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Cost Implications of an Evidence-Based Approach to Radiation Treatment After Lumpectomy for Early-Stage Breast Cancer

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QUESTION ASKED: What are the potential cost savings associated with an evidence-based radiation treatment (RT) approach among women with early-stage breast cancer treated in the United States?

SUMMARY ANSWER: When women with early-stage breast cancer were treated with the least expensive radiation regimen for which they were safely eligible, RT costs were reduced by 39%, for a potential cost savings of $164 million per year.

WHAT WE DID: Using the National Cancer Database, we identified women with T1-T2 N0 invasive breast cancers who were treated with lumpectomy during 2011. We then compared the RT that they received with the RT for which they were safely eligible, as defined by previously published clinical trial eligibility. RT costs were obtained from the Centers for Medicare & Medicaid Services Medicare Physician Fee Schedule for 2011, and cost per RT regimen was calculated. Costs of actual treatment received were compared with costs of an evidence-based approach.

WHAT WE FOUND: We determined 57% of women were eligible for shorter RT or omission of RT, compared with what they received. Annual estimated RT costs for this population were $420.2 million during 2011, compared with $256.2 million had women been treated with the least expensive regimens for which they were safely eligible. Use of an evidence-based approach was associated with a potential savings of $164 million and a 39% reduction in RT costs.

BIAS, CONFOUNDING FACTORS, DRAWBACKS: Our findings support previously published literature reporting that many women with early-stage breast cancer continue to receive longer and more costly RT than may be medically necessary. Use of Medicare costs may underestimate the economic implications of additional treatment, when compared with actual charges and patient out-of-pocket costs. Our study is limited by use of a national data set to determine what RT women received. This does not completely capture clinical details important to decision making or details on loss to follow-up, treatment elsewhere, or recurrences. As a result, our findings may not account for care that was appropriately delivered based on individual patient variables.

REAL-LIFE IMPLICATIONS: Ultimately, our study highlights an example of evidence-based practice translating to reduced health care treatment costs. Opportunities exist for patients to receive high-quality breast cancer care at lower costs, and these options should be encouraged in the clinical setting as long as oncologic outcomes and patient autonomy can be maintained. JOP

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Abstract

Introduction

Breast cancer treatment costs are rising, and identification of high-value oncology treatment strategies is increasingly needed. We sought to determine the potential cost savings associated with an evidence-based radiation treatment (RT) approach among women with early-stage breast cancer treated in the United States.

Patients and Methods

Using the National Cancer Database, we identified women with T1-T2 N0 invasive breast cancers treated with lumpectomy during 2011. Adjuvant RT regimens were categorized as conventionally fractionated whole-breast irradiation, hypofractionated whole-breast irradiation, and omission of RT. National RT patterns were determined, and RT costs were estimated using the Medicare Physician Fee Schedule.

Results

Within the 43,247 patient cohort, 64% (n = 27,697) received conventional RT, 13.3% (n = 5,724) received hypofractionated RT, 1.1% (n = 477) received accelerated partial-breast irradiation, and 21.6% (n = 9,349) received no RT. Among patients who were eligible for shorter RT or omission of RT, 57% underwent treatment with longer, more costly regimens. Estimated RT expenditures of the national cohort approximated $420.2 million during 2011, compared with $256.2 million had women been treated with the least expensive regimens for which they were safely eligible. This demonstrated a potential annual savings of $164.0 million, a 39% reduction in associated treatment costs.

Conclusion

Among women with early-stage breast cancer after lumpectomy, use of an evidence-based approach illustrates an example of high-value care within oncology. Identification of high-value cancer treatment strategies is critically important to maintaining excellence in cancer care while reducing health care expenditures.

INTRODUCTION

Among women with early-stage breast cancer eligible for breast conservation, both observational and randomized clinical trial data have demonstrated that lumpectomy plus radiation treatment (RT) is a safe alternative to mastectomy, with no difference in disease-specific or overall survival, and results in excellent locoregional control.[1-6] Breast conservation initially included

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lumpectomy followed by 6 to 7 weeks of conventionally fractionated whole-breast external-beam irradiation (CF-WBI). Alternative RT regimens became increasingly widespread as randomized clinical trial data supported their use, demonstrating equivalent overall survival and excellent locoregional control with fewer treatments.

In 2002, Whelan et al[7] first suggested that RT regimens with fewer treatments and higher doses of radiation (hypofractionation) were both oncologically safe and provided acceptable cosmesis among women with early-stage node-negative invasive breast cancer treated with lumpectomy.[7] At 10 years of follow-up, women treated with hypofractionated whole-breast irradiation (42.5 Gy in 16 fractions over 22 days) had equivalent locoregional and overall survival rates when compared with those treated with traditional 6-week RT (50 Gy in 25 fractions over 35 days).[7,8] Ten-year data from the UK START (Standardization of Breast Radiotherapy) trial confirmed that hypofractionated RT was safe and effective with good cosmetic results.[9] These data support the use of hypofractionation in carefully selected patients.

Moreover, clinical trial data support that some carefully selected patient populations may be safely managed by lumpectomy without RT. In 2004, Hughes et al[10] evaluated the omission of RT after lumpectomy among women age ≥ 70 years with clinical T1N0, hormone receptor–positive invasive breast cancers receiving tamoxifen and randomly assigned to surgery alone or surgery with RT. After lumpectomy, women receiving RT plus tamoxifen had no difference in overall or disease-specific survival compared with women who received tamoxifen alone. Although omission of RT was associated with a higher risk of locoregional recurrence at 10 years, there was no difference in conversion to mastectomy, and survival remained excellent.[10,11] Shorter RT regimens have been well supported by clinical trials as being oncologically safe while providing less treatment burden for patients.

The choice of RT regimen or omission of RT after lumpectomy has important cost implications for health care spending. Breast cancer treatment costs are the highest among all cancer types, estimated to reach $20 billion by 2020.[12,13] Costs of RT after lumpectomy are directly associated with the number of delivered fractions, with longer RT regimens correlating with higher health care spending.[14,15] As part of the Choosing Wisely initiative to reduce unnecessary or duplicative treatment, the American Society of Radiation Oncology has recommended consideration of shorter treatment regimens among women age ≥ 50 years with early-stage invasive cancer.[16] Delivery of hypofractionated RT or omission of RT after lumpectomy has the potential to translate to major cost savings when implemented in routine breast cancer care across the United States. The purpose of our study was to determine national treatment patterns of RT after lumpectomy for women with early-stage invasive breast cancer and to what extent treatment costs could be reduced through appropriate use of evidence-based alternative RT regimens.

PATIENTS AND METHODS

After institutional review board approval, we conducted a retrospective study using the American College of Surgeons National Cancer Database (NCDB), a compilation of clinical and demographic data from tumor registries capturing approximately 70% of all newly diagnosed cancers in the United States.[17] Women with clinically node-negative, T1-T2 invasive breast cancers treated with lumpectomy during 2011 were defined as the study cohort because of the availability of both NCDB and Medicare cost data within a single calendar year. Collected clinical and patient characteristics were as follows: age at diagnosis (18 to 29, 30 to 49, 50 to 69, or ≥ 70 years), tumor size, tumor histology (ductal, lobular, or mixed), grade (low, intermediate, high, or unknown), and expression of estrogen receptor (ER) and/or progesterone receptor. Women with pure ductal carcinoma in situ were excluded from our study cohort. In addition, those treated with mastectomy or unknown RT regimens were excluded from the analysis. The patient population was limited to the single year of 2011 to correlate with the most recent available Medicare Physician Fee Schedule data on RT costs.

Eligibility for RT

Women were considered candidates for three evidence-based alternative RT regimens: CF-WBI (defined as 25 to 36 fractions at 45 to 66 Gy), hypofractionated whole-breast irradiation (HF-WBI; defined as 15 to 24 fractions at 40 to 58 Gy), and lumpectomy without RT (no RT). Women were categorized as eligible for either omission of RT or HF-WBI, but not both, based on the lowest-intensity regimen for which they were eligible. Women age ≥ 50 years with T1-T2N0 invasive breast cancers were deemed eligible for HF-WBI, women age ≥ 70 years with T1N0, ER-positive breast cancers were considered eligible for omission of RT, and all remaining women defaulted to CF-WBI. Eligibility criteria were based on inclusion criteria from the original randomized trials (Whelan et al[7,8] and Haviland et al[9] for hypofractionation and Hughes

et al[10] for omission of RT based on CALGB [Cancer and Leukemia Group B] 9343). Accelerated partial-breast irradiation (APBI) was not considered as a potential alternative regimen, based on pending data from the National Surgical Adjuvant Breast and Bowel Project B-39/RTOG 0413 trial.[18] However, the women identified as having received APBI within the NCDB were reported as such in the calculation of estimated treatment costs.

Cost Analysis

Medicare reimbursements are widely accepted in the literature as a proxy for medical care costs.[19] Average costs per RT regimen were calculated using the most common Current Procedural Terminology codes billed per regimen at our institution and the 2011 Medicare reimbursement rates as published in the US Department of Health and Human Services Medicare Physician Fee Schedule Search.[20] Procedural codes and associated costs have been previously published.[15] All calculations were based on the assumption that the costs of daily treatment fractions and boost treatment fractions were equivalent and that the assigned RT was completed in its entirety.

RESULTS

There were 43,247 women with T1-2N0 invasive breast cancers treated during 2011. Median patient age was 63 years (range, 19 to 90 years). Median tumor size was 1.2 cm. Clinical and patient characteristics are listed in Table 1. Overall, 64% of the study cohort received CF-WBI, 13% received hypofractionated RT, 1% received APBI, and 22% received no RT. On the basis of the defined criteria, 62.2% of women in the study cohort met eligibility for hypofractionated irradiation, and 22.3% were eligible for omission of RT according to published results from the CALGB 9343 trial. Among the 26,911 women (62.2%) who met inclusion criteria for HF-WBI, 68.4% received conventional fractionation, 13.1% received hypofractionated irradiation, 1.1% received APBI, and 17.4% received no RT. There were 9,651 women (22%) age ≥ 70 years with ER-positive tumors who fulfilled inclusion criteria for CALGB 9343. Of these, 4,245 (44.0%) received CF-WBI, 1,768 (18.3%) received HF-WBI, 153 (1.6%) received APBI, and 3,485 (36.1%) received no RT. On the basis of defined criteria, 28% of the total cohort received the least expensive evidence-based RT regimen for which they were potentially eligible, whereas 57% of patients were treated with more costly RT regimens. Interestingly, 15% of women were recorded as having received less RT than they were safely eligible for according to the previously mentioned criteria.

Table 1. Characteristics of the Study Cohort, Year 2011 (N = 43,247)

Characteristic	No. (%)
Age, years	
18-29	0 (0)
30-49	6,609 (15)
50-69	23,625 (55)
≥ 70	12,937 (30)
Tumor histology	
IDC	34,973 (87)
ILC	3,477 (9)
Mixed	1,916 (5)
Tumor size, cm	
< 1.0	13,786 (32)
1.0-2.0	21,009 (49)
> 2.0	8,452 (20)
Grade	
1	12,794 (31)
2	18,291 (44)
3	10,563 (25)
Unknown	67 (0)
Hormone receptor status	
ER positive	36,380 (85)
ER negative	6,441 (15)
RT	
None	9,349 (22)
APBI	477 (1)
HF-WBI	5,724 (13)
CF-WBI	27,697 (64)

Abbreviations: APBI, accelerated partial-breast irradiation; CF-WBI, conventionally fractionated whole-body irradiation; ER, estrogen receptor; HF-WBI, hypofractionated whole-body irradiation; IDC, invasive ductal carcinoma; ILC, invasive lobular carcinoma; RT, radiation treatment.

The estimated cost per patient for RT treatment was $13,358.37 for CF-WBI, $8,327.98 for HF-WBI, and $0 for lumpectomy without RT. Actual RT treatment costs for the 43,247-women cohort were estimated at $420.2 million during 2011. When costs were calculated had women received the least expensive RT regimens for which they were safely eligible, treatment of the same cohort was estimated at $256.2 million. This translated to an annual cost savings of $164.0 million, a reduction in costs of 39%. Use of HF-WBI and lumpectomy without RT per CALGB 9343 contributed $91.8 million (56%) and $72.2 million (44%), respectively, to the total cost savings. Table 2 summarizes actual treatment patterns and associated

costs in comparison with costs of treatment in an evidence-based approach.

DISCUSSION

Among women with early-stage invasive breast cancers treated with lumpectomy in 2011 and identified in the NCDB as candidates for alternative RT, a majority received CF-WBI. Long-term randomized trial data support the use of HF-WBI or omission of RT in many of these patients.[7-11] Despite this evidence, our study contributes to a growing body of literature demonstrating underuse of these alternative shorter RT regimens.

Bekelman et al[14] reported an increase in the national use of HF-WBI from 10.6% in 2008 to 34.5% in 2013 among so-called hypofractionated-endorsed women (ie, those age $\geq$ 50 years with node-negative cancers without history of chemotherapy). Among women age $<$ 50 years with a history of chemotherapy or axillary lymph node involvement (ie, hypofractionated-permitted women), use of HF-WBI also increased from 8.1% in 2008 to 21.2% in 2013.[14] Although patient out-of-pocket costs were no different among women who received 3 to 5 weeks of RT when compared with those who received 5 to 7 weeks of treatment, costs to the health care system were significantly higher in the latter group.[14]

Palta et al[21] reported similar patterns of underuse of lumpectomy without RT after publication of the CALGB 9343 trial. Of the 40,583 women identified in SEER as eligible for omission of RT, 61% to 68% still received adjuvant RT, consistent with our study findings within the NCDB. The authors reported that use of adjuvant RT had decreased across all age groups, with the greatest reduction among the very old (age $\geq$ 85 years).

Our study also supports the finding that a majority of women in the United States are receiving longer and more costly adjuvant RT than current data deem medically necessary. Only 26% of women in our cohort received the least costly regimen for which they were safely eligible. Treatment with

Table 2. Cost Comparison of Adjuvant RT After Lumpectomy: Actual Versus Evidence-Based, Reduced-Cost Regimens (N= 43,247)

	Actual Regimen Received			Projected Evidence-Based Regimen		
RT Eligibility*	Treatment	No. (%)	Cost ($)	Treatment	No.	Cost ($)
No RT (CALGB 9343; n = 9,651; 22.3%)	No RT	3,485 (36.1)	72.2 million	No RT	9,651	0
	APBI	153 (1.6)				
	HF-WBI	1,768 (18.3)				
	CF-WBI	4,245 (44.0)				
HF-WBI (n = 26,911; 62.2%)	No RT	4,694 (17.4)	276.8 million	HF-WBI	26,911	185.0 million
	APBI	288 (1.1)				
	HF-WBI	3,521 (13.1)				
	CF-WBI	18,408 (68.4)				
CF-WBI (n = 6,685; 15.5%)	No RT	1,170 (17.5)	71.2 million	CF-WBI	6,685†	71.2 million†
	APBI	36 (0.5)				
	HF-WBI	435 (6.5)				
	CF-WBI	5,044 (75)				
Total cost, $		420.2 million			256.2 million	

NOTE. $164.0 million saved when treated with evidence-based, reduced-cost RT regimens equals a 39% reduction in costs.

Abbreviations: APBI, accelerated partial-breast irradiation; CALGB, Cancer and Leukemia Group B; CF-WBI, conventionally fractionated whole-body irradiation; HF-WBI, hypofractionated whole-body irradiation; RT, radiation treatment.

*Patients were considered for the least expensive treatment option for which they were eligible; those eligible for no RT were excluded from the HF-WBI group.

†For women who defaulted to CF-WBI, actual treatment costs were used in the calculation of evidence-based treatment costs to account for the subset of women who did not receive RT.

shorter RT regimens or omission of RT per CALGB 9343 would have resulted in a $164 million savings in a single year when compared with defaulting to standard 6- to 7-week CF-WBI. The patients included in the cohort were only considered candidates for alternatives to CF-WBI if they safely fit the strict eligibility criteria outlined in the original clinical trials. Extrapolation of these regimens to broader eligibility criteria would presumably translate to increased savings.

The National Cancer Institute reported the cost of breast cancer care in the United States to be the highest among all cancer types, estimated at $16.5 billion in annual cost for 2010.[12] Locoregional therapy contributes to high initial-phase costs in the first year after diagnosis, through costs of surgery, associated hospitalizations, and RT.[19] Although high-quality care remains the priority in cancer treatment, our prior research has demonstrated that adherence to evidence-based guidelines can translate into reductions in health care spending for locoregional treatment.[15,22] We previously demonstrated that evidence-based adjuvant RT after lumpectomy not only provided data-driven care, but additionally decreased treatment costs within a single-institution cohort.[15] Our current results continue to support that significant reductions in cancer-related treatment costs remain possible through the practice of evidence-based breast cancer care.

There are several limitations to our study. A proportion of women in our cohort were not safely eligible for shorter or omitted RT after lumpectomy, yet either did not receive RT at all or received abbreviated regimens. It is unknown whether this was because the patients were lost to follow-up or because of limited access to care, noncompliance, or inaccurate coding. When matched with New York insurance claims data, the NCDB was highly concordant with insurance claims for surgery; however, it captured only 38% of women receiving RT for breast cancer.[23] Additionally, Jagsi et al[24] demonstrated underascertainment of RT for breast cancer in SEER when compared with patient-reported survey analysis of receipt of RT.[24] Our study, therefore, may not have captured the complete cohort of women who received RT after lumpectomy within a calendar year; thus, our results may represent a more conservative estimate of cost savings than would have actually been the case. An important limitation of our study was our inability to estimate the costs of locoregional recurrence when comparing RT regimens. The NCDB does not include recurrence rates or patterns of treatment after recurrence, and we were therefore unable to accurately estimate these potential costs. This is especially important among women age $\geq$ 70 years with ER-positive invasive cancers who forego RT; these women experience an 8% higher rate of locoregional recurrence when compared with those who receive RT after lumpectomy. Our analysis focused on initial-phase treatment costs, although cancer recurrences would be expected to contribute additional cancer treatment costs.

Use of the Medicare Physician Fee Schedule data to estimate RT costs also likely underestimates the potential economic impact of an evidence-based RT strategy. Medicare payments for medical services are generally lower than payments from other insurers, and actual charges and reimbursements within the current payer system would likely be far greater than those seen in our results. Additionally, institutional variations likely exist in the billing codes used for RT regimens, and ultimate cost per regimen may differ from place to place. Importantly, our study was not intended to definitively quantify an exact number of women treated or exact dollar amounts, but instead to provide an example of high-quality evidence-based breast cancer care that translates to decreased national health care spending.

Additionally, it is important to acknowledge the risk of perceived overtreatment within this study when women may have in fact received appropriate care. Clinical decisions made by the treating team are often based on patient factors and features of disease that are not captured within large national databases, making women seem erroneously overtreated for the sake of our study. Importantly, it should be noted that the trials supporting HF-WBI included certain dosimetric and patient anatomy requirements that not all patients in our cohort are likely to have met. Shared decision making between patients and providers remains an important value in our current health care system, and consideration of individual patient circumstances is important when deciding on adjuvant therapy. In this process, costs of treatment to the health care system or to patients themselves may supersede treatment preferences held by patients and their physicians.[25,26] We contend that patient preference is best maintained when all treatment options are discussed with eligible women.

High health care costs exist along all aspects of the breast cancer treatment continuum, from diagnosis to treatment and follow-up.[19] Within the setting of locoregional treatment of early-stage invasive breast cancer, evidence-based practice and guideline-concordant care have the potential to translate to significant reductions in health care spending. Other studies have reported the significant costs of breast cancer screening and treatment and strategies for carefully reducing spending (Table 3). The American Society of Clinical Oncology Value in

Table 3. Summary of Selected Studies Evaluating the Health Care Costs Associated With Breast Cancer Locoregional Treatment

Focus	Year	Major Findings
Overall treatment costs		
Mariotto[12]	2011	Treatment costs for female breast cancer were the highest among all cancer sites ($16.5 billion in 2010)
Warren[19]	2008	Costs of hospitalizations during cancer treatment accounted for the largest proportion of total cost, with surgery accounting for 24% and RT accounting for 11% of total payments in 2002
Surgery		
Barlow[27]	2001	Costs of mastectomy alone were less than those for BCT at 1 year and largely depended on costs associated with adjuvant chemotherapy; at 5 years, BCT was less expensive than mastectomy
Camp[28]	2012	Application of the ACOSOG Z0011 criteria was associated with an 18% reduction in perioperative costs
Greenup[22]	2014	$31 million per year of Medicare reimbursements saved with adherence to the SSO-ASTRO Consensus Guideline on Margins for Breast Conserving Surgery in Stage I and II Invasive Cancers
RT		
Hayman[29]	1998	RT increased direct treatment costs but was cost effective when considering local and distant recurrences and salvage surgery ($28,000 per QALY in 1995 dollars through Markov modeling)
Dwyer[30]	2010	24% reduction in treatment costs with hypofractionated RT when compared with conventional treatment
Smith[31]	2011	Intensity-modulated RT contributed to a 33% increase in breast RT costs from 2001 to 2005 in SEER-Medicare billing data; reimbursement setting strongly correlated with use of IMRT
Greenup[15]	2012	43% reduction in estimated RT costs with evidence-based RT approach
Beckelman[14]	2014	Hypofractionated RT was associated with 10% lower total and RT-related health care expenditures

Abbreviations: ACOSOG, American College of Surgeons Oncology Group; ASTRO, American Society for Radiation Oncology; BCT, breast-conserving therapy; IMRT, intensity-modulated radiation therapy; QALY, quality-adjusted life-year; RT, radiation treatment; SEER, Surveillance, Epidemiology, and End Results; SSO, Society of Surgical Oncology.

Cancer Care Task Force has defined value in cancer care by considering clinical benefit (efficacy), toxicity (safety), and cost (efficiency) in the context of patient-centered care.[32] As we seek to control costs and improve broader access to high-quality cancer care, thoughtful consideration of the clinical impact of used health care dollars on the patient and the health care system becomes increasingly important.

In conclusion, our study highlights an underused opportunity for high-value cancer care within breast oncology. Evidence-based RT after lumpectomy illustrates an example of a systematic approach for identifying cost-effective alternatives to conventional RT. Opportunities exist for patients to receive high-quality breast cancer care at reduced costs, and these options should be encouraged in the clinical setting as long as oncologic outcomes and patient autonomy can be maintained. JOP

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Authors' Disclosures of Potential Conflicts of Interest

Disclosures provided by the authors are available with this article at jop.ascopubs.org.

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AUTHORS' DISCLOSURES OF POTENTIAL CONFLICTS OF INTEREST

Cost Implications of an Evidence-Based Approach to Radiation Treatment After Lumpectomy for Early-Stage Breast Cancer

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