Social Science & Medicine 89 (2013) 32–38

Contents lists available at SciVerse ScienceDirect

Social Science & Medicine

journal homepage: www.elsevier.com/locate/socscimed

Racial disparities in travel time to radiotherapy facilities in the Atlanta metropolitan area

Lucy A. Peipins [a,*], Shannon Graham [b], Randall Young [b], Brian Lewis [c], Barry Flanagan [c]

[a] Centers for Disease Control and Prevention, Division of Cancer Prevention and Control, 4770 Buford Hwy, NE, K-55, Atlanta, GA 30341, USA
[b] Agency for Toxic Substances and Disease Registry, Geospatial Research, Analysis, and Services Program, Atlanta, GA, USA
[c] Hewlett-Packard Enterprises, Palo Alto, GA, USA

ARTICLE INFO

Article history:
Available online 29 April 2013

Keywords:
Breast cancer treatment
Geographic disparities
Radiation therapy
Geographic information systems
Healthcare access

ABSTRACT

Low-income women with breast cancer who rely on public transportation may have difficulty in completing recommended radiation therapy due to inadequate access to radiation facilities. Using a geographic information system (GIS) and network analysis we quantified spatial accessibility to radiation treatment facilities in the Atlanta, Georgia metropolitan area. We built a transportation network model that included all bus and rail routes and stops, system transfers and walk and wait times experienced by public transportation system travelers. We also built a private transportation network to model travel times by automobile. We calculated travel times to radiation therapy facilities via public and private transportation from a population-weighted center of each census tract located within the study area. We broadly grouped the tracts by low, medium and high household access to a private vehicle and by race. Facility service areas were created using the network model to map the extent of areal coverage at specified travel times (30, 45 and 60 min) for both public and private modes of transportation. The median public transportation travel time to the nearest radiotherapy facility was 56 min vs. approximately 8 min by private vehicle. We found that majority black census tracts had longer public transportation travel times than white tracts across all categories of vehicle access and that 39% of women in the study area had longer than 1 h of public transportation travel time to the nearest facility. In addition, service area analyses identified locations where the travel time barriers are the greatest. Spatial inaccessibility, especially for women who must use public transportation, is one of the barriers they face in receiving optimal treatment.

Published by Elsevier Ltd.

Introduction

Radiation therapy following breast conserving surgery is a currently recommended treatment for local-regional breast cancer and completion of the required course of radiation therapy has been shown to substantially reduce the risk of recurrence as well as to reduce risk of breast cancer mortality (EBCTCG, 2011; Fisher et al., 2002; Julien et al., 2000; National Institutes of Health, 1991; Veronesi et al., 2002; Wapnir et al., 2011). Studies have shown African American and Hispanic women are less likely to receive radiation therapy compared to white women. Women with lower SES and education compared to women with higher SES and education, uninsured women compare to insured women, and women having Medicaid as their health insurance compared to women with other sources of insurance are also less likely to receive radiation therapy (Foley et al., 2007; Parise, Bauer, & Caggiano, 2012; Royak-Schaler et al., 2012; Smith et al., 2010; Tuttle et al., 2012; Voti et al., 2006).

Because radiation therapy requires daily sessions over the course of five to six weeks, initiation and completion of therapy may be especially vulnerable to transportation availability and travel time and distance barriers. These barriers may potentially affect the choice between a mastectomy and breast-conserving surgery. Several studies described a greater likelihood of women undergoing mastectomy rather than breast conserving surgery if they were at a greater distance from a radiation facility or if they were in a rural vs. urban geographic location (Boscoe et al., 2011; Jacobs, Delley, Rosson, Detrain, & Chang, 2008). A study using SEER registry data found that women living 15 miles or further from a radiation facility were less likely to undergo breast-conserving surgery (Nattinger, Kneusel, Hoffmann, & Gilligan, 2001). A study of travel time in northern England found that women who lived further from a radiotherapy center were less likely to undergo

* Corresponding author. Tel.: +1 770 488 3034; fax: +1 770 488 4639.
E-mail address: lbp6@cdc.gov (L.A. Peipins).

0277-9536/$ – see front matter Published by Elsevier Ltd.
http://dx.doi.org/10.1016/j.socscimed.2013.04.018

radiation therapy (Jones et al., 2008). Similarly in New Zealand, poorer breast cancer survival time was associated with longer travel time to a cancer center (Haynes, Pearce, & Barnett, 2008). Once treatment is initiated, time and distance barriers to facilities may also play a role in the completion of radiation therapy. Ramsey et al. (2009) examined completion of therapy among Washington State Medicaid enrollees and found that 22% of women beginning radiation therapy did not complete the recommended course of treatment and that 24% had at least one interruption. This measure of suboptimal treatment may contribute to the poorer survival rates. In particular, African American women have higher mortality rates compared with white women despite their lower incidence rates (30.5 vs. 21.6 per 100,000 respectively) (U.S. Cancer Statistics Work Group, 2013).

Whereas most of these studies describe time and distance as barriers to healthcare in rural settings or for larger geographic areas comparing both urban and rural settings, simple distance and time measures of access have received less attention and may be less meaningful for urban areas (Guagliardo, 2004). Of the five dimensions of access described by Penchansky and Thomas (1981), the measurements of availability (supply of services) and accessibility (mobility to services) may require a different approach in urban areas. In contrast with rural areas, urban areas have more healthcare facilities, shorter distances to facilities, and multiple modes of travel and routes to these facilities. Nevertheless transportation barriers may exist for lower income, minority, or disadvantaged populations who may depend on public transportation. Access to a private vehicle differs by race in urban areas such as Atlanta where more than 15% of black households have no private vehicle access while only 4% of white households have no private vehicle access (US Census, 2000).

Focusing on public transportation, the aim of our study was to quantify travel time transportation barriers to radiation facilities in the two-county Atlanta metropolitan area. Approaches to quantifying transportation barriers typically have included methods such as Euclidean distance measures from point to point, using the number of facilities within buffers around a point as a measure of accessibility, and the use of trip planners to better quantify travel time barriers. Our approach involved the construction of a multimodal transportation network that allowed us to create services areas for each radiation facility, enabling us to quantify the proportion of women within specified travel times to the nearest facility as well as to highlight geographic areas where travel time to treatment was especially difficult for women using public transportation.

Methods

Overview

Two methods were used to examine access to radiotherapy facilities. The first allowed us to calculate time and distance to facilities and the second provided a way of mapping accessibility to facilities within specified travel times. Both relied on the construction of a multi-modal transportation network model that included all bus and rail routes and stops, and system transfers that provided for the capture of travel, walk, and wait times experienced by public transportation system travelers in the Atlanta metropolitan area. We also built a private transportation network to model travel times by automobile. Using these networks, we calculated travel times to radiation facilities via public and private vehicle transportation from a population-weighted center of each of the 282 census tracts located within the 2-county area served by the Metropolitan Atlanta Rapid Transit Authority (MARTA). A full description of the construction of the multimodal public transportation models has been published previously (Peipins et al., 2011).

Service areas for each facility were created using the network model to map the areal coverage for specified travel times (30, 45 and 60 min) for both public and private vehicle modes of transportation. Using these service areas, we calculated the number of women over 40 years of age within a given travel time to the radiation facilities.

Data sources

We used 2000 U.S. Census data to determine the number of women 40 years of age and older, race, and household access to a private vehicle in each census tract of our study area. The 2000 Census definition of vehicle access describes the number of private vehicles (none, 1, 2, 3, 4, and 5 or more automobiles, vans, or small trucks) available for use by members of a household. We defined access to a private vehicle as none vs. 1 or more vehicles available to a household and categorized access to a private vehicle into tertiles defined as: low vehicle access = more than 20% of the population had no access to a private vehicle, medium vehicle access = 5%–20% of the population had no access to a private vehicle, and high vehicle access = less than 5% of the population had no access to a private vehicle. Race categories included non-Hispanic black, non-Hispanic white, and all other races (Asian, American Indian and Alaska Native, Native Hawaiian and Pacific Islander and those noting 2 or more races) classified by majority (> = 50%).

No comprehensive database of all radiation therapy facilities in the United States exists (Ballas, Elkin, Schrag, Minsky, & Bach, 2006), so lists must be compiled from a variety of sources. We identified 18 facilities in the two-county study area from facilities listed with the Georgia Department of Community Health, Division of Public Health and the Radiologic Physics Center (Georgia Department of Community Health, 2010). The locations of radiation oncology facilities were geocoded to the street address level of precision using Centrus geocoding software.

The Metropolitan Atlanta Rapid Transit Authority (MARTA) provided an extensive route network containing streets, all bus and rail routes, bus and train and stops, and station entrances as of October 2008. MARTA runs several hundred buses over 138 routes covering over 1000 route-miles. The train system includes 59 miles of rail lines and 38 stations, largely limited to the city of Atlanta and a portion of the surrounding area (MARTA, 2009).

Mapping and analysis

Dasymetric mapping was used to locate a population-weighted centroid for each census tract so as to provide a more realistic representation of the actual distribution of the population within a census tract (Wright, 1936). TeleAtlas boundary file data were used to identify uninhabited areas such as parks, shopping centers, and bodies of water. Population counts of women 40 years and older were used at the census block level. Using the mean center algorithm provided with ArcGIS 9.3 software (ESRI, Redlands, California), the centroid was calculated as an average of the *x* and *y* geometric center values of the zero-population areas and the census blocks within each tract using population counts as weights. Because zero population areas have no weight, the census tract centroid is 'pulled' toward those blocks with the highest population counts.

ArcGIS Network Analyst® was used to estimate the minimal travel time from the population-weighted centroids of each tract to the closest radiation facility (by time) for both public and private transportation. We did not attempt to model the variability seen in day-to-day commutes that is due to inclement weather, traffic congestion, time of day, road conditions, road repair work, crashes, and individual variability in walking or driving. Our travel time was a constant that varied only by mode of transportation. Each travel