Published in final edited form as:

Breast Cancer Res Treat. 2011 August ; 129(1): 269–275. doi:10.1007/s10549-011-1549-4.

The influence of travel time on breast cancer characteristics, receipt of primary therapy, and surveillance mammography

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Abstract

Travel time has been shown to influence some aspects of cancer characteristics at diagnosis and care for women with breast cancer, but important gaps remain in our understanding of its impact. We examined the influence of travel time to the nearest radiology facility on breast cancer characteristics, treatment, and surveillance for women with early-stage invasive breast cancer. We included 1,012 women with invasive breast cancer (stages I and II) who had access to care within an integrated health care delivery system in western Washington State. The travel times to the nearest radiology facility were calculated for all the U.S. Census blocks within the study area and assigned to women based on residence at diagnosis. We collected cancer characteristics, primary and adjuvant therapies, and surveillance mammography for at least 2.5 years post diagnosis and used multivariable analyses to test the associations of travel time. The majority of women (68.6%) lived within 20 min of the nearest radiology facility, had stage I disease (72.7%), received breast conserving therapy (68.7%), and had annual surveillance mammography the first 2 years after treatment (73.7%). The travel time was not significantly associated with the stage or surveillance mammography after adjusting for covariates. Primary therapy was significantly related to travel time, with greater travel time (>30 min vs. ≤10 min) associated with a higher likelihood of mastectomy compared to breast conserving surgery (RR = 1.53; 95% CI, 1.16–2.01). The travel

time was not associated with the stage at diagnosis or surveillance mammography receipt. The travel time does seem to influence the type of primary therapy among women with breast cancer, suggesting that women may prefer low frequency services, such as mastectomy, if geographic access to a radiology facility is limited.

Keywords

Mammography; Travel time; Integrated delivery system; Breast carcinoma; Breast cancer therapy

Introduction

Travel time to health care services has been shown to influence both access and utilization. For women with breast cancer, increased travel time to health care facilities has been associated with greater risk of presenting with advanced stage [1], decreased breast conserving therapy (BCT) use [2, 3], and lower enrollment in clinical trials [4]. However, most previous studies have not included a study population with similar access to services, as found in an integrated healthcare delivery system. A more detailed understanding of clinical patterns in relation to travel time is still needed, as is assessment of follow-up care for breast cancer patients.

Stage at breast cancer diagnosis in relation to travel time needs to account for tumor characteristics to best isolate any effects of travel time from disease-specific characteristics. Given the prior reported relation between increased travel time and lower use of BCT [2, 3], a more nuanced examination of treatment, including adjuvant therapy is warranted, particularly in populations where access and financial barriers are reduced. The evidence suggests that only 75% [5] of all women with early-stage breast cancer and 69% of those women aged 75 and older [6] receiving BCT also receive the recommended radiation therapy. Further, although annual surveillance mammography is the guideline for women with early-stage breast cancer who have completed active treatment [7–10], a number of studies have demonstrated suboptimal surveillance rates between 62% [11] and 80% [12–14]. Several factors, such as geographic region [12], no visits to an oncologist, breast surgeon [12, 13], gynecologist, or primary care physician [14], older age [12], comorbidities [14], non-white race [11, 12], and mastectomy versus lumpectomy [11], have been shown to be associated with the lower receipt of surveillance mammography, but the role of travel time has not been assessed.

In this study, we examined the influence of travel time to the nearest radiology facility on breast cancer characteristics, treatment, and surveillance among a cohort of women with incident early-stage invasive breast cancer (stages I–IIb) [15]. The travel time was examined in relation to the tumor size, stage, primary and adjuvant treatments, and receipt of the surveillance mammography. We were able to better isolate the effect of travel time by examining its role in relation to breast cancer care within an integrated health care delivery system, and thus minimizing other non-geographic access barriers, such as insurance, services available and covered, and practice and referral patterns.

Methods

Study population

The study population [16, 17] consisted of women enrolled at Group Health, an integrated health care delivery system serving approximately 600,000 individuals in Washington State. The data were collected as part of two studies [6, 16, and 18] that linked Group Health data to the western Washington Surveillance, Epidemiology, and End Results (SEER) cancer

registry [19]. Eligibility was based on a diagnosis of a first primary, invasive, stage I, IIA, or IIB unilateral breast carcinoma [15]. Both the studies were approved by the institutional review board. The first study included women 65 years old, who were diagnosed between January 1, 1990 and December 31, 1994 [6, 21]. The eligible women in the second study included those 18 years old and diagnosed between January 1, 1996 and December 31, 1999 [17]. Women were required to be enrolled at Group Health in the year before and after diagnosis (unless died in the year following diagnosis), and to have received definitive surgical treatment (i.e., mastectomy or breast conserving treatment). Women were ineligible if they (1) had another clinically active malignancy, except non-melanoma skin cancer diagnosed 5 years before or 30 days after their breast cancer diagnosis, (2) had bilateral breast cancer, or (3) were enrolled in their health system for < 12 months before or after diagnosis. Women who died < 12 months after the diagnosis were not excluded from this study.

Our study cohort ($N = 1306$) consisted of 398 women from the first study and 908 women from the second study. In contrast to the primary studies, we further required women to be alive and enrolled for 2.5 years after diagnosis. We excluded 170 women for whom we did not have 2.5 years of follow up, 121 women without an address able to be geocoded, and three women not residing in the study area at diagnosis.

Data

Trained medical records abstractors completed standardized abstractions and entered information into a computerized data collection system that included a variety of preloaded automated data from cancer registry, administrative, and clinical databases [20]. The charts were reviewed from 1 year before diagnosis to the first of the following time points: time of death, disenrollment from Group Health, or 5 years after diagnosis. Data elements included demographics, comorbidities, and stage data based on the American Joint Committee on Cancer (AJCC) tumor-node-metastasis (TNM) system [15], tumor size, primary breast cancer treatment (mastectomy or BCT), evaluation of lymph nodes, and information on radiation use.

The point location of each woman in the study population was geocoded based on street address at the time of breast cancer diagnosis and the travel time for the census block in which she resided was assigned to her. We derived travel time estimates to the nearest radiology facility by using geographic centroids of census blocks and geocoding the Group Health radiology facilities based on street address. Six radiology facilities serving 24 primary care clinics were included. We calculated the travel time using a Network Analyst (ArcInfo v 9.1) by determining the shortest travel time route from each census block centroid to the nearest destination point (radiology facility) based on a national major and minor road network with associated speed limits (ESRI Streetmap USA Network Dataset), and did not account for ferry-boat travel.

Measures

The main effect of interest was the travel time to the nearest radiology facility. The main outcomes of interest included the stage, type of primary therapy, and receipt of surveillance mammography following the end of treatment [21]. We further classified stage as invasive cancer 1 cm and node negative status versus invasive cancers >1 cm with nodal involvement to reflect clinically meaningful categories. Primary therapy was categorized as receiving mastectomy (with or without radiation), BCT with radiation, or BCT without radiation [6]. Women were considered eligible for surveillance mammography 120 days after original diagnosis or through completion of surgery(ies) in the first course of treatment, whichever was longer [13, 21]. First- and second-year surveillance mammographies were

defined as those occurring 6–18 months and >18–30 months, respectively, after becoming eligible for surveillance.

Statistical analysis

We calculated frequencies of women characteristics (demographics, cancer characteristics, cancer treatment, and mammography surveillance after breast cancer) stratified by the travel time to mammography facility. We tested for bivariable relationships between the characteristics and the travel time using Pearson's Chi-Square Test for difference between groups.

To assess the association between the travel time and all cancer outcomes including stage of diagnosis, primary treatment, and receipt of surveillance mammography, we calculated relative risks (RR) and 95% Confidence Intervals (CI) using binomial-generalized linear regression models with a log link adjusting for categorical age and race (non-Hispanic white versus other). Specifically for stage of diagnosis outcomes, we ran four different analyses. We first ran an analysis assessing the binary outcome having larger tumor size (≥ 2 cm) compared with smaller tumor size. Then, we ran an analysis with the binary outcome having a later stage (node positive involvement or invasive cancer ≥ 1 cm) compared with early stage. The final set of models compared changes within tumor stage subcategories with the following two binary outcomes: (1) stage IIA compared to having stage I; and (2) stage IIB compared to having stage I. Therefore, the number of women represented in each analysis depended on the stage used in the model. For primary treatment outcomes, we first ran an analysis with the binary outcome having a mastectomy, and then we ran a second analysis among women with BCT using the outcome receipt of radiation compared with no radiation.

We examined the receipt of annual surveillance mammography in the first 2 years after initial therapy by the travel time. The binary outcome for these analyses was defined as the women having at least one mammogram in both years one and two post therapy. We ran the following three analyses: unadjusted, adjusted for categorical age and race (non-Hispanic white versus other), and adjusted for categorical age, race, and primary surgical therapy. All confidence interval and *P*-values are based on the Wald statistic with statistically significant associations at the $P < 0.05$ level and *P*-values being two sided. Data analyses were conducted using R software, Version 2.10.1 [22].

Results

Of the 1,012 women in our study population, the majority (70.6%) of women were 60 years or older and were non-Hispanic Caucasians (92.8%). Most women (68.6%) lived within 20 min of the nearest radiology facility, with only 10% living more than 30 min away (Table 1). For all measures of stage and cancer characteristics, most women had lower stage (72.7% Stage 1), no nodal involvement (86.5%), and smaller tumor size (73.9%) (Table 1). Almost one third of women received mastectomy, 59% underwent BCT with radiation, and 10% received BCT without radiation. The surveillance mammography in the first year following completion of primary treatment occurred for 85.7% of the study participants, but slightly dropped to 82.9% in the second year, with 73.7% receiving surveillance mammography in both the years.

In adjusted analyses examining the association of travel time with stage characteristics, we found no significant relation between travel time and stage, even among those having the earliest cancer (Table 2). Primary therapy was significantly associated with travel time, with longer travel time increasing the likelihood of undergoing mastectomy rather than BCT. Women with travel times of ≥ 30 min were 1.5 times as likely to have mastectomy instead of BCT compared to women with travel times of < 10 min (RR: 1.53, 95% CI 1.16–2.01).

(Table 2). A significant effect of the travel time on surveillance mammography was not found (Table 3).

Discussion

This study demonstrates how travel time is associated with cancer characteristics, treatment, and surveillance among women with early-stage breast cancer with access to healthcare in an integrated healthcare delivery system. We found that travel time was related to primary therapy, with longer travel increasing the likelihood of mastectomy instead of BCT. Travel time was not related to stage, tumor size, or nodal involvement. Surveillance mammography also had no significant association with travel time. The influence of travel time seems to vary across the cancer control continuum—from diagnosis, to treatment, and to surveillance. These differences may reflect preferences based on frequency of services, perceived importance of services, or other factors which should be explored.

We observed no relation between travel time and stage of initial diagnosis. However, this study was limited only to women with early-stage breast cancer. Other studies examining travel time (or distance) to services and stage at diagnosis for several cancers have yielded inconsistent evidence. In a sample of women with breast cancer in Los Angeles county, increased distance to mammography was associated with greater risk of advanced disease at diagnosis [1]. Similarly, for melanoma diagnosis, increasing travel time was significantly linked to greater disease severity [23]. In contrast, a study examining distance to a tertiary center in North Dakota and stage at diagnosis of colorectal cancer found no association [24]. The link between travel time/distance and stage at diagnosis is far from clear, but is likely to be mediated by a number of factors including characteristics of the population, natural history of the cancer, use of screening, effectiveness of screening, and which services are being measured for access.

The choice of travel time rather than travel distance as the geographic measure of access was based on the idea that distances travelled are only comparable if the associated speed limits are accounted for, and that travel time is a more accurate measure of proximity regarding access to care. Prior evidence shows a correlation between travel distance and travel time of 0.826 for distances less than 15 miles [25]. Given the relatively urban/suburban locations of our study participants, we chose to use the more accurate measure geographic access, travel time. Further, geographic theory and evidence suggests that perceived distance is based on travel time rather than objective distance [26], and thus travel time is more relevant for decisions to access health care [26].

Previous reports have shown that greater travel distance is associated with higher likelihood of mastectomy and lower likelihood of adjuvant radiotherapy among women with BCT [1, 2, 5]. We demonstrated the relation between longer travel time and mastectomy instead of BCT, but did not find any relation with receipt to radiation among women with BCT. This may be due to women in our study population incorporating travel time into their decision making process for primary therapy before choosing therapy. A reasonable hypothesis is that travel time may have been a factor in their decision about receiving radiation therapy, which factor has been used in selecting mastectomy instead of BCT. Given that randomized clinical trials comparing BCT (with radiation) and mastectomy in women with early-stage breast cancer have shown nearly equivalent survival [27–31], factoring travel time into decision making may be appropriate.

We examined the relation of travel time with surveillance mammography because many studies have identified factors associated with lack of surveillance mammography [11–14], but none have examined whether variation is mediated by travel time. Our results suggest

that travel time does not significantly influence receipt of surveillance mammography. National guidelines from the American Cancer Society, American Society of Clinical Oncology, and the National Comprehensive Cancer Network recommend annual surveillance mammography following treatment of invasive breast cancer because of increased risk of a new primary or recurrence [7–10]. Studies have consistently demonstrated room for improving adherence to these guidelines [11–14]. The relation of travel time with surveillance mammography may be confounded by type of primary therapy received, but in this study even after adjusting for primary therapy, there were no statistical or clinically significant associations. Our findings suggest that geographic access as measured by travel time is not likely to play an important role, and thus helping one to better target factors on which to focus.

A key strength of this study is its examination of the effect of travel time across the cancer care continuum in the same population of women where barriers to health care access are removed. This approach allows a more reliable comparison of the role of travel time in pre-diagnostic, treatment, and surveillance phases of care. Considering our findings of the role of travel time in relation to stage, primary treatment, and surveillance taken together, a broader pattern of behavior is suggested. Therefore, how women factor travel time into their decisions or their capacity to obtain services is likely related to how often they need to travel to the service. We found that travel time was not significant for either stage measures, which are mediated by screening mammography or for surveillance mammography, but was significant for primary therapy. These findings are consistent with women weighting longer travel times more heavily for an intense period of use during primary treatment, than for low frequency, or annual services, in their patterns of use. Our study adds new evidence to the literature on the role of travel time and corroborates existing evidence, thereby demonstrating external validity.

Our results should be interpreted with consideration of several limitations. First, there was not a wide distribution of travel times within this study population, which reflects the base population of the Group Health system. Importantly, all women in our study had access to health care and medical insurance, including women with HMO-Medicare and HMO-Medicaid, reducing differences in our outcome variables that could arise due to socioeconomic status or other factors potentially associated with health insurance coverage and health care access. It is possible that travel time could have greater influence in outcomes outside an integrated group practice. Further, given the small proportion of non-white participants in the study (7%), our results may not be generalizable to other racial or ethnic groups. Also, the members of the Group Health system may not be representative of the general population in key ways, such as access to services, health behaviors, socioeconomic characteristics, and health status. However, this selectivity within our study population also provides a major strength, in that health care availability is relatively similar for the study group, and thus the effect of travel time may have been easier to isolate. Our travel time measure was based on proximity (nearest radiology facility), which may not have been the actual facility where mammography and primary therapy were received, and so some misclassification of actual travel time category may have occurred. This approach was necessary to make comparisons of travel time to services between women who did and did not receive services. Thus, our proximity-based measure captures *potential* access, which is likely to be included in women's decision making about seeking services. We were not able to account for the specific mode of transportation, or the actual use of specific transportation; transportation has been shown to be associated with mammography receipt previously available in our membership [32]. Also, our study only included women with definitive breast cancer surgery, and thus would not account for the effect of travel time on breast cancer treatment among women who do not undergo surgery. Further, our study population only included women with stage I, IIa, or IIb invasive cancer, and therefore it

may have been less likely to detect an effect of travel time on stage if travel time is mostly associated with more advanced cancer.

Population-based laboratories, such as integrated health care delivery systems, provide a unique opportunity to study spatial factors related to health care utilization. These study settings tend to have similar access for individuals in terms of capacity, thereby helping one to reduce bias in effect estimates of spatial factors. Travel time is only one of many potentially important factors in determining health care utilization, but others, such as locations and times of primary daily activities, co-location of primary and specialty services, and provider-specific factors should also be examined in similar settings.

In summary, we performed a broad examination of the role of travel time in breast cancer characteristics, treatment, and surveillance among a sample of women followed longitudinally. This study suggests that longer travel time influences choice of primary therapy for women with breast cancer but does not impact stage at diagnosis or receipt of surveillance mammography among insured women. For women with limited geographic access to services, travel time may be an important factor in the type of services received in some phases of care along the cancer control continuum.

Acknowledgments

This study was funded by Group Health Research Institute, and the Cancer Research Network (CRN) through grant 5U19CA079689-10, "Cancer Research Network Across Health Care Systems Pilot Funds." We would like to extend our thanks to Edward H. Wagner, MD, and MPH for making these funds available.

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Patient demographics, cancer characteristics, and cancer treatment of women with breast cancer from 1990–1999 in the Group Health integrated system

Table 1

Travel time to mammography facility					
	Overall N (%)	0–10 min N (%) ^a	>10–20 min N (%) ^a	>20–30 min N (%) ^a	>30 min N (%) ^a
Total	1012	252 (24.9)	442 (43.7)	217 (21.4)	101 (10.0)
Demographics					
Age at diagnosis (years)					
18–39	17 (1.7)	3 (17.6)	10 (58.8)	3 (17.6)	1 (5.9)
40–49	110 (10.9)	31 (28.2)	46 (41.8)	16 (14.5)	17 (15.5)
50–59	171 (16.9)	40 (23.4)	71 (41.5)	41 (24.0)	19 (11.1)
60–69	269 (26.6)	55 (20.4)	118 (43.9)	66 (24.5)	30 (11.2)
70–79	320 (31.6)	86 (26.9)	140 (43.8)	71 (22.2)	23 (7.2)
80	125 (12.4)	37 (29.6)	57 (45.6)	20 (16.0)	11 (8.8)
Race					
White, non-Hispanic	939 (92.8)	230 (24.5)	407 (43.3)	203 (21.6)	99 (10.5)
Other	73 (7.2)	22 (30.1)	35 (47.9)	14 (19.2)	2 (2.7)
Charlson index (year prior to diagnosis)					
0	715 (70.7)	182 (25.5)	313 (43.8)	145 (20.3)	75 (10.5)
1 or 2	267 (26.4)	62 (23.2)	120 (44.9)	62 (23.2)	23 (8.6)
3	30 (3.0)	8 (26.7)	9 (30.0)	10 (33.3)	3 (10.0)
Cancer characteristics					
Stage at diagnosis					
I	736 (72.7)	183 (24.9)	328 (44.6)	152 (20.7)	73 (9.9)
IIA	214 (21.1)	53 (24.8)	91 (42.5)	47 (22.0)	23 (10.7)
IIB	62 (6.1)	16 (25.8)	23 (37.1)	18 (29.0)	5 (8.1)
Early versus later stage ^b					
Early stage	679 (67.1)	172 (25.3)	288 (42.4)	144 (21.2)	75 (11.0)
Late stage	333 (32.9)	80 (24.0)	154 (46.2)	73 (21.9)	26 (7.8)
Nodal involvement					
No/no surgical evaluation	875 (86.5)	221 (25.3)	382 (43.7)	183 (20.9)	89 (10.2)
Yes	137 (13.5)	31 (22.6)	60 (43.8)	34 (24.8)	12 (8.8)

Travel time to mammography facility					
	Overall N (%)	0–10 min N (%) ^a	>10–20 min N (%) ^a	>20–30 min N (%) ^a	>30 min N (%) ^a
Tumor size					
< 2.0 cm	748 (73.9)	190 (25.4)	333 (44.5)	153 (20.5)	72 (9.6)
2.0 cm	264 (26.1)	62 (23.5)	109 (41.3)	64 (24.2)	29 (11.0)
Cancer treatment					
Primary Therapy					
Mastectomy with or without radiation	317 (31.3)	81 (25.6)	119 (37.5)	72 (22.7)	45 (14.2)
Breast conserving surgery with radiation	598 (59.1)	151 (25.3)	271 (45.3)	128 (21.4)	48 (8.0)
Breast conserving surgery without radiation	97 (9.6)	20 (20.6)	52 (53.6)	17 (17.5)	8 (8.2)
Mammography Surveillance					
Annual mammogram first 2 years after cancer diagnosis ^c					
No	266 (26.3)	62 (23.3)	117 (44.0)	58 (21.8)	29 (10.9)
Yes	746 (73.7)	190 (25.5)	325 (43.6)	159 (21.3)	72 (9.7)

^aRow percents

^bEarly stage defined as those with invasive cancers 1 cm and node negative involvement

^cAnnual mammogram in first 2 years is defined as a mammogram 6–18 and 18–30 months after eligible for surveillance

Table 2
Analyses assessing cancer characteristics association with travel time adjusted for age and race

	Tumor size (2 cm vs. < 2 cm)	Stage of diagnosis		Primary therapy	
		Later versus early stage ^a	Among those with stage IIA and I (n = 950): IIA vs. I	Among those with stage IIB and I (n = 798): IIB vs. I	Among those with breast conserving therapy (n = 695): radiation versus no radiation
N(%) with outcome	413 (40.8)	679 (67.1)	214 (22.5)	62 (7.8)	317 (31.3)
Travel time					
Time to closest facility, RR (95% CI)					
0–10 min	1	1	1	1	1
>10–20 min	1.02 (0.78, 1.33)	0.97 (0.87, 1.08)	0.98 (0.73, 1.32)	0.80 (0.44, 1.48)	0.87 (0.68, 1.10)
>20–30 min	1.25 (0.93, 1.68)	1.00 (0.88, 1.13)	1.06 (0.75, 1.49)	1.23 (0.65, 2.35)	1.05 (0.81, 1.36)
>30 min	1.17 (0.80, 1.70)	1.10 (0.96, 1.26)	1.07 (0.70, 1.64)	0.75 (0.28, 1.96)	1.53 (1.16, 2.01)

^aEarly stage defined as those with invasive cancers < 1 cm and node negative involvement

Bold indicates statistical significance at the 0.05 alpha level

Table 3

Analyses assessing annual mammography surveillance in the first 2 years after cancer diagnosis

Received annual surveillance in the first 2 years (yes/no)			
	Unadjusted	Adjusted for age and race	Adjusted for age, race, and primary therapy
Time to closest facility, RR (95% CI)			
0–10 min	1	1	1
>10–20 min	0.98 (0.89, 1.07)	0.98 (0.90, 1.06)	0.97 (0.89, 1.05)
>20–30 min	0.97 (0.87, 1.08)	0.97 (0.88, 1.07)	0.96 (0.87, 1.06)
>30 min	0.95 (0.82, 1.09)	0.94 (0.82, 1.08)	0.93 (0.82, 1.07)