Surgeon and Facility Variation in the Use of Minimally Invasive Breast Biopsy in Texas

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Objective and Background: Minimally invasive breast biopsy (MIBB) rates remain well below guideline recommendations of more than 90% and vary across geographic areas. Our aim was to determine the variation in use attributable to the surgeon and facility and determine the patient, surgeon, and facility characteristics associated with the use of MIBB.

Methods: We used 100% Texas Medicare claims data (2000–2008) to identify women older than 66 years with a breast biopsy (open or minimally invasive) and subsequent breast cancer diagnosis/operation within 1 year. The percentage of patients undergoing MIBB as the first diagnostic modality was estimated for each surgeon and facility. Three-level hierarchical generalized linear models (patients clustered within surgeons within facilities) were used to evaluate variation in MIBB use.

Results: A total of 22,711 patients underwent a breast cancer operation by 1226 surgeons at 525 facilities. MIBB was the initial diagnostic modality in 62.4% of cases. Only 7.0% of facilities and 12.9% of surgeons used MIBB for more than 90% of patients. In 3-level models adjusted for patient characteristics, the percentage of patients who received MIBB ranged from 7.5% to 96.0% across facilities (mean = 50.1%, median = 49.2%) and from 8.0% to 87.0% across surgeons (mean = 50.3%, median = 50.9%). The variance in MIBB use was attributable to facility (8.8%) and surgeon (15.4%) characteristics. Lower surgeon and facility volume, longer surgeon years in practice, and smaller facility bed size were associated with lower rates of MIBB use.

Conclusions: Identification of surgeon and facility characteristics associated with low use of MIBB provides potential targets for interventions to improve MIBB rates and decrease variation in use.

Type of Study: Retrospective cohort

Keywords: facility characteristic, hierarchical models, minimally invasive breast biopsy, surgeon characteristics, variation

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For patients presenting with palpable breast masses or mammographic abnormalities, minimally invasive breast biopsy (MIBB) offers several advantages over open surgical biopsy. Diagnostic accuracy is similar for both procedures, but women who undergo MIBB experience less periprocedural pain and have lower rates of postprocedure complications.[1] In cases of malignancy, an MIBB approach is more cost-effective and reduces the overall number of surgical procedures.[2,3] The minimally invasive approach also provides clinicians with the opportunity for multidisciplinary planning before surgical intervention. The 2009 National Comprehensive Cancer Network (NCCN) guidelines recommend MIBB as the gold standard and first-line approach to the diagnosis of suspicious breast masses, citing a target of more than 90% MIBB rates for women presenting with palpable breast masses or mammographic abnormalities requiring biopsy.[4]

Despite these guidelines and the advantages associated with MIBB, population-based studies have demonstrated that MIBB rates are significantly below the NCCN target of more than 90%.[5-9] Although these studies demonstrate an improvement in MIBB rates since the initial 2001 NCCN consensus statement, the use of open biopsy remains unacceptably high, with open biopsy rates exceeding 20% to 30% reported in observational studies through 2008.[7-11] Furthermore, a recent population-based study from Texas found variation in the use of MIBB across geographic areas (hospital service areas) with similar demographic characteristics and access to MIBB. In addition, improvement in the use of MIBB across geographic regions was variable over time.[6] These findings suggest that physician and facility practice patterns may explain some of the observed geographic variation in the use of MIBB.[6,9]

The aim of this study was to evaluate the proportion of variance in MIBB use attributable to the surgeon and the facility and to evaluate the surgeon and facility characteristics associated with low MIBB use. We hypothesize that a large proportion of the variance in MIBB use across geographic regions can be explained by facility and physician practice patterns. Identifying characteristics of facilities and physicians associated with low MIBB use will highlight potential targets to improve the delivery of patient care and meet the NCCN target guidelines of more than 90% MIBB rates.

METHODS

The study was reviewed by the institutional review board at the University of Texas Medical Branch, Galveston, and granted exemption, as it was not considered human subjects research.

Data Source

This study used enrollment and claims data for 100% of Medicare beneficiaries in the state of Texas from 2000 to 2008. Demographic and enrollment information for each beneficiary was obtained from the Denominator File. Race/ethnicity was assigned on the basis of the Medicare enrollment race variable for patients who did not have Part D data available. The Outpatient Standard Analytic File (OUTSAF), which contains claims submitted by institutional outpatient providers, and the Carrier Standard Analytic File, which contains claims submitted by noninstitutional providers, were used to identify outpatient facility services and physician services. The Medicare Provider Analysis and Review (MEDPAR) files were used to obtain inpatient hospital admissions and claims data.

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US Census data for the year 2000 provided ZIP code–level education and population estimates. The ZIP code–level income was obtained from the 2006 ZIP Code Tabulation Area population estimations produced by the Dartmouth Atlas of Health Care.

Cohort Selection

The study cohort selection is summarized in Figure 1. We used Medicare claims data to identify all minimally invasive and open breast biopsies performed between 2001 and 2008 for any reason, including breast masses and mammographic abnormalities as previously described; the *CPT* (*Current Procedural Terminology*) codes for minimally invasive and open biopsy are shown in Table 1.[6] *CPT* codes 10021 and 10022 identify fine-needle aspiration done for any reason. Therefore, to identify fine-needle aspirations done specifically for breast lesions, we chose only those associated with a diagnosis of breast mass, benign or malignant [*ICD-9* (*International Classification of Diseases, Ninth Revision*) diagnosis codes 174.0–174.9, 217, 233.0, 238.3, 239.3, 610.0–610.9, 611.0–611.9].

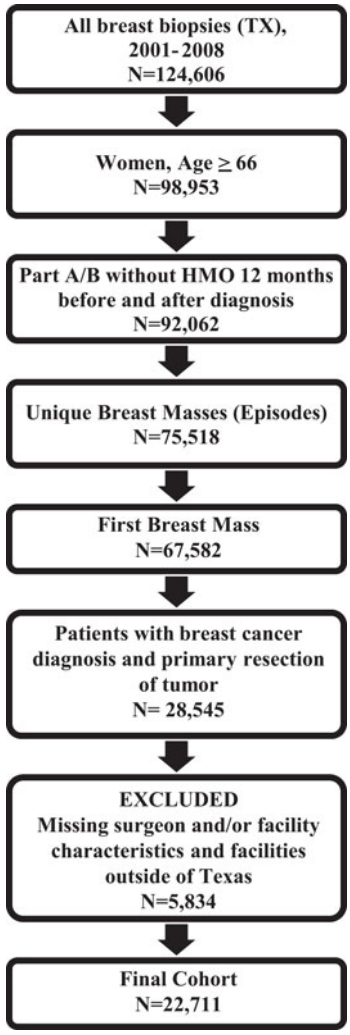

FIGURE 1. Cohort selection. We identified all breast biopsies for women 66 years and older in Texas, 2001 to 2008. Unique episodes of care and unique patients were included. Only women with a breast cancer diagnosis and primary operation for breast cancer were included. N = 22,711.

To identify the treating surgeon and facility, we then limited our cohort to women with a diagnosis of breast cancer defined by identification of *ICD-9-CM* (*International Classification of Diseases, Ninth Revision, Clinical Modification*) diagnosis codes for breast cancer with a subsequent breast cancer operation in the year after the initial biopsy, also shown in Table 1. If a woman had more than 1 breast cancer episode over the time period, we included only the first episode. We also excluded patients in whom we could not identify the surgeon (N = 1031) or the facility (N = 4377) and those who had operations in facilities outside Texas (N = 426). The final study cohort included 22,711 women with surgically treated breast cancers.

Biopsy

For each patient, the initial breast biopsy in the episode of care was classified as either minimally invasive or open as previously described.[6] MIBB included fine-needle aspiration and core-needle biopsies. Open surgical procedures included incisional and excisional biopsies.

Facility Identification

The facility where the breast cancer operation was performed was identified by the facility ID on the OUTSAF or MEDPAR claim. Facility ID was linked to the Provider of Service file from the Centers for Medicare & Medicaid Services to obtain facility characteristics, including type of hospital (nonprofit, profit, government), bed size (<200, 200–324, 325–500, >500), and medical school affiliation (major, limited, graduate, and none). For procedures done at ambulatory surgical centers (ASCs) (N = 1164), we were unable to determine facility characteristics.

Surgeon Identification

The surgeon who performed the breast cancer operation was identified by the Unique Provider Identification Number (UPIN, 2001–2007) or National Provider Identifier (2008) number on the OUTSAF or Carrier claim for the operation. Surgeon UPIN was linked to the American Medical Association Physician Masterfile to obtain surgeon age, sex, year of medical school graduation, graduation from US or foreign medical school, specialty in surgery (surgical oncology vs general surgery vs others), and board certification status. Years in practice were calculated from Medical School graduation date. As age and years in practice were collinear, only years in practice was used in the multivariable models. For procedures done at ASCs, we could not identify individual surgeons for breast cancer operations because an ASC UPIN is used on these claims.

Patient Characteristics

Patient covariates included age, race/ethnicity (white, black, Hispanic, and other), year of biopsy, and size of the Metropolitan Statistical Area (<10,000, 10,000–250,000, 250,001–1 million, and ≥1 million population). Beneficiary race/ethnicity was obtained from the Part D Denominator File (2006–2008), which uses first and last name algorithms to designate race/ethnicity.[12] Race/ethnicity was assigned on the basis of the Medicare enrollment race variable for patients who did not have Part D data available. Median income and education levels (percentage of residents with <12 years of education) in the ZIP code were stratified into quartiles.

Statistical Analysis

Unadjusted differences in the use of MIBB and open biopsy were compared by patient, surgeon, and facility characteristics using χ^2 tests for categorical variables and *t* tests for continuous variables.

TABLE 1. Biopsy Modality and Cancer Operation (N = 22,711)

***CPT* or *ICD-9* Code**	**Procedure**
To identify all breast biopsies for any reason	
Core biopsy	
19100	Breast biopsy; percutaneous, needle core, not using imaging guidance
19102	Breast biopsy, percutaneous, needle core with imaging guidance
19103	Biopsy of breast; percutaneous, automated vacuum-assisted or rotating biopsy device, using imaging guidance
Open	
19101	Breast biopsy; open, incisional
19120	Excision of cyst, fibroadenoma, or other benign or malignant tumor, aberrant breast tissue, duct lesion, nipple or areolar lesion, open, 1 or more lesions
19125	Excision of breast lesion identified by preoperative placement of radiological marker, open; single lesion
FNA	
10021*	FNA; not using imaging guidance
10022*	FNA; using imaging guidance
To identify patients with breast cancer after biopsy	
Breast cancer	
174.0†	Malignant neoplasm of nipple and areola of female breast
233.0†	Carcinoma in situ of breast
19110	Nipple exploration, with or without excision of a solitary lactiferous duct or a papilloma lactiferous duct
19120	Excision of cyst, fibroadenoma, or other benign or malignant tumor, aberrant breast tissue, duct lesion, nipple or areolar lesion, open, 1 or more lesions
19125	Excision of breast lesion identified by preoperative placement of radiological marker, open; single lesion
19126	Excision of breast lesion identified by preoperative placement of radiological marker, open; each additional lesion separately identified by a preoperative radiological marker
19160	Mastectomy, partial
19162	Mastectomy, partial, with axillary lymphadenectomy
19301	Mastectomy, partial (eg, lumpectomy, tylectomy, quadrantectomy, segmentectomy)
19302	Mastectomy, partial (eg, lumpectomy, tylectomy, quadrantectomy, segmentectomy); with axillary lymphadenectomy
19180	Mastectomy, simple, complete
19182	Mastectomy, subcutaneous
19200	Mastectomy, radical, including pectoral muscles, axillary lymph nodes
19220	Mastectomy, radical, including pectoral muscles, axillary, and internal mammary lymph node
19240	Mastectomy, modified radical, including axillary lymph nodes, with or without pectoralis minor muscle, but excluding pectoralis major muscle
19303	Mastectomy, simple, complete
19304	Mastectomy, subcutaneous
19305	Mastectomy, radical, including pectoral muscles, axillary lymph nodes
19306	Mastectomy, radical, including pectoral muscles, axillary and internal mammary lymph nodes
19307	Mastectomy, radical, including pectoral muscles, axillary and internal mammary lymph nodes

**CPT* codes 10021 and 10022 identify fine-needle aspiration done for any reason. Specifically for breast lesions, we chose only those associated with a diagnosis of breast mass, benign or malignant (*ICD-9* codes: 174.0–174.9, 217, 233.0, 238.3, 239.3, 610.0–610.9, 611.0–611.9).

†To identify facilities and surgeons, we chose breast cancers associated with an operation in the year after the initial biopsy (*ICD-9-CM* codes: 85.22-85.26, 85.4-85.48; *CPT* codes: 19110, 19120, 19125-6, 19160, 19162, 19301-2, 19180, 19182, 19200, 19220, 19240, 19303-7).

From the initial cohort of 22,711 patients, 525 facilities, and 1226 surgeons, we included only facilities or surgeons who performed 5 or more cases to create stable estimates of variation in unadjusted and multilevel models. There were 295 facilities performing more than 5 cases (N = 22,331 patients) and 793 surgeons performing more than 5 cases (N = 21,902 patients). We calculated the percentage of the total number of patients treated by each facility or surgeon who underwent MIBB as the first diagnostic modality and evaluated the unadjusted range of MIBB across the 295 facilities and 793 surgeons.

We used multilevel hierarchical modeling to evaluate the variation in the use of MIBB in Texas Medicare beneficiaries treated for breast cancer (2000–2008). In multilevel analyses, we adjusted for patient characteristics including age, race/ethnicity, education, size of the Metropolitan Statistical Area, and year of biopsy. With various levels of data clustered within each other, hierarchical modeling allows for the estimation and partitioning of variance in MIBB use between the patient, surgeon, and facility levels. We used both 2-level [patients (level 1) clustered within facilities (level 2), N = 22,331] and 3-level [patients (level 1) clustered within surgeons (level 2) and surgeons clustered within facilities (level 3), N = 17,076] hierarchical models. To address issues with cross-classification in the 3-level model, surgeons who operated in more than 1 facility were assigned to the facility where they did the most number of cases. Cases performed outside the facility where they did the greatest number of cases (N = 4921) and cases done by surgeons or facilities with fewer than 5 cases (N = 714) were removed. The final cohort for the 3-level model included 17,076 patients undergoing breast cancer operations by 792 surgeons at 229 facilities. A 2-level model of patients clustered within facilities was performed with the smaller, cross-classified cohort as well. We estimated adjusted variation in surgeon and hospital MIBB use in both the 2- and 3-level models. To prevent overestimation of the true variation, we generated empirical Bayes "shrunken" estimates.[13] To account for chance in these models, the unstructured covariance of random effects was used to allow for each variance and covariance to be distinct.[14]

We estimated the intraclass correlation coefficients (ICCs) in each model using the threshold technique that is appropriate for dichotomous outcomes.[15] The residual ICCs represent the percentage of the total variance in MIBB use attributable to each level of the model. The 2-level model was performed to determine the percentage of the variance in MIBB use attributable to the facility alone. The 3-level model was used to determine the percentage of the variance attributable to the surgeon and the percentage of the facility variance that was explained by the surgeon. The change in the ICC for facility levels between the 2- and 3-level models can be interpreted as the amount of facility variation explained by surgeon characteristics. The 2- and 3-level models were used to calculate adjusted facility and surgeon rates of MIBB, represented graphically in caterpillar plots. In these plots, each surgeon- and facility-specific rate was adjusted toward the mean of the overall rate as a factor of panel size. For surgeons or facilities with low caseloads, the rates were less reliable and had more adjustment toward the mean and for those with high caseloads, less adjustment was required.

To determine surgeon and facility characteristics associated with the use of MIBB, additional 3-level hierarchical generalized models were estimated including patient, surgeon, and facility-level predictors of MIBB. Because we did not have facility characteristics for ASCs, cases performed at ASCs along with surgeons and facilities performing fewer than 5 cases were removed (N = 1260) for a total cohort of 16,530 cases within this model. Statistical significance was accepted at the $P < 0.05$ level. All analyses were performed with SAS version 9.3 (SAS, Inc) and STATA 13. All multilevel models and empirical Bayes estimates were performed with STATA 13.

RESULTS

Patient, Surgeon, and Facility Characteristics

A total of 22,711 patients undergoing breast biopsy met our inclusion criteria. Table 2 demonstrates overall cohort characteristics and the results of the unadjusted analysis demonstrating MIBB rates by patient, surgeon, and facility characteristics. MIBB was the initial diagnostic modality for 14,171 patients (62.4%). It was performed by a radiologist in 70.0% of cases, by surgeons in 24.9% of cases, and other physicians of other specialties in 5.1% of cases. A majority of open biopsies (85.9%) were performed by surgeons. Of note, in 86.6% of the 8254 patients who underwent open biopsy as the initial treatment modality, the surgeon who performed the definitive operation also performed the breast biopsy.

In an unadjusted analysis, patient characteristics associated with the lower use of MIBB included Hispanic race, lower education level, and residence in nonmetropolitan or smaller areas. Surgeon characteristics associated with the low use of MIBB included male sex, training outside the United States, and lower case volume. Facility characteristics associated with the low use of MIBB included nonteaching hospitals, fewer than 200 beds, and low case volume (Table 2).

Unadjusted Variation in MIBB Use

There was significant variation in the use of MIBB as the initial diagnostic modality across facilities and surgeons. Only 7.0% of facilities and 12.9% of surgeons performed MIBB among more than 90% of patients. MIBB use across 295 facilities ranged from 0% to 100%, with a mean of 50.9% [median = 53.2%; interquartile range (IQR) = 27.1%–74.2%]. The unadjusted MIBB use across 793 surgeons also ranged from 0% to 100%. Of note, the unadjusted mean percentage of patients receiving MIBB across surgeons was 56.4% (median = 60.0%; IQR = 32.0%–80.9%).

TABLE 2. Percent MIBB by Patient, Surgeon, and Facility Characteristics (Total N = 22,711)

	Overall N	MIBB n (% MIBB)	*P*
Patient characteristics			
Overall cohort	22,711	14,171 (62.4)	
Race			<0.0001
White	18,609	11,773 (63.3)	
Black	1,692	1,064 (62.9)	
Hispanic	2,200	1,189 (54.1)	
Other	210	145 (69.1)	
Age			0.4200
66–74	11,705	7,333 (62.7)	
75+	11,006	6,838 (62.1)	
Area of residence			<0.0001
Metropolitan	17,696	11,484 (64.9)	
Nonmetropolitan	4,579	2,433 (53.1)	
Rural	436	254 (58.3)	
Education level* (quartile)			<0.0001
1—lowest	5,688	3,199 (56.2)	
2	5,675	3,393 (59.8)	
3	5,443	3,481 (64.0)	
4—highest	4,995	3,575 (71.6)	
Unknown	910	523 (57.5)	
Metropolitan Statistical Area			<0.0001
>1 million	11,419	7,973 (69.8)	
250,000–1 million	2,406	1,136 (47.2)	
10,000–250,000	3,871	2,375 (61.4)	
<10,000	5,015	2,687 (53.6)	
Surgeon characteristics			
Age			<0.0001
Mean (SD)	54.45 (9.5)	53.74 (9.6)	
Median	54.0	53.0	
Years of practice			<0.0001
Mean (SD)	27.81 (10.0)	27.03 (10.1)	
Median	27.0	26.0	
Sex			<0.0001
Male	18,280	10,905 (59.7)	
Female	4,431	3,266 (73.7)	
US trained			<0.0001
Yes	20,292	13,123 (64.7)	
No	2,419	1,048 (43.3)	
Specialty			<0.0001
General surgery	20,170	12,472 (61.8)	
Surgical oncology	1,315	1,031 (78.4)	
Others	1,226	668 (54.5)	
Volume of surgeon (quartile)			<0.0001
1—lowest	5,604	2,994 (53.4)	
2	5,634	3,096 (55.0)	
3	5,891	3,649 (62.0)	
4—highest	5,582	4,432 (79.4)	
Facility characteristics†			
Type of facility			<0.0001
Nonprofit	12,030	7,737 (64.3)	
Profit	6,525	3,957 (60.6)	
Government	3,165	1,902 (60.1)	
teaching hospital			<0.0001
Yes	8,227	5,652 (68.7)	
No	13,493	7,944 (58.9)	
Facility bed size			<0.0001
<200 beds	5,769	2,749 (47.7)	
200–324 beds	3,714	2,982 (53.4)	
325–500 beds	5,051	3,567 (70.6)	
>500 beds	7,186	5,298 (73.7)	
Volume of facility (quartile)			<0.0001
1—lowest	5,099	2,346 (46.0)	
2	5,652	3,394 (60.1)	
3	5,280	3,343 (63.3)	
4—highest	5,689	4,513 (79.3)	
ASC only	991	575 (58.0)	<0.0001

*Lowest level of more than 12 years of schooling.
†Only hospital patients.

Percentage of Variance in MIBB Use Attributable to Facility and Surgeon

In the 2-level hierarchical model (patients clustered within facilities) adjusted for patient characteristics, 33.6% of the variance in MIBB use was attributable to the facility (ICC = 33.6%, Table 3, model 1). Of note, when the 2-level model of patients clustered within facilities was performed with the cohort excluding cross-classified cases, the ICC was similar at 35.8% for facilities (Table 3, model 2).

We then identified the variance in MIBB use at the surgeon and facility levels using a 3-level model of patients clustered within surgeons clustered within facilities (Table 3, model 3). In the 3-level model, the ICC for the surgeon contribution to variance in MIBB was 15.4% (Table 3, model 3). The percentage of variance in MIBB use attributable to the facility decreased from 33.6% in the 2-level model (Table 3, model 1) to 28.7% in the 3-level model (Table 3, model 3) demonstrating that approximately 15% of the facility-level variance was explained by the surgeon. These models are depicted graphically.

TABLE 3. Hierarchical Multilevel Models: Percentage of Variance in MIBB Use Attributable to Patient, Surgeon, and Facility Characteristics

Characteristics	% Variance in MIBB Use,* Adjusted for Patient Characteristics
2-level model (patient, facility)	
Model 1	
No. patients	22,331
No. facilities	295
Residual ICC (% variance)—facility*†	33.6%
2-level model (patient, facility)	
Model 2	
No. patients	17,716
No. facilities	249
Residual ICC (% variance)—facility*†	35.8%
3-level model (patient, surgeon, facility)	
Model 3	
No. patients	17,076
No. surgeons	792
No. facilities	229
Residual ICC (% variance)—surgeon*†	15.4%
Residual ICC (% variance)—facility*†	28.7%

Model 1: For the 2-level hierarchical models, only 295 facilities with 5 cases or more were included from the initial cohort of 525 facilities for a final N = 22,331. Model 2: The 2-level hierarchical model was repeated with the cohort of cross-classified cases. Surgeons were assigned to facilities where they performed the greatest number of cases; cases done at other facilities (N = 4921) and facilities with less than 5 cases (N = 714) were excluded resulting in 17,716 patients. Model 3: Surgeons were assigned to facilities where they performed the greatest number of cases; cases done at other facilities (N = 4921) and facilities with less than 5 cases (N = 714) were excluded resulting in 17,076 patients. The percentage of variance in MIBB use attributable to the facility decreased from 33.6% in the 2-level model to 28.7% in the 3-level model.

*Hierarchical generalized linear models: 2-level model "level 1" variables are patient characteristics and "level 2" variables are facility identifiers. Three-level model "level 1" variables are patient characteristics, "level 2" variables are surgeon identifiers, and "level 3" variables are facility identifiers.

†The percentage of variance attributable to the surgeon and facility are calculated with a threshold model, after simultaneous adjustment of all available patient characteristics. The denominator for the calculation of the percentage was composed of the variance attributable to the facility (2-level model) or surgeon and facility (3-level model), after adjustment for available patient characteristics, and the variance attributable to unexplained patient variables plus error.

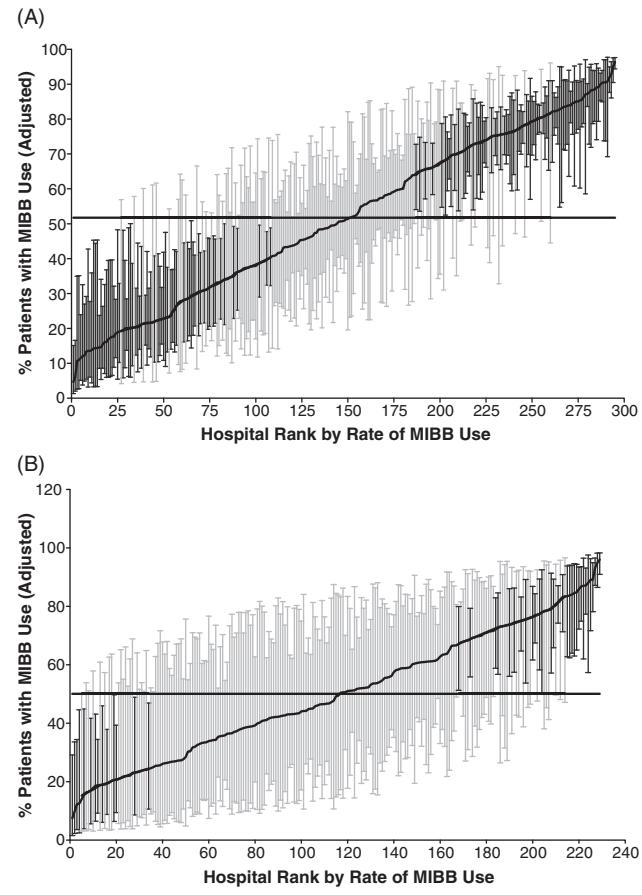

FIGURE 2. A, Empirical Bayes shrunken estimates of facility variation in the adjusted rates of MIBB based on the 2-level hierarchical model adjusted for patient characteristics (N = 22,331). Two hundred ninety-five facilities performed 5 or more surgeries and were ranked from lowest to highest MIBB use with a range of 5.0% to 96.3%. The horizontal line represents the overall mean rate of MIBB use. Error bars represent 95% confidence intervals for the MIBB rates of individual facilities. Black error bars represent facilities that have rates statistically significantly ($P < 0.05$) above or below the mean rate of 51.7% (median = 51.0%; IQR = 31.4%–73.1%), and light gray bars represent rates that are not different from the mean rate. B, Empirical Bayes shrunken estimates of facility variation in the adjusted rates based on 3-level hierarchical model (patients clustered with surgeons and surgeons clustered with facilities) adjusted for patient characteristics (N = 17,076). Two hundred twenty-nine facilities performed 5 or more surgeries and were ranked in the 3-level model from lowest to highest MIBB use with a range of 7.5% to 96.0%. The horizontal line represents the overall mean rate of MIBB use. Error bars represent 95% confidence intervals for the MIBB rates of individual facilities. Black error bars represent facilities that have rates statistically significantly ($P < 0.05$) above or below the mean rate of 50.1% (median = 49.2%; IQR = 33.4%–68.3%), and light gray bars represent rates that are not different from the mean rate.

From the 2-level model of patients clustered within facilities (Table 3, model 1), the adjusted rates of MIBB across facilities were plotted by rank in MIBB use from lowest to highest, ranging from 5.0% to 96.3% (Fig. 2A). Of these 295 facilities, 24.1% (N = 71) had rates of MIBB use significantly below and 28.1% (N = 83) had rates significantly above the adjusted mean facility rate of 51.7% (Fig. 2A, $P < 0.05$). Figures 2B, 3 reflect the 3-level model of patients clustered within surgeons clustered within facilities. Using the 3-level model to evaluate facility variance, 6.1% of facilities had rates significantly lower than the mean MIBB use of 50.1%; 13.5% of facilities had rates significantly higher than mean ($P < 0.05$). Facility variation in the 3-level model is shown in Figure 2B. Variability in MIBB use across facilities decreased to 7.5% to 96.0% (median = 49.2; IQR = 33.4%–68.3%) after adjusting for surgeon factors. Comparing Figures 2A and B, facility variation in MIBB use diminished after accounting for surgeons in the model. In other words, a proportion of the variation among facilities was due to variation in practice patterns among surgeons.

We then used the 3-level model to evaluate adjusted surgeon variation. Adjusted MIBB use across 792 surgeons ranged from 8.0% to 87.0% (Fig. 3). One hundred nine surgeons (13.8%) had rates of MIBB use significantly different from those of the mean; 6.9% were significantly lower and 6.8% significantly higher than the mean of 50.3% (median = 50.9; IQR = 39.8%–61.2%).

Patient, Surgeon, and Facility Characteristics Associated With MIBB Use

Surgeon and facility characteristics were added to the aforementioned 3-level hierarchical model to determine the patient, surgeon, and facility factors associated with high MIBB use (N = 16,530, ambulatory surgery centers excluded). Surgeons with more years in practice and surgeons with lower case volume were less likely to use MIBB. Facility factors associated with lower MIBB use included smaller facility bed size and low facility volume (Table 4).

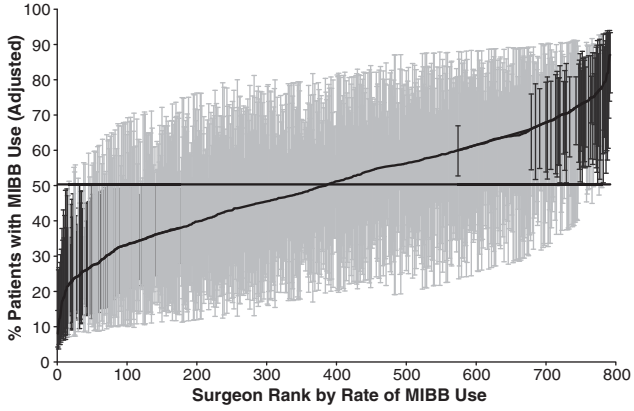

FIGURE 3. Empirical Bayes shrunken estimates of surgeon variation in the adjusted rates of MIBB use for 792 surgeons doing more than 5 cases were ranked from lowest to highest MIBB use with a range of 8.0% to 87.0% (N = 17,076). Rates were generated from the 3-level hierarchical model (adjusted for patient characteristics). The horizontal line represents the overall mean rate of MIBB use. Error bars represent 95% confidence intervals for the MIBB rates of individual surgeons. Black error bars represent facilities that have rates statistically significantly ($P < 0.05$) above or below the mean rate of 50.3% (median = 50.9%; IQR = 39.8%–61.2%), and light gray bars represent rates that are not different from the mean rate.

TABLE 4. Three-level Model (Patients Within Surgeon Within Facilities) Adjusted for Patient, Surgeon, and Facility Characteristics (N = 16,530)

Variables	Odds Ratio	95% CI
Patient characteristics		
Age (ref: <74), yr		
75+	1.13	1.05–1.23
Biopsy year (ref: 2001–2003)		
2004–2006	1.90	1.74–2.08
2007–2008	3.44	3.05–3.87
Race (ref: white)		
Hispanic	0.91	0.77–1.07
Black	0.97	0.82–1.15
Others	0.85	0.55–1.31
Education (ref: Q1)		
Q2	1.06	0.93–1.20
Q3	0.99	0.87–1.13
Q4—highest	0.98	0.86–1.12
Metropolitan Statistical Area (ref: 1M)		
250,000–1 million	0.61	0.47–0.81
10,000–0.25 million	0.69	0.56–0.84
<10,000 vs 1 million	0.78	0.66–0.92
Surgeon characteristics		
Year of practice (ref: Q1)		
Q2	0.73	0.57–0.94
Q3	0.54	0.42–0.70
Q4—highest	0.49	0.38–0.64
Surgeon sex (ref: male)		
Female	1.16	0.87–1.15
US trained (ref: yes)		
No	0.91	0.69–1.21
Specialty (ref: general surgery)		
Others	0.99	0.68–1.44
Surgical oncology	1.25	0.64–2.44
Surgeon volume (ref: Q1)		
Q2	1.17	0.94–1.45
Q3	1.54	1.19–1.99
Q4—highest	2.14	1.48–3.11
Facility characteristics		
Type of hospital (ref: nonprofit)		
Government	1.27	0.83–1.94
Profit	1.10	0.70–1.75
Teaching hospital (ref: yes)		
No	0.99	0.61–1.60
Facility bed size (ref: <200 beds)		
200–324	1.54	0.92–2.56
325–500	3.40	1.89–6.13
>500	3.15	1.54–5.95
Facility volume (ref: Q1)		
Q2	1.48	0.92–2.36
Q3	1.24	0.67–2.29
Q4—highest	2.60	1.09–5.98

DISCUSSION

To our knowledge, ours is the first study to use multilevel hierarchical models to evaluate surgeon- and facility-level variation in the use of MIBB as the initial diagnostic modality in a woman presenting with a palpable breast mass or mammographic abnormality. Consistent with previous population-based studies,[6,10,11] MIBB use in our cohort fell well below the NCCN target rate of 90%, with only 62.4% of women undergoing MIBB as the initial diagnostic modality. We identified only 7.0% of facilities and 13% of surgeons performing MIBB in more than 90% of their breast cancer cases. We observed wide variation in the use of MIBB across surgeons (8.0%–87.0%) and facilities (7.5%–96.0%). In our multilevel models, more than 28% of the variance in MIBB use was attributable to the facility and 15%

attributable to the surgeon. Among the 295 facilities that performed 5 or more cases, 279 facilities had the capacity to perform MIBB; therefore, availability of technology was not a driver of variation in our study. Finally, we also identified specific surgeon and facility characteristics associated with a low use of MIBB.

The role of physician characteristics in practice variation across a variety of disease processes has been previously evaluated.[16-21] In a retrospective cohort study, Feinstein et al[21] used hierarchical linear regression models to demonstrate that surgeons accounted for as high as 15.7% of the variance in a patient's receipt of radiation therapy after breast conserving surgery. This is similar to the findings in our study in which the percentage of variance in MIBB use attributable to the surgeon was 15.4%. When the amount of practice variation attributable to the physician is high (as in our study), efforts directed at changing physician behavior would potentially have a significant impact on outcomes. As a result, our findings suggest that interventions targeted at changing physician behaviors could potentially improve MIBB rates dramatically. This idea is supported by a single-institution quality improvement initiative by Lovrics et al,[22] where surgeon-directed strategies resulted in the increase of MIBB rates from 73% to 92%.

Previous studies have demonstrated similar findings of facility variation in practice patterns.[23,24] In a study evaluating blood transfusion and patient outcomes in cardiac surgery, 30% of the variance in transfusion practices was attributable to the facility despite specific recommendations from evidence-based guidelines.[24] In such cases, efforts directed at implementing a hospital-wide quality improvement program improved guideline adherence rates.[25] In our study, a comparable percentage of the variation in MIBB use was attributable to the facility at 28.8%. We identified lower volume facilities and smaller facilities as having lower rates of MIBB use. Quality improvement initiatives targeted at low-volume, smaller hospitals may improve MIBB rates at the facility level, leading to decreased variation.

Finally, we observed that US-trained high-volume surgeons were more likely to use MIBB. We also found an inverse correlation between surgeon years in practice and use of MIBB. This may represent a higher proportion of young surgeons with specialized training and practices devoted to breast disease or an increased willingness of young surgeons to adopt current guidelines. A previous study using Medicare claims data also identified an association between high surgeon volume and adherence to guidelines, specifically adequate lymphadenectomy in early-stage breast cancer.[26] In a single-institution, retrospective study of 465 breast cancer patients, Clarke-Pearson et al[7] identified differences in MIBB rates between academic breast surgeons (91%), private practice breast surgeons on the clinical faculty (74%), and general surgeons performing breast cases (58%) as part of their practice. Although we were not able to determine the proportion of a surgeon's practice dedicated to breast disease or surgeons who were breast fellowship trained, we observed a volume-outcomes relationship in the use of MIBB. Our findings support that interventions to improve physician use of MIBB may be directed toward underperforming surgeons with longer years in practice and lower volumes.

Our study assigns patients to the surgeon or hospital that did the definitive breast cancer operation. However, previous data demonstrate that more than 70% of minimally invasive biopsies are performed by radiologists and not the surgeon doing the definitive breast cancer operation.[6] Likewise, it is possible that surgeons who did the definitive operation but not the original open biopsy would be incorrectly classified as having made this decision, when instead the patient was referred after the open biopsy had occurred. However, 86.6% of the open biopsies were performed by the same surgeon who did the biopsy. Three hundred fifty-six of the 792 surgeons in the cohort operated on 1 or more of the 1146 patients in whom the open biopsy was performed by a different surgeon. As such, most surgeons only had few cases that were inappropriately classified. Conversely, many patients may have minimally invasive biopsy before being referred to a surgeon, who might have otherwise done the biopsy open. We chose the surgeon doing the breast cancer operation as the unit of analysis because this person is easy to identify in the claims data, but we feel this represents a larger systemic issue and reflects both referral and practice patterns and should be evaluated in this context.

In many settings, such as large academic, multidisciplinary breast centers, mammography and biopsy occur without surgeon involvement and surgeons evaluate patients only after a tissue diagnosis is established and multidisciplinary consultation is underway. It is likely that in this setting, patients referred without biopsy would be sent for minimally invasive biopsy as this is standard practice. This is evidenced by reports of MIBB exceeding 90% in academic centers.[27] In private settings, surgeons may be referred patients with breast masses before diagnosis and open breast biopsy may represent a significant proportion of a surgeon's practice. In the study by Clarke-Pearson et al,[7] diagnostic excisional biopsy made up 10% of academic breast surgeon practices but 35% of private practice breast surgeon practices and 37% of general surgeon practices. Increasing referring physician awareness and surgeon awareness of the current recommendations may lead to improved MIBB rates.

Our study has several limitations. Our study cohort was limited to women who were Medicare beneficiaries older than 66 years in the state of Texas and results may not be generalizable to other age groups or geographic regions. In addition, we included only patients with breast cancer. Rates of open biopsy have been shown to be higher in patients with benign disease,[6] so we may have actually overestimated rates of MIBB use. In addition, we limited our cohort to patients who had a cancer operation after biopsy to identify the surgeon and the facility. Patients with breast cancer may be more likely to be treated by a breast specialist or at a multidisciplinary center. Variability in the use of MIBB across surgeons and facilities may differ for a cohort of women who have both benign and malignant diseases. Finally, we were able to identify surgeon specialty as surgical oncology versus general surgery using the Medicare claims. However, these data are self-reported and have not been validated. We were unable to identify surgeons who are breast fellowship trained or have practices devoted to breast disease.

CONCLUSIONS

We used multilevel hierarchical modeling techniques to demonstrate that a large amount of the observed variation in MIBB use was attributable to both surgeon and facility characteristics. In addition, we identified several surgeon and facility factors associated with low MIBB use. These data points can be used as specific targets for intervention to achieve MIBB rates of more than 90% for breast cancer patients in Texas.

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