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Effect of Travel Distance and Time to Radiotherapy on Likelihood of Receiving Mastectomy

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Abstract

Background—Breast-conserving surgery (BCS) followed by adjuvant radiation therapy (RT) is the standard of care for women with early-stage breast cancer as an alternative to mastectomy. The purpose of this study was to examine the relationship between receipt of mastectomy and travel distance and time to RT facility in New Jersey (NJ).

Methods—Data were collected from a cohort of 634 NJ women diagnosed with early-stage breast cancer. In patients receiving RT, the precise RT facility was used, whereas in patients not receiving RT, surgeons were contacted to determine the location of RT referral. Travel distance and time to RT facility from the patients' residential address were modeled separately using multiple binomial regression to examine their association with choice of surgery while adjusting for clinical and sociodemographic factors.

Results—Overall, 58.5 % patients underwent BCS with median travel distance to the radiation facility of 4.8 miles (vs. 6.6 miles for mastectomy) and median travel time of 12.0 min (vs. 15.0 min for mastectomy). Patients residing >9.2 miles compared with 9.2 miles from radiation facility were 44 % more likely to receive mastectomy. Additionally, patients requiring >19 min compared with 19 min of travel time were 36 % more likely to receive mastectomy.

Conclusions—These data found that travel distance and time from RT facility act as barriers to undergoing BCS in women with early-stage breast cancer. Despite being in an urban region, a significant number of women in NJ with early-stage breast cancer did not receive BCS.

Breast conservation surgery followed by whole breast irradiation (BCS + RT) became the standard of care for women with early-stage breast cancer when the National Surgical Adjuvant Breast and Bowel Project (NSABP) B-06 trial, which compared mastectomy to

lumpectomy with and without radiotherapy in women with invasive carcinoma, reported a threefold reduction in local recurrence at 20 years with the addition of RT after BCS.¹ Similarly, other randomized trials demonstrated equivalent survival and local control rates among women treated with either mastectomy or lumpectomy followed by whole breast RT.^{2–5} Despite the advantages of BCS + RT, up to 30 % of patients who have BCS do not receive adjuvant RT.^{6–9} Many patients choose mastectomy or BCS alone over BCS + RT to avoid the protracted course of daily treatment involved with RT, which consists of daily radiotherapy to the whole breast followed by a boost to the tumor bed, delivered over the course of 6–7.5 weeks. Physician referral patterns, patient's cultural background and beliefs, socioeconomic factors, personal preference, and distance to the nearest RT center are major factors that influence the treatment algorithm and may affect the utilization of RT.^{7,10,11}

Several studies have shown a relationship between rates of mastectomy and accessibility of a RT facility, defined as the closest facility to the patient's residential address.^{10,12–14} Nattinger et al. reported findings in 21,135 women with stage I or II unilateral breast cancer identified using the Surveillance Epidemiology and End Results (SEER) registry between 1991 and 1992. Patients living greater than 15 miles from the nearest RT facility were found to have a statistically significant lower probability of undergoing BCS [odds ratio (OR) = 0.52; 95 % confidence interval (CI) 0.46–0.58].¹² Voti et al. reported on 26,423 primary breast cancer patients in Florida and found a negative association between the distance to the closest RT facility and BCS with 3 % decrease in odds of receiving BCS with a 5-mile increase in distance.¹⁴

These studies all share a similar conclusion but also are limited uniformly by their method of analysis between travel distance and receipt of RT; first and foremost, travel distances were calculated by the assumption of receipt of RT at the nearest facility, not the actual facility used. Therefore, the purpose of the present study was to assess the relationship between breast cancer surgery and geographic access to RT through two measures of accessibility: travel distance and travel time between patient's residential address and RT facility where treatment was delivered.

MATERIALS AND METHODS

Data Source and Study Population

Data collected in the Breast Cancer Treatment Disparity Study (BCTDS) was used for this analysis. BCTDS is a retrospective cohort study that includes 634 African American (AA) and white patients, diagnosed with early-stage breast cancer (stage I,II, T₃N₁M₀) between 2005 and 2011, 20–85 years of age at diagnosis, and residing in northern and central New Jersey (NJ). Patients with the following criteria were excluded from the BCTDS: neither AA nor white, nonresidents of NJ, diagnosed with inflammatory breast cancer or with histologic features other than adenocarcinoma, or diagnosed with any other cancer besides nonmelanoma skin cancer. Patients for the BCTDS were selected from the participants of Women Circle of Health Study who were identified and recruited using rapid case ascertainment conducted by the New Jersey State Cancer Registry staff at major hospitals in the Passaic, Bergen, Hudson, Essex, Union, Middlesex, and Mercer counties.¹⁵ Informed consents were obtained from all participants and the study was approved by the Institutional

Review Board. Patients who agreed to participate in BCTDS provided names and addresses of all the healthcare providers involved in their breast cancer care. Medical records were obtained from the providers listed by the patient and were retrospectively reviewed to collect information for the study. Women whose RT facility could not be identified ($n = 1$), women who did not undergo BCS or mastectomy ($n = 3$), and women who travelled to RT facility from an address listed outside NJ ($n = 7$) were excluded. A total of 623 patients met these criteria and were included in this analysis.

Study Outcome

The outcome of this study was the definitive type of surgery patient received: mastectomy or BCS. Identification of BCS included partial mastectomy, lumpectomy, excisional biopsy, reexcision of the biopsy site to obtain negative margins, and quadrantectomy. Mastectomy included total (simple) mastectomy, modified radical mastectomy, radical mastectomy, skin-sparing mastectomy, and bilateral mastectomy. Patients who received BCS followed by a mastectomy were included as a part of the mastectomy group ($n = 85$), except for those who received RT in between BCS and mastectomy ($n = 2$) who were classified into the BCS group.

Travel Distance and Travel Time

The independent variables included travel distance and travel time required to reach the radiation facility from patients' home. Patient's residential address information at the time of diagnosis and information on the address of the radiation facility where patients received RT was provided by the patient at the time of participation and also was verified from the medical records ($n = 427$). For patients who did not receive radiation or whose RT facility was not available ($n = 207$), phone calls were made to the respective surgeon's offices and the referral to the specific radiation facility for each patient was obtained.

Two travel measures were then calculated for each patient. The first was the travel distance from patient's residential address to the actual RT facility for each patient. The second measure was the travel time from patient's residential address to the actual RT facility for each patient, as a measure of realized access to care. The shortest one-way travel distance and travel time required to reach the radiation facility from patient's residential address was calculated using Google maps (maps.google.com), which takes into account the latitude and longitude for the locations and calculates the driving distance and travel time between the two. If more than one route was suggested, the route with the shortest distance and time was chosen.

Covariates

The sociodemographic factors (age at diagnosis, race, marital status, education level, annual household income, and type of primary insurance), clinical characteristics [menopausal status, body mass index (BMI), and comorbidity count], tumor characteristics [histological grade, American Joint Committee on Cancer (AJCC) stage, estrogen receptor (ER)/progesterone receptor (PR) status, human epidermal growth factor receptor 2 (HER2) status, triple-negative status], and receipt of adjuvant RT were examined as covariates in the study.

Statistical Analysis

Descriptive statistics for the sociodemographic, clinical, and tumor characteristics were evaluated for the BCS and mastectomy groups using Chi square tests. Distribution of travel distance and travel time was compared between the two groups using median with interquartile range (IQR) and quartiles computed from the distribution of all subjects. Association between type of surgery and the independent variables was examined using separate binomial regression models to estimate the relative risk (RR) of undergoing mastectomy with 95 % CI for each quartile of travel distance and travel time. We further examined the effect of clinical and sociodemographic covariates on the risk of undergoing mastectomy. Two separate adjusted models were established called the partially adjusted and fully adjusted models. The partially adjusted model included only clinical and tumor characteristics including BMI, tumor grade, AJCC stage, and triple-negative receptor status. The fully adjusted model also adjusted for sociodemographic characteristics (age at diagnosis and primary health insurance) in addition to the covariates included in partial adjustment. All statistical analysis was performed using SAS software version 9.3 (Cary, NC).

RESULTS

The study population consisted of 623 patients; of which, a total of 365 patients received BCS and 258 patients received mastectomy (Table 1). Overall, 47.8 % of patients were AA, 37.7 % had at least a college education, 36.4 % had a household income greater than \$70,000, and 69.0 % were privately insured. In addition, 55.5 % of patients were Stage I, 73.5 % were node-negative, 78.6 % ER- or PR-positive, 14.4 % triple-negative, 16.9 % HER2-positive, and 65.7 % of patients received RT.

Characteristics of the study subjects stratified by surgery type are shown in Tables 1 and 2. As expected, patient and tumor characteristics, such as younger age, premenopausal status, large tumor size, positive nodal status, and high AJCC stage, were each associated with receipt of mastectomy (all $p < 0.05$). Interestingly, low BMI, few comorbidities, and HER2 positivity also were significantly associated with receipt of mastectomy. Whereas distribution of race, marital status, education level, income, health insurance, ER/PR status, and triple negativity was not different between BCS and mastectomy groups.

As shown in Table 3, the median one-way distance to the RT facility was 4.8 miles [interquartile range (IQR): 2.9–7.9] for patients undergoing BCS and 6.6 miles (IQR: 3.5–10.2) for patients undergoing mastectomy (Kruskal–Wallis $p < 0.001$). The median one-way travel time to the RT facility was 12 min (IQR: 8–18) for patients undergoing BCS and 15 min (IQR: 10–22) for those undergoing mastectomy (Kruskal–Wallis $p < 0.001$).

Results from the unadjusted binomial regression model (Table 3) demonstrated that travel distance in the highest quartile, i.e., >9.2 miles was associated with a significantly higher risk of receiving mastectomy compared with the lowest quartile, i.e., <3.2 miles (relative risk [RR]: 1.63; 95 % CI 1.25–2.12). The risk remained significantly elevated for travel distance >9.2 miles compared with <3.2 miles after adjusting (Table 4) for clinical characteristics

(RR: 1.55; 95 % CI 1.18–2.04) and after adjusting for clinical and sociodemographic characteristics (RR: 1.42; 95 % CI 1.07–1.9).

Similar results were observed when unadjusted and adjusted association between surgery type and travel time was assessed (Tables 3 and 5). The univariate model revealed a significantly higher risk of receiving mastectomy for travel time >19 min compared with <9 min (RR: 1.58; 95 % CI 1.22–2.05). The partially and fully adjusted models also showed a significantly higher risk of undergoing mastectomy when highest quartile of travel time was compared with the lowest quartile (RR: 1.47; 95 % CI 1.12–1.93 and RR: 1.35; 95 % CI 1.02–1.79, respectively). In both the fully adjusted models, BMI < 24.5 versus > 30.0, AJCC stage II and above versus stage I, and age < 55 years versus ≥ 65 years also were significantly associated with the receipt mastectomy.

DISCUSSION

According to the 2010 U.S. Census data, the state of NJ has the 11th highest population in the United States (8,791,894 in 2010) occupying only 7,354.2 square miles, making it the densest state in the country with 1,195.5 persons per square mile. In addition, NJ does not have a certificate of need for megavoltage linear accelerators allowing for an abundance of RT facilities. Our results indicate that travel distance and travel time to reach radiation facility plays an important role in determining the choice of breast cancer surgery; an increase in the adjusted risk of receiving mastectomy (35 %) occurred at distances >9.2 miles versus < 3.2 miles or travel times >19 min versus < 9 min between the patient's residential address and that of the treating RT facility. The association between travel distance and time retained statistical significance in a model controlling for BMI, grade, AJCC stage, triple-negative receptor status, age at diagnosis, and insurance.

Several studies have examined the association of travel distance and receipt of RT; however, these studies used the nearest radiation facility to the patient while approximating the patient's residential location using the centroid of the zip code in which they lived.^{10,12–14} The present study estimated travel distances and times using the addresses of the radiation facilities where patients actually received radiation and their complete street address; this afforded a more accurate estimation of the accessibility of care while taking into account physician referral patterns. Our inclusion of travel time may give a more accurate representation of the geographic barriers to receipt of RT, such as quality of the roads and traffic patterns, especially in a densely populated state as NJ. Moreover, we were able to assess the impact of private insurance, BMI, number of comorbidities, and receptor status in our cohort of patients, which revealed that only lower BMI was associated with higher rate of mastectomy in the multivariate analysis. To our knowledge, this is the first study to include a large array of sociodemographic data and tumor characteristics. It is notable that a difference in the receipt of mastectomy with such a small absolute difference in travel distance and time was observed. We believe that even in an urban state like NJ there is a paucity of public transportation for patients to use to access such medical facilities. We were unable to find a difference in receipt of mastectomy across varying income levels in our descriptive analysis, although data were missing for 178 patients. Inclusion of income in the fully adjusted model (data not shown) in 399 patients found that income (<\$70,000) did not

affect the patients risk of mastectomy. In this model, the risk of mastectomy remained significantly elevated for travel distance >9.2 miles compared with <3.2 miles (RR: 1.42; 95 % CI 1.00–2.03), but not for travel time >19 min compared with <9 min (RR: 1.38; 95 % CI 0.97–1.96). The data included in this study were collected from patients and their medical records primarily for research purposes and has a high level of accuracy and completeness compared to other datasets (e.g., SEER, Medicare), which lends to the strength of this study. Recently, Jaggi et al. concluded that SEER registry data may not be an appropriate source for documentation or for investigating geographic variation of receipt of radiotherapy in breast cancer patients.¹⁶ In this analysis, the authors evaluated data from 2,290 survey respondents with nonmetastatic breast cancer in Detroit and Los Angeles and were merged with SEER data. They reported that underascertainment of radiotherapy was significantly associated in each registry with stage, income, mastectomy receipt, chemotherapy receipt, and diagnosis at a hospital that was not accredited by the American College of Surgeons.

Modified radical mastectomy is a standard of care alternative to BCS + RT and so the increase in mastectomy found among patients living >9.2 miles or >19 min away from the treating RT facility does not imply that these patients received an inferior treatment. Nonetheless, these women may not perceive access to a RT facility as a realistic treatment option. Our data suggest that the statistically significant effect of travel distance and time on receipt of mastectomy in NJ may be even more exaggerated in less urban areas.

It is interesting that women with a low BMI (<24.9) were more likely to receive a mastectomy; this may be explained by the receipt of reconstructive surgery or bilateral mastectomy, which we did not examine. Our data, however, did include 87 women who initially underwent BCS but eventually received a mastectomy; these women were mostly included under mastectomy for the purposes of this study. This cohort of women were treated with a myriad of treatment regimens, and it can be inferred based on their treatment paradigm most likely included women with multiple positive margins after BCS, unacceptable cosmetic outcome after BCS, patient choice, poor response to neoadjuvant therapy, and tumor recurrence after BCS. One major limitation of all previously published studies is that they could not quantify the effect of these unique circumstances, which accounted for approximately 25 % of all BCS patients in our study.

Even given the unique strengths of our study, there are several limitations of the analysis that also are present in previously published reports. First, our method of calculating travel distance and travel time does not take into consideration the traffic conditions that may vary at different times of day. It also is possible that factors, such as collagen vascular diseases, cardiomyopathy, and previous radiation to the breast, affected the choice of surgery; these data were not available for analysis.

In conclusion, we found that despite being an urban region, a significant number of women in NJ with early-stage breast cancer did not receive BCS given the distance or time needed for the patient to travel to the treating RT facility. Oncologists and surgeons should consider the barrier to access the radiation facilities while making treatment recommendations to patients with early-stage breast cancer.

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TABLE 1

Sociodemographic characteristics by surgery type

Characteristics	Lumpectomy (N = 365) n (%)	Mastectomy (N = 258) n (%)	p value
Age at diagnosis (year)			<0.001
<45	49 (13.4)	73 (28.3)	
45–54	102 (27.9)	84 (32.6)	
55–64	134 (36.7)	70 (27.1)	
65	80 (21.9)	31 (12.0)	
Race			0.673
White	193 (52.9)	132 (51.2)	
AA	172 (47.1)	126 (48.8)	
Marital status			0.324
Married or living as married	153 (41.9)	118 (45.7)	
Separated/divorced/widowed	82 (22.5)	49 (19.0)	
Single/never married	46 (12.6)	41 (15.9)	
Unknown	84 (23.0)	50 (19.4)	
Highest education level			0.727
Less than high school	26 (7.1)	11 (4.3)	
High school/GED graduate	82 (22.5)	59 (22.9)	
Technical/vocational school/ some college	78 (21.4)	59 (22.9)	
College graduate	76 (20.8)	60 (23.3)	
Postgraduate	60 (16.4)	39 (15.1)	
Unknown	43 (11.8)	30 (11.6)	
Annual household income			0.514
<\$35,000	66 (18.1)	47 (18.2)	
\$35,000–\$69,999	63 (17.3)	42 (16.3)	
\$70,000	125 (34.2)	102 (39.5)	
Unknown	111 (30.4)	67 (26.0)	
Primary insurance			0.084
Government insurance	80 (21.9)	39 (15.1)	
Private insurance	244 (66.8)	186 (72.1)	
No insurance (charity or self-pay)	18 (4.9)	20 (7.8)	
Unknown	23 (6.3)	13 (5.0)	

p values are derived from Chi square tests

AA African American

TABLE 2

Clinical and tumor characteristics by surgery type

Characteristics	Lumpectomy (N = 365) n (%)	Mastectomy (N = 258) n (%)	p value
Menopausal status			<0.001
Pre	88 (24.1)	115 (44.6)	
Post	277 (75.9)	143 (55.4)	
BMI (kg/m ²)			0.001
<24.9	95 (26.0)	107 (41.5)	
25.0–29.9	117 (32.1)	61 (23.6)	
30.0	149 (40.8)	87 (33.7)	
Unknown	4 (1.1)	3 (1.2)	
Comorbidity count			0.006
0	66 (18.1)	75 (29.1)	
1	105 (28.8)	64 (24.8)	
2	194 (53.2)	119 (46.1)	
Tumor grade			0.064
Well differentiated	81 (22.2)	36 (14.0)	
Moderately differentiated	147 (40.3)	108 (41.9)	
Poorly differentiated	120 (32.9)	99 (38.4)	
Unknown	17 (4.7)	15 (5.8)	
Tumor size (cm)			<0.001
0.5	44 (12.1)	49 (19.0)	
>0.5 to 1.0	99 (27.1)	34 (13.2)	
>1.0 to 2.0	134 (36.7)	70 (27.1)	
>2.0	88 (24.1)	105 (40.7)	
Node status			<0.001
Negative	293 (80.3)	165 (64.0)	
Positive	68 (18.6)	91 (35.3)	
Unknown	4 (1.1)	2 (0.8)	
AJCC stage			<0.001
Stage I	237 (64.9)	109 (42.2)	
Stage II and above	124 (34.0)	145 (56.2)	
Unknown	4 (1.1)	4 (1.6)	
ER/PR status			0.388
One positive	45 (12.3)	30 (11.6)	
Both positive	245 (67.1)	170 (65.9)	
Both negative	75 (20.5)	56 (21.7)	
Unknown	0 (0.0)	2 (0.8)	
HER2 status			0.019
Positive	52 (14.2)	53 (20.5)	
Negative	304 (83.3)	192 (74.4)	

Characteristics	Lumpectomy (N = 365) n (%)	Mastectomy (N = 258) n (%)	p value
Unknown	9 (2.5)	13 (5.0)	0.199
Triple-negative status			
Yes	51 (14.0)	39 (15.1)	
No	305 (83.6)	206 (79.8)	
Unknown	9 (2.5)	13 (5.0)	<0.001
Radiation therapy			
Yes	356 (97.5)	53 (20.5)	
No	7 (1.9)	205 (79.5)	
Unknown	2 (0.5)	0 (0.0)	

p values are derived from Chi square test

BMI body mass index, *AJCC* American Joint Committee on Cancer, *ER* estrogen receptor, *PR* progesterone receptor, *HER2* human epidermal growth factor receptor 2

TABLE 3

Travel distance and travel time by surgery type

	Lumpectomy (N = 365)	Mastectomy (N = 258)	RR (95 % CI)
Travel distance (miles)			
Median (IQR)	4.8 (2.9–7.9)	6.6 (3.5–10.2)	–
<i>p</i> < 0.001			
Quartiles, n (%)			
<3.2	106 (29.0)	52 (20.2)	Ref
3.2–5.6	101 (27.7)	60 (23.3)	1.13 (0.84–1.53)
5.7–9.2	86 (23.6)	63 (24.4)	1.28 (0.96–1.72)
>9.2	72 (19.7)	83 (32.2)	1.63 (1.25–2.12)
Travel time (min)			
Median (IQR)	12 (8–18)	15 (10–22)	–
<i>p</i> < 0.001			
Quartiles, n (%)			
<9	106 (29.0)	55 (21.3)	Ref
9–13	101 (27.7)	50 (19.4)	0.97 (0.71–1.32)
14–19	87 (23.8)	70 (27.1)	1.31 (0.99–1.72)
>19	71 (19.5)	83 (32.2)	1.58 (1.22–2.05)

p values are derived from Kruskal–Wallis test*RR* relative risk, *CI* confidence interval, *IQR* interquartile range

TABLE 4

Effect of travel distance (quartiles) on the risk of undergoing mastectomy

	Partially adjusted RR (95 % CI) N = 571	Fully adjusted RR (95 % CI) N = 539
Travel distance (miles)		
<3.2	Ref	Ref
3.2–5.6	1.28 (0.94–1.75)	1.24 (0.9–1.7)
5.7–9.2	1.28 (0.95–1.72)	1.37 (1.01–1.85)
>9.2	1.55 (1.18–2.04)	1.42 (1.07–1.9)
BMI (kg/m ²)		
<24.9	1.37 (1.1–1.71)	1.33 (1.07–1.65)
25.0–29.9	1.00 (0.76–1.31)	0.95 (0.72–1.25)
30.0	Ref	Ref
Tumor grade		
Well differentiated	Ref	Ref
Moderately differentiated	1.18 (0.86–1.62)	1.12 (0.82–1.53)
Poorly differentiated	1.17 (0.84–1.64)	1.18 (0.86–1.64)
AJCC stage		
Stage I	Ref	Ref
Stage II and above	1.7 (1.38–2.11)	1.47 (1.18–1.83)
Triple-negative status		
Yes	1.03 (0.8–1.32)	0.90 (0.69–1.17)
No	Ref	Ref
Age at diagnosis (year)	–	
<45		1.89 (1.29–2.76)
45–54		1.58 (1.06–2.35)
55–64		1.30 (0.87–1.94)
65		Ref
Primary insurance	–	
Non-private		Ref
Private		0.92 (0.77–1.1)

RR relative risk, CI confidence interval, BMI body mass index, AJCC American Joint Committee on Cancer

TABLE 5

Effect of travel time (quartiles) on the risk of undergoing mastectomy

	Partially adjusted RR (95 % CI) N = 571	Fully adjusted RR (95 % CI) N = 539
Travel time (min)		
<9	Ref	Ref
9–13	1.03 (0.75–1.41)	0.99 (0.72–1.37)
14–19	1.30 (0.98–1.72)	1.31 (0.98–1.76)
>19	1.47 (1.12–1.93)	1.35 (1.02–1.79)
BMI (kg/m ²)		
<24.9	1.34 (1.08–1.68)	1.30 (1.05–1.62)
25.0–29.9	0.99 (0.76–1.3)	0.94 (0.72–1.23)
30.0	Ref	Ref
Tumor grade		
Well differentiated	Ref	Ref
Moderately differentiated	1.15 (0.84–1.58)	1.09 (0.8–1.49)
Poorly differentiated	1.13 (0.81–1.58)	1.15 (0.83–1.6)
AJCC stage		
Stage I	Ref	Ref
Stage II and above	1.68 (1.36–2.08)	1.45 (1.16–1.8)
Triple-negative status		
Yes	1.04 (0.82–1.33)	0.89 (0.68–1.16)
No	Ref	Ref
Age at diagnosis (year)	–	
<45		1.89 (1.29–2.76)
45–54		1.58 (1.06–2.35)
55–64		1.27 (0.85–1.91)
65		Ref
Primary insurance	–	
Non-private		Ref
Private		0.93 (0.78–1.1)

RR relative risk, CI confidence interval, BMI body mass index, AJCC American Joint Committee on Cancer