Patterns of Surveillance Advanced Imaging and Serum Tumor Biomarker Testing Following Launch of the Choosing Wisely Initiative

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ABSTRACT

Background: The purpose of this study was to assess advanced imaging (bone scan, CT, or PET/CT) and serum tumor biomarker use in asymptomatic breast cancer survivors during the surveillance period. **Patients and Methods:** Cancer registry records for 2,923 women diagnosed with primary breast cancer in Washington State between January 1, 2007, and December 31, 2014, were linked with claims data from 2 regional commercial insurance plans. Clinical data including demographic and tumor characteristics were collected. Evaluation and management codes from claims data were used to determine advanced imaging and serum tumor biomarker testing during the peridiagnostic and surveillance phases of care. Multivariable logistic regression models were used to identify clinical factors and patterns of peridiagnostic imaging and biomarker testing associated with surveillance advanced imaging. **Results:** Of 2,923 eligible women, 16.5% (n=480) underwent surveillance advanced imaging and 31.8% (n=930) received surveillance serum tumor biomarker testing. Compared with women diagnosed before the launch of the Choosing Wisely campaign in 2012, later diagnosis was associated with lower use of surveillance advanced imaging (odds ratio [OR], 0.68; 95% CI, 0.52–0.89). Factors significantly associated with use of surveillance advanced imaging included increasing disease stage (stage III: OR, 3.65; 95% CI, 2.48–5.38), peridiagnostic advanced imaging use (OR, 1.76; 95% CI, 1.33–2.31), and peridiagnostic serum tumor biomarker testing (OR, 1.35; 95% CI, 1.01–1.80). **Conclusions:** Although use of surveillance advanced imaging in asymptomatic breast cancer survivors has declined since the launch of the Choosing Wisely campaign, frequent use of surveillance serum tumor biomarker testing remains prevalent, representing a potential target for further efforts to reduce low-value practices.

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Background

The Institute of Medicine estimates that nearly 30% of all medical expenses result from inappropriate or unnecessary practices, increasing strain on the US healthcare system.¹ In oncology, total healthcare expenditures are projected to reach \$173 billion by 2020, a \$50 billion increase compared with 2010.² Efforts to identify and improve practices by physicians, payers, and policymakers led to the Choosing Wisely campaign by the ABIM Foundation (ABIMF).

In 2012, a “Top Five” list of low-value practices in oncology that could be avoided without impacting patient care was released through the Choosing Wisely initiative in partnership with ASCO.^{3,4} Surveillance testing of asymptomatic breast cancer survivors using advanced imaging (whole-body imaging with bone scan, CT, or PET/CT) and/or serum tumor biomarkers (carcinoembryonic antigen, CA 15-3, and CA 27.29) was one measure included on this list. Randomized controlled trials have shown no survival benefit or decreased time to detection of disease recurrence in women receiving advanced imaging tests.^{5,6} Furthermore, numerous potential harms associated with advanced imaging use in breast cancer survivors have been reported, including increased patient anxiety, exposure to ionizing radiation, and false-positive results leading to further invasive testing.⁷

Current NCCN and ASCO evidence-based guidelines for breast cancer follow-up and management after primary treatment include routine history, physical examination, and mammography.^{8,9} Physical examination is recommended every 3 to 6 months for the first 3 years, every 6 to 12 months for years 4 and 5, and annually thereafter. For women who have received breast-conserving therapy, a posttreatment mammogram is recommended 1 year after the initial mammogram and at least 6 months after completion of radiation therapy (RT), followed by yearly mammography.

Despite consensus on the Choosing Wisely recommendations advising against use of low-value surveillance

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care, variable adherence to these measures has been observed.¹⁰ Predictors of nonconcordance with recommendations have yet to be clearly elucidated, which limits efforts to develop interventions aimed at reducing unnecessary surveillance testing. Understanding determinants of advanced surveillance testing will be key in implementing effective strategies to increase concordance with Choosing Wisely guidelines. Thus, the objectives of our study were to evaluate advanced imaging use during breast cancer surveillance and to identify drivers of potential advanced imaging overuse, as outlined by the ASCO/ABIMF Top Five recommendations.

Patients and Methods

A retrospective cohort study was performed involving 18,912 unique individuals diagnosed with breast cancer between January 1, 2007, and December 31, 2014. Insurance enrollment data from 2 major commercial insurers in the region, Premera Blue Cross and Regence Blue Shield, were linked with cancer registry records from the Cancer Surveillance System (CSS), which includes 13 counties in western Washington State, and claims for inpatient and outpatient services were extracted for eligible individuals during the study period. This HIPAA-compliant study received Institutional Review Board approval to link registry and commercial insurance data and to perform analyses.

We included women aged ≥ 18 years at the time of diagnosis who had AJCC 7th edition stage 0–III breast

cancer who underwent primary treatment with curative intent (Figure 1). Primary therapy was defined as either mastectomy or lumpectomy with RT within 180 days of diagnosis.¹¹ Exclusion criteria included women who (1) had a prior history of breast cancer (2) had an unknown breast cancer diagnosis date or a diagnosis date outside the study period, (3) were diagnosed at autopsy, (4) had AJCC stage IV breast cancer, (5) did not have continuous insurance enrollment from 3 months before diagnosis through 14 months after diagnosis, (6) did not receive curative therapy (ie, mastectomy 6 months after diagnosis or lumpectomy with RT within 180 days after surgery), and (7) did not have continuous insurance enrollment during the surveillance period (15-month period starting 4 months after completion of primary therapy).

Clinical data included age at diagnosis, race, diagnosis year, family history of breast cancer, and breast cancer–specific genetic mutation status. Tumor characteristic data included AJCC stage, grade, size, and estrogen receptor (ER), progesterone receptor (PR), and HER2 status. Survival information was obtained from the CSS.

Evaluation and management codes from claims data were used to determine advanced imaging (whole-body imaging with bone scan, CT, and/or PET/CT) and serum tumor biomarker testing during both the peridiagnostic period (ie, 1 month before diagnosis until completion of primary therapy) and the surveillance

Figure 1. CONSORT diagram of cohort creation.

Table 1. Clinical and Tumor Characteristics of Study Cohort

Characteristic	Total n (%)	Restarted Treatment During Surveillance n (%)	Completed Surveillance n (%)
Total, N	2,923	161	2,762
Age, y			
<45	416 (14.2%)	25 (15.5%)	391 (14.2%)
45–54	856 (29.3%)	50 (31.1%)	806 (29.2%)
55–64	897 (30.7%)	52 (32.3%)	845 (30.6%)
65–74	503 (17.2%)	23 (14.3%)	480 (17.4%)
≥75	251 (8.6%)	11 (6.8%)	240 (8.7%)
Race			
White	2,609 (89.3%)	144 (89.4%)	2,465 (89.2%)
Other	314 (10.7%)	17 (10.6%)	297 (10.8%)
Diagnosis year			
2007	182 (6.2%)	17 (10.6%)	165 (6.0%)
2008	320 (10.9%)	20 (12.4%)	300 (10.9%)
2009	352 (12.0%)	20 (12.4%)	332 (12.0%)
2010	351 (12.0%)	22 (13.7%)	329 (11.9%)
2011	488 (16.7%)	26 (16.1%)	462 (16.7%)
2012	532 (18.2%)	24 (14.9%)	508 (18.4%)
2013	485 (16.6%)	19 (11.8%)	466 (16.9%)
2014	213 (7.3%)	13 (8.1%)	200 (7.2%)
Cancer stage			
0	695 (23.8%)	31 (19.3%)	664 (24.0%)
I	1,342 (45.9%)	57 (35.4%)	1,285 (46.5%)
II	720 (24.6%)	51 (31.7%)	669 (24.2%)
III	166 (5.7%)	22 (13.7%)	144 (5.2%)
Cancer stage categories			
0–IIa	2,561 (87.6%)	123 (76.4%)	2,438 (88.3%)
≥IIb	362 (12.4%)	38 (23.6%)	324 (11.7%)
Tumor grade			
1	698 (23.9%)	37 (23.0%)	661 (23.9%)
2	1,220 (41.7%)	62 (38.5%)	1,158 (41.9%)
3	927 (31.7%)	55 (34.2%)	872 (31.6%)
Tumor size, mm			
<20	1,836 (62.8%)	85 (52.8%)	1,751 (63.4%)
20–49	812 (27.8%)	56 (34.8%)	756 (27.4%)
≥50	161 (5.5%)	13 (8.1%)	148 (5.4%)
ER status			
Positive	2,523 (86.3%)	126 (78.3%)	2,397 (86.8%)
Negative	354 (12.1%)	32 (19.9%)	322 (11.7%)
PR status			
Positive	2,166 (74.1%)	102 (63.4%)	2,064 (74.7%)
Negative	553 (18.9%)	46 (28.6%)	507 (18.4%)

(continued on next page)

Abbreviations: ER, estrogen receptor; PR, progesterone receptor; RT, radiation therapy.

Table 1. Clinical and Tumor Characteristics of Study Cohort (cont.)

Characteristic	Total n (%)	Restarted Treatment During Surveillance n (%)	Completed Surveillance n (%)
HER2 status			
Positive	159 (5.4%)	10 (6.2%)	149 (5.4%)
Negative	1,438 (49.2%)	71 (44.1%)	1,367 (49.5%)
Curative therapy			
Lumpectomy + RT	1,792 (61.3%)	80 (49.7%)	1,712 (62.0%)
Mastectomy	1,131 (38.7%)	81 (50.3%)	1,050 (38.0%)
Family history			
Yes	641 (21.9%)	35 (21.7%)	606 (21.9%)
No	2,282 (78.1%)	126 (78.3%)	2,156 (78.1%)
Genetic mutation			
Yes	52 (1.8%)	6 (3.7%)	46 (1.7%)
No	2,871 (98.2%)	155 (96.3%)	2,716 (98.3%)

Abbreviations: ER, estrogen receptor; PR, progesterone receptor; RT, radiation therapy.

period (ie, 15-month period starting 4 months after completion of primary therapy).^{12,13} Tumor biomarker testing performed after advanced imaging surveillance was excluded. Censoring occurred during surveillance at death or restart of treatment, defined as claims data documenting surgery, chemotherapy, or RT during surveillance, an end point that was used as a proxy for disease recurrence.^{10,14,15}

Clinical and tumor characteristic data were compared between women who completed their surveillance period without further treatment and those who ended surveillance early due to restart of treatment. Use of advanced imaging and serum tumor biomarker testing was compared between women with less advanced versus more advanced disease (stage 0–IIa vs stage ≥IIb, respectively) during both the peridiagnostic and surveillance periods. Use of surveillance advanced imaging and serum tumor biomarker testing in these 2 groups was then compared based on whether treatment was restarted during surveillance to assess potentially

appropriate versus inappropriate use of surveillance testing.

Multivariable logistic regression was used to identify clinical factors and patterns of care (peridiagnostic advanced imaging and tumor biomarker testing and surveillance tumor biomarker testing) that were associated with surveillance advanced imaging. For the regression model, we excluded patients who underwent surveillance biomarker testing that did not precede surveillance advanced imaging. Specifically, the following covariates were included in the model: patient age and race; diagnosis year; cancer stage; ER, PR, and HER2 status; curative therapy; family history; genetic mutation; peridiagnostic advanced imaging; and peridiagnostic tumor biomarker testing. Patients with unknown ER/PR status were excluded. There was no interaction between covariates. All statistical tests were 2-sided, and *P* values <.05 were considered statistically significant.

For the fully adjusted multivariable model, we used multiple imputation via chained equations to impute

Table 2. Peridiagnostic Advanced Imaging and Serum Tumor Biomarker Testing

	All Women n (%)	Stage 0–IIa n (%)	Stage ≥IIb n (%)
Total, N	2,923	2,561	362
No advanced imaging	2,508 (85.8%)	2,306 (90.0%)	202 (55.8%)
Advanced imaging ^a	415 (14.2%)	255 (10.0%)	160 (44.2%)
Bone scan	134 (4.6%)	77 (3.0%)	57 (15.7%)
CT	289 (9.9%)	182 (7.1%)	107 (29.6%)
PET/CT	205 (7.0%)	101 (3.9%)	104 (28.7%)
Serum tumor biomarker testing	388 (13.3%)	287 (11.2%)	101 (27.9%)

^aIncluding any combination of bone scan, CT, and/or PET/CT.

Table 3. Surveillance Advanced Imaging and Serum Tumor Biomarker Testing

	All Women n (%)	Stage 0-IIa n (%)	Stage ≥IIb n (%)
Total, N	2,923	2,561	362
No advanced imaging	2,443 (83.5%)	2,207 (86.2%)	236 (65.2%)
Advanced imaging ^a	480 (16.5%)	354 (13.8%)	126 (34.8%)
Bone scan	132 (4.5%)	94 (3.7%)	38 (10.5%)
CT	370 (12.7%)	266 (10.4%)	104 (28.7%)
PET/CT	85 (2.9%)	54 (2.1%)	31 (8.6%)
Serum tumor biomarker testing ^b	930 (31.8%)	748 (29.2%)	182 (50.3%)

^aIncluding any combination of bone scan, CT, and/or PET/CT.

^b185 women (6.3%) received both surveillance advanced imaging and tumor biomarker use.

missing HER2 data in 1,123 women.^{16,17} This method imputed missing variables using a regression model conditional on all the other variables in the model. Ten imputations were conducted using STATA, version 14 (StataCorp LP), and estimates were combined across imputations using standard methods for multiple imputation.¹⁸

Results

After applying inclusion and exclusion criteria, 2,923 women were included in the final study cohort. Clinical data including demographic and tumor characteristics are shown in Table 1. Median age was 57.2 years (interquartile range, 48–65 years), and nearly half of all women (n=1,342; 45.9%) were diagnosed with AJCC stage I disease. Most tumors were <20 mm (n=1,836; 62.8%), ER-positive (n=2,523; 86.3%), and PR-positive (n=2,166; 74.1%). Most women (n=1,792; 61.3%) underwent breast conservation therapy, whereas 38.7% (n=1,131) underwent mastectomy. A minority of women had a family history of breast cancer (n=641; 21.9%) or breast cancer-specific genetic mutation (n=52; 1.8%). The surveillance period ended early for 5.5% of women (n=161) due to restart of treatment; these women were more likely to have advanced disease stage, larger tumor size (>20 mm), and ER-negative status at primary breast cancer diagnosis compared with those who did not restart treatment.

During the peridiagnostic phase of care, 14.2% of all women (n=415) received at least 1 advanced imaging test (bone scan, CT, and/or PET/CT) and 13.3% (n=388) received serum tumor biomarker testing (Table 2). Additionally, compared with those with early-stage breast cancer (stage 0–IIa; n=2,561), a greater proportion with advanced-stage breast cancer (stage ≥IIb; n=362) received advanced imaging (44.2% vs 10.0%) and serum tumor biomarker testing (27.9% vs 11.2%).

During the surveillance phase of care, 16.5% of all women (n=480) received advanced imaging and 31.8% (n=930) received serum tumor biomarker testing (Table 3).

CT scan (n=370) was the most frequently used advanced imaging modality, followed by bone scan (n=132) and PET/CT (n=85). Compared with those with early-stage breast cancer, more women with advanced-stage breast cancer received advanced imaging surveillance (34.8% vs 13.8%) and serum tumor biomarker testing (50.3% vs 29.2%). Serum tumor biomarker testing among all women increased from 13.3% (388/2,923) to 31.8% (930/2,923) between the peridiagnostic and surveillance phases of care.

Multivariable logistic regression modeling indicated that advanced imaging use during surveillance was most significantly associated with increasing disease stage (stage III: OR, 3.65; 95% CI, 2.48–5.38) (Table 4). Compared with women diagnosed before the launch of Choosing Wisely in 2012, later diagnosis was associated with lower use of advanced imaging surveillance (OR, 0.68; 95% CI, 0.52–0.89). Additional factors significantly associated with advanced imaging surveillance included peridiagnostic advanced imaging (OR, 1.76; 95% CI, 1.33–2.31) and serum tumor biomarker testing (OR, 1.35; 95% CI, 1.01–1.80).

Among women who received advanced imaging during surveillance (n=480), 19.1% (24/126) with advanced-stage breast cancer restarted treatment compared with 6.5% (23/354) with early-stage breast cancer (Table 5). More than 90% of women with early-stage breast cancer who received either advanced imaging or serum tumor biomarker testing during the surveillance phase of care did not restart treatment.

Discussion

Several studies have shown limited clinical benefit from advanced imaging surveillance and serum tumor biomarker testing in asymptomatic breast cancer survivors.^{5–7} In our study population of 2,923 women treated for primary breast cancer with curative intent, we found that only 16.5% received surveillance advanced imaging, representing a lower proportion compared with prior studies evaluating advanced imaging use among breast cancer

Table 4. Multivariable Analysis of Association Between Clinical Characteristics and Surveillance Advanced Imaging

Variable ^a	Odds Ratio (95% CI)	P Value
Age, y		.41
<45	1.18 (0.84–1.67)	
45–54	1.27 (0.96–1.67)	
55–64	Ref	
65–74	1.18 (0.85–1.63)	
≥75	1.43 (0.97–2.11)	
Race		.93
White	Ref	
Nonwhite	1.02 (0.71–1.46)	
Diagnosis year		<.01
2007–2012	Ref	
2013–2014	0.68 (0.52–0.89)	
Cancer stage		<.01
0	0.55 (0.38–0.80)	
I	Ref	
II	1.85 (1.45–2.37)	
III	3.65 (2.48, 5.38)	
ER status		.33
Positive	0.82 (0.54–1.23)	
Negative	Ref	
PR status		.36
Positive	0.85 (0.60–1.20)	
Negative	Ref	
HER2 status		.96
Positive	0.99 (0.64–1.52)	
Negative	Ref	
Curative therapy		.86
Mastectomy	Ref	
Lumpectomy + RT	0.98 (0.78–1.23)	
Family history		.63
Yes	1.07 (0.82–1.38)	
No	Ref	
Genetic mutation		.46
Yes	1.30 (0.65–2.60)	
No	Ref	
Tumor marker testing (peridiagnostic)		.04
Yes	1.35 (1.01–1.80)	
No	Ref	

(continued)

Abbreviations: ER, estrogen receptor; PR, progesterone receptor; RT, radiation therapy.

^aCovariates included in the model: patient age and race; diagnosis year; cancer stage; ER, PR, and HER2 status; curative therapy; family history; genetic mutation; peridiagnostic advanced imaging; and peridiagnostic tumor biomarker testing.**Table 4. Multivariable Analysis of Association Between Clinical Characteristics and Surveillance Advanced Imaging (cont.)**

Variable ^a	Odds Ratio (95% CI)	P Value
Tumor marker testing (surveillance)		.19
Yes	0.86 (0.68–1.08)	
No	Ref	
Advanced imaging use (peridiagnostic)		<.01
Yes	1.76 (1.33–2.31)	
No	Ref	

Abbreviations: ER, estrogen receptor; PR, progesterone receptor; RT, radiation therapy.

^aCovariates included in the model: patient age and race; diagnosis year; cancer stage; ER, PR, and HER2 status; curative therapy; family history; genetic mutation; peridiagnostic advanced imaging; and peridiagnostic tumor biomarker testing.

survivors.¹⁰ Nearly one-third of women in this study received surveillance serum tumor biomarker testing, however, reflecting that care that may be discordant with Choosing Wisely guideline recommendations.^{3,4}

Of women receiving surveillance advanced imaging, 6.5% (23/354) treated for early-stage disease and 19.1% (24/126) treated for advanced-stage disease restarted treatment because of probable recurrent or metastatic disease. In contrast, overall low treatment restart rates were seen in women receiving surveillance serum tumor biomarker testing (5.3%; 49/930) for probable recurrent or metastatic disease, despite nearly one-third of survivors of primary breast cancer receiving these tests. Additionally, increased surveillance tumor biomarker testing was not associated with follow-up surveillance advanced imaging, indicating that biomarker testing had little effect on subsequent clinical management and supporting its limited clinical benefit in this population.

Overall, variable surveillance advanced imaging estimates ranging from 24% to 55% have been previously reported, likely attributable to differences in study setting, patient selection, and definitions of advanced imaging surveillance.^{19–23} Panageas et al,²³ for example, who showed advanced imaging surveillance use in 40% of early-stage breast cancer survivors using SEER-Medicare linked data, included breast MRI in their analysis, likely contributing to comparatively higher overall advanced imaging use rates. Our study results were more aligned with more recent studies showing lower use rates, supporting decreasing use of surveillance advanced imaging over time.^{19,20} In a recent analysis, Schumacher et al²⁰ found that although patients were more likely to receive surveillance imaging at their first follow-up examination, lower use was seen in subsequent years. Similar to our findings, their study supported surveillance imaging use in patients with

Table 5. Treatment Restart Status

	Treatment Restarted		Total, N
	Yes* n (%)	No n (%)	
Advanced imaging performed			
Stage 0–IIa	23 (6.5%)	331 (93.5%)	354
Stage ≥IIb	24 (19.1%)	102 (80.9%)	126
Total	47 (9.8%)	433 (90.2%)	480
Serum tumor biomarker performed			
Stage 0–IIa	33 (4.4%)	715 (95.6%)	748
Stage ≥IIb	16 (8.8%)	166 (91.2%)	182
Total	49 (5.3%)	881 (94.7%)	930

^aPotentially appropriate use of surveillance testing for recurrence based on claims data documenting surgery, chemotherapy, or radiotherapy during surveillance.

higher recurrence risk, including those with ER/PR-negative tumors. Greater awareness of the Choosing Wisely initiative may influence this trend toward more evidence-based surveillance practice patterns that has been reported in more recent studies,²⁴ as well as expansion of high-deductible health plans in the private market over time.²⁵ This possibility is supported by our findings, which showed that earlier date of primary breast cancer diagnosis, before the launch of the Choosing Wisely campaign in 2012, was a predictor of surveillance advanced imaging use. Lastly, prior authorization requirements for surveillance testing by health insurance companies for women with early-stage breast cancer may have influenced study results, although not directly evaluated in our study.²⁶

Advanced imaging and tumor biomarker testing performed during the peridiagnostic phase of care was associated with increased use of surveillance advanced imaging. Considering that these tests were performed before surgery, it seems that peridiagnostic ordering patterns may significantly influence surveillance advanced imaging use by potentially informing recurrence risk. These findings may be supported by recent data showing a positive association between surveillance PET imaging use and mastectomy + RT, indicating that rates of advanced imaging use may be higher in women with increased risk of recurrence.²⁷ Patient age, family history, and tumor characteristics represent additional factors that may influence perception of recurrence risk in breast cancer survivors.^{15,19} Of these previously studied factors, however, only increasing disease stage was associated with surveillance advanced imaging use in our study.

Variation in regional practice patterns and guideline adherence may also influence clinical decision-making when considering surveillance imaging.²⁸ Although oncologists have been shown to make guideline-concordant decisions in most clinical scenarios,²⁹ higher instances of guideline-discordant care have been reported regarding

the diagnostic use of PET imaging and serum tumor biomarker tests in early-stage breast cancer survivors,^{15,21,29} similar to our findings. Although clinician unfamiliarity with Choosing Wisely guidelines may play a partial role, anecdotal experience with perceived benefits of non-recommended tests and reliance on smaller studies may also contribute to guideline-discordant surveillance care.

Our study has several limitations. Claims data do not include information on clinical indication or test results, which limits assessment of the appropriateness of follow-up testing based on suspicious clinical history and/or physical examination findings. Additionally, limited data were available on the number of patients per physician and clinic with which to analyze physician- and clinic-level variables. Detailed information on pre-authorization policies and pathways was also limited in our dataset.¹⁵ Lastly, because our study focused on women receiving guideline-concordant surgical therapy, we did not include those receiving lumpectomy without RT, who are at greater risk of local recurrence. As a result, our study results may not be generalizable to this small subpopulation of women.

Conclusions

As breast cancer survivorship continues to increase, the potential negative impact of inappropriate surveillance testing on individuals, and the US healthcare system overall, will only be magnified.^{30,31} Prior reports demonstrating potential imaging overuse highlight the importance of evidence-based initiatives such as the Choosing Wisely campaign.³² Moreover, it is unclear how recently established guidelines by the American College of Radiology suggesting annual breast MRI in breast cancer survivors aged >50 years or who have dense breast tissue will impact messaging around appropriate use of advanced imaging in this population.³³ Although our study shows that guideline-discordant care may be declining after the launch of Choosing Wisely, non-recommended surveillance testing remains prevalent. Continued efforts to reduce low-value care are needed to reduce costly, unnecessary tests and procedures, with special focus on surveillance tumor biomarker testing.

Initiatives such as ASCO's Quality Oncology Practice Initiative, an oncologist-led, practice-based quality assessment and improvement program, aim to promote evidence-based cancer care by encouraging constant self-inspection to reduce discordant practice patterns while creating a platform to compare variation across diverse practices.³⁴ Peridiagnostic ordering patterns that may lead to guideline-discordant surveillance testing, as seen in our study, could be documented, compared, and used to target physicians who are more likely to not adhere to Choosing Wisely guidelines. Overall, increased efforts to educate health practitioners and patients regarding

evidence-based breast cancer surveillance practices will be required to further increase concordance with Choosing Wisely guidelines.

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