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The Role of Organizational Affiliations and Research Networks in the Diffusion of Breast Cancer Treatment Innovation

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Abstract

Introduction—The National Institutes of Health (NIH) sees provider-based research networks and other organizational linkages between academic researchers and community practitioners as promising vehicles for accelerating the translation of research into practice. This study examines whether organizational research affiliations and teaching affiliations are associated with accelerated diffusion of sentinel lymph node biopsy (SLNB), an innovation in the treatment of early-stage breast cancer.

Methods—Surveillance Epidemiology and End Results-Medicare data were used to examine the diffusion of SLNB for treatment of early-stage breast cancer among women aged 65 years and older diagnosed between 2000 and 2002, shortly after Medicare approved and began reimbursing for the procedure.

Results—In this population, patients treated at an organization affiliated with a research network —-the American College of Surgeons Oncology Group (ACOSOG) or other National Cancer Institute (NCI) cooperative groups—-were more likely to receive the innovative treatment (SLNB) than patients treated at unaffiliated organizations (odds ratio: 2.70, 95% confidence interval: 1.77–4.12; odds ratio: 1.84, 95% confidence interval: 1.26–2.69, respectively). Neither hospital teaching status nor surgical volume was significantly associated with differences in SLNB use.

Discussion—Patients who receive cancer treatment at organizations affiliated with cancer research networks have an enhanced probability of receiving SLNB, an innovative procedure that offers the promise of improved patient outcomes. Study findings support the NIH Roadmap and programs such as the NCI's Community Clinical Oncology Program, as they seek to accelerate the

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The interpretation and reporting of these data are the sole responsibility of the authors.

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This study used the linked SEER-Medicare database.

translation of research into practice by simultaneously accelerating and broadening cancer research in the community.

Keywords

breast cancer; translational research; diffusion of innovation; organization and administration; provider-based research networks

Scientific advances are rapidly reshaping cancer care. Much original research takes 17 years before yielding patient care benefits,[1] and so the accelerating pace of discovery places a premium on the need for rapid translation of research into practice. The National Institutes of Health has clearly recognized this need.[2–5] As one means of addressing it, the National Cancer Institute (NCI) has emphasized moving beyond traditional teaching systems by linking academic centers to community practitioners who treat the majority of cancer patients. For example, the NCI Community Clinical Oncology Program (CCOP) effectively connects the NCI Cooperative Groups (researchers primarily at academic centers developing and managing clinical trials) with a nationwide provider-based research network of community physicians treating cancer patients and enrolling them on clinical trials.[6] CCOP organizational goals include not only enrolling patients on trials, but also accelerating the diffusion of evidence-based innovations into practice, among others.[2,6–10]

Sentinel lymph node biopsy (SLNB) is an important innovation in breast cancer treatment. In breast cancer, the presence or absence of cancer in the axillary lymph nodes is the most important predictor of recurrence and death. On the basis of lymph node involvement, treatment may variably include more extensive surgery, radiation therapy, or chemotherapy; therefore, accurate assessment of lymph nodes is critical in determining the optimal treatment plan.[11,12] Axillary lymph node dissection (ALND) has long been an effective means of assessing lymph node involvement and an integral part of treatment.[13,14] ALND is an extensive procedure in which 10 or more lymph nodes are removed and a surgical drain is placed, followed by one or more night stays in a hospital. It is associated with considerable surgical morbidity including lymphedema, nerve paresthesias, axillary seromas, and infections.[15] Several studies have demonstrated that a newer procedure, SLNB, is a safe and accurate alternative for examining lymph nodes. SLNB and ALND are equivalent in terms of disease control and patient survival. Because it necessitates removal of only 1 to 3 nodes, SLNB is associated with substantially fewer and less severe morbidities and commonly no overnight hospital stay.[16–24] Accordingly, SLNB has been widely adopted by surgeons as an innovative alternative to routine ALND for axillary staging in early breast cancer.

As with many other innovations, adoption of SLNB has not been uniform.[25] Factors previously shown to be associated with variation in use of SLNB include patient characteristics (eg, age, race, insurance coverage) and organizational factors (eg, surgical volumes, being an NCI-designated cancer center).[26–31] Although prior research has established that these organizational characteristics are relevant, a more specific question remains largely unanswered: Are organizational affiliations relating to teaching and research associated with accelerated adoption of innovative breast cancer treatments? This study examines the diffusion of SLNB among organizations providing breast cancer treatment, and hypothesizes that research and teaching affiliation are associated with accelerated innovation diffusion.

METHODS

Conceptual Model

This study is informed by diffusion theory,[32,33] which posits the following 5 stages in the innovation-decision process: knowledge, persuasion, decision, implementation, and confirmation. In the knowledge stage, individuals are exposed to information regarding the existence of an innovation, often through general or mass media. Progress through the innovation-decision process is facilitated when the individual is receptive, the innovation suits their norms, and the information is from a credible source. In the persuasion stage, individuals assess the innovation's relevance and potential advantage for themselves, and form favorable or unfavorable attitudes, although decreasing their uncertainty about it. A decision to adopt is facilitated through interpersonal communication among homophilous peers exchanging personal experiences. It is more likely in the case of homophily and greater exposure to advocates, including opinion leaders and early adopters who tend to be more influenced by mass media and whose subsequent personal influence spreads the innovation to their followers.[32] Implementation allows first-hand evaluation and further opportunity to reduce uncertainty about the innovation, particularly in a controlled environment.

For this study, clinical communication channels comprise a baseline context. In this study, all clinicians might be exposed to information about innovations through the mass media, clinical media (eg, newsletters, journals), and their peers. Through these channels, exposure to this information is comparatively passive, unfocused, and often unsolicited; however, through these channels, individuals may first learn of innovations and choose to gather and evaluate more information. With the passage of time, innovative treatments will diffuse, perhaps slowly and unevenly, to community hospitals and practices through clinical communication channels.

Organizations participating in graduate medical education are hypothesized to have more effective pathways for innovation diffusion than those that do not. In the present study, local thought leaders (eg, instructors) and information seekers (eg, interns, residents, and other attending physicians) are commonly at these organizations due to their own interest and motivation, and so exposure to information is both more active and more focused, particularly within specialties and among those in later years of training. In addition, knowledge of "the state-of-the-art" is encouraged and reinforced in these environments that value communicating it through didactic, lecture-based, or practicum-based learning. Therefore, community hospitals and practices that are organizationally linked to academic centers through teaching relationships will experience innovation diffusion more quickly than those with no such linkages.

Organizations affiliated with clinical research networks like the American College of Surgeons Oncology Group (ACOSOG) or other NCI cooperative groups are hypothesized to have even more effective pathways for innovation diffusion. Through research meeting attendance, community practitioners gain access to the latest scientific findings before publication. In addition, through social interaction, academic researchers and receptive community practitioners can exchange information about the innovative relevance and potential advantages of the treatment. Finally, direct participation in the clinical research sponsored by the networks affords community practitioners opportunity to gain first-hand experience with the innovation. Therefore, organizations that participate in clinical research networks are likely to adopt innovative treatments faster than those that participate in teaching networks or those that receive information primarily through clinical communication channels.

Data

Data are from the Surveillance Epidemiology and End Results (SEER)-Medicare linked data, which have been previously described.[34] Briefly, SEER-Medicare is a collaborative effort between the NCI and Centers for Medicare and Medicaid Services (CMS), which links routinely collected population-based data from cancer registries across the country to Medicare administrative data and health care claims. The SEER data include demographic and incident cancer characteristics including grade and stage, as well as treatment information and vital status for approximately 25% of the US cancer population. Medicare provides health insurance for 97% of Americans aged 65 years and older, and these data reflect health care services used and comorbid health conditions. Hospital-level data characterize structure and research network affiliation among other factors.

Study Population

The sample included women who were White or African American, aged 65 years or older, diagnosed in a SEER region with stage I or II breast cancer (ie, the tumor is relatively small and invasive, but has not spread to other parts of the body) as first or only primary cancer, for which they received breast-conserving surgery. Those in the sample had complete claims for 12 months prior through 24 months subsequent to diagnosis. To allow examination of racial disparities in breast cancer treatment in the context of population heterogeneity,[35] the sample was limited to SEER registries with 5% or greater African Americans. The analysis was restricted to women receiving some form of axillary staging (either SLNB or ALND), thus allowing a focus on factors associated with differential utilization of each option, rather than factors associated with receipt versus nonreceipt of any staging. SLNB was introduced in the 1990s, though this analysis focused on those diagnosed during 2000 and 2002, to capture meaningful expansion in this innovation's use immediately after Medicare's approval and initiation of coverage of SLNB in the year 2000, subsequent to the initiation or completion and positive findings of several relevant clinical trials.[16–24]

Main Outcome

The primary outcome of interest was the type of lymph node removal procedure used. The innovation was defined as the receipt of SLNB only or SLNB followed by ALND, because subsequent ALND might be appropriate, depending on the sentinel pathology results of the lymph nodes. The alternative categorization was the prior standard of care, defined as ALND alone. To characterize SLNB, this outcome was assessed in the following 2 ways: using SEER data (specified sentinel node removal with or without subsequent ALND) and Medicare billing codes (HCPCS codes for sentinel dye injection procedure or lymphoscintigraphy). Similarly, patients were categorized as receiving ALND using SEER data (specified removal of regional lymph nodes with at least 10 nodes examined [concordant with clinical guidelines for ALND]) and Medicare HCPCS (ALND).

Variables of Interest

Using the SEER-Medicare Provider file, organizational research affiliation was measured as affiliation with NCI cooperative research groups that have substantial breast cancer clinical research activity (Eastern Cooperative Oncology Group, Cancer and Leukemia Group B, Southwest Oncology Group, and National Surgical Adjuvant Breast and Bowel Project).[36] Participation in the NCI Cancer Centers program was examined, because these 65 NCI-designated cancer centers have substantial transdisciplinary cancer research programs. Affiliation with the American College of Surgeons Oncology Group (ACOSOG) was measured separately from other cooperative groups for 2 reasons. First, ACOSOG focuses specifically on cancer surgery research, including studies of SLNB,[37] whereas other cooperative groups focus more on medical research. Second, the majority of ACOSOG sites

are also accredited by the ACOS Commission on Cancer (CoC), which encourages and accredits organizations with integrated, programmatic approaches in improving cancer care quality across a broad spectrum of services and quality measures[38]; therefore, ACOSOG affiliation may also be a marker of clinical care quality network affiliation. Teaching status was measured through medical school affiliation and teaching hospital designation. Breast cancer-specific surgical volume, an established organizational performance indicator, was also included.[25,28,29,39]

Patient-level characteristics include race, age at diagnosis, NCI comorbidity index, and marital status dichotomized as married or unmarried. Tumor characteristics at diagnosis include stage, grade, and estrogen receptor status. Census tract-level variables for income and education were used as indicators of socio-economic status for each patient and assigned to each patient on the basis of year 2000 data for their area of residence, as done previously.[29]

Statistical Methods

Variables were examined in bivariate analyses to assess crude associations between all variables, to examine functional form, and to ensure that organizational constructs were independent indicators. Medical school affiliation was highly correlated with all other organizational variables. Because all NCI centers were also affiliated with cooperative groups, they saw a very small number of patients (155, or 4%), and because the cooperative group affiliation measure allows the characterization of clinical research participation in a broader range of institutions including community hospitals, NCI designation and medical school affiliation were excluded from subsequent analyses in favor of the organizational variables reflecting organizational cooperative group affiliation, ACOSOG affiliation, teaching status, and cancer surgical volume.

To examine organizational differences in innovation diffusion, we used a generalized linear mixed model with maximum likelihood estimates, implemented through the GLIMMIX procedure in SAS 9.2 (SAS, 2009). The multilevel model used the logit link function. The dependent variable was receipt of SLNB with or without ALND versus receipt of ALND alone. Random effects variables were SEER region and hospitals nested within SEER region. Fixed effects variables were ACOSOG affiliation, cooperative group affiliation, volume of breast cancer surgery, year of diagnosis, age, race, within region median income quartile, and percent of high school education. Predicted probabilities from the adjusted logistic models were used to construct figures describing the receipt of SLNB over time. Potential effect modification between the organizational level variables, receipt of SLNB, and race were examined by stratifying our sample by race and exploring both the main effects and adjusted models separately.

RESULTS

Although the sample was limited to SEER regions with significant African American populations, the percentage of African Americans in the sample remained relatively low at 7.7% (Table 1). Most patients received their surgery at an institution affiliated with a cooperative group (74.1%), a teaching hospital (56.2%), or ACOSOG (36.7%). A large majority of patients (83.6%) received their care at high-volume institutions. The mean age for the population was 74.2 years (SD: 5.5), 65.7% had Stage I disease, and the majority was quite healthy, with two-thirds having a comorbidity index score of 0. In examining crude associations between organizational factors and SLNB, ACOSOG affiliation and organizational surgical volume demonstrated the strongest association with a 2-fold greater probability of SLNB (Table 2).

In multivariable analysis, the diffusion of SLNB into practice is demonstrated in the consistently increasing odds of having the procedure between 2000 and 2002 (Table 3). Compared with patients in 2000, patients were 1.74 times as likely to receive SLNB in 2001 (95% confidence interval [CI]: 1.42–2.13) and 2.70 times as likely in 2002 (95% CI: 2.18–3.34). Patients were more likely to receive SLNB if their surgery was at a cooperative group or ACOSOG-affiliated institution (odds ratio [OR]: 1.84, 95% CI: 1.26–2.63; OR: 2.70, 95% CI 1.77–4.12, respectively). After adjustment for these organizational linkage characteristics, the probability of receiving SLNB was not statistically different among hospitals with different surgical volumes or among teaching hospitals compared with nonteaching hospitals. Relative to the youngest women (age, 65–69), women aged 80 years or older were significantly less likely to receive SLNB (OR: 0.67, 95% CI 0.51–0.87). Women with more advanced (Stage II) disease were less likely to receive SLNB compared with women with less-advanced (Stage I) disease. Women with less-aggressive (well-differentiated) tumors were more likely to receive SLNB than women with aggressive (poorly differentiated) tumors. The odds of receiving SLNB were significantly lower for African American women than for White women. There was no effect modification of the organizational variables by race or race by year in sensitivity analyses (data not shown).

Figure 1 graphically illustrates the progressive increase in the probability of receiving SLNB over time, as well as the differential probability of receiving SLNB at hospitals with different organizational affiliations.

DISCUSSION

This study examined whether organizational research and teaching affiliations are associated with accelerated diffusion of SLNB, an innovation in the treatment of early-stage breast cancer. Examining a population of breast cancer patients aged 65 years and older, it demonstrates that modifiable organizational linkages are associated with the diffusion of evidence-based innovations into clinical practice. Specifically, it was found that women receiving surgery for early-stage breast cancer at organizations affiliated with NCI cooperative groups and ACOSOG were more likely to receive the innovative procedure compared with women treated at other organizations.

These findings provide empirical evidence of a long anecdotally observed association between organizational clinical research participation and accelerated diffusion of innovations into evidence-based practice; however, characterizing such associations as causal is exceedingly challenging, as is most demonstration of causation. These findings reinforce diffusion theory, which specifies S-shaped diffusion curves that differ between early adopters and later adopters.[32] As presented in Figure 1, we observed nonaffiliated organizations' (later adopters) SLNB adoption climbing at a comparatively faster rate (ie, a steeper slope up the vertical aspect of the "S"), as they catch up to the cooperative group or ACOSOG-affiliated organizations (earlier adopters) who have passed this point, and whose adoption rates have begun to plateau. Projections of the curves in Figure 1 suggest that nonaffiliated organizations are approximately 3 to 5 years behind the "ACOSOG and Cooperative Group" organizations in their relative adoption of SLNB.

ACOSOG affiliation was found to be the strongest predictor for receipt of SLNB, with patients experiencing almost 3-fold greater odds of receiving SLNB compared with those observed at unaffiliated hospitals. ACOSOG's stronger association compared with the other cooperative groups suggests a special or distinct nature of this affiliation.[37] This measure might very plausibly also be a marker, connoting the value of these organizations having an integrated, programmatic approach in improving cancer care quality across a broad spectrum of services and quality measures.[38] Coupling this with research participation among its

member institutions, surgeons would likely have had direct experience with SLNB (and other surgical innovations) in their practice, possibly through the controlled setting of a clinical trial, in a supportive environment with systems to measure and assure clinical care quality. In addition, these physicians likely had many opportunities for professional education and training through ACOS, including attendance at national meetings featuring leaders in the field, which would reinforce the external communication associated with this affiliation.

Unexpectedly, this study also found that organizational factors previously associated with cancer care quality and outcomes—-teaching affiliation and surgical volume—-did not contribute independently to the early adoption of innovative breast cancer treatments. In bivariate models, the correlations between volume, teaching status, and SLNB use were positive, and there was a trend of increasing SLNB use with increasing organizational volume. This suggests the relevance of these measures; however, for this population, it might be that they were dwarfed by the other factors.

We found that African American and older women were less likely to receive the innovative and less invasive SLNB procedure. In sensitivity analyses, organizational research affiliation was associated with slight attenuation in the racial differences in receipt of this state-of-the-art procedure (data not presented). Findings of lower SLNB utilization among the oldest patients and among African Americans suggest a troubling persistence of disparities in receipt of this innovative procedure among those who may benefit most. The slight attenuation in racial disparities is promising; however, the small sample size of African Americans and the focus of this study on organizational-level findings precluded more extensive examination.

Measuring organizational-level characteristics in SEER-Medicare data presents several challenges. For example, studies have shown that an organization's Medicare-specific patient volume and overall patient volume show similar associations with outcomes[26]; however, accurately measuring organizational volume for hospitals outside of SEER regions is difficult. Accurate Medicare volume estimates for such organizations necessitate Medicare claims for individuals living in those regions, which are under-represented in these data.

A unique variable specifically characterizing cancer care quality, for example, accreditation by the ACOS CoC, was not available in these data, and thus represents an opportunity for future research. In the absence of CoC accreditation, ACOSOG-affiliation may partially serve as a proxy because most of the ACOSOG-affiliated hospitals are CoC accredited.[40] Regarding the overlap among organization-level variables, correlation between ACOSOG affiliation and (other) cooperative group affiliation was low, and their demonstrated independence in the model indicates they are indeed indicators of independent constructs, justifying their independent inclusion.

Finally, generalizability of these findings to younger women is unknown; however, the importance of the population in this study is not to be underestimated, given that more than 40% of newly diagnosed breast cancer cases occur in women aged 65 years and older.[41]

CONCLUSIONS

Recent reports of the Institute of Medicine and NCI Operational Efficiency Work Group have presented the case for change in the NCI Cooperative groups and cooperative group research[42– 43]; however, the findings of this study are promising and supportive of the NCI cooperative groups. Specifically, the findings of this study provide empirical evidence that beyond success in their primary goal of conducting clinical research, these provider-based

research networks also play a role in accelerating the translation of research into practice.[2,6] Notably, this evidence suggests that the NCI is influential not only in the science of our national cancer research endeavor, but also in cancer care delivery. For the NCI, the implications are that it might see value in further support or expansion of programs such as CCOP to extend its success. For policy-makers, this study illustrates the symbiosis of cancer clinical research and clinical care, and might cast a new light on coverage policies and nascent pay-for-performance programs. For example, rather than perpetuating efforts to separate the funding and management systems for clinical care and clinical research programs, there may be merit in evaluating systems for their integration.

Although its results are promising, this study also raises a cautionary flag. In addition to facilitating the adoption of tested and effective innovations, these mechanisms may also accelerate the adoption of unproven technologies and procedures. Accordingly, further research should examine how to modulate innovation adoption to accelerate proven technologies while tempering the adoption of those that are unproven, less effective, or less safe. It should also expand upon this study's preliminary findings of attenuation in racial differences in receipt of SLNB. Confirming these findings would further support the NCI's vision of increasing minority accrual into clinical trials as a means of reducing cancer health disparities.[10] While examining these issues, future work should use more granular measures and enhance generalizability of the findings by studying them among different treatment modalities. Awaiting confirmation of these findings, institutions may evaluate the prospective benefits that research participation and ACOSOG affiliation may contribute to their organizational missions.

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References

1. Balas, E. Information technology and physician decision support. Program and abstracts of Accelerating Quality Improvement in Health Care: Strategies to Speed the Diffusion of Evidence-based Innovations, sponsored by National Committee for Quality Health Care; January 27–28, 2003; Washington, DC.
2. Zerhouni E. The NIH Roadmap. Science 2003;302:63–72. [PubMed: 14526066]
3. Zerhouni E. Translational and clinical science—time for a new vision. N Engl J Med 2005;353:1621–1623. [PubMed: 16221788]
4. Lenfant C. Shattuck lecture—clinical research to clinical practice—lost in translation? N Engl J Med 2003;349:868–874. [PubMed: 12944573]
5. Lenfant C. Claude Lenfant, MD: retiring NHLBI director looks ahead. Interviewed by Brian Vastag. JAMA 2003;290:1017–1018. [PubMed: 12941662]
6. Minasian LM, Carpenter WR, Weiner BJ, et al. Translating research into evidence-based practice: the National Cancer Institute Community Clinical Oncology Program. Cancer 2010;116:4440–4449. [PubMed: 20572032]
7. National Cancer Institute. Designing for dissemination conference summary report. Washington, DC: National Cancer Institute; 2002.

8. Trans-HHS Cancer Health Disparities Progress Review Group. Making Cancer Health Disparities History-Report of the Trans-HHS Cancer Health Disparities Progress Review Group. Washington, DC: Department of Health and Human Services; 2004.
9. Lamb, S.; Greenlick, MR.; McCarty, D., editors. Institute of Medicine. Bridging the Gap Between Practice and Research. Washington, DC: National Academy Press; 1998.
10. National Cancer Institute. The NCI Strategic Plan for Leading the Nation to Eliminate the Suffering and Death Due to Cancer. Rockville, MD: National Cancer Institute; 2007.
11. Fisher ER, Anderson S, Redmond C, et al. Pathologic findings from the National Surgical Adjuvant Breast Project protocol B-06. 10-year pathologic and clinical prognostic discriminants. Cancer 1993;71:2507–2514. [PubMed: 8453574]
12. Carter CL, Allen C, Henson DE. Relation of tumor size, lymph node status, and survival in 24,740 breast cancer cases. Cancer 1989;63:181–187. [PubMed: 2910416]
13. Cabanes PA, Salmon RJ, Vilcoq JR, et al. The Breast Carcinoma Collaborative Group of the Institut Curie. Value of axillary dissection in addition to lumpectomy and radiotherapy in early breast cancer. Lancet 1992;339:1245–1248. [PubMed: 1349666]
14. Orr RK. The impact of prophylactic axillary node dissection on breast cancer survival—a Bayesian meta-analysis. Ann Surg Oncol 1999;6:109–116. [PubMed: 10030423]
15. Chen SL, Iddings DM, Scheri RP, et al. Lymphatic mapping and sentinel node analysis: current concepts and applications. CA Cancer J Clin 2006;56:292–309. quiz 316–317. [PubMed: 17005598]
16. Krag DN, Anderson SJ, Julian TB, et al. Technical outcomes of sentinel-lymph-node resection and conventional axillary-lymph-node dissection in patients with clinically node-negative breast cancer: results from the NSABP B-32 randomised phase III trial. Lancet Oncol 2007;8:881–888. [PubMed: 17851130]
17. Veronesi U, Paganelli G, Viale G, et al. Sentinel-lymph-node biopsy as a staging procedure in breast cancer: update of a randomised controlled study. Lancet Oncol 2006;7:983–990. [PubMed: 17138219]
18. Veronesi U, Paganelli G, Viale G, et al. A randomized comparison of sentinel-node biopsy with routine axillary dissection in breast cancer. N Engl J Med 2003;349:546–553. [PubMed: 12904519]
19. McMasters KM, Tuttle TM, Carlson DJ, et al. Sentinel lymph node biopsy for breast cancer: a suitable alternative to routine axillary dissection in multi-institutional practice when optimal technique is used. J Clin Oncol 2000;18:2560–2566. [PubMed: 10893287]
20. Schrenk P, Rieger R, Shamiyeh A, et al. Morbidity following sentinel lymph node biopsy versus axillary lymph node dissection for patients with breast carcinoma. Cancer 2000;88:608–614. [PubMed: 10649254]
21. Krag D, Weaver D, Ashikaga T, et al. The sentinel node in breast cancer—a multicenter validation study. N Engl J Med 1998;339:941–946. [PubMed: 9753708]
22. Giuliano AE, Kirgan DM, Guenther JM, et al. Lymphatic mapping and sentinel lymphadenectomy for breast cancer. Ann Surg 1994;220:391–398. discussion 398–401. [PubMed: 8092905]
23. Lucci A, McCall LM, Beitsch PD, et al. Surgical complications associated with sentinel lymph node dissection (SLND) plus axillary lymph node dissection compared with SLND alone in the American College of Surgeons Oncology Group Trial Z0011. J Clin Oncol 2007;25:3657–3663. [PubMed: 17485711]
24. Krag D, Anderson SS, Julian TB, et al. Primary outcome results of NSABP B-32, a randomized phase III clinical trial to compare sentinel node resection (SNR) to conventional axillary dissection (AD) in clinically node-negative breast cancer patients. J Clin Oncol 2010;28:18s. abstr LBA505.
25. Chen AY, Halpern MT, Schrag NM, et al. Disparities and trends in sentinel lymph node biopsy among early-stage breast cancer patients (1998–2005). J Natl Cancer Inst 2008;100:462–474. [PubMed: 18364506]
26. Begg CB, Cramer LD, Hoskins WJ, et al. Impact of hospital volume on operative mortality for major cancer surgery. JAMA 1998;280:1747–1751. [PubMed: 9842949]

27. Bilimoria KY, Balch CM, Wayne JD, et al. Health care system and socioeconomic factors associated with variance in use of sentinel lymph node biopsy for melanoma in the United States. J Clin Oncol 2009;27:1857–1863. [PubMed: 19273706]
28. Hillner BE, Smith TJ, Desch CE. Hospital and physician volume or specialization and outcomes in cancer treatment: importance in quality of cancer care. J Clin Oncol 2000;18:2327–2340. [PubMed: 10829054]
29. Keating NL, Kouri E, He Y, et al. Racial differences in definitive breast cancer therapy in older women: are they explained by the hospitals where patients undergo surgery? Med Care 2009;47:765–773. [PubMed: 19536008]
30. Maggard MA, Lane KE, O'Connell JB, et al. Beyond the clinical trials: how often is sentinel lymph node dissection performed for breast cancer? Ann Surg Oncol 2005;12:41–47. [PubMed: 15827777]
31. Onega T, Duell EJ, Shi X, et al. Influence of NCI cancer center attendance on mortality in lung, breast, colorectal, and prostate cancer patients. Med Care Res Rev 2009;66:542–560. [PubMed: 19454624]
32. Rogers, E. Diffusion of Innovations. 5. New York, NY: Free Press; 2003.
33. Sales A, Smith J, Curran G, et al. Models, strategies, and tools. Theory in implementing evidence-based findings into health care practice. J Gen Intern Med 2006;21(suppl 2):S43–S49. [PubMed: 16637960]
34. Warren JL, Klabunde CN, Schrag D, et al. Overview of the SEER-Medicare data: content, research applications, and generalizability to the United States elderly population. Med Care 2002;40(suppl 8):IV-3–IV-18.
35. Dunn BK, Agurs-Collins T, Browne D, et al. Health disparities in breast cancer: biology meets socioeconomic status. Breast Cancer Res Treat 2010;121:281–292. [PubMed: 20437200]
36. Laliberte L, Fennell ML, Papandonatos G. The relationship of membership in research networks to compliance with treatment guidelines for early-stage breast cancer. Med Care 2005;43:471–479. [PubMed: 15838412]
37. Olson JA Jr, McCall LM, Beitsch P, et al. Impact of immediate versus delayed axillary node dissection on surgical outcomes in breast cancer patients with positive sentinel nodes: results from American College of Surgeons Oncology Group Trials Z0010 and Z0011. J Clin Oncol 2008;26:3530–3535. [PubMed: 18640934]
38. American College of Surgeons Commission on Cancer. Commission on cancer: about the CoC. 2010 [Accessed June 1, 2010]. Available at: http://www.facs.org/cancer/coc/whatis.html
39. Gooden KM, Howard DL, Carpenter WR, et al. The effect of hospital and surgeon volume on racial differences in recurrence-free survival after radical prostatectomy. Med Care 2008;46:1170–1176. [PubMed: 18953228]
40. American College of Surgeons Commission on Cancer. Follow-up: DEcIDE Stakeholder Meeting —Questionnaire: ACOSOG/ACOS CoC Accreditation. Chicago, IL: WR Carpenter; 2010.
41. Horner, M.; Ries, LAG.; Krapcho, M., et al. SEER-Cancer Statistics Review, 1975–2006. Bethesda, MD: National Cancer Institute; 2009.
42. Institute of Medicine. A National Cancer Clinical Trials System for the 21st Century: Reinvigorating the NCI Cooperative Group Program [Prepublication Copy]. Washington DC: N.A. Press; 2010.
43. National Cancer Institute. Report of the operational efficiency working group of the Clinical Trials and Translational Research Advisory Committee. Bethesda, MD: DHHS; 2010.

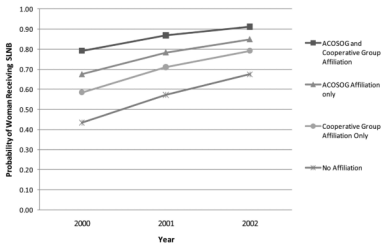

FIGURE 1.
Predicted probability of SLNB by Affiliation Status of Surgical Institution, 2000–2002. *Adjusted for race, age, marital status, grade, stage, estrogen receptor status, comorbidity index, census tract education, and income.

TABLE 1

Sample Descriptive Statistics

	No. Patients	Percentage
Patient characteristics		
Race		
White	3574	92.3
Black	300	7.7
Age		
Age, mean (SD)	74.2	(5.5)
65–69 yr	941	24.3
70–74 yr	1183	30.5
75–79 yr	1071	27.7
>80 yr	679	17.5
Stage		
AJCC Stage I	2545	65.7
AJCC Stage IIA	986	25.5
AJCC Stage IIB or NOS	343	8.9
Tumor grade		
Well differentiated	961	24.8
Moderately differentiated	1586	40.9
Poorly differentiated	943	24.3
Unknown, not assessed	384	9.9
Estrogen receptor status		
Positive	2825	72.9
Negative	437	11.3
Unknown	612	15.8
Comorbidity		
Comorbidity index = 0	2578	66.6
Comorbidity index >0	1296	33.5
Year of diagnosis		
2000	1279	33.0
2001	1281	33.1
2002	1314	33.9
Patients with SLNB only	1172	30.3
Patients with SLNB and subsequent ALND	1468	37.9
Patients with ALND only	1234	31.9
Organization characteristics (of treating hospital)		
Cooperative group affiliated	2871	74.1
ACOSOG affiliated	1423	36.7
Teaching hospital/affiliation	2178	56.2
NCI cancer center designated	155	4.0
Volume at treating facility		

	No. Patients	Percentage
Tertile 1: patients treated at low volume facility	168	4.3
Tertile 2: patients treated at mid-volume facility	467	12.1
Tertile 3: patients treated at high-volume facility	3238	83.6
Environmental characteristics		
SEER region		
San Francisco	224	5.8
Detroit	683	17.6
Atlanta and Rural Georgia	271	7.0
Los Angeles	591	15.3
Kentucky	470	12.1
Louisiana	328	8.5
New Jersey	1307	33.7
Education: proportion of patient's census tract population with high school education or greater		
Quartile 1: >75%	984	25.4
Quartile 2: 51%–75%	978	25.3
Quartile 3: 26%–50%	955	24.7
Quartile 4: <25%	952	24.6
Income: median household income in patient's census tract		
Quartile 1: low income	933	24.1
Quartile 2: med-low income	956	24.7
Quartile 3: med-high income	951	24.6
Quartile 4: high income	1029	26.6

SD indicates standard deviation; SLNB, sentinel lymph node biopsy; ALND, axillary lymph node dissection; ACOSOG, American college of surgeons oncology group; NCI, national cancer institute; SEER, surveillance epidemiology and end results; AJCC, American Joint Committee on Cancer; NOS, not otherwise specified.

TABLE 2

Crude Associations Between SLNB and Organizational Variables in Individual Models

Organizational Variable	OR	95% CI
Cooperative group-affiliated	1.96	(1.69–2.28)
ACOSOG-affiliated	2.09	(1.80–2.42)
Teaching hospital/affiliation	1.26	(1.10–1.44)
Breast cancer Medicare volume top tertile (>66.66 percentile)	2.01	(1.69–2.40)

OR indicates odds ratio; CI, confidence interval; SLNB, sentinel lymph node biopsy; ACOSOG, American college of surgeons oncology group.

TABLE 3

Multivariable Analysis: Probability of Receipt of SLNB Among Early-Stage Breast Cancer Patients

	OR	95% CI
Cooperative group-affiliated hospital	1.84	(1.26–2.69)
ACOSOG-affiliated hospital	2.70	(1.77–4.12)
Teaching hospital/affiliation	1.14	(0.79–1.66)
Hospital Medicare breast cancer volume: top tertile (>66.6 percentile; ref = <66.6 percentile)	1.28	(0.97–1.70)
Year of diagnosis (ref = 2000)		
2001	1.74	(1.42–2.13)
2002	2.70	(2.18–3.34)
Race, African American (ref = white)	0.54	(0.39–0.75)
SEER-modified AJCC stage (ref = Stage I)		
Stage IIA	0.80	(0.66–0.98)
Stage IIB	0.43	(0.32–0.58)
Age categories (ref = 65–69)		
70–74	0.88	(0.70–1.11)
75–79	0.83	(0.66–1.06)
80 yr+	0.67	(0.51–0.87)
Unmarried (ref = married)	0.88	(0.74–1.05)
Grade (ref = poorly differentiated)		
Unknown, not assessed	1.18	(0.85–1.62)
Moderately differentiated	1.19	(0.95–1.48)
Well differentiated	1.35	(1.05–1.75)
Estrogen receptor status (ref = positive)		
Negative	0.81	(0.61–1.06)
Unknown	1.01	(0.80–1.29)
Education: proportion of patient's census tract population with high school education or greater (ref = Quartile 4 [most non-high school graduates, >75 percentile])		
Quartile 1 (Fewest non-high school grads, <25 percentile)	1.00	(0.69–1.44)
Quartile 2 (25–50 percentile)	1.16	(0.84–1.58)
Quartile 3 (50–75 percentile)	1.13	(0.87–1.48)
Income: median household income in patient's census tract (ref = Quartile 4 [top 25% income])		
Quartile 1 (Lowest 25% income)	0.72	(0.50–1.05)
Quartile 2 (25–50 percentile)	0.84	(0.62–1.15)
Quartile 3 (50–75 percentile)	0.77	(0.59–1.01)
Comorbidity score (ref = 1+)		
NCI combined comorbidity index 0	0.88	(0.63–1.23)
NCI combined comorbidity index 0 < 1	0.73	(0.52–1.04)

	Intercept	Full	Difference
Likelihood ratio test of full model vs. intercept only model	4319.67	4045.21	274.46
Df	26		
P (based on χ^2)	$P < 0.0001$		

Education: proportion of patient's census tract population with high school education or greater.

OR indicates odds ratio; CI, confidence interval; SLNB, sentinel lymph node biopsy; SEER, Surveillance Epidemiology and End Results; AJCC, American Joint Committee on Cancer; ACOSOG, American college of surgeons oncology group; NCI, National Cancer Institute.