer surveillance practices of young women, ages 25–50, in this high risk population. There were several notable findings. Nearly half of the women under age forty have never had a mammogram. Encouragingly, the likelihood of initiating screening increased with age; over 75% of women forty years and older reported a screening mammogram within the previous two years. For perspective, data from the 2006 Behavioral Risk Factor Surveillance System survey indicates that 69% of U.S. women ages 40–49 reported a mammogram within the past two years.[47] However, only half were established in a regular pattern of screening (at least two screening mammograms within the past four years). Though they have a significantly higher risk of breast cancer than women in the general population, their screening rates in this age period (40–50 years) were only minimally higher than women in the two comparison groups.

Breast cancer screening, beginning at age 30, is recommended for women with a familial risk of breast cancer.[23] In the 2000 NHIS, there were 480 women ages 30–49 with a first-degree relative with either breast or ovarian cancer. Wu and colleagues reported that 23.4% and 55.7% of women ages 30–39 and 40–49, respectively, reported a mammogram (screening or diagnostic) within the past year.[48] Similarly, among 551 women in our study, 23.3% and 53.6% of those who were ages 25–39 and 40–50, respectively, reported a mammogram (screening or diagnostic) within the past year. Although the mammography rates for women in our study were similar to this other high risk population, both were markedly lower than recommended.

There was not a lack of medical contact among our study participants; 92% reported a clinical breast exam within the previous two years and almost 90% had a recent Pap smear. Despite this high rate of clinical contact focused on women's heath issues, only half of participants reported that a health care professional had recommended a mammogram in the past year. This was particularly evident among younger women, ages 25–39: 72% reported a clinical breast exam within the past year, but only 33% reported a physician recommendation for a mammogram. Women who received a recommendation were three times as likely to have a mammogram. The importance of physician recommendation has been similarly reported for women with a familial risk of breast cancer[49] and women age 40 and older in the general population.[31] While a variety of factors undoubtedly contribute to a physician recommendation for mammography, one of the primary barriers is likely a lack of clinician familiarity with childhood cancer survivors and their risk of breast cancer. This is supported by our finding that women age 40 and older were more likely to report a physician recommendation than women age 25–39. Thus, studies evaluating the effectiveness of clinician-based interventions are warranted.

This study also provides key insights for developing targeted interventions for women at risk of breast cancer following chest radiation. Having a positive view of screening mammography, reflected by the pros of mammography outweighing the cons, was associated with an increased likelihood of screening, regardless of age. Other facilitators and barriers to screening varied by age group and should be considered when developing targeted screening interventions for this population. One issue that may be raised when designing an intervention aimed at increasing the rate of breast cancer surveillance among this population is the potential harm associated with further radiation exposure with mammography. Among younger women with a *BRCA* gene mutation, it has been suggested that the increased risk of radiation-induced breast cancers may outweigh the benefit of mammography.[50] However, this is less likely to be an issue among women treated with moderate to high dose therapeutic chest radiation. The estimated dose of radiation with a standard 2-view screening mammogram is about 3.85 mGy.[50–52] In other words, for a woman who has been treated with 3500 cGy mantle irradiation, a single 2-view screening mammogram increases the radiation exposure from 3500 cGy to 3500.385 cGy. Assuming an annual 2-view screening mammogram from age 25 to age 69 (44 years), the cumulative radiation exposure would be 16.94 cGy, thus increasing the radiation exposure in this woman from 3500 cGy to 3516.94 cGy (an increase of less than 1% of the net radiation exposure). While it is not known if this small incremental increase in radiation exposure will significantly affect risk of breast cancer in someone who has already had moderate to high dose therapeutic irradiation, international expert panels and cooperative groups continue to recommend annual screening mammograms with breast MRI in this population.[1–6, 13–23]

When interpreting our study findings, it is important to consider several limitations. Mammogram history was provided by self-report without validation of medical records. However, mammography self-report correlates well with confirmed radiology reports[53] and has been used in other studies, including the NHIS.[48,49,54] Since the study cohort is not population-based, selection bias should be considered when generalizing the findings. That being said, the CCSS is the largest cohort of childhood cancer survivors and previous findings regarding morbidity and mortality are similar to those in smaller population-based studies from Europe.[4, 42, 55–57] The study sample was predominantly white, non-Hispanic and thus the findings may under or overestimate the breast cancer surveillance practices of ethnic or minority groups. Lastly, the participants in this study, including women in our target population and the two comparison groups, have participated in a longitudinal cohort for over ten years and have been receiving regular newsletters highlighting ways to maintain or improve health, including appropriate cancer screening. It is likely that women in this cohort, as evidenced by their high adherence to general women's health recommendations, represent a highly motivated and educated group. Thus, our estimates of breast cancer screening rates, while much lower than recommended, may overestimate the rates among the many women in this risk group who are not participants in the CCSS, highlighting low screening rates nationally for pediatric cancer survivors.

In summary, our study suggests that most young women at risk of breast cancer following chest radiation for a pediatric cancer, including women at highest risk (Hodgkin lymphoma survivors), are not being appropriately screened. Findings from this study should provide the foundation for targeted interventions involving both clinicians and cancer survivors.

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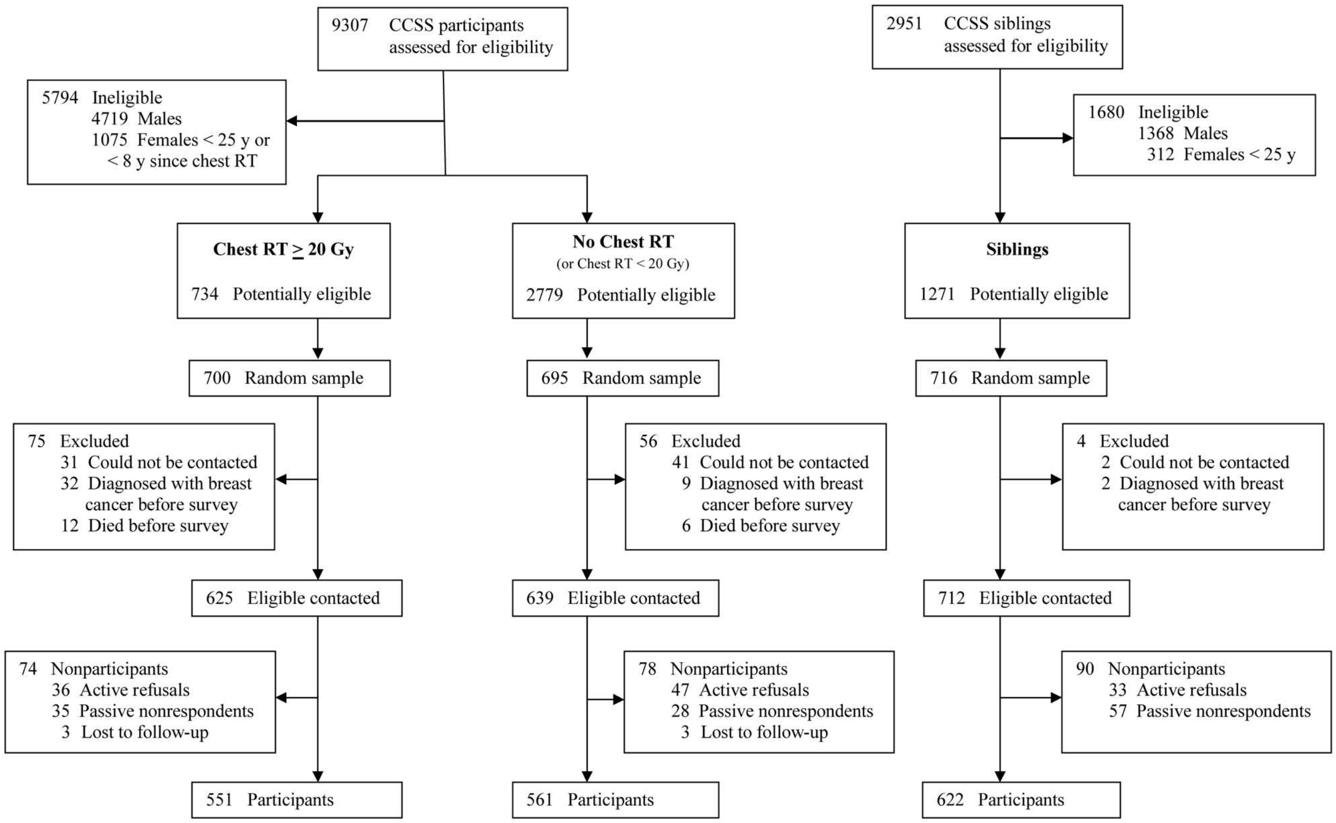
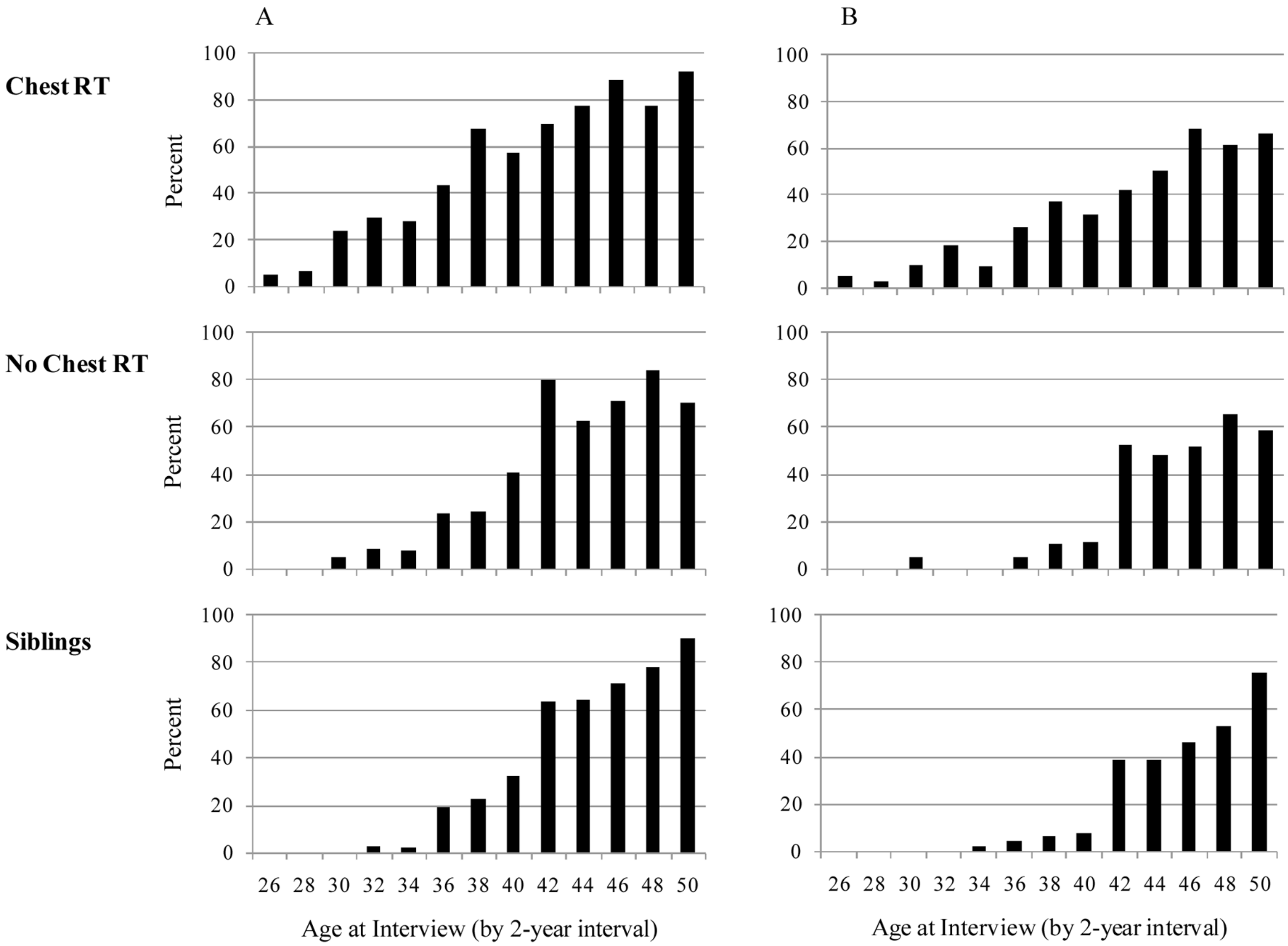


Figure 1.
Flow diagram of participants in the study cohort



No.	25-26	27-28	29-30	31-32	33-34	35-36	37-38	39-40	41-42	43-44	45-46	47-48	49-50
Chest RT	21	33	21	34	54	53	53	54	67	63	54	31	13
No Chest RT	15	34	22	35	54	64	50	57	71	56	55	31	17
Siblings	14	36	34	36	48	74	66	53	75	76	52	37	21

Figure 2.

Proportion of participants reporting screening mammogram frequency of at least one in the last two years (Panel A) or at least two within the last four years (Panel B). 30

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Table 1

Characteristics of participants*

	Ages 25–39						Ages 40–50					
	Chest RT (n=296)		No Chest RT (n=304)		CCSS Siblings (n=331)		Chest RT (n=255)		No Chest RT (n=257)		CCSS Siblings (n=291)	
Characteristics	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Age at time of study												
25–29 y	63	21.3	64	21.0	64	19.3						
30–34 y	100	33.8	96	31.6	104	31.4						
35–39 y	133	44.9	144	47.4	163	49.2						
40–44 y							157	61.6	154	59.9	181	62.2
45–50 y							98	38.4	103	40.1	110	37.8
Race and ethnicity												
White, non-Hispanic	268	90.8	279	92.4	300	93.8	240	94.1	241	94.1	272	95.8
Minority	27	9.2	23	7.6	20	6.2	15	5.9	15	5.9	12	4.2
Self-described living area												
Rural	81	28.4	90	30.8	101	31.3	87	35.4	82	32.4	90	31.4
Urban	70	24.6	61	20.9	56	17.3	62	25.2	51	20.2	45	15.7
Suburban	134	47.0	141	48.3	166	51.4	97	39.4	120	47.4	152	53.0
Primary care physician#												
Yes	271	91.6	279	91.8	305	92.1	237	92.9	246	95.7	277	95.2
No	25	8.4	25	8.2	26	7.9	18	7.1	11	4.3	14	4.8
Cancer diagnosis												
Hodgkin lymphoma	118	39.9	5	1.6	N/A		200	78.4	10	3.9	N/A	
Wilms tumor	72	24.3	35	11.5			3	1.2	5	1.9		
Neuroblastoma	32	10.8	14	4.6			1	0.4	3	1.2		
Non-Hodgkin lymphoma	25	8.4	13	4.3			22	8.6	13	5.1		
Soft tissue sarcoma	17	5.7	35	11.5			9	3.5	41	16.0		
Bone tumor	16	5.4	27	8.9			15	5.9	76	29.6		
Leukemia	13	4.4	128	42.1			2	0.8	70	27.2		
CNS tumor	3	1.0	47	15.5			3	1.2	39	15.2		

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	Ages 25–39						Ages 40–50					
	Chest RT (n=296)		No Chest RT (n=304)		CCSS Siblings (n=331)		Chest RT (n=255)		No Chest RT (n=257)		CCSS Siblings (n=291)	
Characteristics	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Age at cancer diagnosis												
0–9 y	163	55.1	209	68.8	N/A		20	7.8	31	12.1	N/A	
10–20 y	133	44.9	95	31.2			235	92.2	226	87.9		

*No. (%) is based on the total participants with available data for each variable. Percentages may not equal 100 due to rounding

#Primary care physician or usual source of care

Abbreviation: RT, radiation therapy

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Table 2

Participants' cancer screening practices, by categories of age at study, for women treated with chest radiation (Chest RT), compared with women who survived cancer but were not treated with chest radiation (No Chest RT) and women who are siblings of CCSS survivors[*]

Ages 25 – 39											
	Chest RT (N=296)			No Chest RT (N=304)			CCSS Siblings (N=331)				
Outcome	**N**	**%**	**95% CI** [†]	**N**	**%**	**95% CI** [†]	**N**	**%**	**95% CI** [†]	***P***[a]	***P***[b]
Mammogram History											
Most recent mammogram[#]											
Within the past year	69	23.3	18.5 – 28.1	32	10.5	7.1 – 13.9	32	9.7	6.5 – 12.9	<0.01	<0.01
1–2 years ago	43	14.5	10.5 – 18.5	20	6.6	3.8 – 9.4	22	6.7	3.9 – 9.3	<0.01	<0.01
≥3 years ago	44	14.9	10.8 – 19.0	47	15.5	11.3 – 19.5	29	8.8	5.7 – 11.9	0.96	0.02
Never	140	47.3	41.6 – 53.0	205	67.4	62.1 – 72.7	248	74.9	70.2 – 79.6	<0.01	<0.01
Screening mammogram, last 2 years	108	36.5	31.0 – 42.0	47	15.5	11.4 – 19.6	35	10.6	7.3 – 13.9	<0.01	<0.01
Regular screening (≥2 in last 4 years)	53	18.6	14.1 – 23.1	12	4.0	1.8 – 6.2	9	2.7	0.9 – 4.5	<0.01	<0.01
Other Cancer Screening Practices											
Breast self exam, most months	113	38.4	32.8 – 44.0	121	39.8	34.3 – 45.3	99	29.9	25.0 – 34.8	0.73	0.02
Clinical breast exam, within past year	212	71.6	66.5 – 76.7	195	64.4	59.0 – 69.8	217	65.6	60.5 – 70.7	0.08	0.07
Pap smear, within last 2 years	271	91.9	88.8 – 95.0	257	85.1	81.1 – 89.1	300	91.2	88.1 – 94.3	<0.01	0.61

Ages 40 – 50										
	Chest RT (N=255)			No Chest RT (N=297)			CCSS Siblings (N=291)				
Outcome	**N**	**%**	**95% CI** [†]	**N**	**%**	**95% CI** [†]	**N**	**%**	**95% CI** [†]	P^a	P^b
Mammogram History											
Most recent mammogram[#]											
Within the past year	135	53.6	47.4 – 59.8	127	49.6	43.5 – 55.7	147	50.7	44.9 – 56.5	0.38	0.53
1–2 years ago	61	24.2	18.9 – 29.5	57	22.3	17.2 – 27.4	52	17.9	13.5 – 22.3	0.60	0.08
≥3 years ago	36	14.3	10.0 – 18.6	38	14.8	10.5 – 19.1	45	15.5	11.3 – 19.7	0.84	0.74
Never	20	7.9	4.6 – 11.2	34	13.3	9.1 – 17.5	46	15.9	11.6 – 20.0	0.06	<0.01
Screening mammogram, last 2 years	195	76.5	71.3 – 81.7	180	70.0	64.4 – 75.6	195	67.0	61.6 – 72.4	0.10	0.02
Regular screening (≥2 in last 4 years)	130	52.6	46.4 – 58.8	119	48.8	42.5 – 55.1	117	41.5	39.5 – 43.5	0.39	<0.01
Other Cancer Screening Practices											
Breast self exam, most months	100	39.2	33.2 – 45.2	87	34.0	28.2 – 39.8	101	34.8	29.3 – 40.3	0.22	0.29
Clinical breast exam, within past year	181	71.3	65.7 – 76.9	165	64.7	58.8 – 70.6	194	66.9	61.5 – 72.3	0.12	0.32
Pap smear, within last 2 years	213	83.9	79.4 – 88.4	219	85.6	81.3 – 89.9	252	86.9	83.0 – 90.8	0.51	0.30

[*] Multivariable Poisson regression model with robust variance estimates, adjusted for age at time of study and race/ethnicity; percentages refer to column %

[†] 95% confidence interval (CI) from binomial distribution (normal approximation)

P^a = Chest RT versus No Chest RT;

P^b = Chest RT versus CCSS Siblings

[#] Screening or diagnostic mammogram

Table 3

Number and percent, by participant characteristics, reporting a screening mammogram in the last two years*

	Ages 25 – 39								
	Chest RT			**No Chest RT**			**CCSS Siblings**		
Characteristics	**N**	**%**	**95% CI** †	**N**	**%**	**95% CI** †	**N**	**%**	**95% CI** †
Total	108	36.5	31.0 – 42.0	47	15.5	11.4 – 19.6	35	10.6	7.3 – 13.9
Age at time of study									
25–29 y	5	7.9	2.6 – 17.5	0	0	0 - 0	0	0	0 - 0
30–34 y	28	28.0	19.2 – 36.8	8	8.3	2.8 – 13.8	2	1.9	0.2 – 6.8
35–39 y	75	56.4	47.9 – 64.7	39	27.1	19.8 – 34.4	33	20.3	14.1 – 26.5
Age at cancer diagnosis									
0–9 y	41	25.2	18.5 – 31.9	24	11.5	7.2 – 15.8		N/A	
10–20 y	67	50.4	41.9 – 58.9	23	24.2	15.6 – 32.8			
Race and ethnicity									
White, non-Hispanic	100	37.3	31.5 – 43.1	42	15.1	10.9 – 19.3	34	11.3	7.7 – 14.9
Minority	8	29.6	12.4 – 46.8	5	21.7	7.3 – 43.7	0	0	0 - 0
Self-described living area									
Rural	29	35.8	25.4 – 46.2	14	15.6	8.1 – 23.1	10	9.9	4.1 – 15.7
Urban	22	31.4	20.5 – 42.3	9	14.8	5.9 – 23.7	7	12.5	3.8 – 21.2
Suburban	54	40.3	32.0 – 48.6	23	16.3	10.2 – 22.4	16	9.6	5.1 – 14.1
Primary care physician									
Yes	102	37.6	31.8 – 43.4	43	15.4	11.2 – 19.6	33	10.8	7.3 – 14.3
No	6	24.0	7.3 – 40.7	4	16.0	4.5 – 36.1	2	7.7	0.9 – 25.1
Physician recommendation¶									
Yes	73	76.0	67.5 – 84.5	25	61.0	46.0 – 75.8	23	50.0	35.6 – 64.4
No	35	17.6	12.3 – 22.9	22	8.4	5.0 – 11.8	12	4.2	1.9 – 6.5
Cancer treatment summary									
Yes	46	43.4	34.0 – 52.8	18	21.7	12.8 – 30.6		N/A	
No or don't know	60	32.6	25.8 – 39.4	29	13.4	8.9 – 17.9			
Chest RT increases BC risk									
Correct knowledge	71	51.8	43.4 – 60.2	8	15.1	5.5 – 24.7		N/A	

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	Ages 25 – 39								
	Chest RT			No Chest RT			CCSS Siblings		
Characteristics	**N**	**%**	**95% CI †**	**N**	**%**	**95% CI †**	**N**	**%**	**95% CI †**
Incorrect knowledge	37	23.4	16.8 – 30.0	39	15.7	11.1 – 20.1			

	Ages 40 – 50								
	Chest RT			No Chest RT			CCSS Siblings		
Characteristics	**N**	**%**	**95% CI †**	**N**	**%**	**95% CI †**	**N**	**%**	**95% CI †**
Total	195	76.5	71.3 – 81.7	180	70.0	64.4 – 75.6	195	67.0	61.6 – 72.4
Age at time of study									
40–44 y	111	70.7	62.8 – 77.2	103	66.9	59.4 – 74.2	110	60.8	53.6 – 67.8
45–50 y	84	85.7	78.8 – 92.6	77	74.8	66.4 – 83.2	85	77.3	69.5 – 85.1
Age at cancer diagnosis									
0–9 y	10	50.0	28.1 – 71.9	16	51.6	34.0 – 69.2		N/A	
10–20 y	185	78.7	73.5 – 83.9	164	72.6	70.0 – 81.2			
Race and ethnicity									
White, non-Hispanic	185	77.1	71.7 – 82.3	170	70.5	64.8 – 76.4	182	66.9	61.3 – 72.5
Minority	10	66.7	42.8 – 90.6	10	66.7	42.8 – 90.6	9	75.0	50.5 – 99.5
Self-described living area									
Rural	60	69.0	59.2 – 78.6	52	63.4	53.0 – 73.8	61	67.8	58.1 – 77.5
Urban	48	77.4	67.0 – 87.8	31	60.8	47.4 – 74.2	27	60.0	45.7 – 74.3
Suburban	80	82.5	74.8 – 90.0	95	79.2	71.8 – 86.4	105	69.1	61.8 – 76.4
Primary care physician									
Yes	187	78.9	73.7 – 84.1	173	70.3	64.6 – 76.0	186	67.2	61.7 – 72.7
No	8	44.4	21.4 – 67.4	7	63.6	35.2 – 92.0	9	64.3	39.2 – 89.4
Physician recommendation ¶									
Yes	138	87.3	82.1 – 92.5	123	80.4	74.1 – 86.7	133	80.6	74.7 – 86.9

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	Ages 40 – 50								
	Chest RT			**No Chest RT**			**CCSS Siblings**		
Characteristics	**N**	**%**	**95% CI** †	**N**	**%**	**95% CI** †	**N**	**%**	**95% CI** †
No	56	58.3	48.4 – 68.2	57	55.3	45.7 – 64.9	61	48.8	39.6 – 57.2
Cancer treatment summary									
Yes	58	84.1	75.5 – 92.7	42	67.7	56.1 – 79.3		N/A	
No or don't know	135	73.8	67.3 – 80.1	136	70.8	64.4 – 77.2			
Chest RT increases BC risk									
Correct knowledge	116	87.2	81.5 – 92.9	32	74.4	61.4 – 87.4		N/A	
Incorrect knowledge	76	63.9	55.2 – 72.4	146	69.5	63.3 – 75.7			

*Percentages refer to row %

†95% confidence interval (CI) from binomial distribution (exact if cell count ≤ 5; all others from normal approximation)

¶A physician or other health care professional recommended a mammogram within the past year

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Table 4

Univariate and multivariable comparison of women treated with chest radiation who have reported at least one screening mammogram in the last two years versus none, ages 25–39 years

	No Screen (n=188)		Screen (n=108)		Univariate Analysis			Multivariable Model[¶]		
Characteristics	**N**	**%**	**N**	**%**	**PR**	**95% CI**	**P-value**	**PR**	**95% CI**	**P-value**
Age at time of study										
Mean (SD)	32.6	(4.0)	35.9	(3.0)	2.2[†]	1.8 – 2.8	<0.001	1.8[†]	1.5 – 2.2	<0.001
Age at cancer diagnosis										
Mean (SD)	7.7	(5.0)	11.2	(5.2)	1.5[†]	1.3 – 1.7	<0.001			
Race and ethnicity										
White, non-Hispanic	168	62.7	100	37.3	1.3	0.7 – 2.3	0.452			
Minority (referent)	19	70.4	8	29.6	1.0					
Self-described living area										
Rural (referent)	52	64.2	29	35.8	1.0					
Urban	48	68.6	22	31.4	0.9	0.5 – 1.5	0.572			
Suburban	80	59.7	54	40.3	1.1	0.7 – 1.8	0.516			
Primary care physician										
Yes	169	62.4	102	37.6	1.6	0.7 – 3.2	0.216			
No (referent)	19	76.0	6	24.0	1.0					
Physician recommendation										
Yes	23	24.0	73	76.0	4.3	3.1 – 5.9	<0.001	3.0	2.0 – 4.0	<0.001
No (referent)	164	82.4	35	17.6	1.0			1.0		
Cancer treatment summary										
Yes	60	56.6	46	43.4	1.3	1.0 – 1.8	0.063			
No or don't know (referent)	124	67.4	60	32.6	1.0					
Chest RT increases BC risk										
Correct knowledge	66	48.2	71	51.8	2.2	1.6 – 3.1	<0.001			
Incorrect knowledge (referent)	121	76.6	37	23.4	1.0					
Health beliefs										
General health concern	3.8	(0.9)	3.9	(0.8)	1.1[*]	0.9 – 1.3	0.176			
Cancer health concern	3.5	(1.1)	4.1	(1.0)	1.4[*]	1.2 – 1.7	<0.001			
BC risk perception	3.5	(0.8)	3.9	(0.7)	1.6[*]	1.3 – 1.9	<0.001	1.3[*]	1.1 – 1.5	0.001

	No Screen (n=188)		Screen (n=108)		Univariate Analysis			Multivariable Model[¶]		
Characteristics	**N**	**%**	**N**	**%**	**PR**	**95% CI**	**P-value**	**PR**	**95% CI**	**P-value**
Pros/cons of mammography										
Pros t-score[‖]	48.7	(10.3)	53.5	(8.3)	1.2[‡]	1.1 – 1.3	<0.001			
Cons t-score[‖]	51.2	(9.6)	43.3	(7.9)	0.8[‡]	0.7 – 0.8	<0.001			
Decisional balance	−2.4	(16.9)	10.3	(13.3)	1.4[‡]	1.3 – 1.5	<0.001	1.1[‡]	1.0 – 1.2	0.006

[¶]Notes: Poisson regression using backward selection with $p \leq 0.05$ to remain in model;

[†]Prevalence ratio (PR) for each five year increase in age;

[*]PR for each 1 unit increase on a 5-point Likert scale, where 1=not at all concerned/much less than the average woman and 5=extremely concerned/much more than the average woman;

[‖]Pros t-score and cons t-score standardized for all participants age 25–39 and omitted from multivariable model due to overlap with decisional balance;

[‡]PR for each 5 unit increase in pros t-score or cons t-score and for each 10 unit increase in decisional balance

Table 5

Univariate and multivariable comparison of women treated with chest radiation who have reported at least one screening mammogram in the last two years versus none, ages 40–50 years

	No Screen (n=60)		Screen (n=195)		Univariate Analysis			Multivariable Model[¶]		
Characteristics	**N**	**%**	**N**	**%**	**PR**	**95% CI**	**P-value**	**PR**	**95% CI**	**P-value**
Age at time of study										
Mean (SD)	43.4	(2.7)	44.5	(2.6)	1.2[†]	1.1 – 1.3	0.007	1.2[†]	1.1 – 1.4	<0.001
Age at cancer diagnosis										
Mean (SD)	14.9	(4.2)	15.9	(3.2)	1.1[†]	0.9 – 1.2	0.090			
Race and ethnicity										
White, non-Hispanic	55	22.9	185	77.1	1.2	0.8 – 1.7	0.434			
Minority (referent)	5	33.3	10	66.7	1.0					
Self-described living area										
Rural (referent)	27	31.0	60	69.0	1.0					
Urban	14	22.6	48	77.4	1.1	0.9 – 1.4	0.245			
Suburban	17	17.5	80	82.5	1.2	1.0 – 1.4	0.037			
Primary care physician										
Yes	50	21.1	187	78.9	1.8	1.1 – 3.0	0.030	1.5	1.1 – 2.3	0.040
No (referent)	10	55.6	8	44.4	1.0			1.0		
Physician recommendation										
Yes	20	12.7	138	87.3	1.5	1.3 – 1.8	<0.001	1.3	1.1 – 1.6	0.002
No (referent)	40	41.7	56	58.3	1.0			1.0		
Cancer treatment summary										
Yes	11	15.9	58	84.1	1.1	0.9 – 1.3	0.056			
No or don't know (referent)	48	26.2	135	73.8	1.0					
Chest RT increases BC risk										
Correct knowledge	17	12.8	116	87.2	1.4	1.2 – 1.6	<0.001	1.2	1.1 – 1.4	0.007
Incorrect knowledge (referent)	43	36.1	76	63.9	1.0			1.0		
Health beliefs										
General health concern	3.4	(1.0)	4.1	(0.8)	1.2[*]	1.1 – 1.3	<0.001	1.2[*]	1.1 – 1.3	<0.001
Cancer health concern	3.4	(1.1)	4.1	(0.9)	1.2[*]	1.1 – 1.2	<0.001			
BC risk perception	3.6	(0.7)	3.9	(0.8)	1.1[*]	1.0 – 1.2	0.009			

	No Screen (n=60)		Screen (n=195)		Univariate Analysis			Multivariable Model[¶]		
Characteristics	**N**	**%**	**N**	**%**	**PR**	**95% CI**	**P-value**	**PR**	**95% CI**	**P-value**
Pros/cons of mammography										
Pros t-score[||]	44.7	(10.4)	51.9	(9.3)	1.1[‡]	1.0 – 1.1	<0.001			
Cons t-score[||]	55.5	(9.6)	47.4	(8.7)	0.9[‡]	0.8 – 0.9	<0.001			
Decisional balance	−10.9	(17.0)	4.5	(15.6)	1.1[‡]	1.1 – 1.2	<0.001	1.1[‡]	1.0 – 1.1	0.009

[¶]Notes: Poisson regression using backward selection with p≤ 0.05 to remain in model;

[†]Prevalence ratio (PR) for each five year increase in age;

[*]PR for each 1 unit increase on a 5-point Likert scale, where 1=not at all concerned/much less than the average woman and 5=extremely concerned/much more than the average woman;

[||]Pros t-score and cons t-score standardized for all participants age 40–50 and omitted from multivariable model due to overlap with decisional balance;

[‡]PR for each 5 unit increase in pros t-score or cons t-score and for each 10 unit increase in decisional balance