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Patient, hospital, and neighborhood factors associated with treatment of early-stage breast cancer among Asian American women in California

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Abstract

Background—Clinical guidelines recommend breast conserving surgery (BCS) with radiation as a viable alternative to mastectomy for treatment of early-stage breast cancer. Yet, Asian Americans (AA) are more likely than other groups to have mastectomy or omit radiation after BCS.

Methods—We applied polytomous logistic regression and recursive partitioning (RP) to analyze factors associated with mastectomy, or BCS without radiation, among 20,987 California AAs diagnosed with stage 0–II breast cancer from 1990–2007.

Results—The percentage receiving mastectomy ranged from 40% among US-born Chinese to 58% among foreign-born Vietnamese. Factors associated with mastectomy included tumor characteristics such as larger tumor size, patient characteristics such as older age and foreign birthplace among some AA ethnicities, and additional factors including hospital (smaller hospital size, not NCI cancer center, low socioeconomic status (SES) patient composition, and high hospital AA patient composition) and neighborhood characteristics (ethnic enclaves of low SES). These hospital and neighborhood characteristics were also associated with BCS without radiation. Through RP, the highest mastectomy subgroups were defined by tumor characteristics such as size and anatomic location, in combination with diagnosis year and nativity.

Conclusions—Tumor characteristics and, secondarily, patient, hospital and neighborhood factors, are predictors of mastectomy and omission of radiation following BCS among AAs.

Impact—By focusing on interactions among patient, hospital, and neighborhood factors in the differential receipt of breast cancer treatment, our study identifies subgroups of interest for further study, and translation into public health and patient-focused initiatives to ensure that all women are fully informed about treatment options.

INTRODUCTION

Breast conserving surgery (BCS) with radiation has been considered a viable alternative treatment to mastectomy for most women with early stage breast cancer since the 1990 NIH Consensus Conference (1, 2) because of evidence that women who undergo BCS with radiation experience equivalent overall survival compared to mastectomy (3–8). BCS with

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radiation may offer advantages for cosmetic outcomes, potentially mitigating psychosocial sequelae (9), but generally involves 5 to 7 weeks of postoperative radiation, which, among other factors, may influence a patient to choose mastectomy over BCS with radiation (10). BCS without radiation increases risk of local recurrence and mortality (8, 11–13) and is considered non-guideline treatment (2); the exception is women ≥70 years of age diagnosed with stage I, hormone receptor (HR) positive breast cancer, and on hormonal therapy, where BCS without radiation may be considered accepted treatment (14). Despite the demonstrated benefits of BCS with radiation, prior research based in representative cancer registry data has shown that Asian American (AA) women are considerably more likely than other racial/ethnic groups to have mastectomy (15–18) as well non-receipt of radiation after BCS (17).

Factors that have been associated with choice or use of BCS with radiation over mastectomy include: younger age (19, 20), smaller tumor size and lack of nodal involvement (21, 22), shorter travel distance to radiation facility (23, 24), higher socioeconomic status (SES) (25, 26), physician preference (27–29), and later years of diagnosis (25, 30). Patient involvement with the decision-making process has been associated with both BCS with radiation and mastectomy (10, 31, 32). It is unclear the extent to which these or other factors influence treatment for early-stage breast cancer among AA women. Compared to non-Hispanic White women, the odds of receiving BCS have been shown to be lower among foreign-born AA women than among US-born AA women (33). Another US study based on 82 Chinese breast cancer patients showed that lower SES, foreign birthplace or recent immigration, and speaking no or limited English were associated with mastectomy (34), and a population-based study showed that adjustment for hospital and provider characteristics explained a substantial proportion of the higher odds of mastectomy among Vietnamese women compared to White women (16). A recent study of women in Tianjin, China, showed that patient SES and insurance status, rather than tumor characteristics, were primary factors driving mastectomy over BCS with radiation (35). A survey of providers in the San Francisco Bay Area who treat AA breast cancer patients showed that tumor-to-breast ratios, patients' attitudes toward preserving the breast, cultural factors, and transportation difficulties were perceived to be important factors in the higher rates of mastectomy in this population (36).

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Therefore, in six AA ethnic groups, we set out to identify factors associated with receipt of mastectomy or BCS omitting radiation in the large, population-based Surveillance, Epidemiology, and End Results (SEER) California Cancer Registry (CCR) dataset enhanced with the ability to assess immigrant status, neighborhood factors including SES and ethnic enclave, and hospital characteristics. In addition to polytomous regression in our observational study, we also apply recursive partitioning (RP) to identify and clustered subgroups with the highest receipt of mastectomy or omission of radiation following BCS.

MATERIALS AND METHODS

Study Population

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We identified from the CCR all Chinese, Japanese, Filipina, Korean, South Asian, or Vietnamese women diagnosed with a first primary, AJCC stage 0-II breast cancer in California from January 1, 1990 to December 31, 2007 (N=23,982). These six AA groups represented 91% of all AA and Native Hawaiian, Pacific Islander (NHPI) breast cancer patients. We excluded tumors for which BCS with radiation is contraindicated (37), including lobular carcinoma *in-situ* (38), tumors greater than 5 cm (39), microscopic tumor foci (15), inflammatory carcinoma (2), and diffuse tumors (2). Further, we excluded women diagnosed on death certificate/autopsy only and cases that were not microscopically confirmed (resulting N=21,146). We also excluded women with bilateral tumors or unknown laterality, unknown nodal involvement, subcutaneous mastectomy, extent of surgery unknown, or no surgical treatment (resulting N=20,987). It was not possible to exclude multifocal tumors given inconsistencies in its coding in the registry over time.

Treatment and tumor characteristics

The registry data contain information for the first course of most extensive cancer treatment, considered treatment administered or initiated within the first four (cases diagnosed 1990–1997) or 12 months following diagnosis (cases diagnosed 1998–2007). BCS includes partial mastectomy, not otherwise specified (NOS); partial mastectomy with nipple resection; less than total mastectomy, NOS; lumpectomy or excisional biopsy; reexcision of biopsy site for residual disease; and segmental mastectomy (including wedge resection, quadrantectomy, tylectomy). Cases were categorized as having received mastectomy (N=10,431); BCS with radiation (N=7,792) (40) (defined as BCS with radiation (N=7,590) or BCS without radiation in older women (≥70 years) with stage I, HR positive breast cancer (N=202) (14)); or BCS without radiation (this excludes older women in the prior group) (N=2764). Cancer registry data on tumor characteristics, including those shown in Table 1, are routinely abstracted by tumor registrars (41). HR status was coded as positive if the tumor was estrogen- and/or progesterone-receptor positive, negative if the tumor was both estrogen- and progesterone-receptor negative, and unknown for the remainder; unknown HR status was more common in earlier years of diagnoses.

Patient- and neighborhood-level immigrant and SES characteristics

Because the ~30% of AA patients in the cancer registry with unknown birthplace data are more likely to be US-born than those with available data (33, 42-44), we applied a validated method based on patients' Social Security numbers (SSN) to classify patient immigrant status for patients with unknown data, as described previously (45).

We used residential address and 1990 (for cases diagnosed 1990–1995) and 2000 (for cases diagnosed 1996+) Census block group-level data to classify neighborhood SES and Asian ethnic enclave status. We assigned neighborhood SES using a previously described index (46) that incorporates data on education, income, occupation, and housing costs. An ethnic enclave is an area that maintains more cultural mores and is ethnically distinct from the surrounding area (47), and is based on an index that includes Census data on Asian race/ethnicity, language, nativity, and recency of immigration (48). Both neighborhood-level indices were classified into quintiles based on their distributions in California, then re-categorized into two groups because of small sample sizes in the quintiles. Because neighborhood SES and ethnic enclave status are correlated, we defined block groups jointly by neighborhood SES and ethnic enclave.

Hospital characteristics

Information on total number of hospital beds, as an indicator of size, was obtained from the 2001 California Office of Statewide Health Planning and Development hospital utilization file (49). In addition, we calculated the percent of AA and NHPI cancer cases reported by each hospital for the years 1990–2007. Hospitals were then dichotomized on whether this percent was above or below the median (10%) for all reporting hospitals statewide. Similarly, hospitals were dichotomized on whether at least 25% of cancer patients reported by that hospital were in the upper neighborhood SES quintile.

Data analysis

Multivariable, polytomous logistic regression models were used to calculate odds ratios (ORs) and 95% confidence intervals (CIs) for the association of treatment (receipt of mastectomy or BCS omitting radiation, relative to receipt of BCS with radiation) with patient, neighborhood, and hospital characteristics. We adjusted for clustering by hospital and by block group simultaneously. Statistical analyses were performed using SAS 9.2 (SAS Institute Inc., Cary, NC); logistic regression was conducted using PROC SURVEYLOGISTIC.

RP, conducted using the RPART routine in R (50), was used to identify mutually exclusive subgroups that varied with regard to the probably of receiving mastectomy, or BCS omitting radiation, relative to BCS with radiation (50–54). RP is a non-parametric regression method used to find the decision tree with the lowest average misclassification rate for classifying future observations; it is particularly useful for identifying multi-way interactions among variables, and clustered subgroups. We constructed one tree modeling the probability of mastectomy versus BCS with radiation, excluding women who had received BCS omitting radiation, and a second tree modeling BCS with radiation versus BCS omitting radiation, excluding women who underwent mastectomy. The same explanatory variables and categories that were used in the regression analyses were submitted into the RP procedures.

RESULTS

Among 20,987 AA women diagnosed with stage 0-II breast cancer between 1990–2007 and eligible for BCS with radiation, 37.2% received BCS with radiation; 49.7% received mastectomy; and 13.2% received BCS with omission of radiation (Table 1).

In multivariate logistic regression analyses, women age 60 and older were more likely than younger age groups to receive mastectomy (Table 2). Compared to US-born Japanese, US-born Korean, and foreign-born Korean, Chinese, Filipina and Vietnamese were more likely to receive mastectomy. Modeled as a linear variable (as opposed to categorical variable as shown in Table 2), successive increases in single year of diagnosis were associated with lower odds of receiving mastectomy (OR=0.94, 95% CI 0.94–0.95). Compared to women diagnosed in 1990, women diagnosed after 2001 were approximately half as likely to receive a mastectomy. Tumor size was the most important clinical predictor of mastectomy; compared to women with <1 cm tumors, women with tumor size 4–5 cm were over 6 times more likely to receive a mastectomy. Histology, grade, HR status, nodal involvement, and anatomic location of the tumor were also associated with mastectomy, as were hospital characteristics including smaller hospital size, non-NCI cancer center, low hospital SES patient composition, and high hospital AA patient composition. Women residing in low SES ethnic enclaves were more likely to undergo mastectomy than those in high SES, less Asian ethnic neighborhoods.

Successive increases in single year of diagnosis were associated with 5% increases in BCS omitting radiation (Table 2). Tumor characteristics including larger tumor size, DCIS or unknown histology, unknown grade, HR status negative, and multifocal or NOSanatomic site were associated with BCS omitting radiation; however, as discussed below, these associations with clinical characteristics need to be interpreted with caution as they may reflect underascertainment of radiation therapy. BCS omitting radiation was also more likely among AA women living in low SES, ethnic enclave neighborhoods, and women diagnosed in hospitals that were smaller, and with relatively lower patient SES and higher composition of AAs.

The RP tree modeling mastectomy versus BCS with radiation (Figure 1 and Table 3) revealed 11 mutually-exclusive subgroups with tumor size being the most important predictor, as indicated by the first tree split. Year of diagnosis and anatomic location were also featured prominently on the RP tree. The subgroups with the highest proportion of mastectomy (71.8%) were AA women in nodes 1 with ≥2 cm tumors, a subgroup that represented 53% of the total sample. Nodes 2–3 were women with tumors <2 cm, but with multifocal or NOS location of the tumor (node 2, 64.9% mastectomy), or foreign-born Chinese, Filipina, Vietnamese, or US-born Japanese, Korean, Vietnamese diagnosed before 1996 (node 3, 64.7% mastectomy). In contrast, the node with the lowest percent mastectomy (node 5, 35% mastectomy) included AA women with tumors <2 cm, tumor mass confined within one quadrant or were overlapping lesions, and diagnosed in the latter part of the study period, between 2003–2007. There were no splits by hospital nor by neighborhood characteristics.

The RP tree modeling BCS omitting radiation versus BCS with radiation revealed that known versus unknown HR status (primarily reflective of calendar year) was the most important predictor (data not shown). Among women with HR positive and negative tumors, 21% omitted radiation, and there were no additional splits after this node. For women with unknown HR status, three subgroups had high proportions (>60%) of omission of radiation: 1) those with grade I-II tumors in public hospitals with relatively higher proportions of Asians; 2) those aged 75 or older with DCIS in hospitals with relatively fewer Asians; and 3) Koreans, foreign-born Vietnamese, and US-born South Asians aged less than 75 with DCIS in hospitals with relatively fewer Asians.

DISCUSSION

AAs are among the most rapidly growing racial/ethnic populations in the US and particularly in California, where more than one-third of all US AAs reside (55–59). Breast cancer is the most commonly diagnosed cancer among AA women, and incidence rates are higher in the US compared to most cancer registries in Asia (60). Rates have been found to be increasing over time among US AA women - rates of invasive breast cancer were 104 per 100,000 in 1988–1994 among Californian US-born AA women, and 136 per 100,000 in 2000–2004; among foreign-born, rates for these same time periods were 71 and 79, respectively; annual percentage changes were as high as 4% per year among US-born Filipinas and foreign-born Koreans (45). Since the 1990 Consensus Conference (2), BCS with radiation has steadily increased in general, but AA women are considerably less likely to have BCS with radiation and more likely to omit radiation after BCS (18, 61). Taking advantage of a large, population-based cancer registry enhanced with patient-level immigrant status, neighborhood characteristics including SES and ethnic enclave (62), as well as hospital characteristics, this report contributes new insights into patterns of treatment for early-stage breast cancer among six large ethnic populations of AA women. Our study found that although tumor characteristics are the most important predictors of treatment, patient race/ethnicity and nativity, and hospital and neighborhood SES and racial/ethnic composition, are also important determinants.

In addition to traditional logistic regression, we used RP to identify interactions among patient, hospital and neighborhood factors, and discrete subgroups of AA women with varying proportions of mastectomy or BCS without radiation. Our results indicate that some factors that were independently significant in logistic regression analyses did not feature in the RP trees, suggesting that their independent effects in the total sample were not seen in more discrete patient subgroups. Our finding that clinical factors, such as tumor size and anatomic location, are most important in the mastectomy decision tree is consistent with clinical practice guidelines (37); yet, the high rates of mastectomy among AA women with even moderate-sized tumors (2–5 cm) suggests that high tumor-to-breast ratio is likely an important consideration for these women. The appearance of year of diagnosis as an important factor in the decision tree likely reflects temporal changes in the adoption of treatment recommendations since the original NIH Consensus Conference (2), as examined previously (25).

AA ethnicity and nativity were also predictors of mastectomy receipt among women diagnosed over the same time period with tumors less than 2 cm. Given the same tumor characteristics, specific AA ethnicities differed by nativity in the extent to which they underwent mastectomy. In decision tree analyses, foreign-born Chinese, Filipina, and Vietnamese had high rates of mastectomy, despite small tumor sizes, while foreign-born Japanese and South Asians, who tend to be English-speaking and more acculturated, even when foreign-born, had low mastectomy rates. These findings are reflective of cultural and immigrant/language factors playing a strong role, and consistent with previous findings (31, 34, 36, 63). Thus, besides being a powerful tool for informing further research to identify underlying reasons for these treatment differences, the RP results can be used by providers and hospitals to develop programs and initiatives, such as patient navigators, cultural competency provider training, and availability of translators, that may be implemented within their institutions to ensure that all women are informed of their treatment options. Results from our qualitative study (unpublished) indicated that low SES AA women who were linguistically isolated were often not informed about their treatment choices; however, within one community (San Francisco Chinatown), community and hospital patient navigator programs were extremely successful in helping the Chinese residents receive BCS with radiation, if desired, by providing transportation, translation, appointment scheduling, and overall navigation services.

To our knowledge, no previous study has evaluated breast cancer surgical treatment type among AA subgroups over an 18-year time interval. We found a trend of decreasing rates of mastectomy, consistent with prior reports (25). In an additional analysis (data not shown), we found increasing rates of BCS with omission of radiation since 1990 in women with stage I-II tumors, but not DCIS tumors, and these trends were more pronounced for cases who also received chemotherapy, for reasons that are unclear, but warrant further investigation. This may be because the standard order of therapies (BCS, chemotherapy for 4-6 months, then radiation) pushes radiation outside of the timeframe in which treatment data are collected by the registry.

Our finding of increased rates of BCS omitting radiation supports a growing body of work (64). Previously implicated predictors for radiation omission following BCS include older age, negative nodes, larger hospital size, tumors greater than 2 cm, geographic location, and race (19, 23, 65–70). In our study, although variations by AA ethnicity and nativity were not statistically significant, neighborhood and hospital race/ethnicity composition and SES were significantly associated with omission of radiation after BCS.

However, our results may be impacted by the under-ascertainment of radiation in the cancer registry, particularly if there are delays in the administration of radiation (71). While a recent report found a 32% under-ascertainment of radiation compared to self-report in the Los Angeles SEER registry, one of the registries included in the current analysis, a comparison of SEER and Medicare claims data showed that agreement on radiation was 94% (kappa = 87%) and under-ascertainment by SEER was 7% (72). In the report based on Los Angeles SEER registry data, radiation under-ascertainment was significantly higher among patients with the following characteristics: White race, more advanced stage, younger age, lower income, Medicare or no insurance, had mastectomy, received chemotherapy, had (self-reported) delays in initiation of radiation, and diagnosed in non-ACoS (American College of Surgeons) hospitals (~40% of California hospitals) (73). As under-ascertainment was more likely among patients of lower SES, this may have over-estimated our findings for the associations we found with neighborhood and hospital characteristics. In particular, the association of clinical characteristics with omission of radiation following BCS should be interpreted with caution; they may be reflective of this under-ascertainment of radiation considering that receipt of chemotherapy is a factor associated with missing data on radiation, and patients with worse prognosis/higher stage are more likely to have received a recommendation for chemotherapy. Our study also has several other potential limitations. We opted to include all stage 0-II tumors, rather than invasive tumors only. Although there has been debate about whether BCS with radiation is the preferred treatment for DCIS, a recent study showed excellent long-term prognosis for both invasive and DCIS tumors (12). Our time trend results were unchanged when we excluded DCIS from our analysis. Our RP analysis was not a concern in this regard, given that RP will naturally discriminate on DCIS/ invasive classification. However, one limitation involved in analyses utilizing RP is potential instability in resultant trees that occurs due to the method RP uses of within-population sampling. In addition, it is possible that a proportion of women with breast site NOS or multifocal (n=2,125) may have had multifocal disease and thus have contraindications for BCS with radiation (2). Our polytomous logistic regression results were not substantively altered when excluding these women, and RP naturally discriminates on breast site to identify the most homogeneous subgroups for this variable. Our results may also be affected by the observational nature and inherent data limitations in cancer registry data. Since registry data on surgery captures the most extensive surgical resection, we are unable to consider women who may have had repeated lumpectomies and unclear margins, and who may opt for mastectomy to avoid further repeated surgeries. In addition, we are unable to consider contraindications to BCS with radiation or radiation due to the lack of comorbidity and other patient-level data (19). The lack of data on language and insurance status is an additional limitation. Finally, our study lacks reliable data on breast reconstruction, and the ability to differentiate those who had mastectomy with reconstruction versus mastectomy only. Given that reconstruction can address many of the psychological impacts of mastectomy alone (74), and, especially when available concurrently with mastectomy, may influence a woman’s decision to choose mastectomy over BCS. However, rates of (self-reported) reconstruction from a previous study were very low (only 1 of 21 Asian women who received mastectomy also received reconstruction), and thus unlikely to greatly impact the findings.

This study has a number of strengths, including the large population-based sample collected over a protracted time period, which allowed sufficient statistical power to detect moderate associations and to apply RP. We used RP, a powerful statistical technique to identify meaningful subgroups of AA most likely to receive mastectomy. Our study is the first, to our knowledge, to apply RP to a large population-based sample of AA women and identify ethnicity and nativity as important predictors.

In a population-based sample of AA breast cancer patients, a group with traditionally high rates of mastectomy, our study shows that immigration, neighborhood and hospital factors are associated with mastectomy and omission of radiation. Additional research is needed to understand cultural factors that underlie the decision-making process among AA women, as well as reasons behind the associations with neighborhood and hospital factors. By focusing on the interactions of patient, hospital, and neighborhood factors in the differential receipt of breast cancer treatment, our study identifies subgroups of women for further study, and, most importantly, results that can be immediately translated into public health and patient-focused initiatives to ensure that all women, regardless of race/ethnicity, immigrant status, SES, and language, are fully informed about their treatment options (9).

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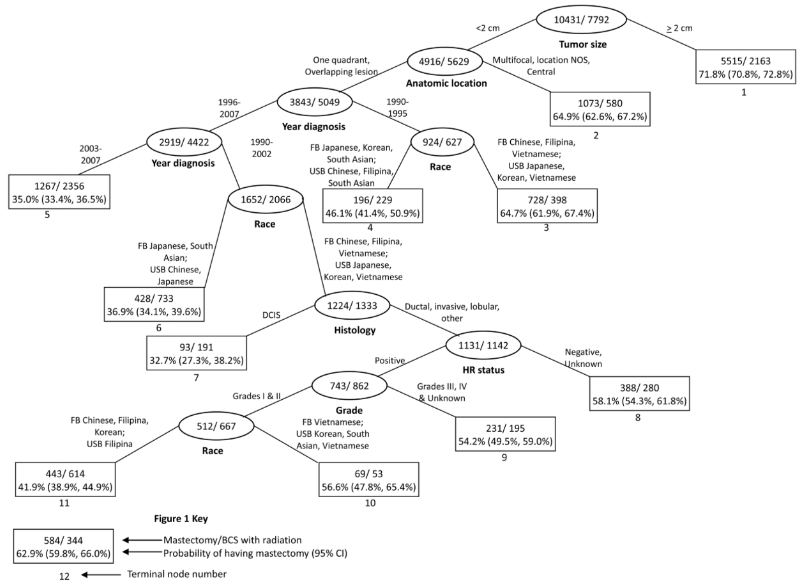

Figure 1. Recursive partitioning tree modeling mastectomy versus BCS with radiation, Asian American Women diagnosed with stage 0–II breast cancer, 1990–2007

Recursive partitioning is a non-parametric regression method that uses the current data set to find the decision tree with the lowest average misclassification rate for classifying future observations. The terminal nodes of the tree partition the participants to subgroups according to a set of explanatory variables. Starting with the original data set, recursive partitioning splits each node by examining each variable and selecting one binary split across the members in that node, based on a variable that maximizes the "purity" in the outcome. This process is repeated until further partitioning is not possible. Because the final tree over-fits the data, ten-fold cross-validation is used to prune the tree. Finally, the "one-standard error" heuristic is used to find the *simplest* tree with a cross-validated error estimate no more than one standard error larger than the best tree. Recursive partitioning has the ability to detect multi-way interactions and handle highly correlated variables; alternatively, this method is less well known and not as powerful as parametric methods when the form of the underlying model is parametric and correctly specified.

Table 1

Select demographic and clinical characteristics by type of surgical treatment among Asian-American women diagnosed with stage 0-II breast cancer, California Cancer Registry, 1990–2007 diagnoses

	BCS no radiation (n=2764)		BCS with radiation[1] (n=7792)		Mastectomy n=10431)		Total (N=20987)
	n	(Row %)	n	(Row %)	n	(Row %)	N
Age*							
<40	220	(12.6)	602	(34.5)	922	(52.9)	1744
40–49	785	(13.7)	2156	(37.7)	2777	(48.6)	5718
50–59	801	(14.0)	2178	(38.1)	2745	(48.0)	5724
60–69	545	(12.6)	1604	(37.2)	2164	(50.2)	4313
70–79	291	(10.9)	979	(36.8)	1393	(52.3)	2663
80+	122	(14.8)	273	(33.1)	430	(52.1)	825
Nativity and race/ethnicity*							
US-born Japanese	258	(12.3)	902	(42.9)	942	(44.8)	2102
US-born Chinese	227	(15.7)	646	(44.8)	570	(39.5)	1443
US-born Filipina	102	(14.3)	294	(41.4)	315	(44.3)	711
US-born Korean	16	(15.4)	34	(32.7)	54	(51.9)	104
US-born South Asian	18	(11.4)	63	(39.9)	77	(48.7)	158
US-born Vietnamese	20	(13.9)	57	(39.6)	67	(46.5)	144
Foreign-born Japanese	205	(14.5)	582	(41.2)	626	(44.3)	1413
Foreign-born Chinese	611	(13.2)	1673	(36.1)	2350	(50.7)	4634
Foreign-born Filipina	804	(12.3)	2222	(33.9)	3528	(53.8)	6554
Foreign-born Korean	171	(13.8)	471	(38.0)	598	(48.2)	1240
Foreign-born South Asian	148	(14.2)	418	(40.2)	474	(45.6)	1040
Foreign-born Vietnamese	184	(12.7)	430	(29.8)	830	(57.5)	1444
Year of diagnosis*							
1990	16	(4.4)	90	(24.8)	257	(70.8)	363
1991	19	(5.1)	74	(19.8)	281	(75.1)	374
1992	45	(6.4)	164	(23.2)	497	(70.4)	706
1993	52	(7.3)	196	(27.5)	466	(65.3)	714

	BCS no radiation (n=2764)		BCS with radiation[1] (n=7792)		Mastectomy n=10431)		Total (N=20987)
	n	(Row %)	n	(Row %)	n	(Row %)	N
1994	66	(8.8)	220	(29.3)	466	(62.0)	752
1995	74	(8.4)	259	(29.5)	546	(62.1)	879
1996	100	(10.3)	339	(34.9)	532	(54.8)	971
1997	142	(13.0)	387	(35.4)	563	(51.6)	1092
1998	133	(11.3)	425	(36.1)	620	(52.6)	1178
1999	185	(14.9)	434	(35.0)	620	(50.0)	1239
2000	160	(12.1)	515	(38.9)	650	(49.1)	1325
2001	211	(14.8)	507	(35.7)	703	(49.5)	1421
2002	266	(16.3)	611	(37.5)	753	(46.2)	1630
2003	216	(13.9)	619	(39.7)	723	(46.4)	1558
2004	231	(14.8)	664	(42.6)	662	(42.5)	1557
2005	258	(15.6)	722	(43.6)	675	(40.8)	1655
2006	272	(16.0)	770	(45.3)	658	(38.7)	1700
2007	318	(17.0)	796	(42.5)	759	(40.5)	1873
Marital status*							
Single, never married	398	(16.3)	866	(35.4)	1179	(48.3)	2443
Married	1857	(12.8)	5494	(37.8)	7182	(49.4)	14533
Separated	17	(9.6)	72	(40.7)	88	(49.7)	177
Divorced	128	(11.5)	478	(42.8)	510	(45.7)	1116
Widowed	290	(12.1)	802	(33.5)	1303	(54.4)	2395
Unknown	74	(22.9)	80	(24.8)	169	(52.3)	323
Tumor size*							
<1 cm	792	(18.5)	2038	(47.6)	1448	(33.8)	4278
1–1.9 cm	1081	(13.3)	3591	(44.1)	3468	(42.6)	8140
2–2.9 cm	580	(11.7)	1502	(30.4)	2859	(57.9)	4941
3–3.9 cm	198	(9.0)	473	(21.5)	1528	(69.5)	2199
4–5 cm	113	(7.9)	188	(13.2)	1128	(78.9)	1429
Stage*							
In situ	984	(28.9)	1315	(38.6)	1110	(32.6)	3409

	BCS no radiation (n=2764)		BCS with radiation[1] (n=7792)		Mastectomy n=10431)		Total (N=20987)
	n	(Row %)	n	(Row %)	n	(Row %)	N
Stage I	892	(10.0)	4219	(47.3)	3818	(42.8)	8929
Stage II	888	(10.3)	2258	(26.1)	5503	(63.6)	8649
Histology *							
Ductal, invasive	1387	(9.9)	5192	(37.0)	7462	(53.1)	14041
Lobular, invasive	203	(10.1)	697	(34.7)	1108	(55.2)	2008
Ductal carcinoma in situ (DCIS)	657	(29.6)	818	(36.9)	741	(33.4)	2216
Other	517	(19.0)	1085	(39.9)	1120	(41.1)	2722
Grade *							
Grade I	425	(13.3)	1534	(47.8)	1248	(38.9)	3207
Grade II	1110	(13.5)	3221	(39.2)	3891	(47.3)	8222
Grade III	766	(11.9)	2066	(32.0)	3630	(56.2)	6462
Grade IV	109	(12.6)	358	(41.4)	398	(46.0)	865
Unknown	354	(15.9)	613	(27.5)	1264	(56.7)	2231
Estrogen receptor (ER) status *							
Positive	1358	(10.6)	5353	(41.9)	6079	(47.5)	12790
Negative	369	(10.4)	1174	(33.1)	2005	(56.5)	3548
Borderline/not done/unknown	1037	(22.3)	1265	(27.2)	2347	(50.5)	4649
Progesterone receptor (PR) status *							
Positive	1116	(10.3)	4588	(42.5)	5085	(47.1)	10789
Negative	499	(10.2)	1713	(34.9)	2700	(55.0)	4912
Borderline/not done/unknown	1149	(21.7)	1491	(28.2)	2646	(50.1)	5286
Hormone receptor (ER and PR) status *							
Positive	1397	(10.6)	5482	(41.5)	6320	(47.9)	13199
Negative	325	(10.5)	1030	(33.3)	1740	(56.2)	3095
Borderline/not done/unknown	1042	(22.2)	1280	(27.3)	2371	(50.5)	4693
Nodal involvement *							
No	2255	(14.3)	6426	(40.8)	7070	(44.9)	15751
Yes[2]	509	(9.7)	1366	(26.1)	3361	(64.2)	5236

	BCS no radiation (n=2764)		BCS with radiation[1] (n=7792)		Mastectomy n=10431)		Total (N=20987)
	n	(Row %)	n	(Row %)	n	(Row %)	N
Laterality							
Right	1320	(12.9)	3808	(37.3)	5073	(49.7)	10201
Left	1444	(13.4)	3984	(36.9)	5358	(49.7)	10786
Site/anatomic location *							
Not-central, one quadrant	1696	(13.2)	5273	(41.2)	5833	(45.6)	12802
Central	146	(9.7)	368	(24.5)	987	(65.8)	1501
Overlapping lesion of breast	626	(13.7)	1706	(37.3)	2243	(49.0)	4575
Multifocal, location NOS	296	(14.0)	445	(21.1)	1368	(64.9)	2109
National Cancer Institute (NCI)-designated cancer center *							
No	2559	(13.1)	7155	(36.7)	9781	(50.2)	19495
Yes	205	(13.7)	637	(42.7)	650	(43.6)	1492
Hospital ownership *							
Public	1337	(13.6)	3807	(38.7)	4691	(47.7)	9835
HMO	605	(12.1)	1957	(39.1)	2447	(48.9)	5009
University	713	(14.2)	1631	(32.5)	2671	(53.3)	5015
Unknown	109	(9.7)	397	(35.2)	622	(55.1)	1128
Hospital size (beds) *							
250+	1745	(13.3)	5147	(39.2)	6244	(47.5)	13136
<250	910	(13.5)	2248	(33.4)	3565	(53.0)	6723
Unknown	109	(9.7)	397	(35.2)	622	(55.1)	1128
Percent cancer patients in hospital that are highest SES quintile *							
25%+	1427	(13.1)	4528	(41.5)	4965	(45.5)	10920
<25%	1337	(13.3)	3264	(32.4)	5466	(54.3)	10067
Percent cancer patients in hospital that are Asian/Pacific Islander *							
0 to 10%	1349	(12.9)	4091	(39.1)	5014	(48.0)	10454
Greater than 10%	1415	(13.4)	3701	(35.1)	5417	(51.4)	10533
Neighborhood socioeconomic status (SES)[3] quintile *							
First (lowest SES)	228	(14.4)	429	(27.1)	926	(58.5)	1583

	BCS no radiation (n=2764)		BCS with radiation[1] (n=7792)		Mastectomy n=10431)		Total (N=20987)
	n	(Row %)	n	(Row %)	n	(Row %)	N
Second	407	(13.8)	928	(31.5)	1614	(54.7)	2949
Third	526	(13.0)	1464	(36.3)	2045	(50.7)	4035
Fourth	728	(13.3)	2174	(39.7)	2580	(47.1)	5482
Fifth (highest SES)	875	(12.6)	2797	(40.3)	3266	(47.1)	6938
Neighborhood ethnic enclave[4*]							
Most ethnic	1517	(13.1)	4225	(36.4)	5866	(50.5)	11608
Least ethnic	1232	(13.3)	3532	(38.2)	4492	(48.5)	9256
Unknown	15	(12.2)	35	(28.5)	73	(59.3)	123
Neighborhood SES and ethnic enclave[5*]							
Low SES, most ethnic	677	(13.7)	1570	(31.9)	2678	(54.4)	4925
Low SES, least ethnic	484	(13.3)	1251	(34.3)	1907	(52.4)	3642
High SES, most ethnic	840	(12.6)	2655	(39.7)	3188	(47.7)	6683
High SES, least ethnic	763	(13.3)	2316	(40.4)	2658	(46.3)	5737

[1]Includes n=202 women at or above age 70 years who omitted radiation after BCS, and are considered to have had guideline concordant BCS

[2]nodal involvement includes women with at least one involved node

[3]includes census (block group level) variables percent of population with blue-collar job, percent older than 16 without job, median household income, percent below 200% of poverty level, median rent, median house value, and education index (percent with given level of education weighted by number of years needed to attain that level of education)

[4]includes census (block group level) variables percent of Asian-language-speaking households that are linguistically isolated, percent of all Asian-language speakers who speak limited English, percent recent immigrants, and percent Asian

[5]"low SES" = quintiles 1–3; "high SES" = quintiles 4–5; "most ethnic" = quintiles 1–4; "least ethnic" = quintile 5

[*]P<.001 for differences across treatment groups

Table 2

Adjusted odds ratios* for receipt of non-guideline treatment or mastectomy (relative to BCS with radiation) among Asian-American women diagnosed with stage 0-II breast cancer, California Cancer Registry, 1990–2007 diagnoses

		BCS no radiation vs. BCS with radiation[1]		Mastectomy vs. BCS with radiation[1]	
	No.	**OR**	**(95% CI)**	**OR**	**(95% CI)**
Age					
<40	1744	1.04	(0.87 – 1.26)	0.97	(0.85 – 1.10)
40–49	5718	0.99	(0.88 – 1.12)	0.94	(0.86 – 1.03)
50–59	5724	1.00	(referent)	1.00	(referent)
60–69	4313	0.93	(0.81 – 1.06)	1.15	(1.05 – 1.26)
70–79	2663	0.80	(0.68 – 0.93)	1.32	(1.18 – 1.47)
80+	825	1.19	(0.94 – 1.49)	1.34	(1.13 – 1.60)
Race/ethnicity & nativity					
US-born Japanese	2102	1.00	(referent)	1.00	(referent)
US-born Chinese	1443	1.17	(0.95 – 1.45)	0.99	(0.84 – 1.16)
US-born Filipina	711	1.07	(0.81 – 1.41)	1.03	(0.85 – 1.26)
US-born Korean	104	1.68	(0.87 – 3.23)	1.80	(1.08 – 3.00)
US-born South Asian	158	0.96	(0.54 – 1.73)	1.18	(0.81 – 1.72)
US-born Vietnamese	144	1.17	(0.67 – 2.04)	1.23	(0.81 – 1.85)
Foreign-born Japanese	1413	1.19	(0.95 – 1.47)	1.00	(0.85 – 1.17)
Foreign-born Chinese	4634	1.08	(0.90 – 1.28)	1.36	(1.20 – 1.53)
Foreign-born Filipina	6554	1.09	(0.92 – 1.28)	1.36	(1.21 – 1.53)
Foreign-born Korean	1240	1.06	(0.84 – 1.33)	1.16	(0.98 – 1.37)
Foreign-born South Asian	1040	1.15	(0.90 – 1.47)	0.97	(0.82 – 1.16)
Foreign-born Vietnamese	1444	1.20	(0.96 – 1.52)	1.75	(1.49 – 2.06)
Year of diagnosis					
1990	363	1.00	(referent)	1.00	(referent)
1991	374	1.74	(0.84 – 3.62)	1.35	(0.93 – 1.95)
1992	706	1.89	(1.01 – 3.53)	1.01	(0.73 – 1.39)
1993	714	1.81	(0.98 – 3.35)	0.79	(0.57 – 1.08)
1994	752	2.06	(1.13 – 3.75)	0.75	(0.55 – 1.03)

	No.	BCS no radiation vs. BCS with radiation[1] OR	(95% CI)	Mastectomy vs. BCS with radiation[1] OR	(95% CI)
1995	879	2.04	(1.13 – 3.70)	0.77	(0.57 – 1.05)
1996	971	2.11	(1.18 – 3.77)	0.56	(0.42 – 0.76)
1997	1092	2.66	(1.50 – 4.70)	0.54	(0.40 – 0.73)
1998	1178	2.23	(1.26 – 3.94)	0.56	(0.42 – 0.75)
1999	1239	3.07	(1.75 – 5.39)	0.53	(0.40 – 0.72)
2000	1325	2.18	(1.24 – 3.85)	0.47	(0.35 – 0.63)
2001	1421	3.13	(1.79 – 5.48)	0.53	(0.40 – 0.71)
2002	1630	3.29	(1.89 – 5.73)	0.46	(0.34 – 0.61)
2003	1558	2.75	(1.57 – 4.82)	0.43	(0.32 – 0.57)
2004	1557	3.10	(1.77 – 5.41)	0.41	(0.31 – 0.55)
2005	1655	3.37	(1.93 – 5.89)	0.38	(0.29 – 0.51)
2006	1700	3.39	(1.95 – 5.92)	0.37	(0.27 – 0.49)
2007	1873	4.01	(2.31 – 6.99)	0.42	(0.31 – 0.56)
Tumor size					
<1 cm	4278	1.00	(referent)	1.00	(referent)
1–1.9 cm	8140	0.95	(0.85 – 1.06)	1.21	(1.10 – 1.32)
2–2.9 cm	4941	1.17	(1.02 – 1.34)	2.13	(1.92 – 2.36)
3–3.9 cm	2199	1.20	(0.98 – 1.45)	3.48	(3.05 – 3.98)
4–5 cm	1429	1.54	(1.19–2.00)	6.42	(5.38 – 7.66)
Histology					
Ductal, invasive	14041	1.00	(referent)	1.00	(referent)
DCIS	2216	1.91	(1.65 – 2.21)	0.57	(0.50 – 0.65)
Lobular, invasive	2008	1.07	(0.90 – 1.28)	1.18	(1.05 – 1.32)
Other	2722	1.46	(1.28 – 1.67)	0.75	(0.68 – 0.83)
Grade					
Grade I	3207	1.00	(referent)	1.00	(referent)
Grade II	8222	1.09	(0.96 – 1.25)	1.16	(1.06 – 1.28)
Grade III & IV	7327	0.97	(0.84 – 1.13)	1.24	(1.12 – 1.38)
Unknown	2231	1.45	(1.21 – 1.74)	1.50	(1.3–1.72)
Hormone receptor status					

	No.	BCS no radiation vs. BCS with radiation[1]		Mastectomy vs. BCS with radiation[1]	
		OR	(95% CI)	OR	(95% CI)
Positive	13199	1.00	(referent)	1.00	(referent)
Negative	3095	1.24	(1.07–1.44)	1.20	(1.09 – 1.33)
Borderline, unknown, not done	4693	2.71	(2.40 – 3.06)	1.67	(1.52 – 1.84)
Nodal involvement					
No	15751	1.00	(referent)	1.00	(referent)
Yes	5236	1.49	(1.31 – 1.69)	1.64	(1.51 – 1.78)
Site/anatomic location					
Not-central, one quadrant	12802	1.00	(referent)	1.00	(referent)
Central	1501	1.13	(0.92 – 1.38)	2.27	(1.99 – 2.59)
Overlapping lesion of breast	4575	1.10	(0.98 – 1.23)	1.24	(1.14 – 1.34)
Breast, NOS; multifocal	2109	1.76	(1.50 – 2.07)	2.94	(2.60 – 3.33)
NCI-designated cancer center					
Yes	19495	1.00	(referent)	1.00	(referent)
No	1492	1.05	(0.88 – 1.25)	1.24	(1.09 – 1.41)
Hospital size (beds)					
250+	13136	1.00	(referent)	1.00	(referent)
<250	6723	1.19	(1.08 – 1.32)	1.24	(1.15 – 1.33)
Unknown	1128	0.73	(0.58 – 0.92)	1.09	(0.94 – 1.27)
Percent cancer patients in hospital that are highest neighborhood SES quintile					
25%+	10920	1.00	(referent)	1.00	(referent)
<25%	10067	1.30	(1.18 – 1.44)	1.33	(1.24 – 1.43)
Percent cancer patients in hospital that are Asian/Pacific Islander					
0 to 10%	10454	1.00	(referent)	1.00	(referent)
Greater than 10%	10533	1.21	(1.09 – 1.33)	1.20	(1.12 – 1.28)
Neighborhood SES and ethnic enclave					
High SES, least ethnic	5737	1.00	(referent)	1.00	(referent)
Low SES, least ethnic	3642	1.10	(0.95 – 1.28)	1.08	(0.98 – 1.20)
High SES, most ethnic	6683	0.90	(0.80 – 1.02)	1.00	(0.91 – 1.09)
Low SES, most ethnic	4925	1.16	(1.01 – 1.32)	1.10	(1.00 – 1.21)

* adjusted for all factors in the table, and for clustering by hospital and by block group

[1] Includes n=202 women at or above age 70 years who omitted radiation after BCS, and are considered to have had guideline concordant BCS

Unadjusted odds ratios (OR) are available upon request.

Table 3

Summary of subgroups identified through recursive partitioning and probability of having mastectomy

Terminal node	Risk group characteristics	N	Probability of having a mastectomy (95% CI)
1	Tumor size ≥2 cm	7678	71.8% (70.8%, 72.8%)
2	Tumor size <2 cm. Multifocal or location NOS, or central mass.	1653	64.9% (62.6%, 67.2%)
3	Tumor size <2 cm. Mass one quadrant or overlapping lesion. Dx 1990–1995. Foreign-born Chinese, Filipina, Vietnamese; US-born Japanese, Korean, Vietnamese.	1126	64.7% (61.9%, 67.4%)
4	Tumor size <2 cm. Mass one quadrant or overlapping lesion. Dx 1990–1995. Foreign-born Japanese, Korean, South Asian; US-born Chinese, Filipina, South Asian.	425	46.1% (41.4%, 50.9%)
5	Tumor size <2 cm. Mass one quadrant or overlapping lesion. Dx 2003–2007.	3623	35.0% (33.4%, 36.5%)
6	Tumor size <2 cm. Mass one quadrant or overlapping lesion. Dx 1990–2002. Foreign-born Japanese, South Asian; US-born Chinese, Japanese.	1161	36.9% (34.1%, 39.6%)
7	Tumor size <2 cm. Mass one quadrant or overlapping lesion. Dx 1990–2002. Foreign-born Chinese, Filipina, Vietnamese; US-born Japanese, Korean, Vietnamese. Histology DCIS.	284	32.7% (27.3%, 38.2%)
8	Tumor size <2 cm. Mass one quadrant or overlapping lesion. Dx 1990–2002. Foreign-born Chinese, Filipina, Vietnamese; US-born Japanese, Korean, Vietnamese. Histology ductal, invasive, lobular, other. HR status negative, unknown.	668	58.1% (54.3%, 61.8%)
9	Tumor size <2 cm. Mass one quadrant or overlapping lesion. Dx 1990–2002. Foreign-born Chinese, Filipina, Vietnamese; US-born Japanese, Korean, Vietnamese. Histology ductal, invasive, lobular, other. HR status positive. Grades III, IV and unknown.	426	54.2% (49.5%, 59.0%)
10	Tumor size <2 cm. Mass one quadrant or overlapping lesion. Dx 1990–2002. Foreign-born Chinese, Filipina, Vietnamese; US-born Japanese, Korean, Vietnamese. Histology ductal, invasive, lobular, other. HR status positive. Grades I and II.	122	56.6% (47.8%, 65.4%)
11	Tumor size <2 cm. Mass one quadrant or overlapping lesion. Dx 1990–2002. Foreign-born Chinese, Filipina, Vietnamese, Korean; US-born Japanese, Korean, Vietnamese, Filipina. Histology ductal, invasive, lobular, other. HR status positive. Grades I and II.	1057	41.9% (38.9%, 44.9%)