Individual, Area, and Provider Characteristics Associated With Care Received for Stages I to III Breast Cancer in a Multistate Region of Appalachia

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Abstract

Purpose: We describe individual, area, and provider characteristics associated with care patterns for early-stage breast cancer in Appalachian counties of Kentucky, North Carolina, Ohio, and Pennsylvania.

Methods: Cases of stages I to III breast cancer from 2006 to 2008 were linked to Medicare claims occurring within 1 year of diagnosis. Rates of guideline-concordant endocrine therapy ($n = 1,429$), chemotherapy ($n = 1,480$), and radiation therapy (RT) after breast-conserving surgery were studied; RT was studied in women age ≥ 70 years with stage I estrogen receptor (ER)–positive/progesterone receptor (PR)–positive cancer, for whom RT was optional ($n = 1,108$), and in all others, for whom RT was guideline concordant ($n = 1,422$). Univariable and multivariable analyses were performed. Independent variables included age, race, county-level economic status, state, surgeon graduation year and volume, comorbidity, diagnosis year, Medicaid/Medicare dual status, histology, tumor size, tumor sequence, positive

lymph nodes, ER/PR status, stage, trastuzumab use, and surgery type.

Results: Population mean age was 74 years; 97% were white. For endocrine therapy, chemotherapy, and RT, guideline concordance was 76%, 48%, and 83%, respectively. Where it was optional, 77% received RT. Guideline-concordant endocrine therapy was lower in North Carolina versus Pennsylvania (odds ratio [OR], 0.60; 95% CI, 0.41 to 0.88) and higher if surgeon graduated between 1984 and 1988 versus ≥ 1989 (OR, 1.58; 95% CI, 1.06 to 2.34). Guideline-concordant chemotherapy varied significantly by state, county-level economic status, and surgeon volume. In guideline-concordant RT, lower surgeon volume (v highest) predicted RT use (OR, 1.63; 95% CI, 1.61 to 2.36). In optional RT, North Carolina residence (v Pennsylvania; OR, 0.29; 95% CI, 0.17 to 0.48) and counties with higher economic status (OR, 0.61; 95% CI, 0.40 to 0.94) predicted RT omission.

Conclusion: Notable variation in care by geographic and surgical provider characteristics provides targets for further research in underserved areas.

Introduction

Disparities in breast cancer mortality by age,¹⁻³ race,^{4,5} socioeconomic status,^{6,7} and geographic region are well documented and cannot be fully explained by variations in stage at diagnosis.⁸⁻¹¹ Suboptimal diagnosis and treatment may contribute.^{12,13} It is important to identify contextual factors that influence quality of care, defined by guideline-concordant care,¹⁴ especially in rural and underserved regions, so we can target changes in health care practice and/or policy that will decrease well-known disparities.

Higher cancer incidence and mortality rates in much of Appalachia compared with the rest of the country make this economically diverse, medically underserved, mostly mountainous region that straddles 420 counties in 13 states rich for study.^{15,16} In Appalachia, nearly one quarter of counties are economically distressed; 42% are rural, which is twice the national average (according to 2012 data from Appalachian Regional Commission [ARC]¹⁷); and median age is higher in mountainous counties than other areas of the country.¹⁸ Therefore, our study of Appalachian counties in four states provides an ideal population for study of disparities and is distinct from other studies using SEER-Medicare

claims-linked databases,^{8,19-21} in which most Appalachian and rural populations are under-represented. We describe breast cancer care patterns in a region of Appalachia by individual, geographic, and physician characteristics.

Methods

The Patterns of Care in Appalachia (Appalachia POC) study was approved by the institutional review boards of Penn State University and Duke University Medical Center.

Sample

Female breast cancer cases from state cancer registries of Kentucky, North Carolina, Ohio, and Pennsylvania diagnosed from 2006 to 2008 among patients residing in Appalachian counties, defined by the ARC, were identified and linked to Medicare data from 2005 to 2009 available from the Centers for Medicare and Medicaid services. Initially, 29,372 patient cases with diagnostic confirmation (positive histology, cytology, or microscopic confirmation), excluding autopsies, were

identified. Derivation of the final sample is shown in Appendix Figure A1 (online only). Included were patient cases linkable to Medicare, where patients were enrolled 1 year before and 1 year after diagnosis in both Medicare Parts A and B. Excluded were patient cases with enrollment in Medicare Advantage or health maintenance organization involvement during the 2-year timeframe, questionable identity because of mismatching sex or birth dates between registry and Medicare sources, prior breast cancer or multiple/concurrent breast tumors or other solid tumors other than breast cancer (except nonmelanoma skin cancer or cervical cancer) diagnosed within 90 days of primary tumor diagnosis, death recorded within 1 year from diagnosis, and ductal carcinoma in situ or metastatic disease. The final sample included 4,893 patients with stages I to III breast cancer.

Four subsamples, in which to assess dimensions of guideline concordance,^{22,23} were selected from the available 4,893 patient cases. The subsample to assess use of guideline-concordant endocrine therapy ($n = 1,429$) included patients with estrogen receptor (ER) –positive/progesterone receptor (PR) –positive tumors, confirmed breast cancer surgery, and Part D Medicare enrollment during the timeframe. The subsample for assessing receipt of guideline-concordant chemotherapy ($n = 1,532$) included patients with confirmed breast cancer surgery and either ER- or PR-negative disease and tumor size > 1 cm (inclusive) or positive lymph nodes (52 patient cases excluded because presence/absence of adjuvant chemotherapy under our identification guidelines could not be determined). Patient cases with only one code or where chemotherapy codes were nonspecific were omitted. The subsamples for assessing use of adjuvant radiation therapy (RT) after breast-conserving surgery (BCS) were composed of two complementary samples; in the first, RT was optional ($n = 1,108$) because age was ≥ 70 years and tumor was ER/PR positive, < 2 cm, and node negative; in the second, RT was indicated (ie, guideline-concordant RT; $n = 1,422$). The guideline-concordant RT subsample included only patient cases with sufficient nonmissing data to verify exclusion from the optional RT group.

Measures

Care provided within 1 year of diagnosis determined guideline concordance (Table 1). Surgery type (mastectomy *v* BCS), surgical facility location, surgical provider identification, date of surgery, and start of RT or chemotherapy were determined from Medicare procedure and diagnostic codes and registry primary surgery variables (Appendix Table A1, online only).

Demographic predictors included age and race from registry data, state of residence at diagnosis, two county-level measures of rurality based US Department of Agriculture rural/urban continuum codes,²⁴ and a five-category economic status designation by the ARC (ie, distressed, at risk, transitional, competitive, and attainment; no county reached attainment status).²⁵

For each provider associated with a patient in a sample, a measure of procedural volume was calculated by identifying all unique episodes of surgical procedures (by claim identifier and day of surgery) found in Medicare claims during calendar year 2008. If a surgeon treated the same patient with separate multiple surgery episodes unique by day and claim identifier, all

episodes were included in the provider volume calculation; this method is equivalent to that used in prior literature.²⁶ Surgeon graduation year, determined from the Medicare Physician Identification and Eligibility Records file available from Res-Dac, current for 2005 to 2007, or, when not available, from Healthgrades,²⁷ was categorized as follows: < 1977 , 1977 to 1984, 1984 to 1989, and > 1989 .

Statistical Analysis

Bivariate analyses were first conducted to compare main predictors with concordance indicators in each subsample. Statistically significant differences were assessed using χ^2 and t tests for continuous variables and Fisher's exact test for borderline cases. Multivariable analyses were then conducted using a multiple imputation procedure with a Markov chain Monte Carlo method to impute cases with the expectation-maximization algorithm to find the initial starting values.^{28,29} For each concordance sample, five data sets with different imputations were created using the SAS procedure PROC MI (SAS Institute, Cary, NC); results for each data set were then combined using the SAS procedure PROC MIANALYZE according to the formulas used in multiple imputation.²⁸ All variables were included in the imputation model, including the outcomes in the multivariable models, as recommended in literature.^{30,31} Categorical variables were included as dummy variables, and in cases where the variable was missing, imputations were left unrounded.^{32,33} A generalized linear mixed model was then fit, taking the form of logistic regression with random intercept for county, concordance as outcome, and fixed effects, including significant predictors from the bivariate analysis (including statistically significant independent variables listed in Table 2). SAS software (version 9.3) was used to calculate the results, and PROC GLIMMIX in SAS was used to calculate the values for the regression models.

Results

The study group included 3,833 patient cases, with mean age of 74.36 years (skewness, 8.90 years); 96.8% were white; 3,205 (83.6%) had hormone receptor–positive cancer (of whom 1,429 were enrolled in Part D enrollment for determination of endocrine therapy use). Disease stage was I, II, and III in 2,085 (54.4%), 1,291 (33.7%), and 457 patients (11.9%), respectively. Most patients ($n = 2,580$ [67.3%]) had undergone BCS.

Univariable Analyses

Table 1 summarizes care delivered in each sample. Older age was consistently associated with received care. Guideline-concordant endocrine therapy occurred in 76.2% of patients with eligible tumors. There was significant variation in use of endocrine therapy by patient age ($P < .001$), state of residence ($P = .028$), and surgeon graduation year ($P = .049$). Overall rate of guideline-concordant chemotherapy was 48.2%; this varied significantly by patient age ($P < .001$), county economic status of patient residence described by ARC class ($P = .028$), and surgical provider volume ($P = .012$). In the guideline-concordant RT group, 83.3% received adjuvant RT; guideline concordance

Table 1. Rate of Concordance With Breast Cancer Treatment Guidelines by Location and Facility and Provider Characteristics (N = 3,833)

Main Predictor	Receipt of Endocrine Therapy Within 1 Year of Diagnosis*			Receipt of Adjuvant Chemotherapy†			Receipt of RT After BCS Within 1 Year of Diagnosis (n = 2,530)					
							Group One‡§			Group Two		
	No.	Yes (%)	P¶	No.	Yes (%)	P¶	No.	Yes (%)	P¶	No.	Yes (%)	P¶
All patients	1,429	76.2		1,480	48.2		1,422	83.3		1,108	77.0	
Age, years			< .001			< .001			< .001			< .001
≤ 65	162	75.3		186	76.9		200	86.0				
66 to 75	580	80.9		664	64.3		731	91.0		399	85.7	
76 to 85	531	75.0		512	27.3		377	81.7		590	77.3	
≥ 86	156	64.1		118	3.4		114	35.1		119	46.2	
Race												
White, non-Hispanic	1,388	76.4		1,428	48.1		1,364	83.3		1,081	77.2	
Other	39	69.2		52	51.9		54	83.3		25	68.0	
Missing	2	100.0		0	0.0		4	100.0		2	50.0	
Rural/urban continuum												
Metropolitan	713	75.5		769	46.3		811	82.5		706	76.3	
Nonmetropolitan	716	77.0		711	50.4		611	84.5		402	78.1	
State			.028			< .001						< .001
Kentucky	181	79.0		182	64.3		142	83.1		80	70.0	
North Carolina	270	69.3		318	44.7		262	82.4		214	57.9	
Ohio	258	78.3		283	44.2		306	84.3		185	81.1	
Pennsylvania	720	77.4		697	47.3		712	83.3		629	83.1	
ARC class						.043						.049
Distressed	118	81.4		116	61.2		80	82.5		48	75.0	
At risk	155	79.4		162	48.8		149	83.2		73	75.3	
Transitional	955	75.0		953	47.4		921	84.3		696	79.6	
Competitive	201	76.6		249	45.0		272	80.5		291	71.5	
Surgeon graduation year			.049									.004
< 1977	289	74.4		345	46.1		313	84.3		253	81.0	
1977 to < 1984	334	76.3		321	49.8		290	82.1		231	75.8	
1984 to < 1989	295	81.0		302	49.0		312	83.7		261	68.6	
≥ 1989	400	72.0		403	48.1		402	84.6		292	79.5	
Missing	111	82.9		109	48.6		105	78.1		71	87.3	
Surgeon volume, quartile						.012			.019			
Low	268	75.4		286	42.7		306	81.7		245	77.1	
Second	361	77.8		377	45.1		309	82.8		235	79.1	
Third	343	77.8		367	49.9		353	89.0		290	75.9	
High	346	71.4		341	54.5		349	81.1		265	73.2	
Missing	111	82.9		109	48.6		105	78.1		73	87.7	

NOTE. Patients with nonmetastatic invasive breast cancer living at diagnosis in Appalachian counties in four states (2006 to 2008). Missing values were excluded. Abbreviations: ARC, Appalachian Regional Commission; BCS, breast-conserving surgery; ER, estrogen receptor; PR, progesterone receptor; RT, radiation therapy.

* For patients with ER-positive and/or PR-positive disease.

† For patients with ER/PR-negative disease and tumor ≥ 1 cm or patients with node-positive disease (regardless of ER/PR status).

‡ Patients age < 70 years with ER/PR-positive stage I disease.

§ Excluded patients with missing tumor information or missing ER/PR or node status.

|| Patients age ≥ 70 years with ER/PR-positive node-negative disease and tumor < 2 cm.

¶ χ^2 test.

varied by patient age ($P < .001$) and surgical provider volume ($P = .019$). Most patients (77.0%) in the optional RT group received RT. Receipt of RT in the optional group varied significantly by age ($P < .001$), state ($P < .001$), county economic status ($P = .049$), and surgeon graduation year ($P = .004$).

Table 3 summarizes the distribution of additional independent variables, including Charlson-Deyo score^{34,35} calculated 1 year before diagnosis, year of diagnosis, dual Medicare/Medicaid status, tumor histology (ie, ductal/lobular, tubular/colloid, or other), tumor size, sequence of tumor (first ever v other), lymph

Table 2. Multivariable Results

Characteristic	Endocrine Therapy*		Adjuvant Chemotherapy†		RT			
					Model One‡		Model Two§	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Age, years								
0 to 65	1.78	1.07 to 2.98	143	48 to 422	11.41	6.01 to 21.6		
66 to 75	2.64	1.75 to 4.00	75	26 to 212	13.18	7.9 to 21.9	7.94	4.84 to 13.1
76 to 85	1.79	1.19 to 2.67	13.7	4.8 to 39	6.91	4.18 to 11.41	4.22	2.72 to 6.65
≥ 86	Ref		Ref		Ref		Ref	
State								
Kentucky	0.98	0.63 to 1.53	1.94	1.08 to 3.51			0.48	0.23 to 1.01
North Carolina	0.60	0.41 to 0.88	0.61	0.45 to 0.85			0.25	0.16 to 0.38
Ohio	1.00	0.67 to 1.50	0.83	0.58 to 1.18			0.72	0.43 to 1.22
Pennsylvania	Ref		Ref				Ref	
ARC class								
Distressed			0.73	0.37 to 1.44			1.06	0.43 to 2.63
At risk			0.76	0.48 to 1.19			0.93	0.48 to 1.81
Transitional			Ref				Ref	
Competitive			0.98	0.70 to 1.38			0.61	0.40 to 0.94
Surgeon graduation year								
< 1977	1.16	0.81 to 1.66					1.08	0.68 to 1.72
1977 to < 1984	1.28	0.90 to 1.81					0.85	0.54 to 1.34
1984 to < 1989	1.58	1.06 to 2.34					0.64	0.41 to 0.98
≥ 1989	Ref						Ref	
Surgical provider volume, quartile								
Low			0.69	0.47 to 1.04	1.63	1.03 to 2.59		
Second			0.66	0.46 to 0.95	1.61	1.21 to 2.59		
Third			0.94	0.66 to 1.35	2.42	1.47 to 3.96		
High			Ref		Ref			

NOTE. Bold font indicates statistical significance.

Abbreviations: ARC, Appalachian Regional Commission; OR, odds ratio; RT, radiation therapy.

* Model includes age, state, tumor sequence, graduation year, tumor size, and positive lymph nodes as predictors.

† Model includes age, state of diagnosis, ARC class, Charlson score, year of diagnosis, tumor stage, provider volume, and estrogen and progesterone receptor status as predictors.

‡ Model includes age, tumor sequence, herceptin status, Charlson score, provider volume, dual Medicaid/Medicare status, histology, stage, and tumor size as predictors.

§ Model includes age, state, ARC status, Charlson score, provider graduation year, and dual Medicaid/Medicare status as predictors.

node status, hormone receptor status (defined as either ER or PR positive), American Joint Committee on Cancer cancer stage (I, IIa, IIb, or III), human epidermal growth factor receptor status (designated positive if claims in carrier and outpatient files included trastuzumab injection [Healthcare Common Procedure Coding System procedure code J9355]), and type of surgery.

Multivariable Analyses

In multivariable analyses, significant predictors of receipt of guideline-concordant endocrine therapy were age, state, and surgeon graduation year. Compared with those age ≥ 86 years, younger women were more likely to receive guideline-concordant endocrine therapy (age ≤ 65 years: OR, 1.78; 95% CI, 1.07 to 2.98; age 66 to 75 years: OR, 2.64; 95% CI, 1.75 to 4.00; age 76 to 85 years: OR, 1.79; 95% CI, 1.19 to 2.67). Compared with those in the reference state of Pennsylvania, women in North Carolina were less likely to receive guideline-

concordant endocrine therapy (OR, 0.60; 95% CI, 0.41 to 0.88). Patients whose surgeons graduated from 1984 to < 1989 were more likely than those whose surgeons who graduated ≥ 1989 to receive guideline-concordant endocrine therapy (OR, 1.58; 95% CI, 1.06 to 2.34).

Patient age, state, and surgical provider volume predicted receipt of guideline-concordant chemotherapy. Compared with those age ≥ 86 years, younger women were more likely to receive guideline-concordant chemotherapy (age 0 to 65 years: OR, 143; 95% CI, 48 to 422; age 66 to 75 years: OR, 75; 95% CI, 26 to 212; age 76 to 85 years: OR, 13.7; 95% CI, 4.8 to 39). Compared with Pennsylvania, chemotherapy was delivered less often in North Carolina (OR, 0.61; 95% CI, 0.45 to 0.85) but more often in Kentucky (OR, 1.94; 95% CI, 1.08 to 3.51). Compared with patients whose surgeons fell in the highest quartile of volume, those with surgeons in the second quartile were less likely to receive chemotherapy (OR, 0.66; 95% CI, 0.46 to 0.95).

Table 3. Distribution of Demographic, Patient, and Tumor Characteristics As Independent Variables in Sample

Covariate	Endocrine Therapy			Adjuvant Chemotherapy			RT					
							Model One			Model Two		
	No.	Yes (%)	P	No.	Yes (%)	P	No.	Yes (%)	P	No.	Yes (%)	P
Charlson score (1 year before)						< .001			< .001			< .05
0	439	78.4		539	53.4		564	89.0		404	80.2	
1	400	76.0		425	51.5		421	82.2		337	78.0	
≥ 2	590	74.7		516	40.1		437	77.1		367	72.5	
Year of diagnosis												
2006	—	—		527	47.6		491	82.1		386	77.7	
2007	718	77.9		496	48.4		456	84.9		349	77.7	
2008	711	74.5		457	48.8		475	83.2		373	75.6	
Medicaid/Medicare dual status									< .001			< .001
Yes	425	76.2		347	49.0		266	72.6		97	58.8	
No	1,004	76.2		1,133	48.0		1,156	85.8		1,011	78.7	
Histology									< .05			
Ductal/lobular	1,336	76.8		1,408	48.6		1,325	83.7		1,015	77.4	
Other	33	66.7		54	48.1		44	68.2		15	86.7	
Tubular/colloid	60	68.3		18	22.2		53	86.8		78	69.2	
Tumor size, cm			< .001						< .001			
< 0.5	70	60.0		12	41.7		63	88.9		95	78.9	
0.5 to 1	245	69.8		64	43.8		198	89.4		331	74.6	
1 to 2	555	80.7		473	42.5		487	90.1		682	77.9	
2 to 3	267	79.0		416	50.5		447	80.1		—		
3 to 4	118	77.1		196	54.6		132	65.9		—		
4 to 5	48	60.4		105	50.5		50	80.0		—		
≥ 5	74	79.7		175	50.9		45	62.2		—		
Missing	52	73.1		39	53.8		—	—		—		
Tumor sequence			< .05						< .05			
First	1,176	77.3		1,260	49.1		1,239	84.3		921	78.1	
≥ Second	253	71.1		220	43.2		183	76.5		187	71.7	
Positive lymph nodes			< .05									
Yes	361	80.6		1,134	48.9		405	84.7		—	—	
No	1,059	74.9		344	45.9		1,017	82.8		1,108	77.0	
Missing	9	55.6		2	50.0		—	—		—	—	
ER/PR positive						< .001						
Positive	1,429	76.2		921	44.7		1,115	83.4		1,108	77.0	
Negative	—	—		517	55.1		307	83.1		—	—	
Missing	—	—		42	40.5		—	—		—	—	
Stage						< .001			< .05			
I	820	75.5		187	43.3		645	88.4		1,105	77.0	
Ila	353	75.4		520	42.1		544	79.6		2	50.0	
Ilb	104	78.8		340	46.5		125	78.4		—	—	
III	152	80.3		433	59.1		108	77.8		1	100.0	
Trastuzumab use						< .001			< .05			
Yes	51	78.4		182	100.0		94	92.6		8	100.0	
No	1,378	76.1		1,298	41.0		1,328	82.7		1,100	76.8	
Surgery type												
BCS	822	76.3		602	45.8		1,422	83.3		1,108	77.0	
Mastectomy	607	76.1		878	49.9		—	—		—	—	

Abbreviations: BCS, breast-conserving surgery; ER, estrogen receptor; PR, progesterone receptor; RT, radiation therapy.

Significant predictors of receipt of guideline-concordant RT in the guideline-concordant RT subsample included patient age and surgical provider volume. Compared with patients age ≥ 86 years, younger women were more likely to receive guideline-concordant RT (age ≤ 65 years: OR, 11.4; 95% CI, 6.01 to 21.6; age 66 to 75 years: OR, 13.2; 95% CI, 7.9 to 21.9; age 76 to 85 years: OR, 6.91; 95% CI, 4.18 to 11.41). Compared with surgeons in the highest quartile of volume, those in the third highest and lowest two quartiles had higher guideline concordance.

In the optional RT group, significant predictors of RT receipt included patient age, state, and county economic status. Compared with patients age ≥ 86 years, younger women were more likely to receive RT (age 66 to 75 years: OR, 7.9; 95% CI, 5 to 13; age 76 to 85 years: OR, 4.2; 95% CI, 2.7 to 6.7). The rate of RT in North Carolina was significantly lower than that in Pennsylvania (OR, 0.25; 95% CI, 0.16 to 0.38). In the optional RT group, use of RT in counties with competitive economic status was lower (OR, 0.61; 95% CI, 0.40 to 0.94) compared with transitional counties.

We compared receipt of RT between guideline-concordant and optional RT subsamples to determine if rates were lower when RT was optional. The rates were not uniformly larger in the guideline-concordant compared with the optional RT group (significance levels not shown).

Discussion

Examining the effect of patient and surgical provider characteristics, geographic location of patients, county-level economic status, rurality, and state, we identified considerable variation in receipt of guideline-concordant care across this economically diverse study region that followed patterns of patient age, county-level economic status, and surgical provider characteristics. These results may help explain disparities in cancer outcomes in underserved areas of Appalachia.

Patient age > 75 years was associated with lower rates of guideline-concordant endocrine therapy, chemotherapy, and RT after BCS. This is consistent with what has been widely reported in the literature; even after controlling for known confounders, older age is a risk factor for less-than-standard management.³⁶⁻³⁸ Although deviation from guideline management is appropriate in some clinically frail older women, it is not appropriate solely on the basis of age. Undertreatment of breast cancer, even in women of advanced age, leads to poorer outcomes.^{37,39} Because counties in the Appalachian mountain area tend to have higher median ages than other areas in the country,¹⁸ undertreatment may explain some of the disparities in this area. Further study of factors associated with receipt of guideline-concordant care in this age group may lead to interventions to decrease cancer regional disparities.

Within the past decade, the standard of care for older women with stage I hormone receptor-positive breast cancer (ie, our optional RT group) has changed; if adjuvant endocrine therapy is planned, it is acceptable to omit adjuvant RT after BCS.⁴⁰⁻⁴² Our study uniquely explores use of adjuvant RT after BCS in this group of older women, for whom it might, according to guidelines, be omitted, and we found that most of these

women did receive RT. Low local recurrence and mortality rates after BCS without RT are dependent on use of endocrine therapy, which decreases the risk of local and distant recurrences.⁴³ Higher-than-expected use of optional adjuvant RT in older women might be the result of concerns about lack of adherence to endocrine therapy as an alternative treatment approach^{44,45} or other factors, such as financial issues.⁴⁶ Other factors, such as patient desire or preference, may play a role in overuse. However, it is interesting that women with hormone receptor-positive stage I breast cancer in the higher socioeconomic group and those living in North Carolina had lesser odds of receiving adjuvant RT after BCS. The latter suggests that some women may have better access to treatment decision support or planning than others, which may vary by facility type and perhaps health literacy. Study of surgical facility characteristics and availability of chemotherapy and RT services is under way.

Surgeon characteristics, including volume and year of graduation, were associated with receipt of guideline-concordant care. Other studies have shown that receipt of adjuvant chemotherapy and RT for breast cancer is associated with higher surgeon caseload,⁴⁷ higher practice efficiency and better quality of care,^{48,49} maintenance of up-to-date practice,^{48,50} and better breast cancer survival.^{51,52} Benefits of higher volume, not yet tested in the literature, could include efficiencies in providing support services, referral networks, and follow-up and risk management.^{53,54} The relationship between caseload and guideline-concordant care is also confounded by socioeconomic status; patients who select their own surgeon, as opposed to those referred by a clinician or health plan, are more likely to be treated by high-volume providers in an American College of Surgeons-approved or National Cancer Institute-designated cancer center and are more likely to be white, highly educated, and affluent.⁴⁹ In the Appalachia POC study, surgical volume was of interest because the region includes large tracts of low-population density regions. We found that surgical provider volume was directly proportional to the use of chemotherapy, presumably through care planning processes, referral networks, navigators, and other services that support multidisciplinary care,⁵⁵ but indirectly proportional to use of RT after BCS. The lower rate of guideline-concordant RT after BCS among high-volume providers suggests that patients may selectively travel to larger-volume providers/centers for surgery but seek other care elsewhere and therefore may be susceptible to gaps in care. Alternatively, perhaps referral patterns within physician networks outside of large centers lead to higher rates of RT use.⁵⁶ Further research on care networks and provider care patterns and locations is needed. Patients with surgeons who graduated from medical school between 1984 and 1988 were more likely to receive guideline-concordant endocrine therapy compared with those whose surgeons graduated ≥ 1989 , which we suspect is the result of educational factors or timing of the release of key study results showing the immense benefits of endocrine therapy in postmenopausal women with hormone receptor-positive breast cancer.

In general, younger woman were more likely to receive RT after BCS. Among elderly women (age ≥ 86 years), underuse of RT after BCS is a widely reported phenomenon,⁵⁷ typically explained by factors weighing into the risk/benefit ratio, such as

frailty, patient preference, and social issues, which are not easily captured by epidemiologic studies. Rates of guideline-concordant RT are also associated with distance to treatment facility.⁵⁸ Interestingly, in North Carolina, where it seemed that newer guidelines were adopted for omission of RT after BCS in older women with hormone receptor–positive stage I cancer, guideline-concordant endocrine therapy and chemotherapy rates were lower. Differences among states are likely multifactorial, involving geographic and health system factors, and should be more thoroughly explored. Women in the higher socioeconomic counties were also less likely to receive RT when it was not necessary, which we postulate is the result of higher health literacy. However, county-level socioeconomic status was not associated with delivery of adjuvant RT in general or with delivery of guideline-concordant chemotherapy, although other studies have shown that a disadvantageous socioeconomic environment is associated with less-than–guideline concordant care.⁵¹

This is the first report to our knowledge describing guideline concordance of adjuvant endocrine therapy, chemotherapy, and RT for early-stage breast cancer in Appalachia, and it is among the first to examine patterns in the United States of use of RT with BCS in older women with stage I hormone receptor–positive breast cancer, in whom RT might reasonably be omitted. Strengths of the study include the large geographically and economically diverse population, distinct from the SEER-Medicare program, which under-represents rural populations such as Appalachia. The conclusions may not be representative of all of Appalachia, because we were not able to include data from all states in Appalachia. In addition, because most of our population was in Pennsylvania, where there are fewer economically distressed counties, power to detect differences in guideline concordance by socioeconomic status was limited. Inclusion of Appalachian states such as West Virginia and Mississippi, where there are more distressed counties, would provide greater opportunity to study the effects of socioeconomic status on care. Information about county-level characteristics (economic status and rural/urban residence), state, and treating surgeon characteristics, in addition to patient, tumor, and treatment information available from Medicare claims, is a strength of this analysis, although the inclusion of only patient cases linkable to Medicare claims limits our study to a primarily older population. However, because more than half of breast cancers are diagnosed in women age > 65 years, we feel that the data are of importance. Other limitations include that claims data may miss care components covered by supplemental insurance, and although our multivariable analysis adjusted for potential mediators of receipt of guideline-concordant therapy, information about patient choices, issues in decision making, and other mediators and latent confounders cannot be taken into account.

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In conclusion, we find that age, county-level economic status, state, and surgical provider characteristics are associated with use of guideline-concordant adjuvant therapy in this Appalachian area. Although the study confirms the well-recognized disparities in care seen with older age and lower county-level economic status, it also identifies regions of Appalachia and surgical provider characteristics where further study may identify resources necessary to improve compliance with guidelines. Further exploration of health system characteristics, geographic variability in health care use, and effect of geography on treatment of breast and other cancers in Appalachia are under way.

Acknowledgment

Supported by National Cancer Institute Grant No. 1 R01 CA140335-01A1. Presented in abstract and poster form at the 49 Annual Meeting of the American Society of Clinical Oncology, Chicago, IL, May 31-June 4, 2013.

Authors' Disclosures of Potential Conflicts of Interest

Although all authors completed the disclosure declaration, the following author(s) and/or an author's immediate family member(s) indicated a financial or other interest that is relevant to the subject matter under consideration in this article. Certain relationships marked with a "U" are those for which no compensation was received; those relationships marked with a "C" were compensated. For a detailed description of the disclosure categories, or for more information about ASCO's conflict of interest policy, please refer to the Author Disclosure Declaration and the Disclosures of Potential Conflicts of Interest section in Information for Contributors.

Employment or Leadership Position: None **Consultant or Advisory Role:** Roger T. Anderson, Bayer (C) **Stock Ownership:** None **Honoraria:** None **Research Funding:** Gretchen G. Kimmick, Wyeth, GlaxoSmithKline, Bristol-Meyers Squibb **Expert Testimony:** None **Patents, Royalties, and Licenses:** None **Other Remuneration:** Gretchen G. Kimmick, Genomic Health

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DOI: 10.1200/JOP.2014.001397; published online ahead of print at jop.ascopubs.org on September 16, 2014.

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Appendix

Table A1. ICD-9 and CPT Codes Used to Define Treatment in Linked Database*

Cancer-Directed Breast Surgery	Registry Site-Specific Codes	ICD-9/NDC Medicare	HCPSCS/CPT Medicare
Partial mastectomy with axillary lymph node dissection, excisional biopsy, tumor destruction	10-29	85.20-85.23, 85.25	19120, 19125, 19126, 19160, 19162 19301, 19302
Mastectomy†	30-80	85.33-85.36, 85.41-85.48	19180, 19182, 19200, 19240, 19303-19307, 19340, 19342
RT		V58.0, V66.1, V67.1, 92.20-92.29	77401-77418, G0174, G0178, G0179, 77520-77525, 77750-77790
Adjuvant chemotherapy‡			96400, 96408, 96410, 96412, 96414, 96417, 96545, 96549, C9415, C9420, C9421, G0355, G0357-G0360, G0362, G0363, J2045, J8520, J8521, J8530, J8999, J9000, J9010, J9070, J9080, J9090-J9097, J9170 J9178, J9180, J9190, J9250, J9260, J9265, J9355, J9999, Q0083, Q0084, Q0085, X7052
Adjuvant endocrine therapy§		First nine NDC digits: 000097663, 000544831, 000544834, 000548831, 000548834, 000780249, 000930782, 000930784, 001725656, 001725657, 003100201, 003100600, 003100604, 003100730, 003100731, 003780144, 003780274, 004031505, 005550446, 005550904, 122800346, 387790341, 494527571, 494527753, 499990986, 515520838, 519272976, 545690382, 545693765, 545695714, 545695716, 545695731, 545695732, 545695857, 545698531, 545698602, 548683004, 548684151, 548684287, 548685000, 548685261, 551755500, 551755505, 552890585, 578666615, 578666618, 580160657, 603460048, 603460900, 629911151, 633040600, 633040601, 633700251, 636291262, 637390269, 661050832	S0187, V0752, V0751

Abbreviations: CPT, Current Procedural Terminology; HCPSCS, Healthcare Common Procedure Coding System; ICD-9, International Classification of Diseases (ninth revision); NDC, National Drug Code; RT, radiation therapy.

* Surgery, RT, and chemotherapy dates and characteristics were determined from combined registry and Medicare data using in-house decision algorithm.

† Includes simple mastectomy, modified radical mastectomy, radical mastectomy, extended radical mastectomy, and subcutaneous mastectomy. Prophylactic mastectomy codes not included.

‡ Adjuvant chemotherapy indicated if at least two codes found or registry chemotherapy date occurred within 1 year of surgery. Patients with one code or nonspecific codes were excluded from chemotherapy sample.

§ Includes tamoxifen, anastrozole, letrozole (Femara; Novartis, Basel, Switzerland), and exemestane (Aromasin; Pfizer, New York, NY).

Appendix Figure 1. Eligibility criteria. AJCC, American Joint Committee on Cancer; HMO, health maintenance organization.