Relationship of Distance From a Radiotherapy Facility and Initial Breast Cancer Treatment

Ann Butler Nattinger, Ronald T. Kneusel, Raymond G. Hoffmann, Mary Ann Gilligan

Substantial variation has been described in the use of breast-conserving surgery (BCS) for early-stage breast cancer (1–4) and in the receipt of radiotherapy by patients undergoing BCS (2,4–6). Increased use of BCS is associated with urban residence and with treatment in a hospital with radiotherapy available (1,3).

These findings raise the question of whether the distance that a patient must travel to a radiotherapy facility affects the likelihood that BCS will be used or that the patient will receive radiotherapy in conjunction with BCS (4,5,7). According to current guidelines, women undergoing BCS should receive postoperative radiotherapy to decrease the likelihood of local disease recurrence (8). Radiotherapy is typically provided in treatments that are given 5 days per week for 5–6 weeks (9,10).

To address these issues, we studied patients from the National Cancer Institute’s Surveillance, Epidemiology, and End Results (SEER) registry national public-use database, by using methods similar to those that we described previously (6). Patients from Hawaii were excluded because of the unusual geographic characteristics of this state.

A cohort was selected of 21,135 women who were aged 30 years or older at the time of first diagnosis of a stage I or II unilateral breast cancer during the period from 1991 through 1992 and who underwent BCS or mastectomy. The 1990 U.S. Census tract of residence for each patient was determined from SEER records, and the latitude and longitude of the census tract were determined from the ZIP Code Equivalency file of the U.S. Bureau of the Census (11). Census tracts were unavailable from SEER for years of diagnosis after 1992. The size of the metropolitan statistical area (MSA) of residence of each patient was determined from the 1990 U.S. Census, as was the percent of adults living in the patient’s census tract who had a college education (a proxy indicator of socioeconomic status) (12). Information on census tract or socioeconomic status was unavailable for 3406 women, leaving a final study cohort of 17,729 women.

Hospitals offering radiotherapy services were determined from the 1990 American Hospital Association (AHA) Annual Survey of Hospitals (13). Of the 1257 such hospitals, the latitude and longitude of 87% were determined from the 1997 AHA Survey (14). (The 1997 AHA Survey was the first year to include hospital latitude and longitude.) For those hospitals not included in the 1997 AHA Survey, we determined the latitude and longitude of the centroid of the hospital’s ZIP code from the U.S. Bureau of the Census (15). For each patient in the cohort, the hospital with the shortest distance from the census tract of residence of that patient was determined by a standard formula for computing the distance between two coordinates of latitude and longitude (16).

Of the 17,729 women in the study cohort, 88.0% were white, 54.9% had stage I disease, and almost 58.3% underwent mastectomy therapy. Of the 7384 patients who underwent BCS, 74.8% underwent radiotherapy, and 2.7% had an unknown status with respect to radiotherapy. The median distance from a hospital with a radiotherapy facility was 4.1 miles, and 89.2% of the patients lived within 15 miles of such a hospital.

Women residing an increased distance from a hospital with a radiotherapy facility had a decreased likelihood of undergoing BCS (Table 1). The lower probability of undergoing BCS was statistically significant for women residing 15 miles or more from the nearest hospital with a radiotherapy facility (odds ratio [OR] = 0.52; 95% confidence interval [CI] = 0.46 to 0.58). We had postulated that any relationship of distance to radiotherapy site and therapy undergone might be more prominent among older women because older women may have more difficulties with transportation (17). However, when the analysis was limited to the 8095 (45.7%) women in the cohort aged 65 years and older, the results were virtually the same as for the entire cohort (Table 1).

Among the 7187 women who underwent BCS and for whom receipt of radiotherapy was known, a statistically significant decrease in the probability of receipt of radiotherapy (OR = 0.55; 95% CI = 0.37 to 0.82) was observed for women living 40 miles or more from a radiotherapy site (Table 1). However, only 1.7% of the patients who received BCS lived this far from a hospital providing radiotherapy.

We were further interested in whether the distance from a radiotherapy facility explained the differential use of BCS previously observed in relation to geographic region and population density. Thus, we assessed the fit of incremental logistic regression models. The likelihood ratio test for a logistic model using the patient covariates plus distance from radiotherapy site was statistically significantly different from a model including only the patient covariates as predictors of receipt of BCS (P < .001, Table 2). When the size of the MSA in which the patient resided was added to the model including distance, the likelihood ratio test was again statistically significant for the difference between the two models (P < .001, Table 2), which implies that MSA size contributes explanatory power incremental to that of the distance from the radiotherapy site and the patient characteristics. Similarly, when the SEER site was added to the model with radiotherapy distance, the likelihood ratio test was statistically significantly different between the two models (P < .001, Table 2), suggesting that geographic region also adds predictive value incremental to that of distance and the patient characteristics.

Using an analogous set of comparisons, we found that the size of the MSA and the SEER geographic site also each...
Table 1. Effect of distance of patient residence to nearest hospital with a radiotherapy facility on the receipt of breast-conserving surgery (BCS) and on radiotherapy after BCS

<table>
<thead>
<tr>
<th>Distance from hospital with radiotherapy facility, miles</th>
<th>Overall OR* (95% CI)</th>
<th>OR* if ≥65 y old (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;5</td>
<td>Referent</td>
<td>Referent</td>
</tr>
<tr>
<td>5 to &lt;15</td>
<td>1.08 (1.00 to 1.06)</td>
<td>1.07 (0.95 to 1.20)</td>
</tr>
<tr>
<td>10 to &lt;15</td>
<td>1.07 (0.95 to 1.19)</td>
<td>0.98 (0.82 to 1.18)</td>
</tr>
<tr>
<td>15 to &lt;20</td>
<td>0.76 (0.62 to 0.92)</td>
<td>0.72 (0.52 to 0.99)</td>
</tr>
<tr>
<td>20 to &lt;30</td>
<td>0.61 (0.50 to 0.75)</td>
<td>0.49 (0.37 to 0.66)</td>
</tr>
<tr>
<td>30 to &lt;40</td>
<td>0.44 (0.34 to 0.58)</td>
<td>0.32 (0.22 to 0.45)</td>
</tr>
<tr>
<td>≥40</td>
<td>0.43 (0.35 to 0.53)</td>
<td>0.42 (0.31 to 0.56)</td>
</tr>
</tbody>
</table>

Table 2. Incremental explanatory effect of distance from RT site, size of MSA, and SEER site on breast cancer treatment

<table>
<thead>
<tr>
<th>Model components†</th>
<th>LR test</th>
<th>P</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of BCS vs. mastectomy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) Covariates</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>2) Covariates + distance</td>
<td>151.9 with 6 df (vs. model 1)</td>
<td>&lt;.001</td>
<td>.275</td>
</tr>
<tr>
<td>3) Covariates + distance + MSA size</td>
<td>79.7 with 2 df (vs. model 2)</td>
<td>&lt;.001</td>
<td>.282</td>
</tr>
<tr>
<td>4) Covariates + distance + SEER site</td>
<td>389.3 with 7 df (vs. model 2)</td>
<td>&lt;.001</td>
<td>.311</td>
</tr>
<tr>
<td>Use of RT among BCS patients</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>5) Covariates</td>
<td></td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>6) Covariates + distance</td>
<td>13.8 with 4 df (vs. model 5)</td>
<td>.008</td>
<td>.368</td>
</tr>
<tr>
<td>7) Covariates + distance + MSA size</td>
<td>56.4 with 2 df (vs. model 6)</td>
<td>&lt;.001</td>
<td>.377</td>
</tr>
<tr>
<td>8) Covariates + distance + SEER site</td>
<td>237.3 with 8 df (vs. model 6)</td>
<td>&lt;.001</td>
<td>.405</td>
</tr>
</tbody>
</table>

†For these analyses, logistic regression models were constructed, incrementally including the distance factor and then the population density or SEER site (geographic region) factors. The incremental fit of these models was assessed with the LR test (18). An R² statistic was used as a measure of the predictive power of the different models (18). Covariates refer to the patient characteristics of age, race, stage of disease, and educational status. All statistical tests are two-sided.

have incremental explanatory power in a model including patient explanatory characteristics and distance as predictors of receipt of radiotherapy after undergoing BCS (Table 2).

In summary, we found a statistically significant decrease in the likelihood of undergoing BCS among women residing 15 miles or more from a hospital with radiotherapy facilities. Among women who underwent BCS, a lower probability of undergoing radiotherapy was observed consistently only among those residing 40 miles or more from a hospital with radiotherapy facilities. However, distance did not account for all of the previously described (1–3,19) geographic variation in treatment or for the previously demonstrated (1,3) fact that women residing in more urban areas have greater use of BCS than other women.

Some unmeasured factor, such as a health systems factor, could account for the observed association between distance from a radiotherapy facility and treatment. However, our results regarding distance and receipt of radiotherapy after BCS are similar to those obtained in a study of patients in New Mexico (20). Although that study did not find an association between receipt of BCS and the distance to a radiotherapy site, our larger sample size gave us better power to detect this association.

The decreased use of BCS among breast cancer patients living 15 miles or more from a radiotherapy site does not necessarily mean that these women undergo inappropriate care. Modified radical mastectomy is an appropriate treatment option for women with early-stage breast cancer (8). Nonetheless, these women may not perceive access to BCS as a realistic treatment option. The finding of a lower use of radiotherapy among BCS recipients living 40 miles or more from a hospital with a radiotherapy facility, however, does raise an issue of appropriateness of care (6). Radiotherapy is clearly recommended for women who undergo breast conservation as primary therapy (8), and women who undergo BCS without radiotherapy have local recurrence rates of about 35% over a 5-year period (21–24).

Although the distance of more than 15 miles from a radiotherapy site had a moderate effect on the receipt of BCS, only 11% of the women in this cohort lived 15 miles or more away from a radiotherapy facility. Similarly, only 3.1% of the entire study cohort and 1.7% of the BCS patients lived 40 miles or more away from a hospital with radiotherapy. Although the SEER population is somewhat more urban than the population in the rest of the United States (25), only a reassuringly small percentage of the U.S. population is likely to be affected by the findings of this study.

REFERENCES


NOTES

1 Editor’s note: SEER is a set of geographically defined, population-based, central cancer registries in the United States, operated by local non-profit 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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