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# Factors associated with guideline-concordant use of radiation therapy after mastectomy in the National Comprehensive Cancer Network

**Rinaa S. Punglia, MD, MPH**, **Melissa E. Hughes, MSc**, **Stephen B. Edge, MD**, **Richard L. Theriault, DO**, **Michael A. Bookman, MD**, **John L. Wilson, PhD**, **Rebecca A. Ottesen, MS**, **Joyce C. Niland, PhD**, and **Jane C. Weeks, MD, MSc**
Dana-Farber Cancer Institute, Boston, MA (RSP, MEH, JCW); Roswell Park Cancer Institute, Buffalo, NY (SBE); MD Anderson Cancer Center, Houston, TX (RLT); Fox Chase Cancer Center, Philadelphia, PA (MAB); Arthur James Cancer Hospital and Richard Solove Research Institute at the Ohio State University, Columbus, OH (JW); City of Hope National Medical Center, Duarte, CA (RO, JCN).

## Abstract

**Purpose—**We examined rates and determinants of appropriate and inappropriate use of post-mastectomy radiation (PMRT), as defined by NCCN practice guidelines, among women with Stage I-II breast cancer (AJCC 5th Edition).

**Methods—**Using clinical characteristics, 1,620 consecutive patients at eight NCCN institutions who received mastectomy between 7/97–6/02 were classified into three cohorts according to whether guidelines (1) recommended PMRT, (2) recommended against PMRT, or (3) made no definitive PMRT recommendation. We defined the absence of PMRT in the first cohort as underuse, and receipt of PMRT in the second cohort as overuse. Multivariable logistic regression was applied to investigate the association of clinical and sociodemographic factors with PMRT.

**Results—**Overall, 23.8% received PMRT. This included 83.6% (199/238) in the "recommend PMRT" cohort, 5.6% (58/1029) in the "recommend against PMRT" cohort, and 38.6% (127/329) in the "consider PMRT" cohort. The only factor associated with underuse in the "recommend PMRT" cohort was not receiving chemotherapy (OR=0.08, p<0.0001). In addition to tumor characteristics, factors associated with overuse in the "recommend against PMRT " cohort included age<50 (OR=2.28, p=0.048), NCCN institution (OR=1.04–8.29, p=0.026), higher education (OR=1.25–9.01, p=0.001), and no reconstructive surgery (OR=2.44, p=0.019). Factors associated with PMRT in the "consider PMRT" cohort included NCCN institution (OR=3.8–9.01, p<0.0001), age<50 (OR=2.26, p=0.041) and tumor characteristics.



Corresponding Author: Rinaa S. Punglia MD, MPH, Dana-Farber Cancer Institute, Center for Outcomes and Policy Research, Smith 274, 44 Binney Street, Boston, MA 02115. Phone: (617) 632-3972. FAX: (617) 632-2270. (rpunglia@partners.org).



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**Conclusions—**Concordance with definitive treatment guidelines was high. However, when current evidence does not support a definitive recommendation for PMRT, treatment decisions appear to be influenced not only by patient age and clinical characteristics, but also by institution-specific patterns of care.

### Keywords

Breast cancer; guideline adherence; mastectomy; quality of health care

## INTRODUCTION

Large randomized trials from Denmark and Canada[1–3] have confirmed that the use of post-mastectomy radiation therapy (PMRT) improves overall survival among women with invasive breast cancer who are at high risk of local or regional recurrence. Based on this and other evidence, the National Comprehensive Cancer Network (NCCN) has developed evidence-based guidelines regarding the use of PMRT in clinically-defined patient cohorts.[4] These guidelines recommend PMRT for women at high risk of recurrence, as defined by tumor involvement in four or more axillary nodes, tumor size greater than 5 cm, and/or positive surgical margins. The guidelines also define patients at low risk of recurrence for whom PMRT is not recommended. Finally, the guidelines identify a cohort of women, those with one to three positive axillary nodes and/or close surgical margins, for whom the value of PMRT is uncertain.

One benefit of evidence-based guidelines is that they create a framework for measuring the quality of care. Poor quality of care occurs when treatments of known effectiveness are underutilized and/or treatments of known ineffectiveness are overutilized.[5] For practices of equivocal effectiveness, a potential marker of poor quality of care is variation in utilization according to provider rather than patient preference.[6,7]

In breast cancer, radiation after breast-conserving surgery is frequently proposed as a useful indicator of the quality of care. There is an extensive literature on rates and determinants of radiation use in this setting,[8–14] largely relying on tumor registry and administrative data. However, estimates from large national sources including data from the Surveillance, Epidemiology and End Results data and the National Cancer Database, indicate that many women with early-stage breast cancer do not receive breast-conserving surgery.[15,16] Although rates of breast-conserving surgery have been increasing, these sources reveal that over one-third of such women with are still treated with mastectomy. A comprehensive evaluation of the quality of breast cancer care, therefore, should also include an assessment of PMRT. Moreover, in women at high risk for local and regional recurrence, PMRT has a demonstrated large survival benefit.[1–3] Therefore, in addition to radiation after breast-conserving surgery, PMRT may also be a critical quality measure.

Appropriate use of PMRT depends on the risk of recurrence, and thus detailed information about the pathology of the primary tumor, regional nodes, and surgical specimen is required to evaluate the quality of care. This level of clinical detail is incompletely captured by tumor registries and is not available at all in administrative data.

We examined the use of PMRT at participating NCCN institutions, using the clinically-detailed data collected as part of the NCCN Outcomes Project.[17–21] We measured the quality of care by examining appropriate and inappropriate use of PMRT as defined by the NCCN guidelines in high and low risk patient cohorts, and examined determinants of PMRT use in the patient cohort where the guidelines do not make a definitive recommendation. We hypothesized that different factors – whether patient- and provider-specific - might drive the decision to treat in

each of these three cohorts. Therefore, we sought to determine the characteristics associated with underuse, overuse, and discretionary use of PMRT.

## METHODS

### Subjects

The study cohort consisted of women receiving their primary breast cancer care at one of eight institutions participating in the NCCN Breast Cancer Outcomes Project:: Arthur G. James Cancer Hospital at the Ohio State University, Columbus, OH, City of Hope National Medical Center, Duarte, CA, Dana-Farber Cancer Institute, Boston, MA, Fox Chase Cancer Center, Philadelphia, PA, H. Lee Moffitt Cancer Center at the University of South Florida, Tampa FL, The University of Texas M. D. Anderson Cancer Center, Houston, TX, Roswell Park Cancer Institute, Buffalo, NY, and University of Michigan Comprehensive Cancer Center, Ann Arbor, MI. The study data collection process, data transmission methods, and data storage protocols were approved by the Institutional Review Boards (IRB) at each institution. At institutions where the IRB required signed informed consent for data collection, only patients who provided consent were included.

Women were eligible for inclusion in this analysis if they had newly diagnosed Stage I and II (AJCC 5$^{th}$ Edition[22]) unilateral breast cancer and presented for care between 7/1/1997 and 6/26/2002. Patients presenting for second opinions, receiving no primary therapy at the NCCN institution, or referred for bone marrow transplantation only, were not eligible for entry into the database. If a woman had multiple breast cancer episodes within the study time period, only the first episode of breast cancer was considered in the analysis. We excluded five DCIS patients with a positive node detected by immunohistochemistry who were Stage IIA (Tis N1) and 275 patients who received neoadjuvant chemotherapy due to different criteria for recommending PMRT in these patients.

From the 6,758 potentially eligible patients, we identified 2,473 who received mastectomy as their definitive surgery for breast cancer prior to recurrence. To ensure that we properly classified patients with respect to radiation use, we restricted the cohort to patients with at least 365 days of follow-up after mastectomy. Patients were excluded if they transferred out of NCCN care, had a bone marrow transplant for breast cancer treatment, or developed a new cancer (other than breast cancer) within the 365 day post-mastectomy time period. Five patients who were registered on protocols that determined radiation therapy use were excluded, leaving a final sample of 1620 patients (666 Stage I and 954 Stage II).

We classified all patients according to whether they fell onto guidelines that (1) recommended PMRT, (2) recommended against PMRT, or (3) made no definitive recommendation. Each patient was classified according to the version of the NCCN guidelines in effect at presentation to the NCCN institution.[4] Patients classified into the “recommend PMRT” cohort, included those with tumors greater than 5 centimeters, positive surgical margins, or 4 or more positive axillary nodes. The second cohort, those for whom guidelines recommended that radiation not be used, included patients who had no positive axillary nodes, tumors 5 centimeters in size or smaller, and who had negative surgical margins. The final cohort, those for whom the NCCN guidelines provided no definitive treatment recommendation, consisted of patients with one to three positive axillary nodes and/or close surgical margins.

Because of changes to the treatment recommendations in the guidelines over time, two exceptions were made to these classification rules: 1) all women with 4 or more positive axillary nodes who presented to a NCCN institution prior to 6/30/1998 fell into the cohort for whom the guidelines provided no definitive treatment recommendation, and 2) postmenopausal women (defined as age above 50 years) with 1 to 3 positive axillary nodes who presented prior

to 6/30/2000 were placed into the "do not recommend PMRT" cohort. There were 24 women with missing tumor information such that they could not be classified into a treatment recommendation cohort.

## Data Sources

Data collected from the patients' medical records included health insurance status at presentation, TNM staging based on AJCC 5th edition, tumor pathology, treatments administered (surgery, radiation, and systemic therapy), enrollment on a clinical trial, and recurrences. Co-morbidity at presentation to the NCCN center was assigned using either the Charlson Index (based on chart review) or the modified version of this index using a patient survey developed by Katz et al.[23,24] The data from these indices have been shown to be highly correlated.[23] Self-designated racial and/or ethnic background, educational status and employment status at diagnosis were determined through patient surveys. The zip code of the patient's residence was linked to 2000 Census data to estimate median household income (US Census 2000, Summary File 3). We were unable to link 18 patients to the Census data based on their reported zip code.

To determine the distance to the nearest radiation therapy facility, we identified the latitude and longitude of 1,197 hospitals offering radiation therapy services from the 2000 American Hospital Association (AHA) Annual Survey of Hospitals.[25] Fifteen of the AHA hospitals did not have latitude and longitude available in the 2000 AHA dataset, and their location was determined using the US Census Bureau website (http://www.census.gov/cgi-bin/gazetteer). The latitude and longitude of each domestic patient's residence was derived from ZIPList5 (Geocode Z5LLDOC.TXT, © 1995–2002, www.zipinfo.com). The distance to the nearest radiation facility for each patient was determined by using an algorithm based on latitude and longitude that calculated the distance from the patient's residence to each radiation therapy facility, and then selected the minimum distance.

Rigorous data quality assurance processes included initial and follow-up data management training; on-line edit checking during web-based data entry; programmed logic checks against the pooled data repository; routine quality assurance reports to the centers for rectification by the data managers; and on-site audits of a random sample of source documents against the submitted data within the first few months of data collection, and repeated annually to ensure the accuracy of the data used.

## Definition of Receipt of Adjuvant Therapy

Patients were classified as receiving radiation as a component of initial adjuvant therapy if treatment was initiated at a NCCN or non-NCCN institution within 365 days of mastectomy and prior to any disease recurrence. Because our objective was to assess the factors that influenced the decision to add radiation therapy after mastectomy, and not the efficacy of the radiation treatment itself, all patients who started adjuvant radiation, even those who may have discontinued radiation during a treatment course, were considered to have received radiation. Patients were considered to have received adjuvant chemotherapy if any chemotherapy regimen was initiated within 365 days of mastectomy and before the development of a recurrence.

## Statistical Methods

Age was analyzed by decades and as a dichotomous and continuous variable. The results were not substantially different. Therefore, results with age dichotomized at 50 years are presented for ease of interpretation. Distance to nearest radiation facility and estimated median household income were divided into quartiles defined by the data.

Variables for education, employment status at diagnosis, race and insurance included a separate category for those with unknown or missing information. Binary variables were used to indicate whether patients had ever been on a clinical trial that did not specify use or omission of PMRT, and whether the mastectomy procedure was performed at the NCCN institution or elsewhere. In addition, post-mastectomy reconstruction procedures were classified as early or delayed based on whether they occurred within 4 weeks of mastectomy. This definition was selected to best reflect whether reconstruction occurred prior to PMRT initiation.

Tumor size and number of involved axillary nodes were categorized *a priori* into clinically reasonable groups. Twenty-two patients had no evaluation of their axillary nodes, and were assigned to a separate 'not evaluated' category. Variables for estrogen receptor status, tumor grade, and lymphovascular invasion included a separate category for those with unknown or missing information. Margin status was classified into positive (DCIS or invasive), close (<2mm), or negative. One patient was missing information about margin status and was excluded. The variable for histology combined mucinous, tubular, adenocystic, papillary and medullary cancers into one category because of small numbers; pure ductal histology was used as the reference.

### Statistical Analysis

Because we hypothesized that different factors might influence treatment choice, modeling of factors potentially associated with receipt of PMRT was conducted separately within each of three cohorts defined by NCCN guidelines. We first performed univariate logistic regression analyses with the following candidate explanatory variables: age, race, education level, employment status at presentation, estimated median household income, insurance type, receipt of chemotherapy, number of co-morbidities, distance to nearest radiation facility, enrollment on a clinical trial, presence of early breast reconstructive surgery, number of positive axillary nodes, tumor size, surgical margin status, estrogen receptor status, tumor grade, tumor histology, presence of lymphovascular invasion, year diagnosed, institution where mastectomy was performed, and specific NCCN institution. Categorization of the variables was consistent across each of the cohorts except for missing strata resulting from the entry criteria into each cohort, or when small numbers resulted in lack of convergence for the odds ratio and/or confidence interval estimates.

We next performed multivariable logistic regression to identify factors independently associated with receipt of PMRT in each of the three cohorts. Because of *a priori* hypotheses regarding their influence, all models included the following variables regardless of significance at the univariate level: age, tumor size, number of positive axillary nodes, surgical margin status and specific NCCN institution. Otherwise, only variables significant in the univariate analysis at an alpha level of 0.2 or less were included as candidates for the final multivariable model. Any category consisting of 10 or fewer patients was excluded from the multivariable model. Model fit was assessed using the Hosmer-Lemeshow test for goodness-of-fit. The final significance level was set to an alpha level of 0.05. Interactions between each pair of the variables included in the final model were tested for additional predictive power.

## RESULTS

The median age of patients eligible for analysis was 52.8 years (Table 1). Tumor size was 2.0 centimeters or smaller in 61.2% of patients, and between 2.1 – 5.0 centimeters in 36.2% of patients. The majority of patients had no involvement of axillary nodes (54.5%) and nearly all patients (97.5%) had negative surgical margins. Overall, 63.0 percent of women received adjuvant chemotherapy. In the entire group of eligible patients, 23.8% received PMRT. This included 83.6% in the "recommend PMRT" cohort, 5.6% in the "do not recommend PMRT" cohort, and 38.6% in the "consider PMRT" cohort (Table 2).

Among the women for whom PMRT was recommended by NCCN guidelines, the only variable associated with underuse of radiation therapy on multivariable analysis was not having received chemotherapy (Table 3). Beyond the clinical criteria required for entry into the "recommend PMRT" cohort, none of the clinical or sociodemographic factors considered were associated with receipt of PMRT.

In the women for whom no PMRT was recommended by NCCN guidelines, age less than 50 years, specific NCCN institution, tumor size greater than 2 cm, greater number of positive axillary nodes (prior to 6/2000), negative estrogen receptor status, non-ductal histology, college education or higher, and no early breast reconstructive surgery were associated with the receipt of PMRT, or overuse, in this cohort (Table 4).

In the women for whom NCCN guidelines did not specify a definitive recommendation regarding PMRT, age less than 50, specific NCCN institution, tumor size between 2–5 centimeters, 4 or more positive axillary nodes (prior to 6/1998), close surgical margins, receipt of chemotherapy and mastectomy at a non-NCCN institution were associated with increased use of PMRT (Table 5).

## DISCUSSION

We found that current practice with respect to PMRT across the NCCN centers generally follows the best available evidence as synthesized in NCCN guidelines. Only 16% of women who were at high risk for disease recurrence did not receive the guideline-recommended PMRT. Only 6% of women with low risk disease received PMRT when it was not recommended. Unlike radiation after breast conserving surgery, there are no large published reports on the extent of appropriate or inappropriate use of radiation therapy among mastectomy patients to which these findings can be compared.

The only factor associated with underuse of PMRT was non-receipt of chemotherapy. Clinical factors such as tumor size and number of positive axillary nodes that influence the decision to treat with radiation are highly correlated with factors used to recommend chemotherapy. Therefore, it may be that non-receipt of chemotherapy in this group is a marker for patients who have elected to forego all curative treatment for their breast cancer, including PMRT.

Overuse of radiation therapy, i.e., use of PMRT among women for whom it is not recommended by the treatment guidelines in place at time of patient diagnosis, occurred in only 6% of women. Clinical, sociodemographic, and provider factors were all associated with PMRT use in this cohort. Younger women, and those with tumors that were larger, axillary lymph node-positive, estrogen receptor negative, or with non-ductal histology, were all more likely to receive PMRT. This suggests that physicians are basing recommendations for radiation on the perceived relative risk of recurrence for this cohort, despite the lack of evidence demonstrating its value. The presence of a gradient of odds ratios for the receipt of PMRT based on the precise number of positive axillary nodes (one versus two versus three) further supports the role of perceived risk in driving treatment recommendations in this cohort. It is important to note that the guidelines were revised in 6/2000 now recommending PMRT or the consideration of PMRT for all women with positive nodes regardless of age. Early breast reconstruction was independently associated with a lower likelihood of overuse in this group. This association may reflect concern that PMRT can lead to a less optimal cosmetic result after breast reconstruction.[26]

Education at the college level or above was associated with overuse of PMRT in this cohort suggesting that patients' perceptions about risk and their preferences also may be contributing to the observed patterns of care. We also found evidence of institutional variability that persisted after controlling for tumor and patient-specific factors. This suggests that there is

non-uniform acceptance of the evidence as synthesized in the NCCN guidelines, and a pattern of local, institution-specific biases in favor of more aggressive treatment as a result. That this practice occurs in the highly specialized centers that form the NCCN is consistent with Wennberg's recent report on healthcare delivery (Dartmouth Atlas of Health Care project) showing that "patients served by even the best academic centers (teaching hospitals) experience unwarranted variations in health care".[7]

Discretionary use of radiation therapy, or use of PMRT in women for whom the NCCN guidelines did not offer a definitive treatment recommendation, was also determined by clinical characteristics, and particularly by institution-specific patterns of care. Younger age, greater number of positive axillary nodes, close surgical margins, and receipt of chemotherapy were all associated with receiving radiation in this cohort. After accounting for these factors, we still found wide variability of PMRT use across NCCN institutions ($p<.0001$). We did not collect information from patients about their treatment preferences, however, it seems unlikely that the degree of variation we observed across this set of institutions could be explained wholly or even in large part by patient preferences. This raises the concern that treatment in this cohort of patients, for whom two medically acceptable options exist, may be driven by provider rather than patient preferences, a situation not consistent with the highest quality of care.[7] Sadly, a randomized trial specifically addressing the benefit of PMRT in this group conducted by Southwest Oncology Group (SWOG S9927) closed due to poor accrual. This suggests that physicians' beliefs about the value of PMRT may not only be driving patterns of use, but may also be serving as a barrier to research informing the optimal use of PMRT.

Our analysis has several limitations. We studied patterns of care in a selected group of cancer centers; the patients and providers in our sample likely differ from the general population, limiting the ability to generalize our findings. Distance from the nearest radiation facility has been shown to be an important predictor of radiation therapy after breast-conserving surgery,[27,28] but we found no effect of travel distance, even though the median distance from the patient to the nearest radiation treatment facility in our study was similar. It is possible that patients in our centers are more motivated to seek treatment, and this motivation was sufficient to overcome the distance barrier.

We also recognize that our analysis is not a population-based study. However, there is no population-based data source that contains the information needed to appropriately control for the clinical factors that do and should drive decisions about radiation after mastectomy, such as margin status. Moreover, the demonstrated striking effect of inter-institutional variability which if present even among the NCCN centers, is likely to be present among institutions outside the NCCN as well.

Our study also has certain strengths. Unlike studies using administrative data with or without linkage to registry data, we had information about key variables such as education and travel distance at the level of the individual patient rather than at the aggregate level. This may explain why we were able to detect an effect of education as a significant, independent predictor of overuse of PMRT. More importantly, the availability of highly detailed clinical data in our study enabled us to fully account for the clinical factors that might drive treatment choice and to examine the effects of other patient characteristics and provider biases unconfounded by these factors.

In summary, we found that rates of concordance with definitive guidelines for PMRT were high. Appropriate use of PMRT among the high-risk cohort was the rule, while overuse of PMRT among women with low risk disease occurred infrequently. The only factor associated with underuse was non-receipt of chemotherapy, suggesting that care may appropriately reflect patient preferences. Although overuse was rare, it appeared to be driven by provider biases,

and in particular, a tendency to treat women with higher risk disease more aggressively despite the absence of consensus opinion supporting this approach. Finally, we found considerable variability in the use of PMRT among women at moderate risk of recurrence, highlighting the need for focused clinical research in this group.

In its report "Ensuring Quality Cancer Care," the National Cancer Policy Board[5] recommended the use of radiation therapy following breast-conserving surgery as a good process indicator to study the quality of cancer care. Indeed, prior studies have largely focused on the use of radiation therapy after breast-conserving surgery as such a measure. Radiation therapy after mastectomy may also be an important quality indicator and national target for intervention, given its significant survival impact and the large number of lives at stake. The challenge will be to develop a quality monitoring system that includes sufficient clinical detail to identify women most likely to benefit from PMRT.

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**TABLE 1**

Overall characteristics of women eligible for analysis

| Characteristics | Overall cohort | (n=1620) | Recommend PMRT | (n=238) | Do not recommend PMRT | (n=1029) | Consider PMRT | (n=329) |
|---|---|---|---|---|---|---|---|---|
| Patient characteristics, median (25th–75th percentile) | | | | | | | | |
| Age, years | 52.8 | (44.5–63.1) | 52.5 | (42.5–63.2) | 55.0 | (48.0–64.7) | 45.6 | (40.3–52.1) |
| Distance (miles) from radiation facility | 7.03 | (3.27–13.54) | 7.79 | (3.41–12.46) | 6.93 | (3.14–13.40) | 7.35 | (3.52–14.71) |
| Income (thousands of dollars) | 45.7 | (35.6–60.5) | 46.1 | (35.4–61.1) | 45.5 | (35.3–59.9) | 46.6 | (36.6–60.7) |
| Caucasian, % | 82.9 | (1343) | 79.0 | (188) | 83.8 | (862) | 83.0 | (273) |
| Managed care | 57.5 | (932) | 55.5 | (132) | 55.6 | (572) | 65.4 | (215) |
| At least some college education | 50.0 | (810) | 46.6 | (111) | 49.5 | (509) | 55.9 | (184) |
| Employed | 43.1 | (698) | 41.2 | (98) | 40.2 | (414) | 54.4 | (179) |
| 2 or more co–morbidities | 9.1 | (147) | 8.4 | (20) | 9.3 | (96) | 7.9 | (26) |
| Clinical characteristics | | | | | | | | |
| Tumor size: | | | | | | | | |
| 0–2.0 cm | 61.2 | (991) | 29.8 | (71) | 71.9 | (740) | 50.2 | (165) |
| 2.1–5.0 cm | 36.2 | (586) | 60.0 | (142) | 28.1 | (289) | 46.5 | (153) |
| > 5.0 cm | 1.3 | (21) | 8.8 | (21) | 0 | - | 0 | - |
| Number of positive axillary lymph nodes: | | | | | | | | |
| 0 | 54.5 | (883) | 11.3 | (27) | 82.0 | (844) | 3.0 | (10) |
| 1–3 | 28.3 | (459) | 2.9 | (7) | 18.0 | (185) | 79.6 | (262) |
| 4 or more | 16.1 | (260) | 85.3 | (203) | 0 | | 17.3 | (57) |
| Surgical margin status: | | | | | | | | |
| negative | 97.5 | (1579) | 89.5 | (213) | 100 | (1029) | 95.1 | (313) |
| positive | 1.1 | (18) | 7.6 | (18) | 0 | - | 0 | - |
| close (<2 mm) | 1.4 | (22) | 2.9 | (7) | 0 | - | 4.6 | (15) |
| Lymphovascular invasion | 25.6 | (415) | 53.8 | (128) | 16.0 | (165) | 36.2 | (119) |
| High grade | 38.1 | (617) | 47.9 | (114) | 33.3 | (343) | 46.2 | (152) |

| Characteristics | Overall cohort | (n=1620) | Recommend PMRT | (n=238) | Do not recommend PMRT | (n=1029) | Consider PMRT | (n=329) |
|---|---|---|---|---|---|---|---|---|
| Estrogen-receptor positive | 72.5 | (1175) | 77.7 | (185) | 72.4 | (745) | 70.2 | (231) |
| Ductal histology | 78.4 | (1270) | 70.6 | (168) | 78.7 | (810) | 83.6 | (275) |
| Treatments received | | | | | | | | |
| Ever on a clinical treatment trial** | 15.9 | (258) | 19.3 | (46) | 12.3 | (127) | 25.5 | (84) |
| Chemotherapy | 63.0 | (1021) | 91.2 | (217) | 47.7 | (491) | 91.8 | (302) |
| Early reconstruction | 38.8 | (629) | 31.1 | (74) | 40.1 | (413) | 41.0 | (135) |
| Surgery at a NCCN institution | 86.8 | (1406) | 79.8 | (190) | 90.2 | (928) | 80.9 | (266) |

** excludes trials specifying receipt or omission of radiation

**TABLE 2**

PMRT use in the entire cohort and within each of the treatment recommendation cohorts

| | Number in cohort | Percent receiving PMRT |
|---|---|---|
| **Entire cohort** | 1620 | 23.8 |
| **Treatment cohort** | | |
| Recommend PMRT | 238 | 83.6 |
| Do not recommend PMRT | 1029 | 5.6 |
| Consider PMRT | 329 | 38.6 |

**TABLE 3**

Significant variables in final multivariable model predicting receipt of PMRT among those for whom it is recommended

| | n | OR* | 95% CI | P-value |
|---|---|---|---|---|
| **Chemotherapy** | | | | **<.0001** |
| Received | 203 | 1.00 | | |
| Not received | 21 | 0.08 | 0.03–0.25 | |

*Adjusted for age, tumor size, number of positive axillary lymph nodes, surgical margin status, and specific NCCN institution.

**TABLE 4**

Significant variables in final multivariable model predicting receipt of PMRT among those for whom it is not recommended

| | OR | 95% CI | P-value |
|---|---|---|---|
| **Age** | | | **0.048** |
| 50 years or older | 1.00 | | |
| Under 50 | 2.28 | 1.01–5.16 | |
| **Education level** | | | **0.001** |
| No college | 1.00 | | |
| At least some college | 3.49 | 1.54–7.92 | |
| Missing | 0.84 | 0.30–2.38 | |
| **Tumor size** | | | **0.0002** |
| Less than or equal to 2 cm | 1.00 | | |
| 2–5 cm | 3.15 | 1.72–5.80 | |
| **Number of positive axillary lymph nodes** | | | **<.0001** |
| 0 | 1.00 | | |
| 1 | 3.88 | 1.47–10.23 | |
| 2 | 13.22 | 5.15–33.94 | |
| 3 | 15.37 | 5.15–45.86 | |
| **Estrogen receptor status** | | | **0.002** |
| Positive/unknown | 1.00 | | |
| Negative | 2.96 | 1.47–5.97 | |
| **Histology** | | | **0.005** |
| Ductal | 1.00 | | |
| All others | 2.72 | 1.36–5.47 | |
| **Early reconstruction** | | | **0.019** |
| Yes | 1.00 | | |
| No | 2.44 | 1.16–5.11 | |
| **NCCN site** | | | **0.026** |

| | OR | 95% CI | P-value |
|---|---|---|---|
| Site 8 | 1.00 | | |
| Site 1 | 5.75 | 0.99–33.38 | |
| Site 2 | 2.71 | 0.52–13.96 | |
| Site 3 | 8.29 | 1.59–43.19 | |
| Site 4 | 1.04 | 0.18–5.98 | |
| Site 5 | 3.73 | 0.71–19.46 | |
| Site 6 | 4.51 | 0.70–28.89 | |
| Site 7 | 2.53 | 0.47–13.49 | |

* all patients in this cohort had negative surgical margins by definition

## TABLE 5

Significant variables in final multivariable model predicting receipt of PMRT among those for whom no definitive recommendation is given

| | OR | 95% CI | P-value |
|---|---|---|---|
| **Age** | | | **0.041** |
| 50 years or older | 1.00 | | |
| Under 50 | 2.26 | 1.03–4.95 | |
| **Tumor size** | | | **0.046** |
| Less than or equal to 2 cm | 1.00 | | |
| 2–5 cm | 2.05 | 1.13–3.75 | |
| Unknown | 0.71 | 0.13–3.75 | |
| **Number of positive axillary lymph nodes** | | | **<.0001** |
| 0–3 | 1.00 | | |
| 4 or more | 42.34 | 13.73–130.57 | |
| **Margin status** | | | **<.0001** |
| Negative | 1.00 | | |
| Close | 28.60 | 6.43–127.19 | |
| **Chemotherapy** | | | **0.032** |
| Not received | 1.00 | | |
| Received | 3.63 | 1.12–11.79 | |
| **Institution where mastectomy performed** | | | **0.004** |
| NCCN | 1.00 | | |
| Outside | 2.88 | 1.39–5.97 | |
| **NCCN site** | | | **<.0001** |
| Site 4 | 1.00 | | |
| Site 1 | 1.25 | 0.27–5.87 | |
| Site 2 | 8.16 | 2.86–23.29 | |
| Site 3 | 3.82 | 1.23–11.83 | |
| Site 5 | 7.33 | 2.24–29.93 | |
| Site 6 | 9.01 | 2.32–34.96 | |
| Site 7 | 1.10 | 0.34–3.53 | |

| | OR | 95% CI | P-value |
|---|---|---|---|
| Site 8 | 7.08 | 1.82–27.60 | |