Cost Comparison of Mastectomy Versus Breast-Conserving Therapy for Early-Stage Breast Cancer

William E. Barlow, Stephen H. Taplin, Cathleen K. Yoshida, Diana S. Buist, Deborah Seger, Martin Brown

Background: Choice of treatment for early-stage breast cancer depends on many factors, including the size and stage of the cancer, the woman’s age, comorbid conditions, and perhaps the costs of treatment. We compared the costs of all medical care for women with early-stage breast cancer cases treated by breast-conserving therapy (BCT) or mastectomy.

Methods: A total of 1675 women 35 years old or older with incident early-stage breast cancer were identified in a large regional nonprofit health maintenance organization in the period 1990 through 1997. The women were treated with mastectomy only (n = 183), mastectomy with adjuvant hormonal therapy or chemotherapy (n = 417), BCT with radiation therapy (n = 405), or BCT with radiation therapy and adjuvant hormonal therapy or chemotherapy (n = 670). The costs of all medical care for the period 1990 through 1998 were computed for each woman, and monthly costs were analyzed by treatment, adjusting for age and cancer stage. All statistical tests were two-sided.

Results: At 6 months after diagnosis, the mean total medical care costs for the four groups differed statistically significantly (P<.001), with BCT being more expensive than mastectomy. The adjusted mean costs were $12987, $14309, $14963, and $15779 for mastectomy alone, mastectomy with adjuvant therapy, BCT plus radiation therapy, and BCT plus radiation therapy with adjuvant therapy, respectively. At 1 year, the difference in costs was still statistically significant (P<.001), but costs were influenced more by the use of adjuvant therapy than by type of surgery. The 1-year adjusted mean costs were $16704, $18856, $17344, and $19081, respectively, for the four groups. By 5 years, BCT was less expensive than mastectomy (P<.001), with 5-year adjusted mean costs of $41930, $45670, $35787, and $39926, respectively. Costs also varied by age, with women under 65 years having higher treatment costs than older women. Conclusions: BCT may have higher short-term costs but lower long-term costs than mastectomy.

Breast-conserving therapy (BCT) for early-stage breast cancers was endorsed by a National Institutes of Health consensus conference in 1990 after randomized trials showed it to be as effective as the prior standard of care, mastectomy (1,2). Subsequent studies (3,4) confirmed this finding. Nevertheless, mastectomy remains popular, with widespread geographic variation in its use (5,6). Factors that influence a woman’s choice between BCT and mastectomy include disease stage, age, and the presence of comorbid conditions (6–8). Another factor that may affect treatment choice is the cost of BCT versus mastectomy (9).

Mastectomy differs from BCT in the degree of initial surgical intervention. BCT, which is sometimes referred to as “lumpectomy,” “tylectomy,” or “quadrantectomy,” involves local excision of the tumor (10). In addition, axillary lymph node dissection may be performed at the time of BCT. By contrast, simple mastectomy involves removal of all breast tissue and some axillary tissue (10). Reconstruction of the affected breast or reduction (mastopexy) of the contralateral breast may also occur. Both surgical therapies require additional follow-up visits with surgeons, oncologists, and primary care physicians for administration of adjuvant chemotherapy, surveillance for local recurrence, evaluation of complications, such as lymphedema and infection, and assessment of psychosocial factors, including depression. Although shorter hospital stays and fewer complications are associated with BCT, this therapy typically requires additional radiation therapy. Thus, it is possible that the total costs of BCT plus radiation therapy may equal or even exceed those of mastectomy, despite the lower surgical costs.

Three studies that used data from the 1980s and early 1990s (11–13) suggested that BCT was more expensive than mastectomy because of the additional radiation treatments. However, these studies used charges rather than actual medical care costs. Furthermore, the charges were primarily for initial therapy and were not evaluated by the patient’s age, although women are known to receive different surgical treatments, depending on their age (6–8). Other analyses (14–17) also did not consider differences by age or were based on Medicare charges and thus were limited to women 65 years old or older. A study using the Connecticut tumor registry that did include younger women (17) showed that medical costs increased with disease stage and decreased with patient’s age. Younger women may be more likely to receive BCT, although a previous study (6) also showed that women aged 85 years or greater were more likely to be treated with BCT than those aged 65–79 years. However, older women were less likely to receive radiation therapy as part of BCT than younger women.

In an earlier study using health maintenance organization (HMO) data to analyze the costs of breast cancer care (18), we included women under age 65 years and found that the costs of initial care (i.e., in the first 6 months after diagnosis) decreased.

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statistically significantly with increasing age at diagnosis. We
did not examine the effect of treatment type, however. To ad-
dress the issue of differential costs by age and to clarify costs by
treatment type, we have now compared the total medical care
costs for women with early-stage breast cancer treated with BCT
or mastectomy up to 5 years after diagnosis. Additional adjuvant
therapy was considered in the cost analysis. Our study includes
all women aged 35 years or greater but included only those
women with BCT who also received radiation treatment. We
focus on early-stage cancers because BCT and mastectomy are
equally efficacious, and we evaluate the medical costs of care up
to 5 years after diagnosis. Because mortality for early-stage
breast cancer is low, the costs of cancer care will depend pri-
marily on the costs of initial surgical treatment and of subse-
quent adjuvant therapy (18). We computed the costs of all medi-
cal care and then derived the net costs of cancer by subtracting
the mean costs for women who were of the same age as the
cancer patients. Both total medical care costs and net costs were
compared by type of surgery—i.e., mastectomy versus BCT—
and by use of adjuvant therapy. The results provide information
for cost analyses of alternative screening and treatment policies
and may explain why BCT may be underutilized compared with
mastectomy.

SUBJECTS AND METHODS

Study Setting

This study was conducted at Group Health Cooperative (GHC), a regional
nonprofit HMO in Washington State, that currently has almost 600,000 enrollees
(about 10% of the state population). GHC has its own salaried professional staff,
comprising primary care and specialty care physicians, physician assistants, and
nurses. Care is provided primarily through GHC’s own inpatient and outpatient
facilities but may include contracted care for services not provided in these
facilities. Outside costs are billed to GHC and are included in the reported costs.
GHC’s Human Subjects Committee granted a waiver of informed consent
because there was no patient contact and medical charts were not reviewed. Only
information from GHC’s computerized data systems and the National Cancer
Institute’s Surveillance, Epidemiology, and End Results (SEER) cancer registry
were used in this article.

Case Identification, Treatment, and Covariate Information

Breast cancer cases were identified with the use of the population-based
Cancer Surveillance System, which is part of the SEER Program. This program
identifies cancers in 13 counties of the Puget Sound region of Washington State.
Internal quality checks demonstrate nearly complete ascertainment of incident
cancer cases in the region (i.e., three missed cases in 24,000) (18). Most GHC
enrollees live in the SEER catchment area, and this article is restricted to resi-
dents of those 13 counties. The extent of disease, as recorded in SEER, was used
to calculate the tumor-node-metastases (TNM) stage at diagnosis, which is
based on criteria of the American Joint Committee on Cancer (19). For the
period January 1, 1990, through December 31, 1997, we identified a total of
1,733 incident invasive breast cancer cases with TNM stage I, IA, or IIB that
were diagnosed among GHC-enrolled women aged 35 years or older. Only the
first diagnosis of breast cancer was used in this article.

The SEER registry includes information on what surgical treatment and ad-
juvant therapy were recommended and/or received up to 6 months after diag-
nosis. These data were supplemented with GHC data, which include information
about the use of additional adjuvant therapy within 1 year after diagnosis. Both
sources were used to classify women as having had mastectomy or BCT and to
determine subsequent adjuvant therapy. There are many ways to partition the
treatment groups, given the multitude of treatment combinations. For the primary
analyses, we classified women into four groups: 1) mastectomy only, 2) mas-
tectomy plus chemotherapy and/or hormonal therapy, 3) BCT with radiation
therapy, and 4) BCT with radiation therapy and chemotherapy and/or hormonal
therapy. For simplicity, we define chemotherapy and/or hormonal therapy as
“adjuvant therapy,” even though the radiation therapy given after BCT could be
regarded as adjuvant. The four groups represent a compromise that reduces the
number of combinations but preserves the ability to compare the costs of surgery
type as well as those of additional adjuvant therapy. One analysis does consider
the separate effects of chemotherapy and hormonal therapy, although most
analyses compare across the four groups.

We excluded 56 women who had had BCT without radiation therapy because
the primary purpose of our study was to evaluate BCT with radiation therapy
versus mastectomy. Women who have BCT without radiation therapy tend to be
older and thus would not be comparable to women in the other treatment groups
(6). Two other women did not receive any treatment and were also excluded,
yielding a final sample size of 1675 women. The allocation of treatment com-
binations is described in the “Results” section.

On the basis of pharmacy data, we computed a chronic disease score (CDS) for
all women in the final sample by using the methodology developed by Von
Korf et al. (20). The CDS was computed with the use of a weighted average of
prescriptions over the year preceding the diagnosis of breast cancer. This score
ranges from 0 to 31, depending on the types of medications prescribed; it is
highly correlated with the health assessment of individuals by their physician and
predicts subsequent hospitalization and death. We used the CDS for the calendar
year preceding the cancer diagnosis, so that the measure would not be influenced
by cancer treatment. We grouped the CDS into three categories: low (0), medium
(1–3), and high (4–31). These cut points were used in our previous study of
cancer costs (18). Body mass index (BMI) was computed by dividing weight (in
kilograms) by the square of height (in meters). For our analyses, we used the
information on height, weight, menopausal status, and history of breast cancer in
first-degree relatives that was obtained at the last visit before the breast cancer
diagnosis.

Cost Data

Costs of medical care were obtained from the automated costing system of
GHC, which is described in detail elsewhere (18, 21). The system automatically
links the general ledger to a clinical and financial data repository through a
cost-accounting management system. An activity-based accounting approach is
used to allocate all overhead costs to each service-level department and its
respective unit of service. These departments include medical staff, nursing,
pharmacy, laboratory, radiology, hospital inpatient, and community health ser-
vices. Each department has a unique unit of service that serves as an activity
basis for costing. The cost per unit of service reflects the actual costs of medical
personnel to provide the service as well as overhead costs, such as supplies,
administration, charting, and automated information systems, that are allocated
to the unit through the costing system. The costs of services used can be associ-
ated with a particular enrollee through the costing system. Costs of care not
delivered directly through GHC facilities, including both medical care and over-
head costs, can also be associated with the enrollee.

We used detailed cost records to create summary datasets to facilitate analysis.
These datasets, which were computed on a monthly calendar basis, collapse costs
into utilization categories (e.g., primary care, specialty care, radiology, and
hospitalization). Details about specific type and date of service are not included
in these summary files. For example, costs were computed starting in the calen-
dar month of diagnosis, rather than from the actual date of diagnosis. Conse-
quently, costs for the first month after diagnosis included, on average, only 2
weeks of costs after diagnosis. An additional limitation was that only month and
year of diagnosis were available from SEER, so costs could not be calculated
starting on the actual day of diagnosis.

We categorized costs into the following seven mutually exclusive categories,
according to the location and type of care delivered: 1) inpatient care, 2) primary
care, 3) specialty care, 4) ambulatory surgery, 5) radiology, 6) pharmacy, and 7)
other (i.e., other services or nonspecified services). The costs of chemotherapy
and other therapies are included in specialty care or pharmacy costs. Descriptive
measures of service use, such as the number of inpatient admissions and the
length of stay in days as well as the number of primary care, specialty care, and
mental health visits, were also computed.

Monthly medical care costs were computed for the period January 1990 to
December 1998 inclusive. To account for changes in medical care costs over this
calendar period, we computed costs in 1998 dollars by adjusting observed costs
by the Bureau of Labor Statistics medical care consumer price index for urban
areas in the western United States. All means and standard deviations are re-
ported in 1998 U.S. dollars. Costs for breast cancer cases were computed
monthly, starting with the calendar month of diagnosis and continuing until
December 31, 1998, death, or disenrollment from GHC, whichever came first.

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Our primary cost analyses include costs of all medical care, not just those directly related to breast cancer treatment. We also computed the annual mean medical care costs for all female GHC enrollees by year of age for each calendar year. To estimate the “net cost,” or the cost attributable to breast cancer for 1 year after diagnosis, we subtracted the mean medical care costs for female GHC enrollees of the same age over the same calendar period. Because only about 4% of the women enrolled in GHC have prevalent breast cancer and their exclusion would have a negligible effect on the costs for the entire age group, we used the mean cost for all female GHC enrollees, regardless of cancer status. This mean cost is based on the medical care costs for several thousand women in the same age group. Thus, we calculated a net cost due to cancer treatment by subtracting the costs for an age- and calendar-time-matched referent group.

Statistical Methods

All analyses were based on a two-sided overall statistical significance level of .05. When computing P values for pairwise differences between means or confidence intervals (CIs) for the four groups (as in Tables 2–4), Sidak’s method (22) for multiple comparisons was used to maintain an overall .05 significance level. Table 5 does not adjust for multiple comparisons because the statistical methodology is different, although individual P values are presented so the reader may adopt a stricter criterion for statistical significance.

Women were grouped into the following age categories: 35–49 years, 50–64 years, 65–79 years, and 80 years or more. These age categories were chosen for both scientific and public policy reasons. Women in the youngest age group are presumed to be primarily premenopausal. The division at age 65 years allows a comparison with studies based on Medicare data. Women in the oldest group are expected to have higher medical care costs and more limited treatment choices.

We used several different methods to compare costs. The first method required that the patients have complete cost information for the specified time interval. We used time periods of 6 months, 1 year, and 5 years; consequently, the denominators decreased as elapsed time increased. This method estimates costs conditional on survival and HMO enrollment to that time period. For these analyses, we performed comparisons across treatment groups by using the non-parametric Kruskal–Wallis test because of the skewness in costs. The second method used monthly costs and included all individuals for each month that they were enrolled in the GHC, so they may more accurately reflect the complete costs of cancer treatment. We modeled the monthly costs by using a mixed linear model that adjusts for the correlation of costs across months within an individual (23). We used a banded Toeplitz correlation structure with six bands that assumes a common correlation r between residual costs in months j and k, where $i = k − j / 2$ is the lag in months between the two monthly costs. We further assumed that there was zero correlation between the residual costs when the costs were more than 5 months apart (23). In short, the model assumed that monthly costs within a 6-month period were correlated and that the amount of correlation depended on how far apart in time the two cost periods were. However, unlike autoregressive correlation structures, the model did not assume that the correlation decreased with the time lag.

The models were fit by use of PROC MIXED in SAS version 8.0 (SAS Institute, Inc., Cary, NC) (24). For protection from incorrect specification of the correlation structure, we used the empirical or robust variance estimates rather than the model-based variance estimates (24). We adjusted for age, cancer stage, time since diagnosis, and interactions of time with age, stage, and treatment. We then obtained adjusted means for each treatment group by assuming a common population with the same age and stage characteristics for all four groups. The referent population was based on the study population and used the marginal frequencies of age and stage at the time of diagnosis. Further modeling was performed by use of adjustment for comorbidity prior to diagnosis (CDS) and year of diagnosis.

In most cases, we directly modeled costs by using a linear model and assumed that the errors were normally distributed. Because costs are skewed, this assumption may not be met, but models are generally robust to this assumption. We also modeled the logarithm of the costs. This method will tend to downgrade the extreme costs and to improve the normality of the errors. Interpretation of the estimates is, however, more difficult. A relative change in costs can be computed using log costs and then exponentiating the coefficients to obtain ratios of estimated costs. We report the analysis of the log costs only in Table 3, because the results of these analyses showed the same pattern of those using the untransformed costs and the latter are more interpretable.

RESULTS

Description of Cases

Table 1 displays descriptive characteristics of women in each of the four treatment groups. Use of BCT increased statistically significantly ($P = .005$) over the period 1990 through 1997 among GHC women, rising from 54% in 1990 to 74% in 1997. There was a less dramatic, but still statistically significant, increase in use of adjuvant chemotherapy and hormonal therapy ($P = .043$) over the same time period. Women who were younger and women with earlier stage breast cancer were more likely to have BCT than to have mastectomy ($P = .0387$ and $P < .001$, respectively). Adjuvant therapy was associated with younger age and more advanced stage at the time of diagnosis ($P < .001$ for both comparisons). Women with stage IIB disease were more likely to receive mastectomy and adjuvant therapy. If BCT was used without adjuvant therapy, it was used primarily for women with stage I breast cancer. However, there were no differences across treatment groups with respect to race, family history of breast cancer in first-degree relatives, previous biopsy, smoking behavior, BMI, or CDS. Consequently, age or initial cancer stage may confound analyses comparing the treatment groups, but family history of breast cancer, comorbidity, or other measured personal characteristics are unlikely to be confounders.

To compare costs of care for the initial periods of 6 months and 1 year after diagnosis, we restricted the analysis to the 1639 women (98% of the sample) who had complete 6-month costs and to the 1605 women (96%) who had complete 1-year costs. Seventeen women died before the end of the first year, including eight for whom breast cancer was the cause of death. Eleven of the 17 had been treated with mastectomy, and five of these women had had adjuvant therapy as well. The remaining six women had been treated with BCT, and three of these women had had adjuvant therapy. A Cox regression analysis showed no difference in overall survival across the four groups after adjustment for age and stage. The costs for women who died or disappeared before the end of the specified time period were not included in the analyses shown in Tables 2–4, so the results are for survivors of breast cancer.

Total Medical Care Costs

At 6 months, treatment costs differed statistically significantly across treatment groups (Table 2). Costs were lowest for women who had mastectomy without adjuvant therapy, both within each age group (data not shown) and for all ages combined. Costs of BCT without adjuvant therapy were lower than costs of either mastectomy or BCT with adjuvant therapy for all ages combined and for each age group except women aged 65–79 years. The most expensive treatment 6 months after diagnosis was BCT with adjuvant therapy. One-year costs were determined primarily by whether adjuvant therapy had been given, with little difference between mastectomy and BCT. The mean costs were not adjusted for stage and other factors that could influence the overall costs, although we examined the effect of these adjustments for monthly costs (see below).

We were also interested in long-term costs, although this analysis requires 5 years of cost information after the breast cancer diagnosis. Consequently, only cases diagnosed in the period 1990 through 1993 could be included. Table 2 shows the 5-year costs for the 610 survivors, with complete 5-year costs by treatment group. Generally, BCT without adjuvant therapy was
the least expensive treatment, and mastectomy with adjuvant therapy was the most expensive, although the pattern was not consistent across all ages. Because discounting is important for long-term costs, we used a standard discount rate of 3%, as suggested by Gold et al. (25). We adjusted these long-term costs by age and stage in a subsequent analysis (see below).

To examine exactly where the costs differed across treatments, we categorized total costs at 1 year after diagnosis into utilization subcategories (Fig. 1). Inpatient care costs were higher for mastectomy than for BCT, but the lower inpatient costs for BCT were offset by the higher radiation therapy costs for this treatment. Specialty care, inpatient care, and pharmacy costs were all higher when adjuvant therapy was given. Analysis of the units of utilization for each major category of service by treatment group showed that adjuvant care increased the number of both specialty care visits and outpatient hospital visits (Fig. 2).

We next investigated the costs of the use of chemotherapy (possibly in combination with hormonal therapy as well) versus hormonal therapy alone within each of the surgery groups. The 417 women who had mastectomy and adjuvant therapy had the following combinations of adjuvant therapy: hormonal therapy (n = 207 [49.6%]), chemotherapy (n = 76 [18.2%]), both hormonal therapy and chemotherapy (n = 72 [17.3%]), radiation therapy and hormonal therapy (n = 19 [4.6%]), radiation therapy and chemotherapy (n = 19 [4.6%]), and radiation therapy, hormonal therapy, and chemotherapy (n = 24 [5.8%]). All of the women in the two BCT groups had radiation treatment, according to the study design. Among the 670 women who had BCT and adjuvant therapy, the following combinations were observed: hormonal therapy (n = 424 [63.3%]), chemotherapy (n = 139 [20.7%]), and both hormonal therapy and chemotherapy (n = 107 [16.0%]). The large number of combi-

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**Table 1.** Baseline characteristics of women with early-stage breast cancer diagnosed during the period from 1990 through 1997 in a nonprofit health maintenance organization by type of surgery and adjuvant therapy*

<table>
<thead>
<tr>
<th></th>
<th>Mastectomy only, No. (%)</th>
<th>Mastectomy + adjuvant therapy, No. (%)</th>
<th>BCT + radiation therapy, No. (%)</th>
<th>BCT + radiation therapy + adjuvant therapy, No. (%)</th>
<th>Total No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total sample size</strong></td>
<td>183 (76.5)</td>
<td>417 (41.5)</td>
<td>405 (16.4)</td>
<td>16 (0.2)</td>
<td>670 (12.8)</td>
</tr>
<tr>
<td><strong>TNM stage</strong></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>I</td>
<td>140 (76.5)</td>
<td>173 (41.5)</td>
<td>388 (95.8)</td>
<td>427 (63.7)</td>
<td>1128 (67.3)</td>
</tr>
<tr>
<td>IIA</td>
<td>30 (16.4)</td>
<td>99 (23.7)</td>
<td>16 (4.0)</td>
<td>117 (17.5)</td>
<td>262 (15.6)</td>
</tr>
<tr>
<td>IIB</td>
<td>13 (7.1)</td>
<td>145 (34.8)</td>
<td>1 (0.2)</td>
<td>126 (18.8)</td>
<td>285 (17.0)</td>
</tr>
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<td><strong>Year of diagnosis</strong></td>
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<td></td>
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</tr>
<tr>
<td>1990–1991</td>
<td>48 (26.2)</td>
<td>103 (24.7)</td>
<td>89 (22.0)</td>
<td>120 (17.9)</td>
<td>360 (21.5)</td>
</tr>
<tr>
<td>1992–1993</td>
<td>52 (28.4)</td>
<td>87 (20.9)</td>
<td>110 (27.2)</td>
<td>168 (25.1)</td>
<td>417 (24.9)</td>
</tr>
<tr>
<td>1994–1995</td>
<td>43 (23.5)</td>
<td>118 (28.3)</td>
<td>90 (22.2)</td>
<td>165 (24.6)</td>
<td>416 (24.8)</td>
</tr>
<tr>
<td>1996–1997</td>
<td>40 (21.9)</td>
<td>109 (26.1)</td>
<td>116 (28.6)</td>
<td>217 (32.4)</td>
<td>482 (28.8)</td>
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<tr>
<td><strong>Age at diagnosis, y</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>35–49</td>
<td>35 (19.1)</td>
<td>104 (24.9)</td>
<td>81 (20.0)</td>
<td>173 (25.8)</td>
<td>393 (23.5)</td>
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<td>50–64</td>
<td>42 (23.0)</td>
<td>129 (30.9)</td>
<td>116 (28.6)</td>
<td>251 (37.5)</td>
<td>538 (32.1)</td>
</tr>
<tr>
<td>65–79</td>
<td>73 (40.9)</td>
<td>149 (35.7)</td>
<td>170 (42.0)</td>
<td>197 (29.4)</td>
<td>589 (35.2)</td>
</tr>
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<td>≥80</td>
<td>33 (18.0)</td>
<td>35 (8.4)</td>
<td>38 (9.4)</td>
<td>49 (7.3)</td>
<td>155 (9.3)</td>
</tr>
<tr>
<td><strong>Race</strong></td>
<td></td>
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<tr>
<td>White</td>
<td>171 (93.4)</td>
<td>382 (91.6)</td>
<td>380 (93.8)</td>
<td>611 (91.2)</td>
<td>1544 (92.2)</td>
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<tr>
<td>Asian</td>
<td>4 (2.2)</td>
<td>25 (6.0)</td>
<td>8 (2.0)</td>
<td>30 (4.5)</td>
<td>67 (4.0)</td>
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<td>6 (3.3)</td>
<td>5 (1.2)</td>
<td>12 (3.0)</td>
<td>22 (3.3)</td>
<td>45 (2.7)</td>
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<td>Other</td>
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<td>5 (1.2)</td>
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<td>7 (1.0)</td>
<td>19 (1.1)</td>
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<td><strong>Family history of breast cancer in first-degree relative</strong></td>
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<td>Yes</td>
<td>30 (19.5)</td>
<td>74 (20.8)</td>
<td>82 (22.2)</td>
<td>97 (17.0)</td>
<td>283 (19.5)</td>
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<tr>
<td>No</td>
<td>124 (80.5)</td>
<td>281 (79.2)</td>
<td>288 (77.8)</td>
<td>472 (83.0)</td>
<td>1165 (80.5)</td>
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<td>Unknown</td>
<td>29 (17.1)</td>
<td>62 (17.2)</td>
<td>35 (9.6)</td>
<td>101 (18.9)</td>
<td>227 (14.1)</td>
</tr>
<tr>
<td><strong>BMI</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Obese, ≥26</td>
<td>67 (44.1)</td>
<td>139 (40.4)</td>
<td>134 (37.0)</td>
<td>219 (39.0)</td>
<td>559 (39.4)</td>
</tr>
<tr>
<td>Not obese, &lt;26</td>
<td>85 (55.9)</td>
<td>205 (59.6)</td>
<td>228 (63.0)</td>
<td>342 (61.0)</td>
<td>860 (60.6)</td>
</tr>
<tr>
<td>Unknown</td>
<td>31 (18.0)</td>
<td>73 (20.8)</td>
<td>43 (11.7)</td>
<td>109 (19.1)</td>
<td>256 (15.3)</td>
</tr>
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<td><strong>CDS</strong></td>
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<td></td>
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<td></td>
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<tr>
<td>Low</td>
<td>70 (41.4)</td>
<td>160 (43.2)</td>
<td>149 (40.7)</td>
<td>287 (47.0)</td>
<td>666 (43.9)</td>
</tr>
<tr>
<td>Moderate</td>
<td>38 (22.5)</td>
<td>78 (21.1)</td>
<td>95 (26.0)</td>
<td>107 (17.5)</td>
<td>318 (21.0)</td>
</tr>
<tr>
<td>High</td>
<td>61 (36.1)</td>
<td>132 (35.7)</td>
<td>122 (33.3)</td>
<td>217 (35.5)</td>
<td>532 (35.1)</td>
</tr>
<tr>
<td>Unknown</td>
<td>14 (8.1)</td>
<td>47 (13.0)</td>
<td>39 (10.4)</td>
<td>59 (10.0)</td>
<td>159 (10.0)</td>
</tr>
<tr>
<td><strong>Postmenopausal</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>117 (80.7)</td>
<td>261 (75.9)</td>
<td>286 (80.8)</td>
<td>405 (75.1)</td>
<td>1069 (77.4)</td>
</tr>
<tr>
<td>No</td>
<td>28 (19.3)</td>
<td>53 (24.1)</td>
<td>68 (19.2)</td>
<td>134 (24.9)</td>
<td>313 (22.6)</td>
</tr>
<tr>
<td>Unknown</td>
<td>38 (23.1)</td>
<td>73 (22.1)</td>
<td>51 (15.0)</td>
<td>131 (23.6)</td>
<td>293 (18.6)</td>
</tr>
<tr>
<td>Reconstruction within 1 y</td>
<td>19 (10.4)</td>
<td>55 (13.2)</td>
<td>1 (0.3)</td>
<td>1 (0.2)</td>
<td>76 (4.5)</td>
</tr>
<tr>
<td>No</td>
<td>164 (89.6)</td>
<td>362 (86.8)</td>
<td>386 (99.7)</td>
<td>647 (99.8)</td>
<td>1599 (95.5)</td>
</tr>
</tbody>
</table>

*BCT = breast-conserving therapy; TNM = tumor-node-metastases; BMI = body mass index (kg/m²); CDS = chronic disease score (see “Subjects and Methods” section).
nation and the small number of women per combination make cost modeling difficult. Because the entire BCT group received radiation therapy whereas only 11% (68 of 600, including six in the mastectomy-only group) of those with mastectomy did, the cost of radiation therapy is reflected largely by the choice of surgery.

Table 3 shows the mean costs 1 year after diagnosis by type of surgery and adjuvant therapy, adjusted for age and TNM stage. Women receiving chemotherapy may have had hormonal therapy as well but were classified by the more expensive therapy. Within each class of adjuvant therapy, the adjusted means for BCT costs were always slightly greater than the corresponding means for mastectomy costs, but the differences were not statistically significant. Also, BCT with hormonal therapy was more expensive than mastectomy with chemotherapy (P = .008). Similarly, BCT with hormonal therapy was more expensive than mastectomy with hormonal therapy (P = .0022). However, both comparisons became statistically nonsignificant if adjusted for multiple comparisons. Costs of BCT with chemotherapy were not statistically different from those of mastectomy with chemotherapy (P = .43). For women receiving mastectomy, hormonal therapy did not increase costs relative to mastectomy alone (P = .22), but chemotherapy increased costs by about 40% (P<.001) relative to mastectomy alone. Adjuvant therapy increased costs for women treated by BCT as well, with hormonal therapy and chemotherapy increasing costs by 9% (P = .47) and 24% (P<.001), respectively, compared with BCT alone.

Table 2. Total mean cost of all medical care at 6 months, 1 year, and 5 years after diagnosis by treatment and age group in 1998 dollars*

<table>
<thead>
<tr>
<th>Treatment</th>
<th>6 mo Mean</th>
<th>1 y Mean</th>
<th>5 y, no discount Mean</th>
<th>5 y, 3% discount† Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mastectomy</td>
<td>12,454</td>
<td>16,462</td>
<td>41,286</td>
<td>39,064</td>
</tr>
<tr>
<td>Mastectomy + adjuvant therapy</td>
<td>14,761</td>
<td>20,269</td>
<td>45,717</td>
<td>43,376</td>
</tr>
<tr>
<td>BCT + radiation therapy</td>
<td>14,443</td>
<td>16,506</td>
<td>33,784</td>
<td>32,246</td>
</tr>
<tr>
<td>BCT + radiation therapy + adjuvant therapy</td>
<td>15,924</td>
<td>20,236</td>
<td>39,274</td>
<td>37,421</td>
</tr>
</tbody>
</table>

Table 3. Mean 1-year medical care costs in 1998 dollars and relative change in costs resulting from the addition of adjuvant therapy, by treatment type adjusted for age and tumor stage*

<table>
<thead>
<tr>
<th>Additional therapy</th>
<th>Mastectomy: adjusted mean</th>
<th>Breast-conserving therapy: adjusted mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>16,944</td>
<td>17,220</td>
</tr>
<tr>
<td>Hormonal therapy</td>
<td>17,853</td>
<td>19,097</td>
</tr>
<tr>
<td>Chemotherapy†</td>
<td>21,411</td>
<td>22,105</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Additional therapy</th>
<th>Mastectomy: relative costs‡</th>
<th>Breast-conserving therapy: relative costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>1.00</td>
<td>1.16</td>
</tr>
<tr>
<td>Hormonal therapy</td>
<td>1.08</td>
<td>1.27</td>
</tr>
<tr>
<td>Chemotherapy</td>
<td>1.40</td>
<td>1.45</td>
</tr>
</tbody>
</table>

*Table includes only those women who had complete costs over the time period indicated. SD = standard deviation; CI = confidence interval; BCT = breast-conserving therapy.
†5-year costs were discounted because discounting is important for long-term costs; a 3% discount rate was used, as suggested by Gold et al. (25).
‡Two-sided P value from the nonparametric (Kruskal–Wallis) test.

P value‡ .0001 .0001 .0001 .0001

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In the previous analysis, we compared costs for women treated with mastectomy with costs for women treated with BCT, not the costs of the procedures themselves. In our costing system, it is difficult to determine the cost of a particular procedure, such as breast reconstruction, particularly if the procedure may involve several follow-up visits. For women for whom complete 1-year costs were available, we compared costs for women who had breast reconstruction ($n = 75$) with those for women who had not ($n = 1530$). The mean costs were $9645 higher for women who had reconstruction, but this increase does not reflect adjustment for age, cancer stage, or other treatment. Breast reconstruction is extremely rare for women undergoing BCT, so the excess costs are primarily a direct function of mastectomy.

### Net Medical Care Costs

Higher total medical care costs were observed for younger women with breast cancer than for older women. Our analyses included all medical care costs, including costs for medical care unrelated to the breast cancer. To apportion costs due to breast cancer, we subtracted the mean medical care costs for a woman the same age in the same calendar period as the woman with breast cancer. Table 4 shows the net medical care costs due to breast cancer by age and treatment at 1 and 5 years after diagnosis. Net 1-year costs were determined primarily by whether adjuvant therapy was given, rather than by the type of surgery received. By 5 years, BCT was less expensive than mastectomy on average, although use of adjuvant therapy had a greater impact on the net cost than the type of surgery. Women under age 65 years had consistently higher 1-year net costs than women aged 65–79 years. Net costs were lowest in all treatment groups for women aged 80 years and above.

All of the preceding analyses used costs for women who were enrolled at the end of the time period being analyzed. Omitting women who died before the period of analysis was complete would underestimate breast cancer costs because the cost of

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**Table 4. Mean net medical care costs in 1998 dollars for 1 and 5 years after diagnosis by treatment and age***

<table>
<thead>
<tr>
<th></th>
<th>1 y after diagnosis by age group</th>
<th>5 y after diagnosis by all ages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>35–49 y</td>
<td>50–64 y</td>
</tr>
<tr>
<td>Mastectomy</td>
<td>Mean net costs</td>
<td>15 979</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>11 868</td>
</tr>
<tr>
<td></td>
<td>95% CI</td>
<td>11 625 to 20 332</td>
</tr>
<tr>
<td></td>
<td>No.</td>
<td>31</td>
</tr>
<tr>
<td>Mastectomy + adjuvant therapy</td>
<td>Mean net costs</td>
<td>21 754</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>13 844</td>
</tr>
<tr>
<td></td>
<td>95% CI</td>
<td>18 993 to 24 515</td>
</tr>
<tr>
<td></td>
<td>No.</td>
<td>99</td>
</tr>
<tr>
<td>BCT + radiation therapy</td>
<td>Mean net costs</td>
<td>14 106</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>5182</td>
</tr>
<tr>
<td></td>
<td>95% CI</td>
<td>12 913 to 15 298</td>
</tr>
<tr>
<td></td>
<td>No.</td>
<td>75</td>
</tr>
<tr>
<td>BCT + radiation therapy + adjuvant therapy</td>
<td>Mean net costs</td>
<td>19 561</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>10 361</td>
</tr>
<tr>
<td></td>
<td>95% CI</td>
<td>17 964 to 21 159</td>
</tr>
<tr>
<td></td>
<td>No.</td>
<td>164</td>
</tr>
<tr>
<td></td>
<td>$P$ value†</td>
<td>.0001</td>
</tr>
</tbody>
</table>

*Only those women for whom complete costs over the time period indicated were available were included in this analysis. SD = standard deviation; CI = confidence interval; BCT = breast-conserving therapy.

†Two-sided $P$ values from the nonparametric (Kruskal–Wallis) test.

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![Fig. 1. Mean total medical care costs at 1 year after diagnosis by treatment group and type of service. Adjuvant = hormonal therapy and/or chemotherapy; BCT = breast-conserving therapy; Rad = radiation therapy.](image-url)
deaths can be substantial (18). Furthermore, these analyses did not use all of the data available because women who left the HMO before the end of the time period were excluded. We, therefore, performed an additional analysis of monthly costs up to the time the woman died or disenrolled. The model for this analysis included treatment, TNM stage, age, and the interactions of these covariates with time since diagnosis. The CDS was a statistically significant predictor of costs as well; however, because it increased the number of missing values, we did not adjust for it in the final model. Fig. 3 shows the modeled costs by treatment and time. The lower costs in the first month reflect the fact that, on average, only 2 weeks of cancer care were included in this month. Mastectomy had higher costs in the first month because of the inpatient surgery. In months 3–5, the costs of BCT were substantially higher than those of mastectomy for both women who received adjuvant therapy and those who did not. After 1 year, the costs for the two BCT groups were lower than those for the corresponding mastectomy groups, and they remained lower until 5 years after diagnosis.

Finally, to provide estimated adjusted mean costs for each time period, we modeled cumulative costs and CIs at 6 months, 1 year, and 5 years after diagnosis (Table 5). These costs were the sum of the monthly costs over the time period. The pairwise mean comparisons are based on cumulative sums and are not adjusted for multiple comparisons. At 6 months after diagnosis, BCT was more expensive than mastectomy, and adjuvant therapy increased the cost of each treatment. By 1 year, there was little difference in the costs of mastectomy and BCT, but there were large differences within each surgery type depending on the use of adjuvant therapy. By 5 years, BCT was less expensive than mastectomy, although adjuvant therapy continued to increase costs of both types of surgery.

**DISCUSSION**

In this study of women aged 35 years or greater with early-stage breast cancer (TNM stage I, IIA, or IIB), we found that the 6-month costs of BCT were higher than those of mastectomy. At 1 year, BCT was equivalent in cost to mastectomy, although costs of both types of surgery were increased considerably by the addition of adjuvant therapy. However, 5 years after diagnosis, medical costs of care were lower for women treated with BCT and radiation therapy than for women treated with mastectomy, even after adjustment for age and cancer stage. This result is surprising, given that other studies (11–13) suggest that BCT is more expensive than mastectomy, but those reports did not consider long-term costs. For example, Munoz et al. (11) examined the costs of BCT and mastectomy in 1983 and 1984 for 79 patients with early-stage breast cancer. The mean costs of BCT and mastectomy were $14176 and $10345, respectively. Their results suggested that 70% of the costs of mastectomy were for inpatient care and 35% of the costs of BCT were for radiation therapy. However, the small number of patients and the limited sources for assessing costs reduce the generalizability of their results.

In our study, we have complete costs of all medical services provided and have distinguished between type of surgery and use of adjuvant therapies. Costs 1 year after treatment with BCT were similar...
to those 1 year after treatment with mastectomy, but the costs were allocated differently. As expected, BCT required greater use of radiation therapy, whereas mastectomy had higher inpatient care costs. Adjuvant therapy increased pharmacy, specialty care, and inpatient costs for women receiving either surgery. Costs by 5 years after diagnosis appeared to be lower for women who received BCT than for those who had mastectomy. One possible explanation for the increase in mastectomy costs relative to BCT costs over time may be a higher complication rate of mastectomy, including surgical breast reconstruction, which may occur well after the first year (12). Even in the first year after diagnosis, surgical breast reconstruction added approximately $9600 to the costs.

The long-term differences in costs cannot be explained by a difference in survival between the two types of surgery. An analysis of survival did not show a statistically significant treatment effect after adjustment for age and TNM stage, although the relative risk estimates showed a trend toward better survival for women treated by BCT. There remains the possibility of bias if healthier individuals select BCT rather than mastectomy. However, although we found that age and stage affected the decision, BMI and our measure of chronic disease (CDS) did not differ over treatment choice. In addition, we omitted from the study 56 women who had BCT without radiation therapy. The women in this group were older in general than those included in the study and may not have been candidates for other therapy choices. A preliminary analysis showed that costs for this group were lower than those for women who had BCT with radiation therapy.

In most studies of the costs of cancer treatment, costs attributable to cancer are calculated directly from services received. However, patients with cancer may be treated less intensely for other diseases, especially soon after their breast cancer diagnosis. Our approach compares the costs of care for women with breast cancer after subtracting the costs of care for women without cancer to yield the net costs of breast cancer. Net care costs not only estimate the costs of cancer but also reflect the effect that cancer may have on the treatment of non-cancer-related illnesses. We found that the net cost is highest in the first year but remains substantial 5 years subsequent to diagnosis.

In our analysis, costs were considered to be individual specific rather than procedure specific. That is, we reported actual costs of treating women who had a certain treatment rather than the cost of the treatment itself. Therefore, unspecified conditions that led to a particular choice of treatment may have influenced costs. Although age and cancer stage may also influence treatment choice, they are not perfect predictors. Consequently, it would be erroneous to conclude that surgery type or adjuvant therapy costs a certain amount without better predictors of the choice of therapy. To categorize treatment in our analysis, it was necessary to combine adjuvant therapies. Table 3 suggests that it is chemotherapy, not hormonal therapy, that makes up the majority of the costs of adjuvant therapy. We are exploring more closely the complex relationships among treatment choice, TNM stage, and personal characteristics. Previously, we found that overall costs often increased with comorbidity and decreased with age (18). One reason for this finding may be that adjuvant therapies were used more commonly with younger women. The decline in costs with age was also found by Polednak et al. (17) in a study of women from the Connecticut cancer registry. Therefore, this finding is not unique to GHC in particular or to managed care in general.

Current estimates based on Medicare data show that, for women aged 65 years and above, the mean 6-month treatment cost for local breast cancer was $10,200 in 1998 dollars (Brown M: unpublished data). Medicare may not cover the full costs of cancer treatment, unlike the pre-paid comprehensive plan in which the women whom we studied were enrolled. An analysis
of costs related to treatment of colorectal cancer (Brown M: unpublished data) showed that unreimbursed costs are about 15% of Medicare costs, so extrapolation would suggest total costs of local breast cancer treatment to be about $11,730. Our study showed somewhat higher costs for this age group ($14,111), with the difference possibly due to higher regional medical care costs compared with national costs. In any case, there appear to be clear differences in costs by age, so cost-effectiveness analysis of screening needs to consider cost differentials by age.

Our study has several potential limitations. First, it is limited to a single nonprofit HMO. Therefore, the mean costs will not necessarily generalize to other health care systems, many of which rely on charges for procedures rather than on the actual costs of delivering those services in a particular setting. For this reason, we have also indicated the type of utilization in Fig. 2 and the relative costs in Table 3.

Second, our analysis considers only the medical care costs to the HMO. It does not include other economic measures, such as lost work time by the patient or her family or items not directly covered by the HMO. Given et al. (26) suggest that out-of-pocket costs may be in the thousands of dollars.

Other limitations of our study include the potential misclassification of treatments or costs. Past audits of GHC cost data have suggested that services are sometimes provided without the costs appearing in the computerized data.

A strength of our study is that the results are based on a large population-based sample of all early-stage breast cancers followed comprehensively up to 5 years after diagnosis. Patients with breast cancer tend to remain enrolled in the HMO plan, so costs after diagnosis can be assessed with very little loss to follow-up.

Overall, our results suggest that there is little difference in the costs between BCT and mastectomy, despite the previous suggestion that the choice of surgery type is made on economic grounds (9). It is unlikely that physicians would advise one surgery type over another strictly on the basis of the cost of the treatment without considering other factors. Because survival rates after the two therapies are similar, it is the characteristics of the woman’s tumor, her medical condition, her physician’s counseling, and her own evaluation of her options that should primarily drive her choice of treatment.

REFERENCES

(16) Riley GF, Potosky AL, Lubitz JD, Kessler LG. Medicare payments from diagnosis to death for elderly cancer patients by stage at diagnosis. Med Care 1995;33:828–41.

NOTES

1"Editor's note: SEER is a set of geographically defined, population-based, cancer registries in the United States, operated by local nonprofit organizations under contract to the National Cancer Institute (NCI). Registry data are submitted electronically without personal identifiers to the NCI on a biannual basis, and the NCI makes the data available to the public for scientific research.

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