VOLUME 32 · NUMBER 9 · MARCH 20 2014

JOURNAL OF CLINICAL ONCOLOGY

ORIGINAL REPORT

Trends and Variation in Use of Breast Reconstruction in Patients With Breast Cancer Undergoing Mastectomy in the United States

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See accompanying editorial on page 873; listen to the podcast by Dr VanderWalde at www.jco.org/podcasts

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Published online ahead of print at www.jco.org on February 18, 2014.

Supported by Grant No. MRSG-09-145-01-CPHPS from the American Cancer Society (R.J.), Grant No. RP101207 from the Cancer Prevention and Research Institute of Texas (B.D.S. and S.H.G.), and The Tracy Starr Breast Cancer Award (S.H.G.).

Presented at the 55th Annual Meeting of the American Society for Radiation Oncology Annual Meeting, Atlanta, GA, September 22-25, 2013.

Authors' disclosures of potential conflicts of interest and author contributions are found at the end of this article.

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0732-183X/14/3209w-919w/$20.00

DOI: 10.1200/JCO.2013.52.2284

ABSTRACT

Purpose
Concerns exist regarding breast cancer patients' access to breast reconstruction, which provides important psychosocial benefits.

Patients and Methods
Using the MarketScan database, a claims-based data set of US patients with employment-based insurance, we identified 20,560 women undergoing mastectomy for breast cancer from 1998 to 2007. We evaluated time trends using the Cochran-Armitage test and correlated reconstruction use with plastic-surgery workforce density and other treatments using multivariable regression.

Results
Median age of our sample was 51 years. Reconstruction use increased from 46% in 1998 to 63% in 2007 ($P < .001$), with increased use of implants and decreased use of autologous techniques over time ($P < .001$). Receipt of bilateral mastectomy also increased: from 3% in 1998 to 18% in 2007 ($P < .001$). Patients receiving bilateral mastectomy were more likely to receive reconstruction (odds ratio [OR], 2.3; $P < .001$) and patients receiving radiation were less likely to receive reconstruction (OR, 0.44; $P < .001$). Rates of reconstruction receipt varied dramatically by geographic region, with associations with plastic surgeon density in each state and county-level income. Autologous techniques were more often used in patients who received both reconstruction and radiation (OR, 1.8; $P < .001$) and less frequently used in patients with capitated insurance (OR, 0.7; $P < .001$), patients undergoing bilateral mastectomy (OR, 0.5; $P < .001$), or patients in the highest income quartile (OR, 0.7; $P = .006$). Delayed reconstruction was performed in 21% of patients who underwent reconstruction.

Conclusion
Breast reconstruction has increased over time, but it has wide geographic variability. Receipt of other treatments correlates with the use of and approaches toward reconstruction. Further research and interventions are needed to ensure equitable access to this important component of multidisciplinary treatment of breast cancer.

J Clin Oncol 32:919-926. © 2014 by American Society of Clinical Oncology

INTRODUCTION

Breast reconstruction has been shown to yield important psychosocial and quality of life benefits for patients with breast cancer who have undergone mastectomy.[1-4] However, concerns about access to breast reconstruction and evidence for disparities in its use have existed for some time.[5-9] The Women's Health and Cancer Rights Act, which mandated insurance coverage of postmastectomy breast reconstruction in 1999,[10] sought to improve access and reduce disparities. Unfortunately, it was found to have little impact in the years immediately following its implementation.[11]

Recent years have brought about a number of changes in the landscape of locoregional breast cancer management. Growing evidence suggests that contralateral prophylactic mastectomy rates are rising,[12-15] even in patients without high-risk genetic mutations.[16] Use of radiation therapy may also be increasing, based on trials that have revealed improved locoregional control and overall survival in selected subgroups of patients undergoing mastectomy for breast cancer.[17-20] Issues related to the

integration of breast reconstruction with these other treatments may influence utilization rates and patterns, including selection of reconstruction technique and timing.

Few data are available regarding the patterns and correlates of breast reconstruction in patients with breast cancer treated in more recent years, and the data that are available generally focus on immediate reconstruction [21,22] or reconstruction received before completion of cancer treatment.[23] A nontrivial minority of breast cancer patients undergoing reconstruction do so after treatment has been completed,[24] particularly when postmastectomy radiation is anticipated, and approach to reconstruction may be quite different in these patients. Therefore, we sought to evaluate use of various types of breast reconstruction in a working-age, commercially insured sample of patients with breast cancer from 1998 to 2007, including all reconstruction procedures initiated within 2 years of breast cancer treatment. We specifically considered whether overall utilization or approaches have changed over time, whether geographic variation exists, and whether reconstruction use is correlated either positively or negatively with plastic surgery workforce density or use of other treatments, such as contralateral mastectomy or postmastectomy radiotherapy.

PATIENTS AND METHODS

Data Set

The MarketScan Commercial Claims and Encounters database (Truven Health Analytics, Ann Arbor, MI) is a large, nationwide, employment-based database that contains information on medical claims for current employees and their spouses and dependents; the data include claims from approximately 45 large employers covered by more than 100 payers. Until 2002, the database included only clients receiving coverage through the large, self-insured companies who contract with Truven Health to help them manage the cost and design of care for their beneficiaries. In 2002, the data set was expanded to include health plan clients—employees and dependents receiving insurance coverage through small- and medium-sized firms.

For the current analysis, we used claims collected from 1998 through 2009 derived from individuals flagged as having a cancer diagnosis.

Cohort Selection

We used a validated, claims-based algorithm to identify incident cases of female breast cancer treated with mastectomy between 1998 and 2007 (n = 44,735).[25] To enable determination of reconstruction within 2 years of mastectomy, we limited our cohort to individuals with continuous enrollment during this interval (n = 24,141). To enhance specificity, the cohort was then limited to patients without distant metastases (as reconstruction is rarely performed in patients with metastatic disease), without radiation within 3 months before mastectomy (as this is uncommon and indicates extremely advanced disease), and at least two or more diagnosis codes for invasive or in situ breast cancer, for a final cohort of 20,560 patients (Appendix Tables A1 and A2 [online-only]).

Definition of Breast Reconstruction

Receipt of breast reconstruction was determined using Common Procedural Terminology and International Classification of Diseases version 9 procedure codes indicating breast reconstruction (Appendix Table A2) present at any time within 24 months of mastectomy. Using these codes, type of reconstruction was classified as autologous, implant-based, combination of autologous and implant-based, tissue expander only (indicating that no definitive reconstruction was performed within 24 months of mastectomy), or other. Patients with a claim for reconstruction present on the same date as mastectomy were classified as immediate reconstruction, whereas patients whose first claim for reconstruction occurred after mastectomy were classified as delayed reconstruction.

Covariates

Age, geographic region, relationship to employer (employee *v* spouse), and insurance type (health maintenance organization [HMO] or capitated preferred provider organization [PPO] *v* noncapitated plan types) were determined using the MarketScan enrollment file. Year of mastectomy, laterality of mastectomy (bilateral *v* unilateral), lymph node surgery (yes *v* no), chemotherapy (no, before mastectomy, or after mastectomy), and radiation (yes *v* no) were determined from claims (Appendix Table A2). Data regarding number of plastic surgeons per state were obtained from the American Society of Plastic Surgeons Web site and specifically represents the number of the society's member surgeons. Cut points for state-level plastic surgeon density were determined using the natural breaks function in ArcGIS v10 (Esri, Redlands, CA). County-level median household income for the year of diagnosis was determined via linkage to the Area Resource File and was divided into quartiles with the unit of measure being counties in the United States for the year of diagnosis.

Statistical Analysis

Associations of baseline covariates with receipt of reconstruction were assessed using Pearson's χ^2 test. Time trends were tested using the Cochran-Armitage test for trend. Covariates associated with receipt of reconstruction at $P < .20$ in unadjusted analyses were included in a multivariable logistic regression model, with iterative model refinement to remove nonsignificant covariates and minimize colinearity. Model fit was assessed using the Hosmer and Lemeshow test. Using similar methods, multivariable models were also constructed to evaluate the outcomes of autologous versus implant-based reconstruction and immediate versus delayed reconstruction. All analyses were conducted using SAS v9.2 (Cary, NC) using two-sided statistical tests. This project was granted exempt status by The University of Texas MD Anderson institutional review board.

RESULTS

Among the 20,560 patients identified, median patient age was 51 years (interquartile range, 45 to 57). As listed in Table 1, 19% of patients (n = 3,921) were enrolled in HMOs or capitated PPOs, and 59% of patients (n = 12,035) held the insurance through their own employment. The sample was drawn from across the country, with 49% of patients (n = 10,097) from the South and 25% (n = 5,178) from the North Central regions. As detailed in Appendix Figure A1 (online only), the distribution of beneficiaries by age, relationship to employer, and insurance type did not vary significantly over time, but the proportion of the sample constituted by those in wealthier counties and from the West increased, reflecting the net effect of both modest temporal changes in the MarketScan cohort over time and also nationwide trends in the receipt of mastectomy during the study period.

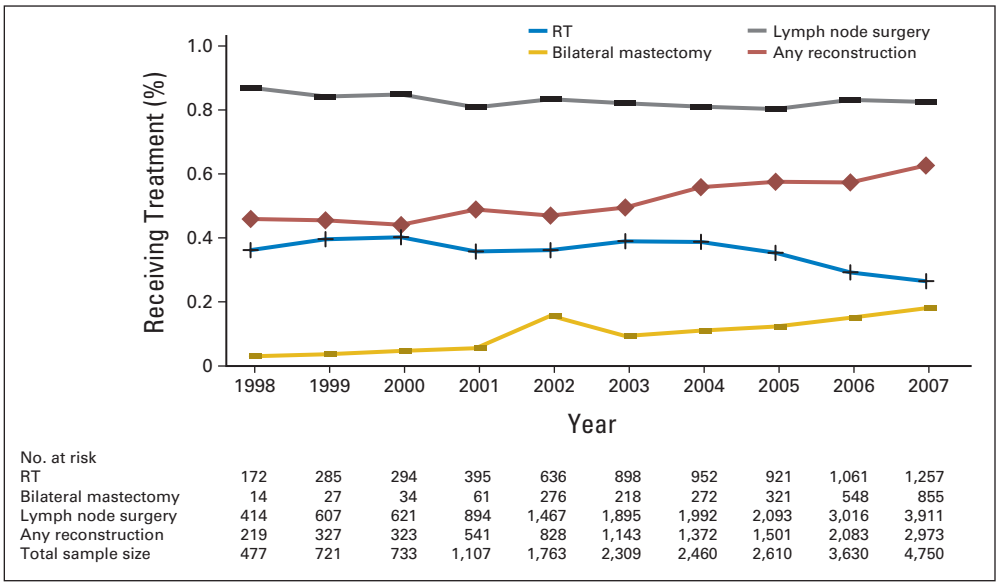
Figure 1 illustrates the patterns of use of other treatments in patients receiving mastectomy. The rate of bilateral mastectomy increased substantially, from 3% of patients (14 of 477) in 1998 to 18% (855 of 4,750) in 2007 ($P < .001$). Rates of lymph node surgery and radiation therapy declined somewhat over time. In 1998, 87% of patients (414 of 477) received lymph node surgery and 36% of patients (172 of 477) received radiation therapy but in 2007 82% of patients (3,911 of 4,750) received lymph node surgery and 27% of patients (1,257 of 4,750) received radiation therapy ($P = .08$ and $P < .001$, respectively).

Overall, 56% of patients (n = 11,610) received breast reconstruction. Use of reconstruction increased dramatically from 46% of patients (219 of 477) in 1998 to 63% (2,973 to 4,750) in 2007, as shown in Figure 1 ($P < .001$). As detailed in Appendix Figures A2 and A3, this increased use of reconstruction appeared unrelated to the expansion

Table 1. Characteristics of the Overall Sample and Those Patients Who Received Reconstruction

Characteristic	Entire Cohort (N = 20,560)		Received Reconstruction (n = 11,310)		
	No. of Patients	Column %	No. of Patients	Row %	P^*
Age at diagnosis, years					< .001
< 40	1,861	9.1	1,408	75.7	
40-49	6,643	32.3	4,434	66.7	
50-59	9,668	47.0	4,671	48.3	
60 and older	2,388	11.6	797	33.4	
Year of mastectomy					< .001
1998	477	2.3	219	45.9	
1999	721	3.5	327	45.4	
2000	733	3.6	323	44.1	
2001	1,107	5.4	541	48.9	
2002	1,763	8.6	828	47.0	
2003	2,309	11.2	1,143	49.5	
2004	2,460	12.0	1,372	55.8	
2005	2,610	12.7	1,501	57.5	
2006	3,630	17.7	2,083	57.4	
2007	4,750	23.1	2,973	62.6	
Region of country					< .001
Northeast	1,601	7.8	977	61.0	
North central	5,178	25.2	2,818	54.4	
South	10,097	49.1	5,664	56.1	
West	3,394	16.5	1,711	50.4	
Plastic surgeon density in patient's state of residence, per 100,000 residents†					< .001
< 1.68	4,737	23.0	2,411	50.9	
1.68 to 2.35	4,429	21.5	2,449	55.3	
2.36 to 3.03	6,892	33.5	3,943	57.2	
≥ 3.04	4,212	20.5	2,367	56.2	
Unknown	290	1.4	140	48.3	
Relationship with employer					.007
Employee	12,035	58.5	6,663	55.4	
Spouse	8,506	41.4	4,643	54.6	
Unknown	19	0.1	4	21.1	
HMO or PPO with capitation					.48
No	16,639	80.9	9,133	54.9	
Yes	3,921	19.1	2,177	55.5	
County-level income quartile					< .001
1st	1,633	7.9	717	43.9	
2nd	2,510	12.2	1,198	47.7	
3rd	4,895	23.8	2,538	51.9	
4th	11,232	54.6	6,717	59.8	
Unknown	290	1.4	140	48.3	
Bilateral mastectomy					< .001
No	17,934	87.2	9,309	51.9	
Yes	2,626	12.8	2,001	76.2	
Breast cancer lymph node surgery					< .001
No	3,650	17.8	2,373	65.0	
Yes	16,910	82.3	8,937	52.9	
Chemotherapy					< .001
No	9,772	47.5	5,926	60.6	
Before surgery	1,981	9.6	955	48.2	
After surgery	8,807	42.8	4,429	50.3	
Radiation					< .001
No	13,689	66.6	8,498	62.1	
Yes	6,871	33.4	2,812	40.9	
Type of reconstruction					< .001
None	9,250	45.0	0	0.0	
Autologous alone	3,676	17.9	3,676	17.9	
Implant alone	3,659	17.8	3,659	17.8	
Autologous and implant	1,638	8.0	1,638	8.0	
Tissue expander alone	2,168	10.5	2,168	10.5	
Not otherwise specified	169	0.8	169	0.8	

Abbreviations: HMO, health maintenance organization; PPO, preferred provider organization.
*χ^2 test.
†Cutpoints were determined using natural breaks in ArcGIS. Density could not be determined for 290 patients whose state of residence could not be determined.



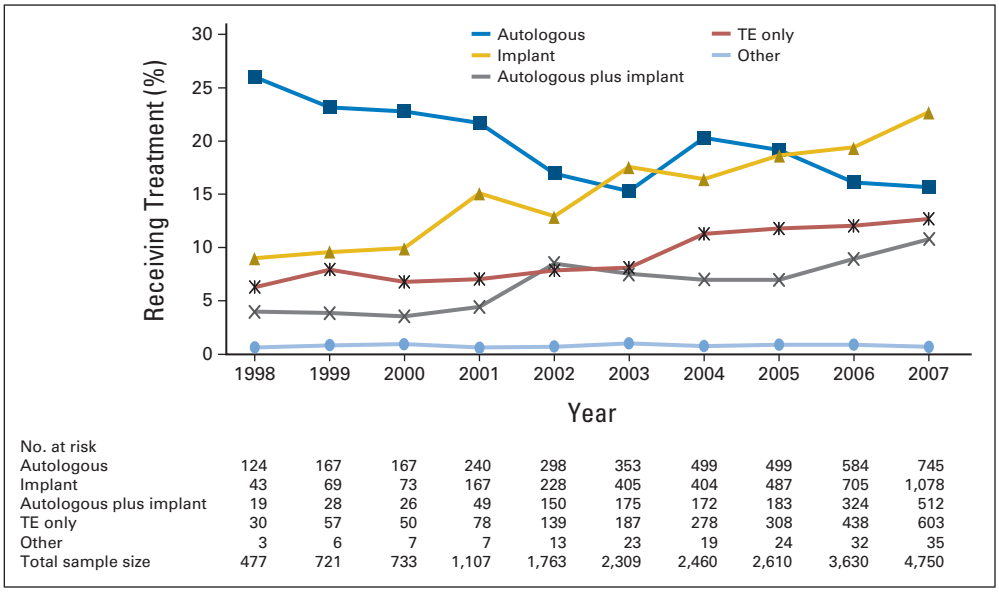
No. at risk										
RT	172	285	294	395	636	898	952	921	1,061	1,257
Bilateral mastectomy	14	27	34	61	276	218	272	321	548	855
Lymph node surgery	414	607	621	894	1,467	1,895	1,992	2,093	3,016	3,911
Any reconstruction	219	327	323	541	828	1,143	1,372	1,501	2,083	2,973
Total sample size	477	721	733	1,107	1,763	2,309	2,460	2,610	3,630	4,750

Fig 1. Time trends in the use of associated treatments in patients undergoing mastectomy for breast cancer, depicting the trends in rates of use of postmastectomy radiation therapy (RT), bilateral mastectomy, lymph node surgery, and breast reconstruction among the breast cancer patients in our sample from the MarketScan claims database.

of the MarketScan cohort over time and was consistently significant in every stratum of age, region, relationship to employer, insurance type, and income, with the exception of the West region. As Figure 2 illustrates, this increase in reconstruction overall was largely driven by increases in the use of implant-based reconstruction. The proportion of patients who received reconstruction with autologous tissue techniques decreased over the time period analyzed, from 56% (124 of 219 patients) in 1998 to 25% (745 of 2,973 patients) in 2007 ($P < .001$).

Table 2 presents a multivariable model of reconstruction receipt. Receipt of reconstruction was significantly associated with the receipt of other treatments associated with mastectomy. Of patients who underwent bilateral mastectomy, 76% (2,001 of 2,626) received reconstruction, and patients undergoing bilateral mastectomy were significantly more likely to receive reconstruction than those undergoing unilateral mastectomy (adjusted odds ratio [OR], 2.3; 95% CI, 2.1 to 2.5; $P < .001$). Patients receiving radiation therapy were less likely to receive reconstruction, with a reconstruction rate of 41% (2,812 of 6,871) in patients who received radiation versus 62% (8,498 of 13,689) in those who did not (adjusted OR, 0.44; 95% CI, 0.41 to 0.47; $P < .001$). Patients who received lymph node surgery were also less likely to undergo reconstruction (adjusted OR, 0.84; 95% CI, 0.77 to 0.91; $P < .001$). There was a significant interaction between age and chemotherapy receipt; older patients were less likely to receive reconstruction overall, as was the case with patients who received chemotherapy, but the negative association of reconstruction receipt with chemotherapy receipt was almost entirely restricted to the youngest patient subgroup.

Figure 3 illustrates dramatic geographic variation in rates of receipt of reconstruction, and there were significant associations between reconstruction use and the density of plastic surgery workforce in each state. Reconstruction rates ranged from a low of 18% (two of 11 patients) in North Dakota to a high of 80% (12 of 15 patients) in



No. at risk										
Autologous	124	167	167	240	298	353	499	499	584	745
Implant	43	69	73	167	228	405	404	487	705	1,078
Autologous plus implant	19	28	26	49	150	175	172	183	324	512
TE only	30	57	50	78	139	187	278	308	438	603
Other	3	6	7	7	13	23	19	24	32	35
Total sample size	477	721	733	1,107	1,763	2,309	2,460	2,610	3,630	4,750

Fig 2. Time trends in the use of different breast reconstruction techniques, depicting the trends in rates of use of various techniques for breast reconstruction (autologous tissue alone, implant-based reconstruction alone, use of both autologous tissue and implants, placement of a tissue expander [TE] only, or other approaches) among the breast cancer patients in our sample from the MarketScan claims database.

Table 2. Multivariable Logistic Model: Predictors of Any Form of Breast Reconstruction

Predictor	OR	95% CI	*P*
Year of diagnosis			
1998	1.00		
1999	1.03	0.79 to 1.34	.83
2000	0.97	0.75 to 1.26	.83
2001	1.15	0.91 to 1.47	.24
2002	0.97	0.77 to 1.22	.77
2003	1.09	0.87 to 1.36	.46
2004	1.48	1.18 to 1.85	**< .001**
2005	1.47	1.18 to 1.83	**< .001**
2006	1.31	1.06 to 1.63	**.01**
2007	1.60	1.29 to 1.99	**< .001**
Plastic surgeon density in patient's state of residence, per 100,000 residents			
< 1.68	1.00		
1.68 to 2.35	1.11	1.01 to 1.22	**.03**
2.36 to 3.03	1.04	0.94 to 1.16	.47
≥ 3.04	1.40	1.20 to 1.63	**< .001**
Relationship with employer			
Employee	1.00		
Spouse	0.90	0.84 to 0.95	**< .001**
County-level income quartile			
1st	1.00		
2nd	1.15	1.00 to 1.32	**.04**
3rd	1.32	1.16 to 1.49	**< .001**
4th	1.70	1.51 to 1.91	**< .001**
Bilateral mastectomy			
No	1.00		
Yes	2.30	2.08 to 2.55	**< .001**
Breast cancer lymph node surgery			
No	1.00		
Yes	0.84	0.77 to 0.91	**< .001**
Radiation			
No	1.00		
Yes	0.44	0.41 to 0.47	**< .001**
Patients who did not receive chemotherapy, age in years			
< 40	1.00		
40-49	0.48	0.37 to 0.61	**< .001**
50-59	0.19	0.15 to 0.25	**< .001**
≥ 60	0.10	0.08 to 0.13	**< .001**
Patients who received chemotherapy, age in years			
< 40	1.00		
40-49	0.61	0.53 to 0.70	**< .001**
50-59	0.29	0.25 to 0.33	**< .001**
≥ 60	0.14	0.12 to 0.18	**< .001**
Chemotherapy among patients age < 40 years			
No	1.00		
Yes	0.62	0.48 to 0.82	.06
Chemotherapy among patients age 40-49 years			
No	1.00		
Yes	0.80	0.71 to 0.90	**.008**
Chemotherapy among patients age 50-59 years			
No	1.00		
Yes	0.93	0.85 to 1.02	**.02**
Chemotherapy among patients age ≥ 60 years			
No	1.00		
Yes	0.88	0.73 to 1.06	.09

NOTE. The final model includes 20,253 patients. Nineteen patients were excluded because of an unknown relationship with employer and 290 because of unknown area-level covariates. Hosmer and Lemeshow *P* value for this model was .24, indicating acceptable goodness of fit. In the overall model, the *P* value for age was < .001, *P* value for chemotherapy was < .001, and the *P* value for the interaction of age with chemotherapy was .01. Boldfaced *P* values indicate significance at < .05.
Abbreviation: OR, odds ratio.

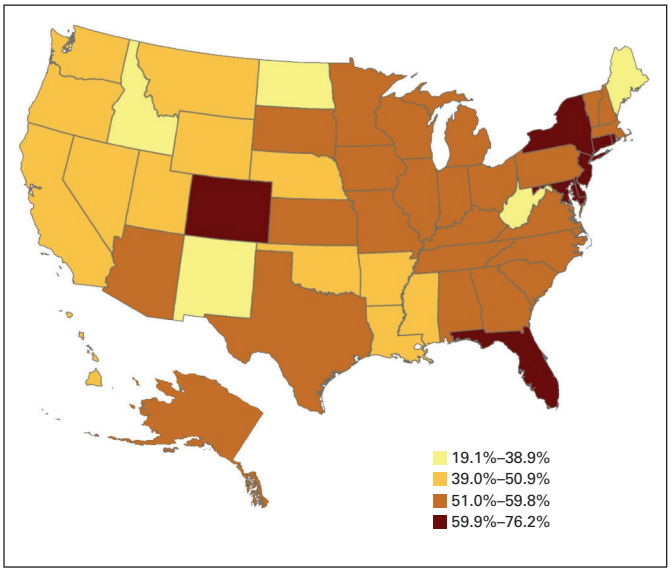


Fig 3. Adjusted receipt of reconstruction for each state in the United States, using final logistic model adjusted for all covariates except for density of plastic surgeons and county-level income. This heat map demonstrates the geographic variability in use of breast reconstruction among the breast cancer patients in our sample from the MarketScan claims database.

Washington, DC. As listed in Table 2, patients living in states with the highest density of plastic surgeons (≥ 3.04 per 100,000 residents) had an adjusted odds ratio of 1.4 of receiving breast reconstruction when compared with patients residing in states with the lowest density (< 1.68 plastic surgeons per 100,000 residents). Rates of receipt of reconstruction also varied significantly based on median household income of the county of residence; with a reconstruction rate of 44% (717 of 1,633 patients) for patients residing in a county with the lowest quartile of income and a reconstruction rate of 60% (6,717 of 11,219 patients) for patients residing in a county with the highest quartile of income (adjusted OR, 1.7; 95% CI, 1.5 to 1.9; $P < .001$).

Among patients undergoing reconstruction, receipt of autologous reconstruction versus implant-based reconstruction was significantly more likely in patients receiving radiation therapy (adjusted OR, 1.8; 95% CI, 1.6 to 2.0; $P < .001$) and less likely in patients who were enrolled in HMOs or capitated PPOs (adjusted OR, 0.7; 95% CI, 0.6 to 0.8; $P < .001$), undergoing bilateral mastectomy (adjusted OR, 0.5; 95% CI, 0.4 to 0.6; $P < .001$), and in the highest income quartile (adjusted OR, 0.7; 95% CI, 0.6 to 0.9; $P = .006$). Delayed reconstruction was performed in 21% of patients who underwent reconstruction (2,421 of 11,310) and was more likely to occur in patients enrolled in HMOs or capitated PPOs (adjusted OR, 1.2; 95% CI, 1.1 to 1.4; $P < .001$) and less likely for patients in the highest income quartile (OR, 0.6; 95% CI, 0.5 to 0.7; $P < .001$).

DISCUSSION

In this large, observational analysis of breast reconstruction utilization in the United States in a commercially insured sample, we observed a strong trend toward increased use of reconstruction over time, with substantial growth in the use of implant-based techniques and decreasing use of autologous reconstruction. We found rates of bilateral

mastectomy to be increasing, and women who received this treatment were highly likely to also receive breast reconstruction. We also found that the use of radiation therapy and lymph node surgery were both negatively associated with receipt of reconstruction. The overall rates of reconstruction receipt observed in this study are higher than in other studies, likely reflecting both the age and insurance status of our sample in contrast with others. Multiple studies have suggested that younger patients and privately insured patients are more likely to receive breast reconstruction than others.[8,22,23] Our study suggests that the majority of insured, working-age patients undergoing mastectomy and the vast majority of patients undergoing bilateral mastectomy now receive reconstruction.

Previous studies have demonstrated wide geographic variability in the use of breast reconstruction. For example, an analysis of Surveillance, Epidemiology, and End Results data from 2000 to 2002 revealed adjusted regional rates to vary more than seven-fold (from a low of 4.5% in Alaska to a high of 34.7% in Atlanta, GA).[11] The current findings suggest that such geographic disparities continue and are associated with workforce distribution of plastic surgeons. The finding that breast reconstruction rates are associated with access to plastic surgeons is particularly concerning in light of a recent survey that revealed many plastic surgeons to be decreasing their volume of breast reconstruction surgeries owing to decreasing levels of reimbursement.[26]

Our findings of an increase in the use of implant-based reconstruction are consistent with the findings from a recent study using the National Inpatient Sample (NIS) database from 1998 to 2008 to evaluate approaches to immediate breast reconstruction. The authors of the NIS analysis noted that their study was limited because autologous techniques might be more likely to be used in patients receiving delayed reconstruction, who could not be ascertained in the database they considered; our current study builds on that work to suggest that even when patients who received delayed reconstruction are included, implant use is rising. Like the current study, the NIS study demonstrated an association of implant techniques with the use of bilateral mastectomy. Preferential use of implants for patients undergoing bilateral mastectomy is understandable because of the ease of achieving symmetry with bilateral implants and the risk of morbidity with bilateral autologous reconstruction. However, like the authors of the NIS study, we find it curious that increasing numbers of patients undergoing unilateral mastectomy are also receiving implant-based reconstruction, given the difficulty of achieving symmetry with this approach and mature data suggesting improved patient satisfaction with autologous techniques.[27,28] This may, in part, be driven by patient preferences for implant-based approaches to minimize acute morbidity, operative time, and hospitalization/recovery time. However, it is noteworthy that autologous approaches are complex and resource-intensive, and surgeons face financial disincentives to pursue them, with one study estimating that surgeons were reimbursed $587 per hour for implants and $322 per hour for autologous reconstructions. This disincentive on the part of surgeons and the difficulties of offering this resource-intensive approach in private office settings may also influence some of the trends observed.[29] Another important factor promoting implant use in the final year of our study may relate to changes in the availability of silicone implants after November 2006. To the extent that silicone implants are believed provide a more natural result and so might be preferred as a closer contender to autologous reconstructions than saline implants, their availability might influence the temporal trends observed at the end of the study period.

The dramatic increase in the use of bilateral mastectomy observed in our study is consistent with other recent studies that have considered population-based datasets and single institution experiences. For example, analyses of Surveillance, Epidemiology, and End Results data have suggested that contralateral prophylactic mastectomy rates increased by more than 150% since 1998, with no indications of a plateau. In general, these observations have generated concern that overly aggressive approaches may be increasing in patients who have little or no expected clinical benefit. One analysis suggested that bilateral mastectomy might be cost-effective, with an incremental cost-effectiveness ratio of $4,689 per quality-adjusted life year gained,[30] but that study failed to include the costs associated with reconstruction. The current findings suggest that because the vast majority of patients receiving bilateral mastectomy also receive breast reconstruction, consideration of those costs in future cost-effectiveness studies would be appropriate.

Our findings of decreased use of lymph node surgery and radiation therapy over time is consistent with a pattern of increasing representation of patients with earlier-stage disease, including ductal carcinoma in situ, in the cohort of patients receiving mastectomy. Of note, patients receiving radiation therapy were considerably less likely to receive reconstruction within 2 years of mastectomy, perhaps reflecting concerns about patient outcomes when radiation and reconstruction are combined. Unfortunately, the quality of the evidence regarding the outcomes of breast reconstruction in the setting of postmastectomy radiation is poor, with most studies having one or more major limitations, such as inclusion of small patient numbers, use of nonstandardized outcomes measures, or failure to consider critical factors known to correlate with surgical complications. The limited evidence that is available does suggest that complication rates may be higher among patients receiving radiation, both in the setting of implants[31-34] and autologous techniques,[35,36] but many patients can successfully undergo both radiation and breast reconstruction when treated with a systematic and carefully considered approach.[37-40] Additional research is necessary to illuminate whether certain approaches to reconstruction are superior when integrated with radiation therapy, so that a substantial proportion of patients are not dissuaded from receiving reconstruction and its important quality of life benefits simply because of their need for radiation to attain optimal tumor control.

Our study has a number of strengths, including its consideration of a large sample of claims-derived data. It also has certain limitations. The sample includes only commercially insured individuals, mostly of working age, whose experiences may differ from individuals with other types of insurance or older age. The cohort itself expanded over time, but analyses reassuringly suggested relative stability in most measurable sociodemographic features and revealed that the increases in receipt of reconstruction appeared temporally unrelated to periods of rapid cohort expansion. Moreover, the temporal trends observed were robustly observed within virtually every sociodemographic stratum, suggesting that these were true changes and not driven by other changes in the beneficiaries sampled over time. There may have been inaccuracies introduced by miscoding, but we used a relatively specific measure to define eligibility (requiring at least two breast cancer diagnosis codes) and a comprehensive list of procedure codes derived from previous studies.[41] Finally, the database we considered lacked

certain information of potential relevance, such as clinical stage and race, which would otherwise have been interesting to explore.

In sum, given the important psychosocial functions of the female breast in human society,[42-44] breast reconstruction is a key consideration in the multidisciplinary management of breast cancer. Previous studies have raised concerns about access to this treatment, but additional data on patterns and correlates of reconstruction use beyond the initial treatment period have been lacking. The observations of our current study regarding trends over time, geographic variability, and correlation with other treatments therefore provide valuable information for clinicians and policy-makers who seek to ensure equitable and appropriate access to this important treatment option.

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:** Reshma Jagsi, Eviti (C) **Stock Ownership:** None **Honoraria:** None **Research Funding:** Reshma Jagsi, AbbVie; Benjamin D. Smith, Varian Medical Systems **Expert Testimony:** None **Patents, Royalties, and Licenses:** None **Other Remuneration:** None

AUTHOR CONTRIBUTIONS

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Financial support: Reshma Jagsi
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Data analysis and interpretation: All authors
Manuscript writing: All authors
Final approval of manuscript: All authors

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Appendix

Table A1. Cohort Creation

Selection Criteria	No. of Included Patients	No. of Excluded Patients
Female breast cancer treated with mastectomy between 1998 and 2007	44,735	
Continuous coverage from 3 months prior through 23 months after mastectomy	24,141	20,594
No diagnosis codes for distant metastasis	21,546	2,595
No radiation administered within 3 months prior to mastectomy	21,101	445
Two or more diagnosis codes for breast cancer or ductal carcinoma in situ from 3 months prior through 12 months after mastectomy	20,560	541

Table A2. Diagnosis and Procedure Codes Used in This Analysis

Diagnosis or Procedure	ICD-9 Diagnosis Codes	ICD-9 Procedure Codes	CPT Codes	Time Interval Relative to Date of Mastectomy
Invasive breast cancer	174.X			−3 through +11 mo
Ductal carcinoma in situ	233.0			−3 through +11 mo
Distant metastasis	196.XX- 199.XX (excluding 196.0, 196.3, 198.2, 198.81)			−3 through +11 mo
Mastectomy		85.4, 85.41-85.48, 85.33, 85.34, 85.35, 85.36	19180, 19182, 19200, 19220, 19240, 19303, 19304, 19305, 19306, 19307	date of mastectomy
Bilateral mastectomy		85.42, 85.44, 85.46, 85.48	19180, 19182, 19200, 19220, 19240, 19303, 19304, 19305, 19306, or 19307 with a modifier of 50	date of mastectomy
Breast cancer lymph node surgery		40.3, 40.23, 40.51, 85.43, 85.45, 85.47	38740, 38745, 38525, 19162, 19200, 19220, 19240, 19302, 19307	−3 through +11 mo
Radiation therapy	V58.0, V66.1, V67.1	92.2, 92.20-92.27, 92.29, 92.3, 92.30-92.39, 92.4, 92.41	77371-77373, 77401-77525, 77761-77799, G0174, G0251, G0339, G0340, G0173, 0082T, 61793, 0182T	−3 through +11 mo
Chemotherapy	V58.1, V66.2, V67.2	99.25	96400-96549, J9000-J9999, Q0083-Q0085, J8520, J8521, J8530, J8540, J8560, J8597, J8610, J8999; the following codes were excluded: J9003, J9165, J9175, J9202, J9209, J9212-J9226, J9240, J9395	−3 through +11 mo
Any reconstruction		85.53, 85.54, 85.33, 85.35, 85.95, 85.70, 85.71, 85.72, 85.73, 85.74, 85.75, 85.76, 85.7, 85.79, 85.86, 85.82, 85.83, 85.84, 85.85, 85.89, 85.86, 85.93, 85.96	19361, 19364, 19366, 19367, 19368, 19369, 19340, 19342, 19357, 19350, 19366, 19350	−0 to +24 mo
Autologous reconstruction		85.70, 85.71, 85.72, 85.73, 85.74, 85.75, 85.76, 85.7, 85.79, 85.84, 85.85	19361, 19364, 19367, 19368, 19369	−0 to +24 mo
Implant reconstruction		85.53, 85.54, 85.33, 85.35	19340, 19342	−0 to +24 mo
Tissue expander		85.95	19357	−0 to +24 mo

Abbreviations: CPT, current procedural terminology; ICD, International Classification of Diseases; mo, months.

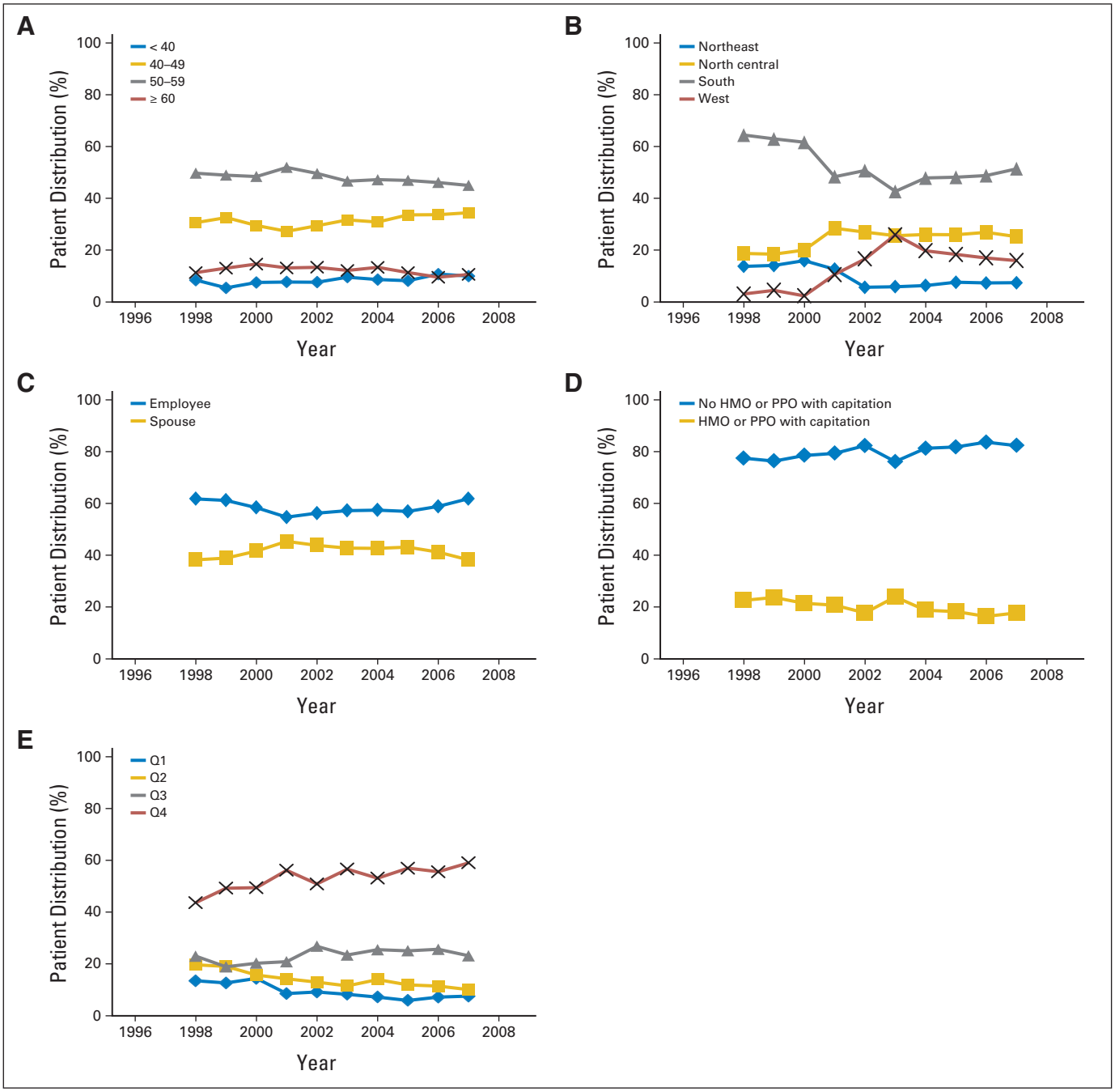

Fig A1. Covariate distributions over time. Given the overall increase in the MarketScan cohort size over time, subsidiary analyses evaluated for stability of covariate distributions in the analytic cohort over time. Trends over time for region and income were statistically significant at $P < .05$, whereas distributions of age, employer relationship, and type of insurance were not. (A) Age at diagnosis; (B) region; (C) relationship to the employer; (D) type of insurance coverage; (E) county-level median income. HMO, health maintenance organization; PPO, preferred provider organization.

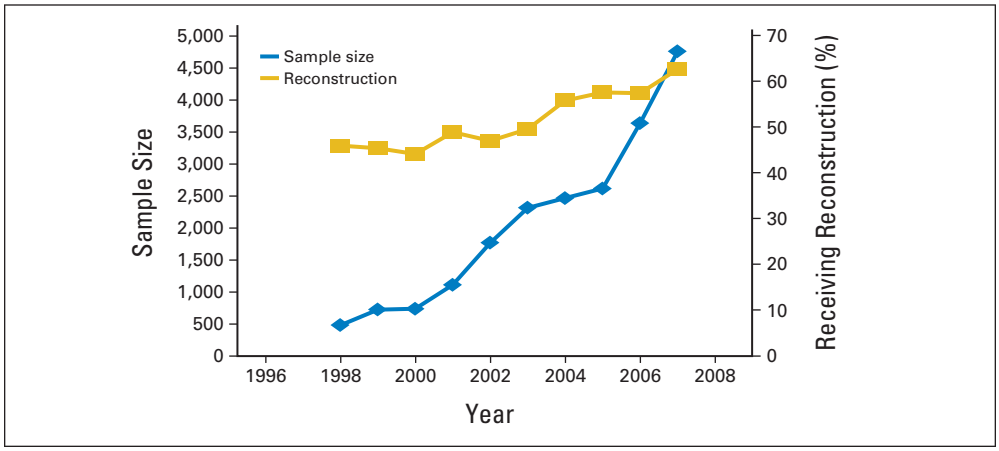

Fig A2. Sample size and percent reconstruction by year, 1998 to 2007, demonstrating changes over time in the sample size of the cohort and also in the percent utilization of reconstruction. As the MarketScan data increased in scope and expanded to include health plan clients, the overall sample size increased substantially. However, the major rise in use of reconstruction occurred between 2003 and 2004, with utilization of reconstruction rising from 50% to 56%. During this time period, the sample size was relatively stable, with 2,309 patients in 2003 and 2,460 patients in 2004, an only 7% relative increase. In contrast, the sample size increased dramatically between 2005 and 2006, rising from 2,610 to 3,630 patients, a 39% increase. However, during this time interval, use of reconstruction was flat, at 58% in 2005 versus 57% in 2006. These observations suggest that the changes in the cohort size were not directly associated with changes in the observed reconstruction rate.

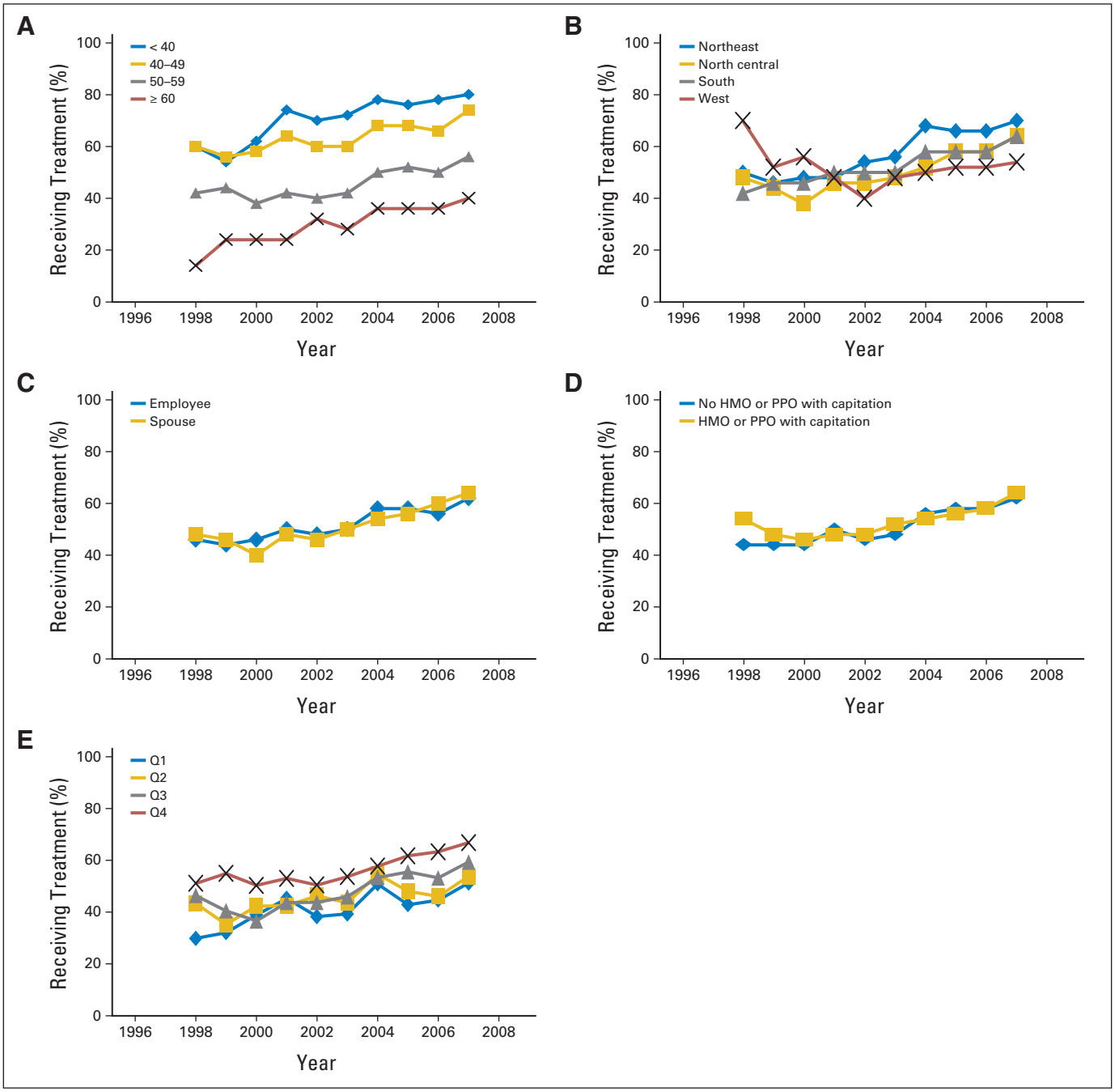

Fig A3. Use of reconstruction over time by covariate strata. Percent use of reconstruction over time was evaluated by (A) age at diagnosis, (B) region, (C) relationship to the employer, (D) type of insurance coverage, and (E) county-level median household income (by quartile, from lowest to highest). There was a significant increase ($P < .05$) in use of reconstruction for all covariate-specific strata evaluated, with the exception of the West region. HMO, health maintenance organization; PPO, preferred provider organization.