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The joint effects of census tract poverty and geographic access on late-stage breast cancer diagnosis in 10 US States

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ABSTRACT

This study evaluated independent and joint effects of census tract (CT) poverty and geographic access to mammography on stage at diagnosis for breast cancer. The study included 161,619 women 40+ years old diagnosed with breast cancer between 2004 -2006 in ten participating US states. Multilevel logistic regression was used to estimate the odds of late-stage breast cancer diagnosis for the entire study population and by state. Poverty was independently associated with late-stage in the overall population (poverty rates >20% OR = 1.30, 95% CI = 1.26- 1.35) and for 9 of the 10 states. Geographic access was not associated with late-stage diagnosis after adjusting for CT poverty. State-specific analysis provided little evidence that geographic access was associated with breast cancer stage at diagnosis, and after adjusting for poverty, geographic access mattered in only 1 state. Overall, compared to women with private insurance, the adjusted odds ratios for late stage at diagnosis among women with either no insurance, Medicaid, or Medicare were 1.80 (95% CI = 1.65, 1.96), 1.75 (95% CI = 1.68, 1.84), and 1.05 (95% CI 1.01, 1.08), respectively. Although geographic access to mammography was not a significant predictor of late-stage breast cancer diagnosis, women in high poverty areas or uninsured are at greatest risk of being diagnosed with late-stage breast cancer regardless of geographic location and may benefit from targeted interventions.

1. Introduction

Breast cancer is second only to non-melanoma skin cancer in leading cancer causes among women in the United States (US) and accounted for an estimated 28% (or 226,870 cases) of all newly diagnosed female cancers in 2011. Breast cancer is also the second leading cause of cancer death in women, exceeded only by lung cancer. In 2012, approximately 39,520 women are expected to die from the disease (American Cancer Society, 2012).

Early detection of breast cancer is a critical component to improving survival and quality of life following treatment. Women diagnosed with early-stage breast cancer (*in situ* or localized) have a full range of treatment options that may reduce co-morbidities and mortality associated with the disease, while women who are diagnosed at more advanced stages (regional or distant) have much more limited clinical interventions available (Maughan et al., 2010). The average 5-year relative survival rate is close to 100% when breast cancer is diagnosed *in situ* (the earliest stage) as compared to 60% for localized and 33% and 5% for the late stages, regional and distant, respectively (Howlader et al., 2012).

While there is evidence that adherence to breast cancer screening guidelines and mammography screening have shifted the stage distribution toward earlier stages at a population level, not all groups have benefited (Chatterjee et al., 2012). There are significant disparities in breast cancer stage at diagnosis in both US and international populations. Research consistently indicates that breast cancer is more likely to be diagnosed when the cancer has progressed to an advanced stage among vulnerable populations, including racial/ethnic minorities (Merkin et al., 2002), the uninsured (Hahn et al., 2007; Halpern et al., 2007), and lower income and lower education groups (Clegg et al., 2009; DeSantis et al., 2010). Area-based measures of socioeconomic disadvantage are also associated with stage at diagnosis for breast cancer, with higher rates of late-stage breast cancer diagnosed among women living in low socioeconomic areas (Baade et al., 2011; Huang et al., 2009;

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Tarlov et al., 2009; Wang et al., 2012), and in impoverished and/or racially segregated urban neighborhoods (Dai, 2010).

Geographic factors such as rurality or proximity to the nearest mammography facility are also routinely examined in the context of breast cancer stage at diagnosis. These factors are of interest because, intuitively, limited access and the added cost, time, and effort needed to travel long distances for screening mammography services may impede the use of breast cancer screening services (Hahn et al., 2007; Hyndman et al., 2000). However, US and international studies investigating this association have reported inconsistent findings. Some have reported no significant association between rural/urban residence and stage at diagnosis (Baade et al., 2011; Blair et al., 2006; Celaya et al., 2010; Clegg et al., 2009), even after using more precise measures of geographic access, like road network distance or travel time to nearest mammography facility (Celaya et al., 2010; Gumpertz et al., 2006; Henry et al., 2011; Jones et al., 2008; Onega et al., 2011; Schroen and Lohr, 2009; Scoggins et al., 2012; Tarlov et al., 2009; Wang et al., 2008). Several studies also suggest that while women living in rural areas may have been at greater risk for late stage diagnosis compared to women living in urban areas in the past, the gap in rural–urban differences has closed over time. Some studies have even reported a reversal with a higher proportion of cancers diagnosed at a late stage in urban areas (MacKinnon et al., 2007; McLafferty et al., 2011; Sheehan and DeChello, 2005).

The inconsistent findings highlight the need for additional research to examine whether geographic access to mammography influences breast cancer stage at diagnosis. Most of the previous studies investigating associations between stage at diagnosis and poverty and geographic accessibility have been limited to single states, limited geographic regions, or focused on specific populations. Therefore, it is difficult to know whether the inconsistencies are a result of the geographic measures employed (e.g. urban–rural classifications, travel time), the geographic units employed (e.g. county vs. census tract), population characteristics (high poverty areas), and/or related settlement patterns. In order to advance research in this area, investigators must be able to explore these issues using data representing a wide variety of geographic areas and demographic and economic groups.

In this study, we use cancer data from 10 state cancer registries to examine the relationship between geographic accessibility, rural/urban residence, and census tract poverty and breast cancer stage at diagnosis. Analysis was conducted for the entire study population as well as by individual state. This research improves upon previous work by including a large and diverse population, using multi-level-level analysis, and utilizing a robust geographic accessibility measure that accounts for both the number of proximal mammography facilities and the distribution of drive times.

2. Materials and methods

2.1. Study population

Individual-level breast cancer data were obtained from 10 statewide population-based cancer registries representing 30% of the US population (Arkansas, California, Idaho, Iowa, Kentucky, North Carolina, New Hampshire, New York, New Jersey, and Oregon). All US North American Association of Central Cancer Registries (NAACCR) member registries ($N=51$) were invited to participate in the study in 2008 and the states in this study are those that agreed to participate. Cases were restricted to women aged 40 years and older, diagnosed between January 1, 2004 and December 31, 2006, with a histologically confirmed first primary *in situ* or invasive tumor of the breast (ICD-O3 C500-C509; excluding histology codes 9590–9989; $N=174{,}609$). In 2009, the US Preventive Services Task Force (USPSTF) issued a recommendation that routine screening start at age 50 (DeAngelis and Fontanarosa, 2010). However, the breast cancer screening recommendation during our study period (2004–2006) was routine mammography starting at age 40 (Knutson and Steiner, 2007).

Individual-level variables included age at diagnosis, tumor stage, race/ethnicity, and insurance coverage. Tumors were staged according to the SEER Summary Stage 2000 system, which groups cancers into five stages: *in situ*, localized, regional distant, and unstaged. Consistent with the majority of previous studies and the fact that mammography screening is effective in diagnosing early-stage cancers, tumors that were *in situ* or localized at the time of diagnosis were categorized 'early stage', and tumors that were regional or distant were categorized 'late stage' (Huang et al., 2009; McLafferty and Wang, 2009; Onega et al., 2011; Schroen and Lohr, 2009; Tarlov et al., 2009). Approximately 3% ($n=4477$) of women were unstaged and, therefore, excluded from analyses. Race/ethnicity was categorized as non-Hispanic black, non-Hispanic white, Hispanic, American Indian/Alaska Native (AI/AN), Asian Pacific Islander (API), and missing/unknown. Health insurance coverage at the time of diagnosis was classified as Medicaid, Medicare, uninsured, insured, and missing/unknown.

Census tract data was assigned by each of the respective registries. Cases were geocoded either to a full street address (87%) or to the postal delivery centroid (8%). About 5% of the cases were not geocoded and, therefore, excluded from the study. Census tract poverty, based on the ACS 2005–2009 estimates, was defined as the percentage of the population below the poverty line and linked to the geocoded census tract of the cases. Census tract poverty was categorized into four commonly used categories based on work by Krieger et al. (2002): $<5\%$ (low poverty), 5–10%, 10–19.9%, and $\geq 20\%$ below poverty (high poverty).

2.2. Mammography facility locations

The mammography facility addresses used for this study were obtained from the 2006 US Food and Drug Administration (FDA) facility certification database (Food and Drug Administration (FDA), 2006). All mammography facilities in the US that produce, process, or interpret mammograms must be certified by the FDA (Food And Drug Administration (FDA), 2012). Mammography facility addresses were geocoded to the street-address level using Integrity Geolocator software and the Tele Atlas street network file ($N=8769$) (Ascential Software, 2006; Tele Atlas, 2006). Facilities that could not be geocoded automatically ($<3\%$) were completed manually using on-line search engines and phone directories.

2.3. Measures of geographic access

Three measures of geographic access to mammography facilities were developed for this study. One measure was based on rural/urban residence as defined by Rural Urban Commuting Area (RUCA) codes. RUCA codes classify US census tracts using measures of urbanization, population density, and daily commuting flows from the 2000 census (Hart et al., 2005; Rural Health Research Center University of Washington, 2007). The 33 RUCA codes were aggregated into four commonly used categories: urban (RUCA codes 1.0, 1.1, 2.0, 2.1, 3.0, 4.1, 5.1, 7.1, 8.1, 10.1); large rural city/town (4.0, 4.2, 5.0, 5.2, 6.0, 6.1); small rural town (7.0, 7.2, 7.3, 7.4, 8.0, 8.2, 8.3, 8.4, 9.0, 9.1, 9.2); and isolated small rural town (10.0, 10.2, 10.3, 10.4, 10.5, 10.6).

Two additional measures of geographic access were based on road-network travel times. The first measure is the shortest