# Disparities and Trends in Sentinel Lymph Node Biopsy Among Early-Stage Breast Cancer Patients (1998–2005)

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**Background** Sentinel lymph node biopsy (SLNB), an acceptable alternative to axillary lymph node dissection for staging patients with breast cancer, was introduced to clinical practice in the late 1990s. We assessed demographic, clinical, and facility-related factors associated with SLNB in women with early-stage breast cancer and evaluated trends in these factors over time.

**Methods** Data on early-stage breast cancers (T1a, T1b, T1c, and T2N0) diagnosed between January 1, 1998, and December 31, 2005, were extracted from the National Cancer Database, a hospital-based registry. Patient demographics, tumor stage, type of lymph node surgery, type of breast cancer surgery, health insurance, treatment facility type, and area-level education and income variables were collected. Multivariable logistic regression analyses were performed to assess predictive factors associated with SLNB, temporal differences in factors associated with SLNB, and differences in rates of SLNB by facility type, race/ethnicity, and type of health insurance over time.

**Results** The total analytic study population included 490 899 women. The use of SLNB increased from 26.8% in 1998 to 65.5% in 2005. Factors associated with lower likelihood of SLNB over the study period included being older (odds ratio [OR] = 0.80, 95% confidence interval [CI] = 0.78 to 0.92 for those aged 72 or older compared with those aged 51 or younger), being of racial/ethnic minority (OR = 0.76, 95% CI = 0.74 to 0.78 for African Americans compared with whites), having no health insurance (OR = 0.77, 95% CI = 0.73 to 0.80 for uninsured compared with having private insurance), having certain government insurance plans (for Medicaid, OR = 0.81, 95% CI = 0.78 to 0.84, and for Medicare at age <65 years, OR = 0.83, 95% CI = 0.80 to 0.87, both compared with private insurance), residing in zip codes with lower proportion of high school graduates (OR = 0.88, 95% CI = 0.86 to 0.89) or with lower median income (OR = 0.79, 95% CI = 0.77 to 0.81), and receiving treatment in facility types other than a teaching or research hospital (for community hospital, OR = 0.84, 95% CI = 0.82 to 0.86; for community cancer center, OR = 0.86, 95% CI = 0.84 to 0.87). The associations with insurance status and sociodemographic characteristics were more pronounced in 2005 than in 1998. For example, the adjusted annual rates of SLNB in 1998 were 0.29 in whites, 0.26 in African Americans, and 0.35 in Hispanics; in 2005 the respective rates were 0.70, 0.64, and 0.67.

**Conclusions** Although use of SLNB increased from 1998 to 2005, disparities persisted in receipt of SLNB that are based on nonclinical factors, including sociodemographic characteristics and insurance status.

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Breast cancer is the leading cancer diagnosed in women, with an estimated 180 510 new cases of invasive breast cancer in women in the United States in 2007 (1). The extent of lymph node involvement and accurate staging of breast cancer are determined traditionally in patients undergoing surgery for breast cancer by axillary lymph node dissection (ALND). The systematic removal of levels I and II axillary lymph nodes allows for comprehensive evaluation of the extent of cancer spread, but it may also lead to substantial morbidity, including lymphedema and functional deficits in the ipsilateral upper extremity (2–4).

Beginning in the late 1990s, clinical trials investigated the use of sentinel lymph node biopsy (SLNB) as a less invasive alternative to ALND. In SLNB, the first echelon of lymph nodes (ie, sentinel lymph nodes) are identified by injecting radioactively labeled colloid and/or blue dye in the breast. Lymph nodes that take up the radiolabeled material or blue dye are then surgically

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harvested and examined for metastases. If metastases are not found in the sentinel lymph nodes, then a full ALND is not required, allowing the patient to avoid the accompanying morbidity. Rates of regional recurrence have been found to be low among patients with negative SLNB results (2,5).

As early as 1998, guidelines from the National Comprehensive Cancer Network have included SLNB in lieu of ALND for women with early-stage invasive breast cancer (cT1N0M0 and cT2N0M0) under defined circumstances (6). In 2005, the American Society of Clinical Oncology issued treatment guideline recommendations for SLNB in early-stage breast cancer (7), concluding that this procedure is an appropriate alternative to ALND for the assessment of pathologic lymph node status among patients with clinically negative axillary lymph nodes.

Despite these recommendations, ALND continues to be performed for many breast cancer patients. This procedure is not necessarily inappropriate because performing successful SLNB requires a trained and experienced multidisciplinary team (8). However, little information is available on the characteristics of patients receiving SLNB vs ALND or on the relationship between the type of treatment facility and receipt of SLNB vs ALND.

The primary objectives of this study were 1) to compare the characteristics of individuals (insurance type, patient demographics, and other factors) initially receiving SLNB vs ALND among patients with early-stage breast cancer treated at American College of Surgeons Commission on Cancer–approved facilities from January 1, 1998, through December 31, 2005, and 2) to evaluate changes over time in how factors predicted receipt of SLNB.

## CONTEXT AND CAVEATS

**Prior knowledge**

Sentinel lymph node biopsy (SLNB), which was introduced to clinical practice in the late 1990s, is an acceptable alternative to axillary lymph node dissection (ALND) for staging patients with breast cancer.

**Study design**

Retrospective population-based study that used data from a hospital-based cancer registry.

**Contribution**

Use of SLNB increased from 1998 to 2005, but disparities in receipt of SLNB that are based on nonclinical factors have persisted. Factors associated with lower likelihood of SLNB included being older, being of a racial/ethnic minority, having no health insurance, having certain government insurance plans, residing in zip codes with fewer high school graduates or a lower median income, and receiving treatment in facility types other than a teaching or research hospital.

**Implications**

Those who are more likely to receive ALND may lack resources to deal with the added burdens associated with its adverse effects.

**Limitations**

Some patients on Medicaid may have presented with no insurance coverage and applied for coverage after diagnosis, leading to an undercount of uninsured patients. Individual-level socioeconomic data, which would have permitted the authors to control for patient socioeconomic characteristics more precisely, were not available. When events, such as receiving SLNB, have high rates, odds ratios exaggerate actual relative risks.

## Patients and Methods

### Study Data Source and Patient Selection

Data from the National Cancer Database, a hospital-based cancer registry jointly sponsored by the American Cancer Society and the American College of Surgeons, were used in this study. The National Cancer Database collects data from approximately 1400 Commission on Cancer–approved cancer program registries annually and, at the time of this analysis, had received case reports on approximately 72% of the estimated incident cancer diagnoses in the United States, a percentage that is based on the total number of cases reported to the National Cancer Database compared with the estimated number of cancer diagnoses reported in the American Cancer Society's Facts and Figures for 2003 (9). The National Cancer Database, in common with population-based registries, contains standardized data elements on patient demographics, tumor characteristics (including stage and histopathology), and first course of treatment. The National Cancer Database also contains information on patient insurance status, county of residence, facility type in which patients were treated, and an encrypted facility identifier.

Data reported to the National Cancer Database are retrospective in nature. No patient or physician identifiers were collected as part of this study. Case identification information was collected for administrative purposes only. Analyses are reported only at the aggregate level to assist hospital cancer programs with quality assurance, rather than being used to make decisions about individuals and their care. Because no patient, provider, or hospital identifiers were included in the research dataset used in this study and no protected health information was present, institutional review board approval was not required for this study. De-identified datasets can be used without institutional review board approval.

Registries in the United States began reporting SLNB procedures with breast cancers diagnosed in 1996. We limited our analysis to cases diagnosed starting in 1998 to avoid problems associated with incomplete or nonuniform coding, which are common in the first few years after the introduction of new abstracting and coding rules. Women were assessed for study eligibility if they were aged 18 years or older when diagnosed with an invasive (behavior code = 3 [malignant]) breast cancer [*International Classification of Disease for Oncology* (*ICD-O*) (10) codes C50.0–C50.9] between January 1, 1998, and December 31, 2005; received all or part of their first course of treatment at the reporting facility (Commission on Cancer specified class 1 or 2); and had a surgical procedure performed.

To identify which of the initially identified 1 067 304 patients were appropriate for study inclusion, we repeated the steps in the clinician's identification of patients with breast cancer who were appropriate for SLNB preoperatively by using clinical staging information or, if that information was unavailable, by using pathologic staging information. To do so, we first identified whether the overall stage (ie, stages I–IV) had been determined based on clinical or pathologic information for patients in the starting population. Overall clinical stage was recorded for 401 717

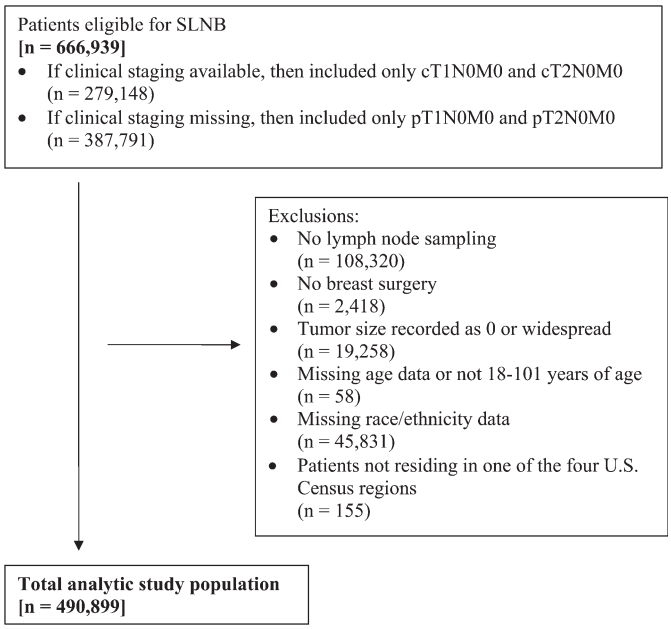


**Figure 1.** Derivation of the sentinel lymph node biopsy (SLNB) study population, National Cancer Database, January 1, 1998, through December 31, 2005.

patients (37.6% of the starting population); pathologic but not clinical stage was recorded for 634612 patients (59.5% of the starting population). Both clinical and pathologic stages were missing for 30974 patients (2.9% of the starting population), and these patients were excluded from the analysis.

Of the 401717 patients with clinical stage information, 348212 patients had overall clinical stage I or II, and 286331 of these were appropriate SLNB candidates, of whom 278839 were classified as cT1N0M0 or cT2N0M0. An additional 7492 patients did not have a clinical tumor–node–metastasis (TNM) stage (despite being classified as overall clinical stage I or II) but had a pathologic TNM stage of pT1N0M0 or pT2N0M0. Of the 634612 patients with pathologic stage information, 569375 patients had overall pathologic stage I or II; 309 of these had clinical TNM stages of cT1N0M0 or cT2N0M0 that were appropriate for study inclusion despite not having overall clinical stage specified, and 380299 patients were classified as pT1N0M0 or pT2N0M0. Therefore, 279148 (278839 + 309) patients were included on the basis of clinical TNM staging and 387791 (380299 + 7492) patients were included on the basis of pathologic TNM staging, for a total of 666939 patients who were appropriate SLNB candidates (Figure 1).

Patients with lymph node stage pN1 disease were excluded from the study population because an unknown proportion of these patients may have been cN1 (or greater) originally and thus would not have been candidates for SLNB. To be sure that we were not introducing selection bias by excluding these patients, we did a frequency analysis with the National Cancer Database for 327471 cases of invasive breast cancer cN0 from 1998 through 2005. Among these cases, only 45213 (13.8%) were pN1; thus, little bias appears to have been introduced. In the current study, among all 261159 invasive breast cancer patients who were stage pN1, clinical lymph node stage was missing for approximately 70%. Among the 81460 (31.2%) of pN1 patients who also had clinical lymph node status available, 36247 had clinical lymph node involvement (ie, were cN1, cN2, or cN3). Therefore, it was appropriate to exclude pN1 patients from the analysis because the treating physicians were likely to have known or suspected that they had positive lymph node status before surgery.

Because the study outcome variable of interest was whether patients initially received SLNB or ALND, we further defined our study population (Figure 1) by excluding patients whose lymph nodes were not examined (n = 108320). We also excluded patients who did not have mastectomy or breast-conserving surgery (n = 2418), patients with tumor size recorded as either 0 or widespread (n = 19258), patients who were missing age data or were not aged 18–101 years (n = 58), patients who were missing race/ethnicity data (n = 45831), and patients not residing in one of the four US census regions (eg, those from Puerto Rico, n = 155). After these exclusions, we obtained an analytic study population of 490899 SLNB candidates. The SLNB rate among patients included in the sample (52.8%) was similar to the rate among patients excluded because of not having mastectomy or breast-conserving surgery (54.3%), tumor size recorded as 1 or widespread (52.5%), or missing race/ethnicity information (54.2%), indicating that these exclusions did not bias the study population. The other excluded groups (58 with missing age and 155 not residing in one of the four US census regions) had substantially different rates of SLNB (43.1% and 7.1%, respectively), but these small numbers did not bias the study population.

### Study Variables

The dependent variable (type of lymph node surgery) was captured according to the Facility Oncology Registry Data Standards (FORDS) "scope of regional lymph node surgery" data item for patients diagnosed from 2003 through 2005 (11). Data for patients diagnosed from 1998 through 2002 were collected according to definitions in the Registry Operations and Data Standards (12); data items of the "scope of regional lymph node surgery" and "number of regional lymph nodes removed" in the Registry Operations and Data Standards were converted to the FORDS coding for inclusion in this analysis. In brief, patients were classified as having received SLNB if they received SLNB initially, whether or not they received subsequent ALND (FORDS codes 2, 6, or 7). Patients who received full ALND without initial SLNB were classified as having received ALND (FORDS codes 1, 3, 4, or 5). Patients with no lymph node procedure or unknown scope of regional lymph node surgery were not included in the analysis.

The independent variables included in this analysis were divided into four categories by the following sources or types of information: patient-level demographics, clinical characteristics, facility-level variables, and area-level information. Patient-level demographic variables were age at diagnosis, race/ethnicity, primary payer or insurance type at diagnosis, and driving distance to treatment facility. Clinical characteristics, which were also captured at the patient level, were tumor stage, whether study inclusion was based on pathologic or clinical TNM staging information, type of breast cancer surgery, and year of procedure (1998–2005). Treatment-level or facility-level characteristics were the volume of breast cancer patients at the treatment

facility and the treating facility type. Area-level characteristics were based on the patient's residence and consisted of census region, education level in patient's zip code, and median household income in patient's zip code.

***Patient-Level Demographic and Insurance Variables.*** For regression analyses, race was categorized as white, African American, Hispanic, and other (Asian American, American Indian, and other), and age at diagnosis was categorized in quartiles of 18–51, 52–61, 62–71, and ≥72 years. Primary payer or insurance type at diagnosis was determined by use of FORDS codes, which were grouped into the following categories: Medicaid, Medicare (including Medicare alone and with supplement), uninsured (which included FORDS codes for not insured—not otherwise specified [NOS], not insured—charity write-off, and not insured—self-pay), other government-funded plans (which included Veterans Administration, Indian Health Service, Public Health Service, welfare, state-funded NOS, and federally funded NOS), private insurance plans (health maintenance organizations, preferred provider organizations, managed-care NOS, and other private insurance [Champus/Tricare, military, and insured NOS]), and missing insurance status. The plans in the private insurance category were grouped together because these plans represent either privately purchased insurance or insurance provided by the military that functions in a similar manner as private insurance (Champus/Tricare). Because Medicare eligibility for individuals younger than 65 years differs from that in those who are 65 years or older, the Medicare category was dichotomized for analyses into Medicare among patients aged 18–64 years and Medicare among patients aged 65 years and older. Distance from the hospital was calculated by measuring the shortest distance between the centroid of the patient's zip code at time of diagnosis and the street address of the treating facility; this distance was categorized by quartiles (0–4.00, 4.01–8.75, 8.76–19.55, and ≥19.56 miles) according to equal-sized patient counts per quartile and also a missing data category.

***Clinical Characteristics.*** For regression analyses, the tumor stage was categorized as T1a (0.1 to ≤0.5 cm), T1b (0.5 to ≤1.0 cm), T1c (1 to ≤2 cm), and T2 (2 to ≤5 cm) (10). A variable that indicated whether the patient had been included in the study based on clinical or pathologic staging information was used to assess and control for potential selection bias from differing inclusion staging criteria. Type of breast surgery included breast-conserving surgery (FORDS codes 20–30) and mastectomy (FORDS codes 40–75).

***Facility-Level Variables.*** Three types of treatment facilities are included in the classification scheme used by the approvals program of the College of Surgeons Commission on Cancer: community cancer programs, comprehensive community cancer programs, and teaching or research centers. Community hospitals treat at least 300 cancer patients a year and have a full range of services for cancer care, but patients need a referral for portions of their treatment. Comprehensive community cancer centers are facilities that offer the same range of services as the community hospitals but treat at least 750 annual cancer patients and conduct weekly cancer conferences. Teaching or research facilities have residency programs and ongoing cancer research. Twenty-nine of the 39 National Cancer Institute–designated Comprehensive Cancer Programs participate in the approvals program of the College of Surgeons Commission on Cancer and were included among teaching or research facilities in this study. Patients with missing treatment facility type were included in a separate category. Quartiles of the number of breast cancer patients treated by an institution (ie, volume of breast cancer patients) were created for each year of the analysis, from making equal-sized hospital-specific quartiles of the volume of SLNB candidates (according to our study inclusion criteria) at each institution in a given year. Regression analyses controlled for the volume quartile of each patient's treating institution during the year of her diagnosis.

***Area-Level Variables.*** Patient residence was based on her reported state of residence at diagnosis and was categorized as West, Midwest, Northeast, or South, as classified in the United States Census Report (13). Patients with missing state of residence were grouped in a separate census region category. Area-based indicators of patient socioeconomic status, education, and income were derived at the zip code level from 2000 US Census data and were included as quartiles of the observed distribution in the general US population. The proportion of the population in a patient's zip code of residence who did not have a high school diploma was stratified as ≥36%, 26%–35.9%, 19%–25.9%, <19%, and missing, and the median household income was stratified as <$20 000, $20 000-$24 999, $25 000-$31 999, ≥$32 000, and missing. These quartiles for income and education levels are defined by the United States Census Report (13).

## Statistical Analyses

Chi-square tests and *t* tests ($\alpha = .05$) were initially used to examine associations between each of the independent variables, as described previously, with patient receipt of SLNB vs ALND (ie, nonreceipt of initial SLNB). Because all variables examined were statistically significant in these bivariate analyses, we then evaluated each of these categorical independent variables as a predictor of receipt of SLNB vs ALND by use of multivariable logistic regression with adjustment of each predictor for all other independent variables. The year of diagnosis was found to be the independent variable that was most strongly associated with receipt of SLNB, and so we used regression models to evaluate temporal trends from 1998 through 2005 for the likelihood of receiving SLNB by assessing interaction terms between year of diagnosis and facility type, race or ethnicity category, or insurance type. To investigate the differential influence that various factors had on the receipt of SLNB over the study period, we used multivariable logistic regression on data from patients diagnosed only during the first (1998) and last (2005) study years. We also included interaction terms between each model variable and the year of diagnosis (1998 vs 2005) to assess statistically significant differences in the ability of these predictive factors between the beginning and the end of the study period. In addition, annual rates of SLNB by race/ethnicity, insurance status, and facility type were calculated with adjustment for all other covariates (including age at diagnosis by quartiles, race/ethnicity, census region, insurance type, driving distance to hospital by quartiles, mastectomy vs breast-conserving surgery, tumor stage, study inclusion by pathology or clinical TNM staging, year of diagnosis, facility type, national quartiles of percentage of population in zip code without high school diploma, and

national quartiles of median household income in zip code) by separate multivariable logistic regression analyses for each year of diagnosis (1998–2005). Results from these analyses were then used to determine annual SLNB rates by facility type from the mean patient characteristics from each year. All analyses were conducted with SAS version 9.1 (Cary, NC). All statistical tests were two-sided.

## Results

### Factors Associated With Receipt of Sentinel Lymph Node Biopsy

Of the 490899 patients eligible for analysis, 259043 (52.8%) had SLNB initially (with or without subsequent ALND) and 231856 (47.2%) received initial ALND (but no SLNB). The use of SLNB increased from 26.8% (95% confidence interval [CI] = 26.5% to 27.2%) in 1998 to 65.5% (95% CI = 65.1% to 65.9%) in 2005. Using (unadjusted) *t* tests (for age at diagnosis) and $\chi^2$ tests (for all other variables), we found statistically significant differences between all characteristics of patients receiving SLNB and those receiving initial ALND ($P < .001$, for all bivariate analyses; data not shown).

We then used multivariable logistic regression analysis to calculate odds ratios (ORs) with 95% confidence intervals for initial SLNB (Table 1). For the period from January 1, 1998, through December 31, 2005, after controlling for the other variables in Table 1, the odds of receiving SLNB were statistically significantly lower among patients who were African American (OR = 0.76, 95% CI = 0.74 to 0.78), Hispanic (OR = 0.91, 95% CI = 0.88 to 0.94), or of other race (OR = 0.89, 95% CI = 0.86 to 0.93) compared with those who were white. Patients in the oldest age group (aged ≥72 years) were also less likely to receive SLNB (OR = 0.80, 95% CI = 0.78 to 0.82), compared with those in the youngest age group (aged ≤51 years). There was no clear relationship between driving distance and likelihood of receiving SLNB.

Individuals without insurance (OR = 0.77, 95% CI = 0.73 to 0.80), with Medicaid coverage (OR = 0.81, 95% CI = 0.78 to 0.84), and with Medicare younger than 65 years (OR = 0.83, 95% CI = 0.80 to 0.87) were less likely to receive SLNB than those with private insurance. Those residing in zip codes with lower proportion of high school graduates (OR = 0.88, 95% CI = 0.86 to 0.89) or with lower median income (OR = 0.79, 95% CI = 0.77 to 0.81) or who received treatment in facility types other than a teaching or research hospital (for community hospital: OR = 0.84, 95% CI = 0.82 to 0.86; for community cancer center: OR = 0.86, 95% CI = 0.84 to 0.87) also had statistically significantly lower likelihoods of receiving SLNB. Patients receiving treatment at facilities with higher volumes of breast cancer patients were statistically significantly more likely to receive SLNB than those treated at lower-volume facilities. The odds of receiving SLNB varied statistically significantly by census region; in the regression analysis evaluating predictive factors of SLNB over the entire study period, the odds were highest for patients residing in the South census region (referent group) and lowest for patients in the West census region (OR = 0.85, 95% CI = 0.83 to 0.86).

Although patients included in the study population because of available pathologic staging information were more likely to receive SLNB than those with complete clinical staging information, the magnitude of this association was small (OR = 1.03, 95% CI = 1.01 to 1.04). Additionally, controlling for inclusion based on pathologic staging information as a covariate did not substantially change the other parameter estimates. Thus, no selection bias was introduced by using both clinical and pathologic staging information as inclusion criteria.

Patients with T2 disease were less likely to receive SLNB (OR = 0.79, 95% CI = 0.78 to 0.81) than those with T1 disease. In addition, patients receiving mastectomy were less likely to receive SLNB (OR = 0.43, 95% CI = 0.42 to 0.43) than those receiving breast-conserving surgery.

Year of diagnosis had the strongest association with receiving SLNB. Compared with patients diagnosed in 1998, those diagnosed in 2005 were more likely to receive SLNB (OR = 5.26, 95% CI = 5.13 to 5.40). Over the entire study period, there was a 23% average annual increase in the odds of receiving SLNB (OR per year = 1.23, 95% CI = 1.226 to 1.233; data not shown).

Patients who were missing data for insurance type or the area-based measure of education or income were not statistically significantly different from the corresponding reference groups in terms of likelihood of receiving SLNB. However, patients with missing facility type were statistically significantly less likely to receive SLNB than those in the reference group (teaching or research hospitals), whereas those with missing driving distance to hospital were statistically significantly more likely to receive SLNB than those with the shortest driving distance. Because those with missing data for facility type or driving distance had associations with the study outcome (receipt of SLNB) that were statistically significantly different from those of their corresponding reference groups, controlling for the category of "missing data" in these variables is an important contribution to the explanation of the variability in the relationship between the predictor (independent) variables and the outcome.

### Trend Analyses

As noted above, the variable associated with the greatest odds of SLNB receipt was year of diagnosis. This result is consistent with SLNB changing over the study period from a new technique performed only at select hospitals to a widely disseminated treatment alternative. To illustrate differences in factors predicting receipt of SLNB from the beginning (in 1998) to the end (in 2005) of the study period, we compared the results of multiple logistic regression analyses on patients diagnosed in 1998 and on patients diagnosed in 2005 (Table 2).

Older age was not associated with the likelihood of receiving SLNB in 1998 (OR = 0.95, 95% CI = 0.88 to 1.03), but it was associated with decreased odds of receiving SLNB in 2005 (OR = 0.83, 95% CI = 0.77 to 0.90); this change in odds between 1998 and 2005 was statistically significant. Patients with Medicaid or private insurance and uninsured patients had an equal likelihood of receiving SLNB in 1998; however, by 2005, Medicaid and uninsured patients were statistically significantly less likely to receive SLNB than patients with private insurance (for Medicaid and uninsured patients in 2005, respectively, OR = 0.76, 95% CI = 0.69 to 0.83 and OR = 0.59, 95% CI = 0.52 to 0.68. The adjusted annual rates of SLNB receipt in 1998 were 0.28 for Medicaid patients,

**Table 1**. Comparison between sentinel lymph node biopsy and axillary lymph node dissection over the period from January 1, 1998, through December 31, 2005*

| Characteristic | Patients with initial SLNB† (n = 259 043) | | Patients with initial ALND† (n = 231 856) | | Patient totals by characteristic | | |
|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | OR (95% CI) | *P* value‡ |
| Patient-level demographics | | | | | | | |
| Quartiles: age at diagnosis | | | | | | | |
| 18–51 y | 69424 | 54.6 | 57732 | 45.4 | 127156 | 1.00 (referent) | – |
| 52–61 y | 68646 | 55.5 | 54950 | 44.5 | 123596 | 0.97 (0.96 to 0.99) | <.001 |
| 62–71 y | 61393 | 52.9 | 54718 | 47.1 | 116111 | 0.89 (0.87 to 0.91) | <.001 |
| ≥72 y | 59839 | 48.1 | 64456 | 51.9 | 124295 | 0.80 (0.78 to 0.82) | <.001 |
| Race/ethnicity | | | | | | | |
| White | 223813 | 53.5 | 194295 | 46.5 | 418108 | 1.00 (referent) | – |
| African-American | 18651 | 45.9 | 22026 | 54.1 | 40677 | 0.76 (0.74 to 0.78) | <.001 |
| Hispanic | 8289 | 50.5 | 8115 | 49.5 | 16404 | 0.91 (0.88 to 0.94) | <.001 |
| Other (Asian, Pacific Islander, Native American) | 8030 | 52.0 | 7419 | 48.0 | 15450 | 0.89 (0.86 to 0.93) | <.001 |
| Census region | | | | | | | |
| Midwest | 61911 | 51.8 | 57500 | 48.2 | 119412 | 0.92 (0.90 to 0.93) | <.001 |
| Northeast | 63984 | 55.1 | 52168 | 44.9 | 116151 | 0.90 (0.88 to 0.91) | <.001 |
| South | 89111 | 52.4 | 80918 | 47.6 | 170029 | 1.00 (referent) | – |
| West | 44296 | 51.6 | 41502 | 48.4 | 85799 | 0.85 (0.83 to 0.86) | <.001 |
| Insurance type | | | | | | | |
| Uninsured | 4145 | 44.8 | 5101 | 55.2 | 9246 | 0.77 (0.73 to 0.80) | <.001 |
| Medicaid | 6994 | 47.0 | 7883 | 53.0 | 14877 | 0.81 (0.78 to 0.84) | <.001 |
| Medicare | | | | | | | |
| Total | 87038 | 49.6 | 88337 | 50.4 | 175376 | – | – |
| Age <65 y | 5440 | 47.4 | 6028 | 52.6 | 11468 | 0.83 (0.80 to 0.87) | <.001 |
| Age ≥65 y | 81340 | 49.7 | 82309 | 50.3 | 163648 | 1.01 (0.99 to 1.03) | .256 |
| Other government insurance | 259 | 52.8 | 232 | 47.2 | 491 | 0.83 (0.69 to 1.01) | .066 |
| Private insurance§ | 154908 | 55.5 | 124275 | 44.5 | 279183 | 1.00 (referent) | – |
| Missing | 6217 | 50.8 | 6028 | 49.2 | 12245 | 0.98 (0.94 to 1.02) | .268 |
| Quartiles: driving distance to hospital | | | | | | | |
| <4.01 miles | 52845 | 49.0 | 54950 | 51.0 | 107795 | 1.00 (referent) | – |
| 4.01–8.75 miles | 56471 | 52.2 | 51704 | 47.8 | 108175 | 0.99 (0.97 to 1.01) | .369 |
| 8.76–19.55 miles | 57767 | 53.7 | 49849 | 46.3 | 107616 | 0.99 (0.97 to 1.01) | .287 |
| >19.55 miles | 56730 | 52.5 | 51240 | 47.5 | 107971 | 1.04 (1.03 to 1.06) | <.001 |
| Missing | 35489 | 59.3 | 24345 | 40.7 | 59834 | 1.28 (1.25 to 1.31) | <.001 |
| Clinical characteristics | | | | | | | |
| Mastectomy | 64502 | 37.8 | 105958 | 62.2 | 170460 | 0.43 (0.42 to 0.43) | <.001 |
| Tumor stage‖ | | | | | | | |
| T1a | 59062 | 54.8 | 48690 | 45.2 | 107752 | 1.00 (referent) | – |
| T1b | 56730 | 57.6 | 41734 | 42.4 | 98464 | 1.04 (1.02 to 1.06) | <.001 |
| T1c | 93515 | 53.5 | 81381 | 46.5 | 174896 | 0.95 (0.93 to 0.96) | <.001 |
| T2 | 49736 | 45.3 | 60051 | 54.7 | 109787 | 0.79 (0.78 to 0.81) | <.001 |
| Study inclusion by pathologic TNM staging | 160089 | 52.8 | 142823 | 47.2 | 302912 | 1.03 (1.01 to 1.04) | <.001 |
| Year of diagnosis | | | | | | | |
| 1998 | 69424 | 29.0 | 169719 | 71.0 | 239142 | 1.00 (referent) | – |
| 1999 | 100509 | 41.5 | 141896 | 58.5 | 242405 | 1.76 (1.72 to 1.81) | <.001 |
| 2000 | 132889 | 54.1 | 112914 | 45.9 | 245803 | 2.96 (2.89 to 3.04 | <.001 |
| 2001 | 145064 | 58.7 | 102017 | 41.3 | 247081 | 3.62 (3.53 to 3.71) | <.001 |
| 2002 | 155685 | 62.7 | 92511 | 37.3 | 248195 | 4.21 (4.11 to 4.32) | <.001 |
| 2003 | 156980 | 63.2 | 91351 | 36.8 | 248331 | 4.22 (4.12 to 4.33) | <.001 |
| 2004 | 162420 | 65.3 | 86482 | 34.7 | 248902 | 4.64 (4.52 to 4.76) | <.001 |
| 2005 | 169673 | 68.0 | 79990 | 32.0 | 249663 | 5.26 (5.13 to 5.40) | <.001 |
| Facility-level variables | | | | | | | |
| Hospital type in which treatment occurred | | | | | | | |
| Community hospital | 34971 | 43.6 | 45212 | 56.4 | 80183 | 0.84 (0.82 to 0.86) | <.001 |
| Community cancer center | 121750 | 52.6 | 109668 | 47.4 | 231418 | 0.86 (0.84 to 0.87) | <.001 |
| Teaching or research hospital | 88852 | 57.4 | 65847 | 42.6 | 154699 | 1.00 (referent) | – |
| Missing | 13729 | 55.2 | 11129 | 44.8 | 24858 | 0.88 (0.86 to 0.91) | <.001 |

*(Table continues)*

**Table 1 (continued).**

| Characteristic | Patients with initial SLNB† (n = 259043) No. | % | Patients with initial ALND† (n = 231856) No. | % | Patient totals by characteristic No. | OR (95% CI) | *P* value‡ |
|---|---|---|---|---|---|---|---|
| Quartiles: breast cancer patient volume¶ | | | | | | | |
| <25% | 9585 | 37.5 | 15998 | 62.5 | 25583 | 1.00 (referent) | – |
| 25%–50% | 30308 | 43.3 | 39647 | 56.7 | 69955 | 1.19 (1.15 to 1.22) | <.001 |
| 50%–75% | 61393 | 50.5 | 60283 | 49.5 | 121676 | 1.48 (1.43 to 1.53) | <.001 |
| ≥75% | 157757 | 57.6 | 116160 | 42.4 | 273917 | 1.81 (1.75 to 1.87) | <.001 |
| Area-level variables | | | | | | | |
| National quartiles: % without high school diploma | | | | | | | |
| <19% | 109057 | 57.2 | 81613 | 42.8 | 190670 | 1.00 (referent) | – |
| 25.9%–19% | 56989 | 51.3 | 54022 | 48.7 | 111012 | 0.89 (0.87 to 0.90) | <.001 |
| 35.9%–26% | 47664 | 49.0 | 49617 | 51.0 | 97281 | 0.88 (0.86 to 0.89) | <.001 |
| ≥36% | 29272 | 46.2 | 34083 | 53.8 | 63355 | 0.88 (0.86 to 0.90) | <.001 |
| Missing | 16061 | 55.7 | 12752 | 44.3 | 28813 | 0.99 (0.43 to 2.27) | .986 |
| National quartiles: median household income | | | | | | | |
| <$20,000 | 22796 | 44.0 | 28982 | 56.0 | 51778 | 0.79 (0.77 to 0.81) | <.001 |
| $20,000–$24,999 | 36784 | 48.1 | 39647 | 51.9 | 76431 | 0.87 (0.85 to 0.89) | <.001 |
| $25,000–$31,999 | 65279 | 51.4 | 61674 | 48.6 | 126953 | 0.94 (0.92 to 0.95) | <.001 |
| ≥$32,000 | 118124 | 57.1 | 88801 | 42.9 | 206924 | 1.00 (referent) | – |
| Missing | 16061 | 55.7 | 12752 | 44.3 | 28813 | 0.76 (0.33 to 1.74) | .520 |

* Analyses were performed by comparing characteristics of patients receiving SLNB vs ALND by multivariable logistic regression with adjustment for all listed factors. SLNB = sentinel lymph node biopsy; ALND = axillary lymph node dissection; OR = odds ratio; CI = confidence interval; TNM = tumor–node–metastasis; – = referent.

† The mean age at diagnosis of patients with initial SLNB was 60.6 years (range 18-101 years) and of patients with initial ALND was 61.9 years (range 18-101 years).

‡ *P* value refers to the statistical significance of the odds ratios for receipt of SLNB assessed by the Wald $\chi^2$ test statistic. All statistical tests were two-sided.

§ Private insurance includes health maintenance organization, preferred provider organization, Tricare/Champus/Military Health Care System, and unspecified private insurance.

‖ According to American Joint Commission on Cancer (AJCC) guidelines (10).

¶ Quartiles were adjusted for breast cancer surgery volume each year.

0.27 for uninsured patients, and 0.29 for privately insured patients; in 2005 the rates were 0.64, 0.58, and 0.70, respectively (Figure 2). In 1998, women who were African American and of "other" races were less likely than white women to receive SLNB, and Hispanic women were more likely than white women to receive SLNB. By 2005, the odds of receiving SLNB had decreased further among African American women and was statistically significantly lower among Hispanic women (Table 2). The adjusted annual rates of SLNB in 1998 were 0.26 among African-Americans, 0.35 in Hispanics, 0.25 in other non-whites, and 0.29 in whites; in 2005 the adjusted annual rates were 0.64, 0.67, 0.68, and 0.70, respectively (Figure 3). The association with census region showed a reversal between 1998 and 2005. In 1998, patients with breast cancer treated at hospitals in the Northeast, Midwest, and West census regions were statistically significantly less likely to receive SLNB than those treated in hospitals in the South census region. In 2005, however, patients in the South census region were statistically significantly less likely to receive SLNB than those in any other region.

Among clinical factors, mastectomy was more strongly associated with not receiving SLNB in 2005 than in 1998. Study inclusion as a result of pathologic staging information was associated with increased likelihood of SLNB in 1998 (OR = 1.10, 95% CI = 1.05 to 1.14) but decreased likelihood in 2005 (OR = 0.91, 95% CI = 0.88 to 0.95).

Although treatment at facilities with higher patient volumes was positively associated with increased likelihood of SLNB in 1998, this association was weaker in 2005. Similarly, although treatment at teaching or research facilities was statistically significantly associated with increased likelihood of SLNB in both 1998 and 2005, the differences between facility types decreased over the study period. In 1998, the percent of high school graduates in the patient's zip code was not statistically significantly associated with receipt of SLNB; however, by 2005, patients from zip codes with the lowest levels of high school graduates were statistically significantly less likely to receive SLNB than patients from other zip codes. In contrast, patients from zip codes with the lowest level of median household income were less likely to receive SLNB in both 1998 and 2005.

To further investigate changes in factors associated with receipt of SLNB over the study period, we performed separate regression analyses by year of diagnosis to determine the annual rates for receipt of SLNB by insurance type, race/ethnicity, and facility type (Figures 2, 3, and 4, respectively). The rate of receiving SLNB was

**Table 2.** Comparison between receiving sentinel lymph node biopsy or axillary lymph node dissection in 1998 and in 2005*

| Characteristic | 1998 (n = 56 031) | | | | 2005 (n = 55 910) | | | | *P* value for interaction with diagnosis year‡ |
|---|---|---|---|---|---|---|---|---|---|
| | No. of Patients with SLNB | % | OR (95% CI) | *P* value† | No. of Patients with SLNB | % | OR (95% CI) | *P* value† | |
| Patient-level demographics | | | | | | | | | |
| Age at diagnosis | | | | | | | | | |
| ≤52 y | 15896 | 28.4 | 1.00 (referent) | | 14615 | 26.1 | 1.00 (referent) | | |
| 52–61 y | 13856 | 24.7 | 0.99 (0.94 to 1.04) | .706 | 14648 | 26.2 | 1.00 (0.95 to 1.05) | .962 | .761 |
| 62–71 y | 13358 | 23.8 | 0.95 (0.89 to 1.01) | .096 | 13435 | 24.0 | 0.95 (0.89 to 1.01) | .070 | .947 |
| ≥72 y | 12921 | 23.1 | 0.95 (0.88 to 1.03) | .184 | 13212 | 23.6 | 0.83 (0.77 to 0.90) | <.001 | .014 |
| Race/ethnicity | | | | | | | | | |
| White | 49083 | 87.6 | 1.00 (referent) | | 47289 | 84.6 | 1.00 (referent) | | |
| African-American | 4012 | 7.2 | 0.84 (0.78 to 0.90) | <.001 | 4361 | 7.8 | 0.75 (0.70 to 0.80) | <.001 | .025 |
| Hispanic | 1765 | 3.2 | 1.31 (1.17 to 1.47) | <.001 | 2147 | 3.8 | 0.85 (0.77 to 0.93) | <.001 | <.001 |
| Other non-white | 1171 | 2.1 | 0.79 (0.69 to 0.90) | <.001 | 2113 | 3.8 | 0.92 (0.83 to 1.01) | .089 | .78 |
| Census region | | | | | | | | | |
| South | 36045 | 64.3 | 1.00 (referent) | | 30689 | 54.9 | 1.00 (referent) | | |
| Midwest | 13851 | 24.7 | 0.72 (0.68 to 0.76) | <.001 | 13346 | 23.9 | 1.19 (1.13 to 1.25) | <.001 | <.001 |
| Northeast | 12237 | 21.8 | 0.54 (0.52 to 0.57) | <.001 | 13899 | 24.9 | 1.37 (1.30 to 1.44) | <.001 | <.001 |
| West | 7749 | 13.8 | 0.53 (0.50 to 0.56) | <.001 | 11322 | 20.3 | 1.89 (1.78 to 2.00) | <.001 | <.001 |
| Insurance type | | | | | | | | | |
| Private insurance§ | 34241 | 61.1 | 1.00 (referent) | | 33747 | 60.4 | 1.00 (referent) | | |
| Uninsured | 1081 | 1.9 | 0.92 (0.80 to 1.06) | .2437 | 744 | 1.3 | 0.59 (0.52 to 0.68) | <.001 | <.001 |
| Medicaid | 1177 | 2.1 | 0.97 (0.85 to 1.11) | .658 | 1918 | 3.4 | 0.76 (0.69 to 0.83) | <.001 | .003 |
| Medicare | | | | | | | | | |
| Age <65 | 1065 | 1.9 | 0.88 (0.93 to 1.06) | .077 | 1359 | 2.4 | 0.88 (0.79 to 0.99) | .029 | .985 |
| Age 65+ | 17605 | 31.4 | 0.99 (0.77 to 1.01) | .8436 | 18037 | 32.3 | 0.99 (0.93 to 1.05) | .648 | .866 |
| Other government insurance | 28 | 0.1 | 1.02 (0.46 to 2.26) | .955 | 62 | 0.1 | 0.70 (0.43 to 1.14) | .151 | .421 |
| Missing | 1916 | 3.4 | 0.93 (0.84 to 1.04) | .202 | 788 | 1.4 | 0.66 (0.58 to 0.77) | <.001 | <.001 |
| Driving distance to hospital | | | | | | | | | |
| <4 miles | 11632 | 20.8 | 1.00 (referent) | | 10970 | 19.6 | 1.00 (referent) | | |
| 4.01 to 8.71 miles | 12669 | 22.6 | 1.02 (0.97 to 1.09) | .422 | 11618 | 20.8 | 0.99 (0.97 to 1.05) | .848 | .482 |
| 8.72 to 19.03 miles | 12366 | 22.1 | 1.06 (1.00 to 1.12) | .067 | 12574 | 22.5 | 1.02 (0.96 to 1.08) | .582 | .353 |
| More than 19.03 miles | 13066 | 23.3 | 1.07 (1.00 to 1.13) | .036 | 12412 | 22.2 | 1.04 (0.99 to 1.11) | .142 | .636 |
| Missing | 6298 | 11.2 | 1.59 (1.46 to 1.73) | <.001 | 8336 | 14.9 | 0.90 (0.84 to 0.97) | .006 | <.001 |
| Clinical characteristics | | | | | | | | | |
| Received mastectomy | 17095 | 30.5 | 0.58 (0.56 to 0.61) | <.001 | 13066 | 23.4 | 0.43 (0.41 to 0.45) | <.001 | <.001 |
| Tumor stage | | | | | | | | | |
| T1a | 11565 | 20.6 | 1.00 (referent) | | 13737 | 24.6 | 1.00 (referent) | | |
| T1b | 11643 | 20.8 | 1.03 (0.97 to 1.09) | .364 | 11724 | 21.0 | 1.12 (1.06 to 1.19) | <.001 | .036 |
| T1c | 21101 | 37.7 | 1.00 (0.95 to 1.06) | .927 | 19076 | 34.1 | 0.98 (0.93 to 1.02) | .312 | .449 |
| T2 | 11722 | 20.9 | 0.94 (0.89 to 1.00) | .037 | 11372 | 20.3 | 0.78 (0.74 to 0.82) | <.001 | <.001 |
| Study inclusion by pathologic TNM staging | 36459 | 65.1 | 1.10 (1.05 to 1.14) | <.001 | 30303 | 54.2 | 0.94 (0.88 to 0.95) | <.001 | <.001 |
| Facility-level variables | | | | | | | | | |
| Hospital type in which treatment occurred | | | | | | | | | |
| Teaching or research facility | 19740 | 35.2 | 1.00 (referent) | | 18618 | 33.3 | 1.00 (referent) | | |
| Community hospital | 7009 | 12.5 | 0.74 (0.68 to 0.80) | <.001 | 8314 | 14.9 | 0.89 (0.84 to 0.96) | .001 | <.001 |
| Community cancer center | 26284 | 46.9 | 0.81 (0.78 to 0.85) | <.001 | 26199 | 46.9 | 0.92 (0.88 to 0.96) | <.001 | <.001 |
| Missing | 2998 | 5.4 | 0.90 (0.82 to 0.99) | .024 | 2779 | 5.0 | 1.31 (1.19 to 1.45) | <.001 | <.001 |
| Breast cancer patient volume | | | | | | | | | |
| <25% | 1950 | 3.5 | 1.00 (referent) | | 2522 | 4.5 | 1.00 (referent) | | |
| 25%–50% | 6970 | 12.4 | 1.39 (1.24 to 1.55) | <.001 | 6575 | 11.8 | 1.01 (0.92 to 1.10) | .874 | <.001 |
| 50%–75% | 12719 | 22.7 | 1.48 (1.32 to 1.66) | <.001 | 12843 | 23.0 | 1.10 (1.01 to 1.21) | .035 | <.001 |
| ≥75% | 34392 | 61.4 | 1.75 (1.56 to 1.96) | <.001 | 33971 | 60.8 | 1.51 (1.38 to 1.65) | <.001 | .043 |

*(Table continues)*

**Table 2 (continued).**

| Characteristic | 1998 (n = 56 031) No. of Patients with SLNB | % | OR (95% CI) | *P* value† | 2005 (n = 55 910) No. of Patients with SLNB | % | OR (95% CI) | *P* value† | *P* value for interaction with diagnosis year‡ |
|---|---|---|---|---|---|---|---|---|---|
| Area-level variables | | | | | | | | | |
| % without high school diploma | | | | | | | | | |
| <19% | 7144 | 12.8 | 1.00 (referent) | | 6396 | 11.4 | 1.00 (referent) | | |
| 25.9%–19% | 11363 | 20.3 | 0.96 (0.91 to 1.01) | .120 | 10204 | 18.3 | 0.98 (0.93 to 1.04) | .527 | .499 |
| 35.9%–26% | 12248 | 21.9 | 1.02 (0.96 to 1.09) | .463 | 12557 | 22.5 | 0.88 (0.83 to 0.94) | <.001 | .001 |
| ≥36% | 22424 | 40.0 | 1.01 (0.93 to 1.10) | .791 | 23124 | 41.4 | 0.88 (0.81 to 0.95) | .002 | .017 |
| Missing | 2852 | 5.1 | 1.19 (0.11 to 13.34) | .889 | 3629 | 6.5 | 1.51 (0.16 to 14.04) | .716 | .886 |
| Median household income | | | | | | | | | |
| <$20,000 | 8674 | 15.5 | 0.81 (0.74 to 0.89) | <.001 | 7934 | 14.2 | 0.87 (0.80 to 0.95) | .001 | .249 |
| $20,000–$24,999 | 14680 | 26.2 | 0.92 (0.85 to 0.98) | .013 | 14128 | 25.3 | 0.95 (0.89 to 1.01) | .105 | .503 |
| $25,000–$31,999 | 24233 | 43.3 | 0.98 (0.93 to 1.04) | .453 | 25333 | 45.3 | 1.03 (0.98 to 1.09) | .274 | .193 |
| ≥$32,000 | 5592 | 10.0 | 1.00 (referent) | | 4892 | 8.8 | 1.00 (referent) | | |
| Missing | 2852 | 5.1 | 0.62 (0.06 to 6.97) | .698 | 3623 | 6.5 | 0.70 (0.08 to 6.51) | .755 | .941 |

* Multivariable logistic regression performed controlling for all of the factors presented in this table. SLNB = sentinel lymph node biopsy; ALND = axillary lymph node dissection; OR = odds ratio; TNM = tumor–node–metastasis.

† *P* values in these columns refer to the statistical significance of the odds ratios for receipt of SLNB in either 1998 or 2005 assessed by the Wald chi-square test statistic. All statistical tests were two-sided.

‡ *P* for interaction refers to the change from 1998 to 2005 (n = 111 941).

§ Private insurance includes health maintenance organization, preferred provider organization, Tricare/Champus/Military Health Care System, and unspecified private insurance.

|| According to American Joint Committee on Cancer (AJCC) guidelines (10).

almost identical among all insurance status groups in 1998 (Figure 2). However, these rates rapidly diverged. Although the rate of SLNB among Medicare patients aged 65 years and older remained similar to that among privately insured patients, SLNB rates among other insurance status groups did not rise as rapidly as those for the private insurance group. Disparities related to race/ethnicity persisted from 1998 through 2005 (Figure 3). The annual rates of receiving SLNB by facility type were based on results from annual regression analyses that used the mean patient characteristics from each year. There was a steady increase in the proportion of patients receiving SLNB at all three facility types until 2002 (Figure 4). Starting in 2002, annual increases in the rate of SLNB were substantially smaller, and the rate of SLNB at teaching or research hospitals decreased slightly between 2002 and

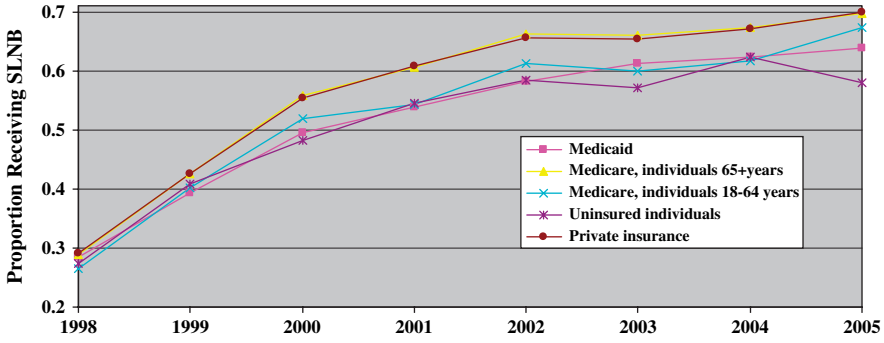


**Figure 2.** Annual adjusted rates of sentinel lymph node biopsy (SLNB) by insurance status (1998–2005). Data were from multivariable logistic regression analyses and mean patient characteristics by year of diagnosis.

| | Private insurance (referent) | Medicaid | Medicare, individuals 65+ years | Medicare, individuals 18-64 years | Uninsured individuals |
|---|---|---|---|---|---|
| 1998 | 0.29 (referent) | 0.28 (0.26, 0.31) | 0.29 (0.28, 0.30) | 0.27 (0.24, 0.29) | 0.27 (0.25, 0.30) |
| 1999 | 0.43 (referent) | 0.39 (0.37, 0.42) | 0.43 (0.41, 0.44) | 0.40 (0.38, 0.43) | 0.41 (0.38, 0.44) |
| 2000 | 0.55 (referent) | 0.50 (0.47, 0.52) | 0.56 (0.55, 0.57) | 0.52 (0.49, 0.55) | 0.48 (0.45, 0.51) |
| 2001 | 0.61 (referent) | 0.54 (0.51, 0.56) | 0.61 (0.59, 0.62) | 0.54 (0.52, 0.57) | 0.54 (0.51, 0.58) |
| 2002 | 0.66 (referent) | 0.58 (0.56, 0.61) | 0.66 (0.65, 0.68) | 0.61 (0.59, 0.64) | 0.58 (0.55, 0.62) |
| 2003 | 0.65 (referent) | 0.61 (0.59, 0.63) | 0.66 (0.65, 0.67) | 0.60 (0.57, 0.63) | 0.57 (0.54, 0.60) |
| 2004 | 0.67 (referent) | 0.62 (0.60, 0.65) | 0.67 (0.66, 0.69) | 0.62 (0.59, 0.64) | 0.62 (0.59, 0.65) |
| 2005 | 0.70 (referent) | 0.64 (0.62, 0.71) | 0.70 (0.68, 0.76) | 0.67 (0.65, 0.70) | 0.58 (0.56, 0.70) |

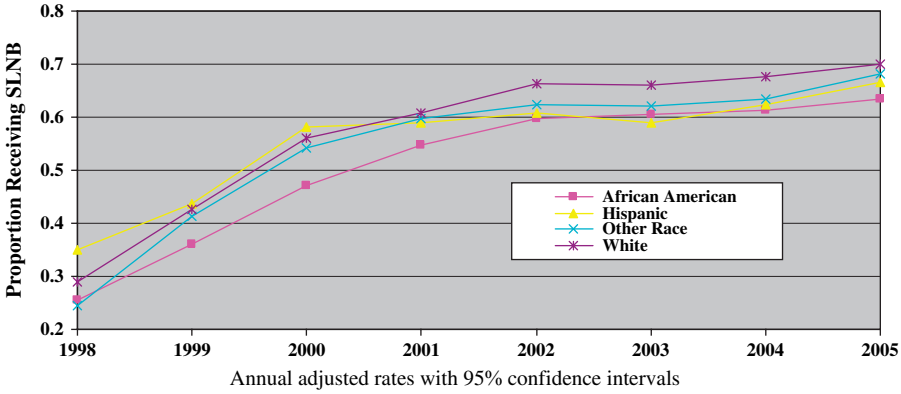


**Figure 3.** Annual adjusted rates of sentinel lymph node biopsy (SLNB) by race/ethnicity (1998–2005). Data were from multivariable logistic regression analyses and mean patient characteristics by year of diagnosis.

Annual adjusted rates with 95% confidence intervals

| | White (referent) | African American | Hispanic | Other non-white |
|---|---|---|---|---|
| 1998 | 0.29 (referent) | 0.26 (0.24, 0.27) | 0.35 (0.32, 0.38) | 0.25 (0.22, 0.27) |
| 1999 | 0.43 (referent) | 0.36 (0.35, 0.38) | 0.44 (0.411 0.46) | 0.41 (0.39, 0.44) |
| 2000 | 0.56 (referent) | 0.47 (0.46, 0.49) | 0.58 (0.44, 0.49) | 0.54 (0.40, 0.45) |
| 2001 | 0.61 (referent) | 0.55 (0.53, 0.56) | 0.59 (0.57, 0.61) | 0.60 (0.57, 0.62) |
| 2002 | 0.66 (referent) | 0.60 (0.58, 0.61) | 0.61 (0.59, 0.63) | 0.63 (0.60, 0.65) |
| 2003 | 0.66 (referent) | 0.60 (0.59, 0.62) | 0.59 (0.57, 0.61) | 0.62 (0.60, 0.64) |
| 2004 | 0.68 (referent) | 0.61 (0.60, 0.63) | 0.62 (0.60, 0.64) | 0.64 (0.61, 0.66) |
| 2005 | 0.70 (referent) | 0.64 (0.62, 0.65) | 0.67 (0.64, 0.69) | 0.68 (0.66, 0.70) |

2003, resulting in similar rates among the three facility types for 2003–2005.

Lastly, multivariable regression analysis was used to evaluate interactions between year of diagnosis and race/ethnicity, year of diagnosis and insurance, and year of diagnosis and facility type, with each being tested in a separate model. Analysis of the interaction between year of diagnosis and race/ethnicity by year showed that, over the study period, the odds of receiving SLNB decreased statistically significantly each year after 1998 for both African American (OR = 0.94, 95% CI = 0.94 to 0.95, for each subsequent year) and Hispanic (OR = 0.93, 95% CI = 0.92 to 0.94, for each subsequent year) patients compared with white patients ($P < .001$ for both comparisons). Analysis of the interaction between year of diagnosis and insurance by year showed that the odds of receiving SLNB decreased each year among patients with no insurance (OR = 0.91, 95% CI = 0.89 to 0.93, for each subsequent year), with Medicaid (OR = 0.96, 95% CI = 0.94 to 0.97, for each subsequent year), and with Medicare for those aged 18–64 years (OR = 0.96, 95% CI = 0.95 to 0.98, for each subsequent year) compared with patients with private insurance ($P < .001$ for both comparisons). Analysis of the interaction between year of diagnosis and facility type by year showed that the annual increase in odds of receiving SLNB was not statistically significantly different between community hospitals and teaching or research hospitals, and it was only slightly

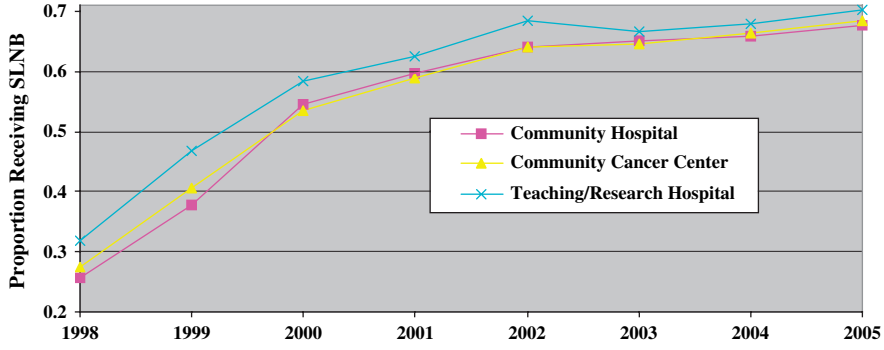


**Figure 4.** Annual rates of sentinel lymph node biopsy (SLNB) by facility type (1998–2005). Data were from multivariable logistic regression analyses and mean patient characteristics by year of diagnosis.

Annual adjusted rates with 95% confidence intervals

| | Teaching/Research Hospital | Community Hospital | Community Cancer Center |
|---|---|---|---|
| 1998 | 0.32 (referent) | 0.26 (0.24, 0.46) | 0.28 (0.27, 0.28) |
| 1999 | 0.47 (referent) | 0.38 (0.36, 0.39) | 0.41 (0.40, 0.42) |
| 2000 | 0.58 (referent) | 0.55 (0.53, 0.56) | 0.54 (0.53, 0.55) |
| 2001 | 0.63 (referent) | 0.60 (0.58, 0.61) | 0.59 (0.58, 0.60) |
| 2002 | 0.68 (referent) | 0.64 (0.62, 0.65) | 0.64 (0.63, 0.65) |
| 2003 | 0.67 (referent) | 0.65 (0.64, 0.66) | 0.65 (0.64, 0.66) |
| 2004 | 0.68 (referent) | 0.66 (0.64, 0.67) | 0.66 (0.65, 0.67) |
| 2005 | 0.70 (referent) | 0.68 (0.66, 0.69) | 0.68 (0.67, 0.69) |

elevated at community cancer centers compared with teaching or research facilities (OR = 1.01, 95% CI = 1.00 to 1.01, $P = .018$).

## Discussion

In our analytic study population of 490 899 women, the use of SLNB increased from 26.8% in 1998 to 65.5% in 2005. After controlling for statistically significant covariates, several patient-level demographics (younger age, being white, and being privately insured), clinical characteristics (T1 primary tumor and being treated in 2005), facility-level variables (treatment in a teaching or research facility and being in the highest quartile of volume of treatment), and area-level variables (zip codes of the highest number of high school graduates and highest median household income) were associated with higher use of SLNB during the study period. Further, several relationships between study factors and receipt of SLNB changed substantially over the study period. In 1998, there was little or no difference by race/ethnicity or by insurance status. From 1999 through 2005, disparities existed by race/ethnicity and by insurance status.

Similar to other reports (14–17), our results demonstrated that younger women (ie, aged 51 years or younger) and white women had the greatest likelihood of receiving SLNB and that women older than 72 years and African American women had a decreased likelihood of receiving SLNB. In addition, insurance status at the time of diagnosis was statistically significantly associated with receipt of SLNB. Women who were uninsured, who had Medicaid, or who were younger than 65 years and had Medicare were statistically significantly less likely to receive SLNB than privately insured women. Medicare recipients aged 65 years and older and women with private insurance had equal likelihoods of receiving SLNB. Interestingly, insurance status was not associated with receipt of SLNB in 1998, when this technique was still being explored and evaluated. However, by 2005, when SLNB was widely disseminated, statistically significant disparities by insurance status in receipt of SLNB were observed.

Teaching or research facilities had the highest rate of SLNB for the first part of our study period. Other studies have also indicated greater rates of SLNB among university hospitals than among community hospitals (18). This finding is consistent with the observation that trials investigating SLNB were more likely to be in university hospitals and that such settings have more surgeons experienced with SLNB as well as the radiology resources necessary to perform SLNB (8,19). However, by 2005, this technique was being used beyond teaching or research hospitals and the differences in the likelihood of receiving SLNB by facility type had diminished.

Area-level socioeconomic status variables were also statistically significantly associated with the likelihood of receiving SLNB. Women residing in communities with lower socioeconomic status—on the basis of their zip code having fewer high school graduates (≥19% without high school degree vs <19% without high school degree) and lower median household income (<$20 000 vs ≥$32 000)—had decreased likelihood for receiving SLNB.

Maggard et al. (20) previously studied rates and predictive factors for SLNB among women with stages I and II breast cancer from January 1, 1998, through December 31, 2000, by use of National Cancer Institute's Surveillance, Epidemiology, and End Results registry data. This study found that 27.2% of women with stage I breast cancer and 22.7% of women with stage II breast cancer had SLNB during this time period. Consistent with our results, this study also found that women older than 60 years were less likely to receive SLNB than younger women and that women from racial and ethnic minority groups were less likely to receive SLNB than white women. Use of SLNB increased over the 3 years of their study, from 13.4% of patients diagnosed in 1998 to 36.4% of patients diagnosed in 2000. Further, there was considerable variation in receipt of SLNB between registry areas, ranging from 7.9% of women in Iowa to 32.7% of women in Seattle–Puget Sound. In our study, using broader geographic parameters (ie, census regions), we also found statistically significant differences in the likelihood of receiving SLNB by census region. We also observed statistically significant changes in associations between census region and receipt of SLNB from January 1, 1998, through December 31, 2005.

Edge et al. (21) examined the rate and time trends of receiving SLNB among breast cancer patients with stage I or II breast cancer treated at one of the five original cancer centers participating in the Breast Cancer Outcomes Project of the National Comprehensive Cancer Network from July 1, 1997, through December 31, 2000. These investigators found that among women newly diagnosed with breast cancer receiving their initial treatment, 13% had SLNB alone, 22% had SLNB plus ALND, 59% had ALND alone, and 6% had no axillary surgery. The overwhelming majority of women who had mastectomies (82%) had ALND alone; among women with breast-conserving surgery, 48% had SLNB (alone or with subsequent ALND) and 43% had ALND alone. We found similar results—62% of women receiving mastectomies and 39% of women receiving breast-conserving surgery had ALND alone (data not shown).

Our study had several limitations. First, some patients who were categorized as having Medicaid may have presented with no insurance coverage; the application for Medicaid coverage may have commenced upon diagnosis, and coverage may have been extended retroactively to the date of diagnosis. Previous studies indicated that patients who enroll in Medicaid at the time of cancer diagnosis may have more advanced stage disease than patients who enrolled in Medicaid before diagnosis (22), although after controlling for stage at diagnosis no statistically significant differences in survival were found between early and late Medicaid enrollers (23). However, because information on date of Medicaid enrollment was not available in the National Cancer Database, we were unable to adjust for this variable and may thus have undercounted the actual number of uninsured patients at the time of diagnosis. Similarly, no information was available on the type of insurance coverage before cancer diagnosis or the consistency of this coverage. Many individuals in the United States may have periods of being uninsured, and these periods are generally longer among lower income individuals than higher income individuals (24). The impact of lack of consistent insurance coverage on receipt of SLNB is unknown. Second, individual-level data would have permitted us to control for patient socioeconomic characteristics more precisely. However, individual-level socioeconomic data were not available through tumor registries; use of area-level measures was the best available means to control for these factors.

Odds ratios are a commonly used measure of association that can be directly derived from logistic regression models. However, the reporting of odds ratios rather than relative risks may increase effect size estimates when the outcome of interest is relatively common. To assess the potential impact of odds ratios on the effect sizes that we observed, we used a method proposed by Zhang and Yu (25) to estimate approximate risk ratios from the adjusted odds ratios for select study variables. Odds ratios and relative risks (RRs) for receiving SLNB were similar for women aged 52–61 years, compared with women younger than 52 years (OR = 0.97, 95% CI = 0.96 to 0.99, and RR = 0.98, 95% CI = 0.97 to 0.99) but different for uninsured patients compared with privately insured patients (OR = 0.77, 95% CI = 0.73 to 0.80, and RR = 0.89, 95% CI = 0.87 to 0.91). We found that the odds ratio estimate was substantially higher than the relative risk for some of the largest effect size estimates. For example, in the analysis of SLNB by diagnosis, the OR for receipt of SLNB among women diagnosed in 2001 compared with 1998 was 3.66, 95% CI = 3.56 to 3.71, and the RR was 2.13, 95% CI = 2.10 to 2.15. However, whereas the magnitude of the effect size estimate does differ between odds ratio and relative risk values for certain comparisons, estimates that were statistically significant based on odds ratios remained statistically significant using relative risks.

Despite these limitations, this study provides important information regarding changes in the rate of SLNB utilization and factors influencing receipt of SLNB. Our study is much larger than previously published studies examining SLNB (approximately 260 000 patients who received SLNB, compared with 52 000–55 000 in previous reports (2,5,6,14–19,26). Our study also covered more years than previous studies (2,5,6,14–19,26) and included more covariates, including race, insurance status, and other socioeconomic indicators (2,5,6,14–19,26).

The disparities that were related to receipt of SLNB in this study are particularly important in light of the clinical advantages associated with this technique. Better outcomes have been reported for patients receiving SLNB than for patients receiving ALND, including decreased edema, pain, hypoesthesia, and paresthesia (2,3). Because guidelines indicate appropriate clinical conditions for use of SLNB, insurance status and other socioeconomic and demographic characteristics should not influence receipt of this less-invasive technique. Although we were not able to identify reasons behind these disparities in receipt of SLNB by nonclinical characteristics, potential explanations include system factors such as limited access to facilities that provide SLNB, patient factors such as preference for traditional or established procedures rather than newer treatments that may be perceived as experimental, and physician factors such as differential recommendation for receipt of SLNB that are based on demographic factors.

Since its introduction in the 1990s, SLNB has become widely disseminated as an alternative to ALND for clinically appropriate breast cancer patients because of its similar clinical efficacy and lower morbidity. However, our analyses found that several patient-level, clinical, facility-level, and area-level characteristics were associated with decreased likelihood of receiving SLNB. Additionally, even though the rate of SLNB increased substantially over the study period, our results indicate that the disparities in receipt of SLNB, including among racial/ethnic minority groups and those with lower socioeconomic status (ie, type of insurance), appear to have increased over time. Lymphedema resulting from ALND can impact patients' functional status, sensory perception, employment, and quality of life. Caregiver burden and the costs of treating lymphedema can be substantial and may be an even greater burden among the underserved population that has a decreased likelihood of receiving SLNB.

## References


1. Jemal A, Siegel R, Ward E, Murray T, Xu J, Thun MJ. Cancer statistics, 2007. *CA Cancer J Clin.* 2007;57(1):43–66.
2. Blanchard DK, Donohue JH, Reynolds C, Grant CS. Relapse and morbidity in patients undergoing sentinel lymph node biopsy alone or with axillary dissection for breast cancer. *Arch Surg.* 2003;138(5):482–487; discussion 487–488.
3. Schulze T, Mucke J, Markwardt J, Schlag PM, Bembenek A. Long-term morbidity of patients with early breast cancer after sentinel lymph node biopsy compared to axillary lymph node dissection. *J Surg Oncol.* 2006; 93(2):109–119.
4. Rietman JS, Dijkstra PU, Geertzen JH, et al. Treatment-related upper limb morbidity 1 year after sentinel lymph node biopsy or axillary lymph node dissection for stage I or II breast cancer. *Ann Surg Oncol.* 2004;11(11):1018–1024.
5. Badgwell BD, Povoski SP, Abdessalam SF, et al. Patterns of recurrence after sentinel lymph node biopsy for breast cancer. *Ann Surg Oncol.* 2003;10(4):376–380.
6. McNeil C. Sentinel node biopsy: studies bring needed data. *J Natl Cancer Inst.* 1998;90(10):728–730.
7. Lyman GH, Giuliano AE, Somerfield MR, et al. American Society of Clinical Oncology guideline recommendations for sentinel lymph node biopsy in early-stage breast cancer. *J Clin Oncol.* 2005;23(30): 7703–7720.
8. Posther KE, McCall LM, Blumencranz PW, et al. Sentinel node skills verification and surgeon performance: data from a multicenter clinical trial for early-stage breast cancer. *Ann Surg.* 2005;242(4):593–599; discussion 599–602.
9. Commission on Cancer. *Site by Stage Distribution of Cases Reported to the NCDB: Diagnosis Year 2003.* Chicago, IL: American College of Surgeons. http://www.facs.org/cancer/ncdb/ver7_site_stage_2003.htm. Accessed February 26, 2008.
10. Greene F, Page D, Fleming I, et al., eds. *AJCC Cancer Staging Manual.* 6th ed. Chicago, IL: Springer; 2002.
11. Commission on Cancer. *Facility Oncology Registry Data Standards (FORDS).* 2002. Chicago, IL: American College of Surgeons.
12. Commission on Cancer. *Registry Operations and Data Standards (ROADS).* 1998. Chicago, IL: American College of Surgeons. http://www.facs.org/cancer/coc/roads/roads1998.pdf.
13. United States Census Report. 2000. Washington, DC. http://www.census.gov/geo/www/us_regdiv.pdf. Accessed February 26, 2008.
14. Caywood J, Gray RJ, Hentz J, Pockaj BA. Older age independently predicts a lower risk of sentinel lymph node metastasis in breast cancer. *Ann Surg Oncol.* 2005;12(12):1061–1065.
15. Edge SB, Gold K, Berg CD, et al. Patient and provider characteristics that affect the use of axillary dissection in older women with stage I–II breast carcinoma. *Cancer.* 2002;94(10):2534–2541.
16. Maloney N, Koch M, Erb D, et al. Impact of race on breast cancer in lower socioeconomic status women. *Breast J.* 2006;12(1):58–62.
17. Gwyn K, Bondy ML, Cohen DS, et al. Racial differences in diagnosis, treatment, and clinical delays in a population-based study of patients with newly diagnosed breast carcinoma. *Cancer.* 2004;100(8):1595–1604.
18. Heimbach JK, Biffl WL, Mitchell EL, et al. Breast conservation therapy in affiliated county, university, and private hospitals. *Am J Surg.* 1999; 178(6):466–469.
19. Hutchinson JR, Chagpar AB, Scoggins CR, et al. Surgeon and community factors affecting breast cancer sentinel lymph node biopsy. *Am J Surg.* 2005;190(6):903–906.

20. Maggard MA, Lane KE, O'Connell JB, Nanyakkara DD, Ko CY. Beyond the clinical trials: how often is sentinel lymph node dissection performed for breast cancer? *Ann Surg Oncol.* 2005;12(1):41–47.
21. Edge SB, Niland JC, Bookman MA, et al. Emergence of sentinel node biopsy in breast cancer as standard-of-care in academic comprehensive cancer centers. *J Natl Cancer Inst.* 2003;95(20):1514–1521.
22. Bradley CJ, Given CW, Roberts C. Late stage cancers in a Medicaid-insured population. *Med Care.* 2003;41(6):722–728.
23. Bradley CJ, Gardiner J, Given CW, Roberts C. Cancer, Medicaid enrollment, and survival disparities. *Cancer.* 2005;103(8):1712–1718.
24. Short PF, Graefe DR. Battery-powered health insurance? Stability in coverage of the uninsured. *Health Aff (Millwood).* 2003;22(6):244–255.
25. Zhang J, Yu KF. What's the relative risk? A method of correcting the odds ratio in cohort studies of common outcomes. *JAMA.* 1998;280(19): 1690–1691.
26. de Kanter AY, Menke-Pluymers MM, Wouters MW, Burgmans I, van Geel AN, Eggermont AM. 5-year follow-up of sentinel node negative breast cancer patients. *Eur J Surg Oncol.* 2006;32(3):282–286.

## Notes

Design of the study: Chen, Schrag, Stewart, Leitch, Ward.

Collection of data: Chen, Schrag, Stewart, Ward.

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