Lifetime Costs of Prophylactic Mastectomies and Reconstruction versus Surveillance

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Background: The past decade has seen an increasing prevalence of prophylactic mastectomy with decreasing ages of patients treated for breast cancer. Data are limited on the fiscal impacts of contralateral prophylactic mastectomy trends, and no study has compared bilateral prophylactic mastectomy with reconstruction to surveillance in high-risk patients.

Methods: Lifetime third-party payer costs over 30 years were estimated with 2013 Medicare reimbursement rates. Costs were estimated for patients choosing contralateral or bilateral prophylactic mastectomy versus surveillance, with immediate reconstructions using a single-stage implant, tissue expander, or perforator-based free flap approach. Published cancer incidence rates predicted the percentage of surveillance patients that would require mastectomies. Sensitivity analyses were conducted that varied cost growth, discount rate, cancer incidence rate, and other variables. Lifetime costs and present values (3 percent discount rate) were estimated.

Results: Lifetime prophylactic mastectomy costs were lower than surveillance costs, $1292 to $1993 lower for contralateral prophylactic mastectomy and $15,668 to $21,342 lower for bilateral prophylactic mastectomy, depending on the reconstruction. Present value estimates were slightly higher for contralateral prophylactic mastectomy over contralateral surveillance but still cost saving for bilateral prophylactic mastectomy compared with bilateral surveillance. Present value estimates are also cost saving for contralateral prophylactic mastectomy when the modeled contralateral breast cancer incidence rate is increased to at least 0.6 percent per year.

Conclusions: These findings are consistent with contralateral and bilateral prophylactic mastectomy being cost saving in many scenarios, regardless of the reconstructive option chosen. They suggest that physicians and patients should continue to receive flexibility in deciding how best to proceed clinically in each case. (*Plast. Reconstr. Surg.* 136: 730e, 2015.)

As observed nationally, our institution has seen a significant increase in the number of prophylactic mastectomy procedures. Over the past decade, we observed a 260 percent increase in bilateral breast reconstructions, particularly because of prophylactic mastectomies in high-risk patients.[1] Patients pursuing surgery are now on average 6 years younger at our institution than a decade ago. Nationwide, patients are increasingly considering risk-reducing mastectomies and trying to better determine their cancer risks. Those undergoing bilateral prophylactic mastectomy are often *BRCA* mutation carriers, whereas those undergoing contralateral prophylactic mastectomy are often simply sporadic unilateral breast cancer patients. Data are needed for physicians and policy makers to understand the

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fiscal impacts of prophylactic mastectomies and breast reconstructions on our health care system. With an estimated 232,430 diagnoses of breast cancer in 2013, up to 10 percent of which are in *BRCA* mutation carriers, the economic implications of prophylactic mastectomy carry significant weight.[2] This topic is timely for many health care providers and policy makers. Given the dearth of data comparing the lifetime costs of surveillance versus contralateral or bilateral prophylactic mastectomy with immediate reconstruction, we aim to estimate their financial implications. Of those studies that evaluated contralateral and bilateral prophylactic mastectomy costs in some way previously, many have concluded that risk-reduction operations can be cost-saving. Since the Women's Health and Cancer Rights Act of 1998, breast reconstruction costs of both breasts, including the opposite breast if performed for symmetry, are covered by third-party payers. Therefore, understanding the fiscal impact of this coverage has become increasingly timely.

Contralateral prophylactic mastectomies were previously evaluated by Zendejas et al., who calculated a cost of $4869 per quality-adjusted life-year.[3] Values below $50,000 per quality-adjusted life-year have traditionally been accepted as cost-effective. A recent cost-utility study also estimated that the average patient undergoing contralateral prophylactic mastectomy would spend $279 less than those pursuing surveillance over 38 years, but estimated that there would be 0.2 quality-adjusted life-year lost, leading to a slightly suboptimal outcome.[4] The study assumed that some of the patients would undergo reconstruction. A retrospective study comparing 24 months of costs after contralateral prophylactic mastectomy and no contralateral prophylactic mastectomy, using claims data, found that among its subset of patients, contralateral prophylactic mastectomy was more expensive, with a mean difference of $6528 between the two groups for immediate contralateral prophylactic mastectomy.[5] However, the retrospective analysis included delayed contralateral prophylactic mastectomy also, and reconstructions occurring within 6 months of the mastectomy were considered immediate, so the model may lead to different conclusions if therapeutic mastectomy and contralateral prophylactic mastectomy were performed on the same day.

One cost-utility study reached the conclusion that bilateral prophylactic mastectomy with bilateral salpingo-oophorectomy costs as little as $100 per quality-adjusted life-year gained.[6] Bilateral prophylactic mastectomy with bilateral salpingo-oophorectomy had a survival advantage in another study, increasing quality-adjusted life-years with a maximum cost of $1277 per quality-adjusted life-year.[7] Bilateral prophylactic mastectomy and bilateral salpingo-oophorectomy were even estimated to be cost-saving compared with tamoxifen chemoprevention or regular surveillance.[8] When factoring in indirect costs and productivity gains, bilateral prophylactic mastectomies are thought to realize greater cost savings.[9]

Among the contralateral prophylactic mastectomy studies, only one evaluated lifetime costs and reconstructive options, but did not include the growing use of single-stage implant reconstruction as an option, whereas none of the bilateral prophylactic mastectomy studies even considered the reconstructive options in the lifetime cost estimates.[4] Given that patients have different reconstructive preferences that impact their quality of life, appropriate follow-up, likelihood of reoperation, and lifetime cost estimates, it is critical to evaluate the mastectomies and reconstructions concurrently. In addition, to fully evaluate the economic impact of each choice, it is also important to estimate the present value of those costs. To do so, future costs must be discounted at a specific percentage annually to account for the time value of money, including its annual interest-earning potential in other investments. Present values are necessary in all resource allocation decisions.

This study estimates the lifetime costs and present values of surveillance versus prophylactic mastectomies among different reconstruction methods. Furthermore, we estimated the lifetime fiscal implications of the increasing use of prophylactic mastectomy in high-risk patients. We hypothesized that the increased initial costs of prophylactic mastectomies would lead to potential cost savings by reducing the need for additional future screening and treatments.

PATIENTS AND METHODS

Reimbursements

This study has been reviewed and approved by the Massachusetts General Hospital Institutional Review Board. Physician, anesthesia, hospital, and ambulatory surgery center Medicare reimbursements were used to estimate the lifetime third-party payer costs per patient of choosing surveillance or prophylactic mastectomy, for patients with a recent diagnosis of unilateral breast cancer considering contralateral prophylactic mastectomy or for *BRCA* gene carriers

considering bilateral prophylactic mastectomy. Patients that underwent therapeutic or prophylactic mastectomy were modeled to undergo immediate breast reconstruction with either single-stage implant, expander, or abdominal perforator free flap [deep inferior epigastric perforator (DIEP)] reconstruction. For contralateral groups, only marginal reimbursements beyond the expected current and future treatment costs for unilateral breast cancer were considered. Physician reimbursements were estimated using Medicare's publicly available fee schedules, using Current Procedural Terminology and Healthcare Common Procedure Coding System codes.[10] The same codes were also used to look up costs of acellular dermal matrices and implants. Medicare's national index reimbursement level was used. All reimbursements are in 2013 U.S. dollars. Anesthesia reimbursements were estimated using base units, time units, and the 2013 conversion factor ($21.92). Reimbursement rate was estimated with the following formula: 2013 conversion factor × (base units + time units). Hospital reimbursements were based on the Acute Care Hospital Inpatient Prospective Payment System using Diagnosis-Related Group codes. Each reimbursement is based on the 2013 Federal Operating Base Payment Rate ($5348.76), 2013 Federal Capital Base Payment Rate ($425.49), and the Diagnosis-Related Group Relative Weights for each hospital admission.[11] Each Diagnosis-Related Group encapsulates a group of hospitalizations expected to have similar resource use and equal reimbursement.[12] The Outpatient Prospective Payment System was used to model appropriate follow-up procedures in ambulatory surgery centers. Billing codes used are listed in Table 1. Given the variability in billing for chemotherapy and irradiation, their reimbursement costs were estimated using previously published figures.[13] End-of-life costs and indirect costs were not estimated.

Cost Models

Twelve cost models were constructed, with each model measuring either contralateral or bilateral patients, starting with surveillance or risk reduction, and ultimately choosing to reconstruct their breasts with a direct-to-implant, tissue expander, or DIEP flap–based approach. Decision tree models were built for each group. A weighted cash flow analysis was created for each tree, using the probabilities of each event to determine how much the cost or present value of each event contributed to the weighted averages. Each surveillance group had its respective estimate of the percentage of patients who would require mastectomy, based on published cancer incidence rates.[3,14] Each group had its appropriate screening, preoperative workup, procedures, follow-up care, and revisions modeled using the National Comprehensive Cancer Network guidelines.[15–17] For situations without established guidelines, our institution's standard of care was used. We modeled patients considering contralateral prophylactic mastectomy that met high-risk criteria (20 percent lifetime risk of breast cancer with risk models) that make it appropriate to choose contralateral prophylactic mastectomy. Decision trees spanned 30 years at 5-year intervals (Fig. 1). Assumptions were as follows: prophylactic mastectomy patients underwent surgery in year 1. Each group's rate of reoperation for complications, aesthetic revisions, and implant exchanges were modeled long term based on literature estimates. All mastectomies were skin-sparing, and reconstructions included nipple-areola complex reconstruction. Follow-up procedures were completed in ambulatory surgery centers. Recurrences were treated with excision and irradiation if the patient had not previously received it. Breasts that developed cancer with prior prophylactic mastectomy were reconstructed with tissue expanders. Risk of death caused by breast cancer was built into the model. All assumptions are presented in Tables 2 and 3.[18–31]

The Medical Care Services Index, the component of the Consumer Price Index that includes professional health services and hospital services, was used to estimate the yearly inflation-adjusted growth rate in reimbursements.[32] The yearly inflation-adjusted reimbursement increase averaged 1.63 percent from 2003 to 2013; thus, an estimate of 1.5 percent was used in our baseline models.[33] An annual 3 percent discount rate was then applied to calculate the present value of reimbursements over 30 years.

Sensitivity Analysis

The annual inflation-adjusted reimbursement growth rate was varied from 0 to 3 percent. The discount rate was varied from 0 to 7 percent, as is the standard.[34] Another sensitivity analysis was also performed that simultaneously varied many of the inputs that could lower the price of surveillance compared with prophylactic mastectomy, to assess how the cost differences would change in scenarios more favorable for surveillance.

Table 1. Billing Codes Used for Cost Modeling

	Code
Surveillance and follow-up*	
Office visit	99214
Computer-aided detection with physician review; diagnostic	77051
Computer-aided detection with physician review of mammogram	77052
Mammography, unilateral	77055
Mammography, bilateral	77056
Screening mammography, bilateral, two-view film study of each breast	77057
Unilateral breast MRI	77058
Bilateral breast MRI	77059
Workup*	
Breast biopsy, needle core, using imaging guidance	19102
Breast biopsy, automated vacuum-assisted device, with imaging guidance	19103
Placement of percutaneous localization clip	19295
MRI guidance for needle placement, radiologic supervision and interpretation	77021
Mammographic guidance for needle placement, breast, each lesion, radiologic supervision and interpretation	77032
Level IV: surgical pathology, gross and microscopic examination (breast biopsy)	88305
Level V: surgical pathology examination (mastectomy)	88307
Level VI: surgical pathology examination (mastectomy with regional lymph nodes)	88309
Immunohistochemistry (for each antibody)	88342
Comprehensive metabolic panel	80053
CBC, automated, and differential WBC count	85025
Imaging*	
Chest CT	71260
Abdominal/pelvic CT	74177
Bone scan (tomographic SPECT)	78320
Surgery*	
Acellular dermal matrix	15777
Excision of chest wall tumor (for recurrence)	19260
Mastectomy	19304
Immediate insertion of breast prosthesis in reconstruction	19340
Delayed insertion of prosthesis in breast reconstruction	19342
Nipple reconstruction	19350
Breast reconstruction with TE, including subsequent expansion	19357
Breast reconstruction with free flap	19364
Revision of reconstructed breast	19380
Lymphangiography for node identification	38792
Biopsy or excision of nodes	38525
Axillary dissection	38745
Implant	L8600
Replacement of expander with implant	11970
Areolar tattoo	11922
Anesthesia†	
Anesthesia for procedures on anterior trunk, not otherwise specified	00400
Anesthesia for breast reconstruction	00402
Anesthesia for mastectomy	00404
Anesthesia for mastectomy with node dissection	00406
Hospitalizations‡	
Other breast procedures without major complications	581
Mastectomy with complications	582
Mastectomy without complications	583

CPT, Current Procedural Terminology; MRI, magnetic resonance imaging; CBC, complete blood count; WBC, white blood cell; CT, computed tomography; SPECT, single photon emission computed tomography; TE, tissue expander; HCPCS, Healthcare Common Procedure Coding System; DRG, Diagnosis-Related Group.
*Current Procedural Terminology code.
†Current Procedural Terminology/Healthcare Common Procedure Coding System code.
‡Diagnosis-Related Group code.

RESULTS

Lifetime Reimbursements

In patients with unilateral breast cancer, lifetime costs (1.5 percent growth, 0 percent discount rate) were higher by $1292 to $1993 in surveillance versus contralateral prophylactic mastectomy, whereas present value (1.5 percent growth, 3 percent discount rate) was $132 to $601 less expensive in surveillance than with contralateral prophylactic mastectomy. Patients considering bilateral prophylactic mastectomy had a wider variability in their totals. Lifetime costs were higher for surveillance than for bilateral prophylactic mastectomy patients, ranging from $15,668 to $21,342 more throughout each patient's life. In

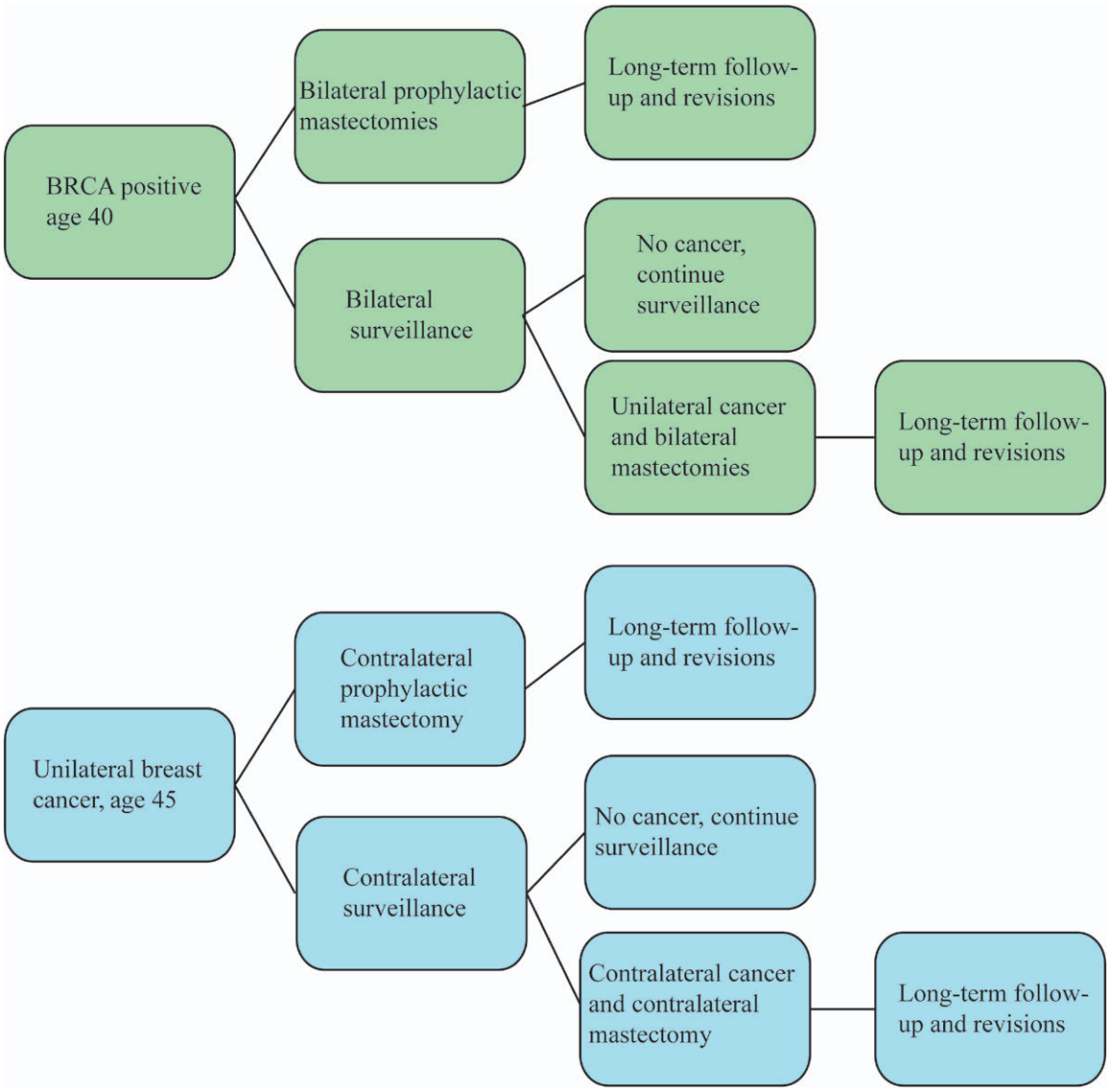

Fig. 1. Simplified decision tree models. The first model follows *BRCA* mutation carriers considering bilateral prophylactic mastectomy from age 40 years. The second model follows unilateral breast cancer patients from age 45 years considering contralateral prophylactic mastectomy. Patients choose surveillance or prophylactic mastectomy of remaining breasts. Prophylactic mastectomy patients undergo surgery in the first year and postoperative follow-up, necessary revisions, and treatment for recurrences. Surveillance patients receive regular screening as recommended by the National Comprehensive Cancer Network guidelines of the intact breast(s). For every 5-year interval, a percentage of surveillance patients remain cancer free. Others develop cancer in a previously unaffected breast and require therapeutic mastectomy with appropriate follow-up. All patients after therapeutic or prophylactic mastectomy are modeled to receive immediate implant, expander, or DIEP reconstruction.

present-value terms, bilateral prophylactic mastectomy would save between $4835 and $8003 compared with surveillance.

Sensitivity Analysis

Sensitivity analysis of the discount rate and the growth rate is presented in Tables 4 and 5. For contralateral prophylactic mastectomy patients, contralateral prophylactic mastectomy was cost-saving when comparing lifetime costs across all growth rates, but was generally slightly more expensive when the discount rate was not 0 percent. However, both lifetime cost and present-value terms were cost-saving for contralateral prophylactic mastectomy if the predicted incidence of developing breast cancer in the contralateral breast was 0.6 percent per year or higher. For *BRCA* patients, lifetime costs and present

Table 2. Shared Model Assumptions

	Baseline Analysis	Sensitivity Analysis	References
Common to all patients			
Starting age			
Contralateral patients with unilateral cancer	45 yr		
Bilateral patients with *BRCA* gene	40 yr		
Modeling intervals	5 yr		
Survival after cancer (years after diagnosis, % alive): 5 (89%), 10 (78%), 15 (72%), 20 (67%), 25 (65%), 30 (63%)			27, 28
Cost per person requiring neoadjuvant or adjuvant chemotherapy	$6444	$3000	13
Cost per person requiring radiation therapy	$5940	$2000	13
Procedure			
Hospital admission for skin-sparing mastectomies of remaining breasts	—	—	
Lymphangiography with SLNB: % of patients receiving it	100%	—	
Immediate reconstruction with implant, expander, or DIEP	—	—	
Acellular dermal matrix for single-stage implant reconstructions	—	—	
Implant for implant and expander-based reconstructions	—	—	
Expander reconstructions: expander-to-implant exchange at 6 mo postoperatively	—	—	
% of patients receiving NAC reconstruction and tattoo	100%	—	
Long-term follow-up			
Plastic surgeon visits in first year			
Direct-to implant: weekly × 3, 3 mo, annual	5	—	
Expander: weekly × 8, 6 mo, 3 after implant exchange	12	—	
DIEP: weekly × 4, 6 wk, 3 mo, 6 mo, annual	8	—	
Annual plastic surgeon visits after first year	1	—	
Follow-up procedures done in ASC	—	—	
Implant and expander reoperations in first 3 yr	—	—	29
Irradiated patients undergoing reoperations	45.4%	20.0%	
Nonirradiated patients undergoing reoperations	21.2%	5.0%	
Annual reoperation rate starting yr 4 for implant and expander reconstruction	7.2%	—	30
DIEP reoperations: radiation does not affect reoperation rate	—	—	29
% of patients undergoing reoperation in yr 1	34.0%	20.0%	31
% of patients undergoing reoperation in yr 2	30.0%	15.0%	31
% of patients undergoing reoperation in yr 3	29.0%	10.0%	31
% of patients undergoing reoperation in yr 4	8.0%	5.0%	31
% of patients undergoing reoperation in yr 5	5.0%	0.0%	31
DIEP revision rates after yr 5	0.0%	0.0%	
Drop in frequency of biopsies	90.0%	—	32
Drop in frequency of cancer after mastectomy	90.0%	—	
Annual MRI screen for implant rupture in patients with implants	0	0.5	
Common to all surveillance patients			
After cancer diagnosis			
Preoperative office visits	2	—	
Diagnostic mammogram, basic laboratory tests	—	—	
Patients at stage III on diagnosis: chest CT, abdominal CT, bone scan	7.4%	5.0%	33, 34
Neoadjuvant chemotherapy: % of patients receiving it	49.0%	10.0%	Institutional data
Procedure			
Axillary dissection for positive SLNB or clinically evident nodes: % of patients receiving it	10.0%	3.0%	
Surgical pathology and immunohistochemistry	—	—	
Irradiation: % of patients receiving it	25.0%	10.0%	35, 36
Adjuvant chemotherapy: % of patients receiving it	18.2%	3.0%	37
Common to all prophylactic mastectomy patients			
Procedure			
Axillary dissection for positive SLNB or clinically evident nodes: % of patients receiving it	5.0%	0.0%	
Surgical abnormality	—	—	
Immunohistochemistry: % of patients with DCIS or cancer	7.0%	—	Institutional data
Irradiation: % of patients receiving it for prophylactic breast	3.0%	—	Institutional data
Adjuvant chemotherapy: % of patients receiving it for prophylactic breast	3.0%	—	Institutional data

ASC, ambulatory surgery center; DCIS, ductal carcinoma in situ; NAC, nipple-areola complex; SLNB, sentinel lymph node biopsy; MRI, magnetic resonance imaging; CT, computed tomography.

values for bilateral prophylactic mastectomy were lower than for surveillance. Trends observed for both models were that as discount rate increased and growth rate decreased, the more favorable surveillance would be relative to prophylactic mastectomy, and vice versa. The other sensitivity analysis involved changing multiple variables in each model simultaneously, and is presented in

Table 6. The variables changed are included in Tables 2 and 3. Even after all simultaneous variable changes, the lifetime costs of contralateral patients remained higher for surveillance and the present values remained lower. In the bilateral patients, lifetime costs remained lower but the present value of DIEP reconstruction is the only reconstructive option that remained less expensive than its surveillance counterpart.

DISCUSSION

Patients increasingly seek more proactive ways of reducing their risk of breast cancer. In patients with lobular carcinoma in situ, a risk marker for breast cancer, the rate of bilateral prophylactic mastectomy has recently increased by 50 percent.[35] More information is needed regarding the impacts of prophylactic mastectomy trends on lifetime costs of treatment. To our knowledge, this analysis is unique in estimating the lifetime costs of contralateral prophylactic mastectomy with direct-to-implant reconstruction, as prior work has reported the cost only of staged implant reconstruction. Furthermore, we report on the impact of reconstruction on lifetime bilateral prophylactic mastectomy costs. Our results suggest that contralateral and bilateral prophylactic mastectomies with immediate reconstruction may be cost-saving throughout a lifetime, and comparable in present-value terms. Contralateral prophylactic mastectomies become cost-saving in present-value terms when the incidence of contralateral breast cancer exceeds 0.6 percent per year, which suggests that for high-risk patients, prophylactic mastectomies do not increase the fiscal impact of health care.

For contralateral prophylactic mastectomy patients, most of the necessary testing, office visits, and hospitalizations can be performed when treating the unilateral malignancy, making the simultaneous treatment of the contralateral breast more inexpensive than treatment of the index breast. Only a few additional costs have to be added to the already expected treatment costs for unilateral mastectomy. Meanwhile, contralateral surveillance leads to separate hospitalizations, anesthesia, and operations if contralateral cancer develops. Therefore, although only a small percentage of patients develop contralateral cancer, the difference in cost of simultaneous contralateral prophylactic mastectomy versus separate hospitalizations and procedures for contralateral breast cancer treatment makes the average cost per patient for both comparable. For patients that decide to pursue a contralateral prophylactic mastectomy after a prior therapeutic mastectomy, these cost estimates do not apply, as separate hospitalizations and operations add significantly to the estimates. In bilateral prophylactic mastectomy, the savings incurred after risk reduction were mostly through the avoidance of future yearly magnetic resonance imaging scans and mammograms that all high-risk patients face, and the significantly lower likelihood of requiring radiation therapy and chemotherapy after bilateral prophylactic mastectomy than after therapeutic mastectomy.

These findings further corroborate the findings in prior studies that contralateral prophylactic mastectomy and bilateral prophylactic mastectomy can both be comparable in cost to surveillance. Perhaps most different from prior estimates is the cost of mastectomy with free flap reconstruction, which in our study was only $24,408 but in prior estimates has been as high as $56,205.[36] A large part of the difference is likely because that study used mostly private insurance claims made for breast reconstruction, which often have reimbursement rates significantly higher than those of Medicare. In addition, the patients included in the study were not necessarily prophylactic mastectomy patients, and therefore had higher rates of radiation therapy, among other cost-intensive measures. The reality is likely between these two estimates.

If efforts to diminish the cost growth of health care are effective, as the sensitivity analysis shows, surveillance would become less expensive relative to prophylactic mastectomy. Long-term costs of surveillance and prophylactic mastectomy are similar because prophylactic mastectomies diminish the need for future magnetic resonance imaging scans, mammograms, biopsies, and higher cost therapeutic mastectomies. Patients undergoing therapeutic mastectomies are also more likely to undergo radiation therapy and revisions.[37] However, both the positive and negative effects of prophylactic mastectomy on quality of life must be considered. Prophylactic mastectomies increase the likelihood of being eligible for nipple-sparing mastectomy, which can improve aesthetic results and patient satisfaction after surgery.[38] Younger patients after bilateral prophylactic mastectomy also rarely need chemotherapy. Nonetheless, prophylactic mastectomies may result in poor outcomes, decreased sexual functioning, and postmastectomy pain syndromes, which must be discussed openly with patients.[39] In addition, some patients can alternatively reduce their breast

Table 3. Specific Model Assumptions

	Baseline	Sensitivity Analysis	References
Contralateral surveillance after unilateral mastectomy			
Before cancer diagnosis			
Additional breast examinations per year	1	—	17
No. of average biopsies before each positive cancer diagnosis	4	—	38
Annual % of patients who develop CBC	0.4%	—	39, 40
Additional annual mammograms*	0	—	16
Long-term follow-up			
Oncologist: additional visits per year for first 5 yr	1	—	17
Additional mammograms per year over those scheduled for prior breast*	0	—	17
Plastic surgeon: additional visits per year starting yr 2*	0	—	
Reoperations assumed to take place at same time as original breast revisions	—	—	
Contralateral prophylactic mastectomy			
Preoperative			
Additional preoperative office visits*	1	—	
No additional laboratory tests	—	—	
Procedure			
Done during same operation for unilateral mastectomy			
Long-term follow-up			
Additional yearly mammograms*	0	—	15
Implant exchanges occur at same time as other breast	—	—	
Plastic surgeon: additional visits per year starting yr 2	0	—	
Additional operations*	0	—	
Patients who develop cancer after prior PM undergo expander reconstruction			
BRCA patients bilateral surveillance			
Before cancer diagnosis			
Age 25 onward: Breast examination every 6 mo, annual screening mammogram and MRI	—	—	
Average no. of biopsies before each positive cancer diagnosis	4	—	38
5-yr conditional probability of cancer-free *BRCA* patient developing cancer	—	—	14
Year 40–45	18.7%	—	
Year 45–50	12.0%	—	
Year 50–55	12.0%	—	
Year 55–60	5.3%	—	
Year 60–65	4.0%	—	
Year 65–70	2.7%	—	
Long-term follow-up			
Oncologist: 2 annual visits first 5 yr, 1 annual visit after	—	—	17
Annual mammograms	1	—	16
BRCA patients bilateral prophylactic mastectomies			
Preoperative			
Preoperative office visits	2	—	
Basic laboratory tests	—	—	

CBC, contralateral breast cancer; PM, prophylactic mastectomy; MRI, magnetic resonance imaging.
*"Additional" refers to services, tests, or spending additional to what was already scheduled for the unilateral cancer treatment.

cancer risk by 50 percent with tamoxifen instead of surgery.

The modeling of Medicare's lifetime reimbursements for each group has multiple limitations. As is true of all models, ours are simplified versions of reality. We attempted to create models that represent the average patient, but given the variability in the procedures, rates of reoperation, and other factors, it is impossible to represent them perfectly. For example, when a patient is admitted for a DIEP free flap reconstruction, the length of stay is 2 to 3 days longer on average than for implant or expander reconstructions, but that difference is not captured by the Diagnosis-Related Group code used for mastectomies. Therefore, in reality, the costs of DIEP reconstructions are underestimated in our model. Terminal life costs, which can be over $70,000 in the last 6 months of life, were not included.[40] We took the third-party payer's perspective, not the societal perspective, which would include indirect costs and is the ideal method of calculation. Another component not covered that would benefit from further study is patient preference, to better inform us about cost utility through quality-adjusted life-year impacts. Finally, the rates of revisions, complications, chemotherapy, and other factors may vary from the rates found in the literature. Our sensitivity analyses, which show the prophylactic mastectomies to be at least

Table 4. Unilateral Breast Cancer Patients Considering Contralateral Prophylactic Mastectomy versus Surveillance

Growth*	Decision	Reconstruction	Discount Rates		
			0%	3%	7%
0%	Surveillance	Implant	$4269	$2701	$1630
		Expander	$4547	$2874	$1733
		DIEP	$4548	$2866	$1721
	Prophylaxis	Implant	$4104	$3905	$3744
		Expander	$4166	$3968	$3807
		DIEP	$3814	$3684	$3598
1.50%	Surveillance	Implant	$5435	$3338	$1948
		Expander	$5795	$3555	$2072
		DIEP	$5807	$3552	$2062
	Prophylaxis	Implant	$4142	$3939	$3772
		Expander	$4205	$4001	$3835
		DIEP	$3814	$3684	$3598
3%	Surveillance	Implant	$7019	$4181	$2352
		Expander	$7493	$4458	$2505
		DIEP	$7519	$4462	$2497
	Prophylaxis	Implant	$4183	$3974	$3801
		Expander	$4246	$4037	$3864
		DIEP	$3814	$3684	$3598

*Growth denotes annual rise in prices after adjusting for inflation.

comparable in cost even in surveillance-favoring scenarios, provide further evidence that our models reach reasonable estimates. These estimates are mostly applicable to hospitals and regions where immediate reconstruction with at least one of the modeled options is available.

We chose to model costs based on the national index reimbursement rate for Medicare for multiple reasons. First and foremost, given that most private insurance companies benchmark their reimbursement rates using the relative value units produced by Medicare, it is a common denominator in terms of cost. Although the absolute values may differ significantly between Medicare and private payers, the relative reimbursement differences between procedures within Medicare and any private payer should be proportional. Moreover, we felt that Medicare reimbursement rates would be more representative of the true resource costs, whereas private insurance reimbursements are more likely aligned with hospital charges but not necessarily resource costs. Given the significant variability in reimbursement by region, insurance company, and hospital, we wanted to choose a source of cost estimates that would estimate more accurately the national fiscal impact, if not in absolute value, then at least in relative value. Therefore, these results should be interpreted more in terms of their relative impact on fiscal health care spending than as representative

Table 5. Bilateral *BRCA* Patients Considering Bilateral Prophylactic Mastectomy versus Surveillance

Growth*	Decision	Reconstruction	Discount Rates		
			0%	3%	7%
0%	Surveillance	Implant	$36,817	$24,221	$15,250
		Expander	$38,409	$25,318	$15,970
		DIEP	$37,451	$24,820	$15,726
	Prophylaxis	Implant	$25,822	$21,065	$17,851
		Expander	$28,946	$24,087	$20,761
		DIEP	$23,790	$21,166	$19,172
1.50%	Surveillance	Implant	$46,491	$29,696	$18,102
		Expander	$48,443	$31,012	$18,945
		DIEP	$47,082	$30,326	$18,629
	Prophylaxis	Implant	$29,592	$23,106	$18,851
		Expander	$32,775	$26,177	$21,802
		DIEP	$25,739	$22,323	$19,825
3%	Surveillance	Implant	$59,415	$36,817	$21,682
		Expander	$61,834	$38,409	$22,675
		DIEP	$59,884	$37,451	$22,256
	Prophylaxis	Implant	$34,734	$25,822	$20,136
		Expander	$37,977	$28,946	$23,131
		DIEP	$28,298	$23,790	$20,618

*Growth denotes annual rise in prices after adjusting for inflation.

Table 6. Multivariable Sensitivity Analysis

	Contralateral		Bilateral	
	Sum	PV	Sum	PV
Surveillance				
Implant	$4746	$2919	$44,843	$28,144
Expander	$5107	$3137	$46,748	$29,427
DIEP	$5010	$3074	$42,152	$27,037
Prophylaxis				
Implant	$3390	$3274	$39,050	$28,187
Expander	$3453	$3337	$42,161	$31,187
DIEP	$3466	$3368	$22,861	$20,001

PV, present value.

of the actual amount per procedure or treatment course, which will continue to vary significantly based on many factors. Admittedly, the best way to estimate the relative fiscal impact of these trends would involve actual reimbursement rates for large samples of patients, over at least 5 to 10 years, and across multiple centers and geographic regions. Any shorter term study would be unlikely to capture any cost savings, as the upfront costs of risk reduction take years to balance.

This study's results support continuing to give patients the flexibility to opt for contralateral and bilateral prophylactic mastectomy, and the flexibility to choose the reconstructive option that best fits their needs. We believe that governments and other third-party payers should continue to cover these options for patients and clinicians, as this study suggests that prophylactic mastectomy may even be cost-saving versus surveillance, and therefore likely does not increase the fiscal burden of health care. Prophylactic mastectomy remains a very difficult and personal decision for many patients, as it has many physical and psychological implications, and should only be appropriately weighed by each individual patient with counsel from her physician. As providers, we should also be armed with these data when advocating for our patients in this time of cost containment and frequent health care reforms.

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