Distribution Agreement

In presenting this thesis or dissertation as a partial fulfillment of the requirements for an advanced degree from Emory University, I hereby grant to Emory University and its agents the non-exclusive license to archive, make accessible, and display my thesis or dissertation in whole or in part in all forms of media, now or hereafter known, including display on the world wide web. I understand that I may select some access restrictions as part of the online submission of this thesis or dissertation. I retain all ownership rights to the copyright of the thesis or dissertation. I also retain the right to use in future works (such as articles or books) all or part of this thesis or dissertation.

Signature:

Jessie A. Gleason _____

Date

DISPARITIES IN THE RECEIPT OF RADIATION THERAPY AMONG WOMEN UNDERGOING BREAST-CONSERVING SURGERY IN GEORGIA

By

Jessie Gleason

MSPH

Epidemiology

Dr. Kevin Ward

Faculty Thesis Advisor

DISPARITIES IN RECEIPT OF RADIATION THERAPY AMONG WOMEN UNDERGOING BREAST CONSERVING THERAPY IN GEORGIA

By

Jessie Gleason

Bachelors of Science

University of Pittsburgh

2006

Faculty Thesis Advisor: Kevin Ward, PhD

An abstract of

A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University

in partial fulfillment of the requirements for the degree of
Master of Science in Public Health
in Epidemiology

2011

DISPARITIES IN THE RECEIPT OF RADIATION THERAPY AMONG WOMEN UNDERGOING BREAST CONSERVING THERAPY IN GEORGIA

By Jessie Gleason

Objectives: The goal of this study was to determine whether there were socioeconomic disparities in the receipt of radiation therapy among women in Georgia who underwent breast conserving surgery (BCS) from 2004-2008. Failure to receive recommended radiation therapy following BCS results in greater risk of tumor recurrence and decreased survival. Exploring disparities in the receipt of guideline concordant therapy among a socioeconomically and racially diverse population of breast cancer patients will help to more fully understand how to bridge the gaps that exist in the receipt of standard of care treatment.

Methods: Using data from the Georgia Cancer Registry, all cases of breast cancer among women in Georgia who underwent breast conserving surgery and met clinical guidelines for radiation therapy were identified. Two measures of SES, derived from U.S. census tract data, were utilized: percentage of persons living in poverty and a composite measure of deprivation in Georgia. Covariates controlled for in multivariate logistic regression models included race, rural-urban residence, marital status, age at diagnosis, year of diagnosis, stage, estrogen receptor status, progesterone receptor status, primary site, and grade.

Results: In our study population, twenty percent of women did not receive the recommended therapy. Women in Georgia residing in low socioeconomic status census tracts have an increased odds of not receiving the standard of care radiation therapy even after controlling for other study covariates, compared to women in high socioeconomic status census tracts(OR 1.61, 95% CI 1.37-1.89 for poverty; OR 1.29, 95% CI 1.10-1.52 for deprivation). This same association was not found among women in the mid-level SES category.

Conclusions: This study has identified socioeconomic status as a risk factor for not receiving of standard of care radiation therapy among women who have undergone breast conserving surgery in Georgia. Women residing in lower SES tracts are at a greater risk of not receiving standard of care radiation therapy following breast conserving surgery. Future interventions in Georgia should be directed towards increasing access to facilities offering radiation therapy and health literacy to women residing in lower socioeconomic areas.

DISPARITIES IN RADIATION THERAPY AMONG WOMEN UNDERGOING BREAST CONSERVING THERAPY IN GEORGIA

By

Jessie Gleason

Bachelor's of Science

University of Pittsburgh

2006

Faculty Thesis Advisor: Kevin Ward, PhD

A thesis submitted to the Faculty of the

Rollins School of Public Health of Emory University

in partial fulfillment of the requirements for the degree of
Master of Science in Public Health
in Epidemiology

2011

Acknowledgements

I am indebted to my mentor and thesis advisor Dr. Kevin Ward. Without his thoughtful guidance from start to finish this thesis would not have been possible.

I would also like to thank Dr. Michael Kramer for his advice and assistance in developing the socioeconomic measures used in this study.

Lastly, I offer my regards to Becky Schwei and my family who supported me in any respect during the completion of this project.
Jessie A. Gleason

Table of Contents

Background and Literature Review

Breast cancer is the leading incident cancer among women in the United States [1]. Persistent disparities in survival rates [2,3], delays in diagnosis [4] and receipt of treatment [5,6] are documented among racial and ethnic minorities. These same disparities have been noted among women of lower socioeconomic status (SES) [7,8,9]. For women with early stage breast cancer, one option for surgical management of the disease is breast-conserving surgery (BCS) followed by post-operative radiation therapy. Numerous prospective randomized trials have demonstrated lower breast cancer recurrence rates with the addition of radiation therapy following BCS [10]. Not all women with medical indications for receipt of radiation therapy following breast-conserving surgery are receiving the recommended post-operative care. Understanding disparities in the receipt of guideline concordant therapy among a socioeconomically and racially diverse population of breast cancer patients will help to more fully understand how to bridge the gaps that exist in the receipt of standard of care treatment.

The Georgia Center for Cancer Statistics of Emory University operates the Georgia Cancer Registry (GCR) which participates in the National Cancer Institute's (NCI) Surveillance, Epidemiology, and End Results (SEER) Program and the Centers for Disease Control and Prevention's National Program of Cancer Registries (NPCR). SEER and NPCR are national surveillance programs which obtain information on all cancers registered in a series of defined geographic areas of the United States. All cases of cancer are mandated by individual state laws to be reported to each state's cancer registry. Population-based surveillance registries in the U.S., including the Georgia Cancer Registry, collect information on patient demographics, primary tumor site, tumor morphology, tumor stage, first course

of treatment, and follow-up for vital status. GCR data are made publicly available through a limited use dataset containing de-identified information.

Estimates from the U.S. Census Bureau (2009) provide comparisons for demographic distributions in the population of Georgia and the United States. As compared to the United States population, Georgia has a slightly younger population with fewer high school graduates, comparable gender distributions, a smaller percentage of foreign born persons, and a higher percentage of persons living in poverty. In Georgia, 65% of the population is white compared to 79.6% of the U.S. The black population, on the other hand, comprises 30.2% of Georgia's population compared to 12.9% of the U.S.

There are two primary local treatment options recommended for women diagnosed with early stage breast cancer: total mastectomy or breast-conserving surgery (i.e. lumpectomy) with radiation. For women who undergo breast-conserving surgery, radiation therapy is recommended within one year of diagnosis [11]. The Breast Cancer Quality of Care Measures by the American College of Surgeons Commission on Cancer and endorsed by the National Quality Forum in April 2007 indicate that females meeting the following criteria are recommended for radiation therapy following breast-conserving surgery:

- age 18 to 69 at the time of diagnosis,
- having no prior cancer diagnoses,
- diagnosed with a primary invasive epithelial tumor of the breast (excluding sarcomas),
- staged by the AJCC system as I, II or III,
- surgically treated by breast conservation therapy (surgical excision less than mastectomy)

- known to be alive with 1 year of diagnosis

Receipt of radiation therapy in these patients will eradicate residual local disease and minimize the rate of disease recurrence [10,12].

Today, breast-conserving surgery followed by radiation treatment is the preferred treatment of choice for women with early stage breast cancer [13]. In a randomized controlled trial, Liljegren et al found a 16% reduction in cancer reoccurrence, over 10 years, for women who received radiation therapy following breast-conserving surgery as compared to surgery alone [12]. Receipt of breast conserving surgery has been shown to increase with increasing SES and among women residing in higher-educated counties [14]. Women of older age groups are less likely to have received BCS [14,15,16,17,18] however findings indicate increasing use of BCS over time [14,16]. When indicators for the therapy exist, surgeon involvement in patient care has been found to be associated with receipt of radiation therapy in breast cancer patients [19]. Patients who did not receive radiation therapy and had strong indications for radiation therapy reported low surgeon involvement. Findings from the North American Fareston vs. Tamoxifen Adjuvant Trial found that surgeon training was also significant in determining whether a woman received radiation therapy following breast conserving surgery [17].

To better understand the underlying mechanisms which lead to health disparities, numerous studies have investigated breast cancer incidence, mortality and treatment by SES in racially diverse populations [20,21,22]. Research describes the persisting racial and socioeconomic disparities among women diagnosed with breast cancer. Racial survival disparities are reported by the National Cancer Institute; white women diagnosed with breast cancer have a 91% five-year survival compared to a 78% five-year survival among African

American women [13]. Additionally, African American women as compared to women from other racial and ethnic groups have been shown in selected studies to have increased delay in diagnosis and receipt of treatment [4,7,26] and to be diagnosed with advance disease more frequently [7,27]. Socioeconomic disparities among women diagnosed with breast cancer also exist. Exploring all-cause and cause-specific mortality, Steenland et al. found that breast cancer mortality differences by SES category persisted through the 1990s [23]. Yu et al. found lower SES to be significantly associated with risk of dying from breast cancer even after controlling for age and year of diagnosis, stage at diagnosis, first course treatment, race and urban-rural residence [8]. Additionally, increased risk of breast cancer mortality was noted among white women with higher levels of socio-economic disparity [7,25,26].

Research on the interplay of racial and socioeconomic disparities among women diagnosed with breast cancer has produced different findings. A study performed by Smith et al. found both race and SES to be significant factors in the risk of dying from breast cancer [18]. While research by Worthington et al. on type of breast cancer treatment received found no differences between black and white women.[28]. SES may in fact be able to explain some of the observed racial disparities. When SES and other known clinical factors were controlled for, Simon et al reported that much of the racial disparity in survival among women with early-stage diagnosis was explained [24]. Alternatively, race was able to explain socioeconomic disparities in some cases. Yu et al. found control for clinical factors, first course of treatment and race were able to explain the socioeconomic disparity in breast cancer survival [8].

Racial and ethnic disparities among receipt of standard-of-care radiation therapy for women receiving breast-conserving therapy persists [18,29,30]. Smith et al. showed that

white women were statistically more likely to receive radiation therapy following breast-conserving surgery than black women [18]. Du Xianglin et al. found that even after controlling for tumor or patient characteristics and year of diagnosis, African American women were less likely to receive standard of care radiation therapy [29]. These findings are consistent with work done by Gross et al. which found that 77.8% of African American women received radiation therapy following BCS, while 85.8% of white women received the standard of care therapy [30]. Smith et al. found that even after SES was controlled for race, remained a statistically significant predictor of radiation therapy following BCS [18]. Research describing socioeconomic disparities in receipt of standard-of-care radiation therapy is limited.

While the incorporation of socioeconomic status into disparities research is developing, studies employ a variety of different methods and indices to measure SES. Determining what SES measures to use is challenging and can have a strong impact on conclusions. Socioeconomic position, in regards to population health, includes the following aspects: occupational class, educational attainment/credentials, income and entitlements/subsidies, wealth and relative social ranking [31]. Recent research in this field has shown that measures of economic deprivation at the level of the census tract, such as the percent of the census population living below the poverty level, are most effective for evaluating health disparities [32]. These measures demonstrate consistent gradients across population subgroups, are robust across a range of disease outcomes, allow for maximal linkage, and are easy to understand and explain. The use of census tract and block group data have been shown to include more homogenous populations as compared to zip code data [33].

To investigate the association between standard of care radiation therapy following breast-conserving therapy with socioeconomic status (SES), we will employ two different measures of SES, both defined at the level of the census tract. While several studies have identified associations between lower receipt of standard of care therapy and black race or low SES populations, none to our knowledge have examined a population as racially and socioeconomically diverse as Georgia.

Methods

Study Population

The initial study population included all 35,033 breast cancer cases diagnosed in Georgia women from 2004-2008. The question aimed to investigate receipt of standard of care radiation therapy among women who are recommended to receive the therapy following breast conserving surgery. Thus the study population was subset in accordance with CoC Quality of Care Guidelines to include:

- Women aged 18 to 69
- With a known or assumed first or only case of cancer
- With primary epithelial invasive tumors of the breast
- Diagnosed at AJCC Stage I, II or III
- Surgically treated by breast conservation
- Known to be alive within one year of diagnosis
- Without a histology of inflammatory carcinoma

The final dataset included 7,515 cases. A diagram detailing the exclusion criteria is presented in Figure 1.

Socioeconomic Status

It has been suggested that there is little to be gained in using multiple measures of socioeconomic status in a single analysis as collinearity among these measures make interpretation difficult. This was highlighted in a study which found that including median income only had better predictive power than when additional measures were included [34]. For this study, the first measure of SES was selected based on recommendations from the

Public Health Disparities Geocoding Project operated through the Harvard School of Public Health. Findings from the Public Health Disparities Geocoding Project have shown that use of the census tract level measure "percent of persons below poverty" was optimal for monitoring socioeconomic inequalities across many health outcomes and levels of racial/ethnic diversity [31].

The second measure of SES used in this study was a neighborhood deprivation index that employed principal components analysis (PCA). PCA reduces a large dataset covering many dimensions and involving many interrelated variables by transforming the variables [35]. The creation of this index was outlined by Messer et al. in the Journal of Urban Health [36]. The index employed a combination of census variables to represent socioeconomic standing which include income/poverty, education, employment, housing and occupation [36].

These measures of SES were used in two separate models to determine whether they have differing impacts. The percentage of the census tract population living below the poverty level was classified into high (0-9.9%), medium (10-19.9%) and low (20-100%) SES categories. Federal definitions define census tracts with greater than 20% of the population living below the poverty level as "poverty areas". The deprivation index, created and utilized for this study, was a combination of eight census variables which were combined into a standard deviation index. Census tracts with a negative deprivation index were in higher SES levels while census tracts with positive indices represented lower SES levels. Using a standard deviation coding allowed a one-unit change to be interpreted as a standard deviation change in deprivation. The deprivation index was categorized into tertiles for the purposes of interpretation and to make the two measures of SES more relatable. The lowest

tertile of the standard deviation index was classified as high SES, the middle tertile as mid SES and the highest tertile as low SES.

Covariate Definitions

In addition to the study's primary exposure of socioeconomic status, a number of other covariates were examined for association with receipt of standard care radiation therapy. One of these covariates was rural-urban residence. The United States Department of Agriculture provides a measure of rural/urban community area (RUCA) codes for census tracts (2000). These codes measure population density, urbanization, and daily commuting [37]. The RUCA codes are broken into ten primary codes which indicate metropolitan, micropolitan, small town and rural commuting areas based on the population size and direction of the primary commuting flow. These codes are further broken into secondary codes which indicate secondary commuting flows [37].

For the purpose of this study, the secondary RUCA codes were categorized into four groups: Urban Core Areas, Suburban Areas, Large Town Areas and Small Town/Isolated Rural Areas. The categorization was aided by guidelines provided by the Washington State Department of Health [38]. All metropolitan areas were coded as Urban Core Areas. Suburban Areas were any secondary RUCA codes that indicated high commuting into urban core areas with the cutoff for high commuting considered as greater than 30% secondary commuting flow into an urban area. Large Town Areas were micropolitan areas with a secondary flow of 10% to 30% to an urban area, or a 30% to 50% commuting flow to a large urban cluster regardless of the micropolitan status. Finally, a small town or isolated areas comprised all remaining codes that had a small population density and a commuting flow less than 30% to an urban cluster or urban area.

Additional covariates of interest included race, Hispanic origin, marital status, age at diagnosis, year at diagnosis, stage, histology, tumor markers, laterality, subsite, and grade. In our study population there were not sufficient numbers to subclassify race groups beyond white and black. An 'other' category was created to include all other races. Marital status was classified as: single, married, separated, divorced, widowed and unknown. Stage was coded as stage I, II, IIA, IIB and III based on the American Joint Committee on Cancer 6th Edition Staging Manual. Histology was grouped into ductal, lobular, medullary, mixed and other [39]. Subsite included central , inner quadrant, outer quadrant, axillary tail, overlapping and breast, NOS (not otherwise specified). Laterality was divided into right or left and grade into low, intermediate and high differentiation. Finally, two important tumor markers used in the treatment decision making process, estrogen and progesterone receptor status, were classified as positive or not positive (negative, unknown, uncertain).

Statistical Analyses

All analyses were performed using SAS statistical software. Univariate analysis investigated the relationship between the covariates of interest and both the outcome, receipt of radiation therapy, and the exposure, our two measures of SES. All variables which had an association with either the exposure or outcome were included in the full logistic model. Categorical covariates were evaluated using a chi-square test while continuous variables were analyzed using t-tests or ANOVA. All tests were 2-sided with a p-value of 0.05.

Multivariate analysis was performed using logistic regression with associations between the binary outcome and predictor variables expressed as adjusted odds ratios (OR) with corresponding 95% confidence intervals (CI). Interaction terms were created between

our main exposure of interest (SES) and each of the other covariates. Two separate models were run for each of the two measures of SES. Collinearity diagnostics were assessed using a free SAS macro [40] with an a priori cutoff of 30 for the Condition Indices (CI) and 0.5 for the variance decomposition proportions (VDP). Collinearity was determined to be present if variables were related by both a high CI and a high VDP. Following assessment of collinearity, backward elimination was performed to assess the statistical significance of the interaction terms.

The study was approved by the institutional review board at Emory University.

Results

The distributions of selected covariates by each of the SES measures are presented in Table 1. Both measures of SES provided similar results in terms of statistically significant predictors. The use of tertile cutoffs for the deprivation index (DEP) resulted in a smaller percentage of women classified in the high SES category as compared to the SES measure based on census poverty alone (POV) (36.9% vs. 46.8%). Both SES measures showed increased receipt of radiation therapy among women in higher SES categories.

Women classified in the high SES category as defined using POV were more likely to live in urban core areas (95.4%) compared to women in the mid or low SES category (72.1% and 64.4%, respectively). They were also more likely to be white, married, slightly younger at diagnosis, and diagnosed with stage I disease, estrogen and progesterone receptor positive tumors and low grade tumors. Women in the low SES category as defined using POV were significantly more likely to be black compared to women in the mid or low SES category (48.1% vs. 30.2% vs. 14.1%). These women were also more likely to live in small towns (16.9% vs. 10.0% vs. 1.1%), be single (20.3% vs. 13.3% vs. 9.7%) and have tumors not classified to a specific breast subsite (10.3% vs. 9.4% vs. 6.7%). Similar results were obtained using DEP. There were no statistically significant associations between either SES classification and Hispanic origin, laterality or histology.

The distributions of selected covariates by receipt of radiation therapy are presented in Table 2. Of women in this population, twenty percent did not receive the standard of care radiation therapy following breast-conserving surgery. Women classified in a high SES category, as defined using POV were more likely to receive radiation therapy (48.8%) than women in a mid or low SES category (32.6% and 18.6%, respectively). Correspondingly,

women in a high SES category, defined by DEP, were more likely to receive radiation therapy (38.4%) than women in mid or low SES categories (24.9% and 26.7%, respectively). Women who received radiation therapy were more likely to live in an urban core area (82.6%) as compared to women who did not receive the therapy (76.6%). Women who did not receive radiation therapy were more likely to reside in a small town (10.9% v. 6.3%), to be black (32.0% vs. 24.9%) to be diagnosed with stage III disease (7.6% vs. 5.1%) and to have tumors not classified to a specific breast subsite (13.3% vs. 7.1%), as compared to women who did receive radiation therapy. These women were also less likely to be married (58.3% vs. 65.9%) and more likely to be single, separated, divorced or widowed. Relative to women who did not receive radiation therapy, women who did receive radiation therapy were more likely to have estrogen and progesterone positive tumors, be slightly older at diagnosis and have low grade tumors. There were no statistically significant associations between SES category and Hispanic origin, laterality and histology.

Table 3 provides the odds (odds ratios and 95% confidence intervals) of not receiving standard of care radiation therapy within one year of undergoing breast conserving surgery by the two study measures of SES in a model adjusted for rural-urban residence, race, marital status, age at diagnosis, year at diagnosis, ER, PR, stage, site, and grade. Both measures of SES showed increased odds of not receiving standard of care radiation associated with women in the lowest SES category relative to the highest SES category (OR 1.61, 95% CI 1.37-1.89 for poverty, OR 1.29 95% CI 1.10-1.52 for deprivation). Similar associations were not seen with the mid SES category for either SES measure.

In the adjusted model using POV, some categories of rural-urban residence, marital status, year of diagnosis, progesterone receptor status, stage and cancer site remained

significant. The odds ratio for receipt of radiation therapy following BCS among women residing in a small town, at time of diagnosis, compared to women who resided in an urban area at time of diagnosis was 1.59 [(1.28, 1.96) 95% C.I.] . Widowed women had a 42% increased odds [(1.13, 1.80) 95% C.I.] of not receiving standard of care radiation therapy as compared to their married counterparts. The odds ratio of not receiving standard of care therapy for women who tested progesterone receptor positive, as compared to women tested negative, did not test or had unknown test results, was 1.39 [(1.17, 1.66) 95% C.I.] . Women with a cancer site classified as breast, not otherwise specified, were at a 67% [(1.34, 2.08) 95% C.I.] increased odds of not receiving radiation therapy following BCS as compared to the odds of women with overlapping histological site.

After adjusting for SES (as defined by DEP), rural-urban residence, race, marital status, year of diagnosis, ER, PR, stage, cancer site and grade, significant associations were observed between rural-urban residence, marital status, year of diagnosis, progesterone receptor status, cancer site and the outcome. Women who resided in a small town at time of diagnosis had a 67% increased odds [(1.35, 2.06) 95% C.I.] of not receiving standard of care radiation therapy as compared to their urban counterparts. Single women had a 22% increased odds [(1.02, 1.46) 95% C.I.] of not receiving standard of care radiation therapy as compared to married women. Widowed women were 42% more likely [(1.13, 1.79) 95% C.I.] to not receive radiation therapy following BCS as compared to their married counterparts. Women diagnosed with a histological site of breast, not otherwise specified were at a 67% increased odds [(1.35, 2.08) 95% C.I.] of not receiving recommended radiation therapy as compared to the odds of women classified with overlapping histological site. Black women in either model, regardless of SES measure, were not at an increased risk of receiving

standard of care radiation therapy following breast conserving surgery compared to white women after control for the above covariates. Table 4 presents the summary odds ratios for the unadjusted and adjusted models for both measures of SES.

Discussion

Women in Georgia who underwent breast-conserving surgery are recommended, based on clinical guidelines, to receive radiation therapy within one year in order to reduce the risk of tumor recurrence. Women who do not receive the standard of care radiation treatment following their surgery are at an increased risk of tumor recurrence [10] and have decreased survival [10]. We found that women in Georgia residing in a census tract with low socioeconomic status have an increased odds of not receiving the standard-of-care radiation therapy even after controlling for rural-urban residence, race, marital status, year of diagnosis, ER, PR, stage, site and grade. This same association was not found among women in the mid-level SES category compared to women from higher SES areas.

Healthy People 2020, a set of national health guidelines published by the U.S. Department of Health and Human Services, recognized the importance of social determinants of health in encouraging or diminishing the health of people. These goals aim to attack this issue in the coming years by placing focused attention on research and programs which examine and target socioeconomic health disparities [41]. This study examined the association of receipt of radiation therapy among a population of women from Georgia. The overall population of Georgia is more likely to be black, lower educated, poorer and have less foreign born individuals. This study supports many of the findings in the existing literature in that low socioeconomic status is associated with increased risk of not receiving recommended radiation therapy following breast-conserving surgery [8].

Our measures of SES were area-based and derived from census tract data provided by the U.S. Census Bureau. Population-based cancer registries do not collect individual level socio-economic information and studies of this type often used area-based measures. An

area-based measure of SES should not be considered a proxy for individual SES but instead highlights the impact of neighborhood and structural influences on health.

Although we controlled for rural-urban residence in the hopes of diminishing issues of access due to distance from facilities, residence in a rural census tract still maintained a statistically significant association on whether a women received the necessary follow-up treatment. Marital status also remained statistically significant after control for SES and other covariates. This association may be related to differences in behavior, income, and social support [42]. The observed socioeconomic disparity, in which women from rural areas and black women are more largely represented, may be an issue of access. This study investigates specific access issues as all of the women in this study have already undergone breast-conserving surgery. Not receiving radiation therapy brings to light the acceptance of breast-conserving surgery without the increased attention to making radiation therapy as easily accessible [29]. Issues of access may be due to the inability of women in lower SES tracts to take off of work, fear of additional medical bills and a lack of health literacy.

Previous studies have investigated the impact of race on receipt of standard-of-care radiation therapy following breast conserving surgery [6,21,29]. We found that after adjusting for SES and covariates of interest race (white, black and other) no longer remained significant. Controlling for SES, rural-urban residence, marital status, year of diagnosis, stage, site, grade, ER and PR were able to explain the disparities in the receipt of standard of care radiation therapy that were observed in our univariate analyses for black women compared to white women in Georgia. This also supports findings from previous studies [28].

We explored the use of two different measures of SES. These measures were not directly comparable but aimed to highlight how the use of different SES measures effect

estimates. The selection of specific cutoffs may have played an important role in the differences observed in this study. The SES variable based on poverty alone was coded based on federal definitions, while the deprivation index was merely categorized by tertiles. However, both measures detected an inverse association with SES and receipt of radiation therapy; as risk of not receiving radiation therapy was greater among those in low SES areas.

In conclusion, women residing in lower SES tracts are at a greater risk of not receiving standard of care radiation therapy following breast conserving surgery. Future interventions in Georgia should be directed towards increasing access and health literacy to women residing in lower socioeconomic areas.

Strengths and Weaknesses

Strengths of this study are our use of census tracts to determine SES as they include a relatively homogenous population and have been shown to capture socioeconomic gradients [32]. As county level information is easier to obtain, many studies make use of this larger area-based measure. Additionally, this is the first study of its kind to look at receipt of radiation therapy following breast-conserving surgery among the socioeconomically and racially diverse women in Georgia.

Weaknesses include the lack of individual level SES data. As there is no clear definition on how to measure SES, these measures may show the impact of area SES on a person's health. An area-based measure may be indicative of a different risk factor than what would be represented with use of individual-level SES information. Additionally, this study used data specific to Georgia which has unique distributions of race, poverty, percentage living in rural areas and educational attainment. This limits the generalizability of these study findings to the larger national population. In controlling for race, there was limited

information on other racial and ethnic minorities as these populations are very small in Georgia. The selection of the SES measures and categories may incorrectly be capturing individuals into incorrect SES categories. The selection of rural-urban residence categories may not appropriately capture rural living. We were also unable to examine cultural and behavioral information which may play an important role in receipt of radiation therapy. Another limitation was that our estimates were not adjusted for family history of breast cancer, or insurance status.

Future Directions

This study has identified socioeconomic status as a risk factor for receipt of standard of care radiation therapy. This disparity is important as women who do not receive this therapy have been documented to have decreased survival rates. A future direction for this study should examine five-year survival of women in this study's population who did not receive radiation therapy as compared to women in this population who did receive the therapy while controlling for SES.

Future directions for this research should also take a qualitative look at the women residing in these lower SES areas. We have identified women at high-risk of not receiving standard or care radiation therapy, but it would be important to determine why these women are not receiving the therapy. By understanding the barriers to the receipt of radiation therapy, public health professionals can better target interventions with the ultimate goal of eliminating disparities in care.

References

1. Society AC Breast Cancer Overview, http://www.cancer.org/Cancer/BreastCancer/OverviewGuide/breast-cancer-overview-key-statistics
2. Chlebowski RT, Chen Z, Anderson GL, et al. Ethnicity and breast cancer: factors influencing differences in incidence and outcome. *J Natl Cancer Inst*. (2005);97: 439-448.
3. Tammemagi CM Racial/ethnic disparities in breast and gynecologic cancer treatment and outcomes. *Curr Opin Obstet Gynecol*. (2007);19: 31-36.
4. Gorin SS, Heck JE, Cheng B, Smith SJ Delays in breast cancer diagnosis and treatment by racial/ethnic group. *Arch Intern Med*. (2006);166: 2244-2252.
5. Shavers VL, Brown ML Racial and ethnic disparities in the receipt of cancer treatment. *J Natl Cancer Inst*. (2002);94: 334-357.
6. Breen N, Wesley MN, Merrill RM, Johnson K The relationship of socio-economic status and access to minimum expected therapy among female breast cancer patients in the National Cancer Institute Black-White Cancer Survival Study. *Ethn Dis*. (1999);9: 111-125.
7. Vona-Davis L, Rose DP The influence of socioeconomic disparities on breast cancer tumor biology and prognosis: a review. *J Womens Health (Larchmt)*. (2009);18: 883-893.
8. Yu XQ Socioeconomic disparities in breast cancer survival: relation to stage at diagnosis, treatment and race. *BMC Cancer*. (2009);9: 364.
9. Breen N, Figueroa JB Stage of breast and cervical cancer diagnosis in disadvantaged neighborhoods: a prevention policy perspective. *Am J Prev Med*. (1996);12: 319-326.
10. Fisher B, Anderson S, Bryant J, et al. Twenty-year follow-up of a randomized trial comparing total mastectomy, lumpectomy, and lumpectomy plus irradiation for the treatment of invasive breast cancer. *N Engl J Med*. (2002);347: 1233-1241.
11. Cancer Co (2007)National Quality Forum Endorsed Commission on Cancer Measures for Quality of Cancer Care for Breast and Colorectal Cancers, American College of Surgeons, May 14, 2007 http://www.facs.org/cancer/qualitymeasures.html
12. Liljegren G, Holmberg L, Bergh J, et al. 10-Year results after sector resection with or without postoperative radiotherapy for stage I breast cancer: a randomized trial. *J Clin Oncol*. (1999);17: 2326-2333.
13. Breast Cancer, NC Institute, National Institutes of Health, September 23rd, 2010 http://www.cancer.gov/cancertopics/factsheet/cancer-advances-in-focus/breast
14. Gilligan MA, Kneusel RT, Hoffmann RG, Greer AL, Nattinger AB Persistent differences in sociodemographic determinants of breast conserving treatment despite overall increased adoption. *Med Care*. (2002);40: 181-189.
15. Samet JM, Hunt WC, Farrow DC Determinants of receiving breast-conserving surgery. The Surveillance, Epidemiology, and End Results Program, 1983-1986. *Cancer*. (1994);73: 2344-2351.
16. Ayanian JZ, Guadagnoli E Variations in breast cancer treatment by patient and provider characteristics. *Breast Cancer Res Treat*. (1996);40: 65-74.
17. Chagpar AB, McMasters KM, Scoggins CR, et al. The use of radiation therapy after breast-conserving surgery in hormonally treated breast cancer patients is dependent on patient age, geographic region, and surgeon specialty. *Am J Surg*. (2008);195: 793-798.
18. Smith GL, Shih YC, Xu Y, et al. Racial disparities in the use of radiotherapy after breast-conserving surgery: a national Medicare study. *Cancer*. (2010);116: 734-741.

19. Jagsi R, Abrahamse P, Morrow M, et al. Patterns and correlates of adjuvant radiotherapy receipt after lumpectomy and after mastectomy for breast cancer. *J Clin Oncol*. (2010);28: 2396-2403.
20. Baquet CR, Commiskey P Socioeconomic factors and breast carcinoma in multicultural women. *Cancer*. (2000);88: 1256-1264.
21. Bernstein L, Teal CR, Joslyn S, Wilson J Ethnicity-related variation in breast cancer risk factors. *Cancer*. (2003);97: 222-229.
22. Hawley ST, Griggs JJ, Hamilton AS, et al. Decision involvement and receipt of mastectomy among racially and ethnically diverse breast cancer patients. *J Natl Cancer Inst*. (2009);101: 1337-1347.
23. Steenland K, Hu S, Walker J All-cause and cause-specific mortality by socioeconomic status among employed persons in 27 US states, 1984-1997. *Am J Public Health*. (2004);94: 1037-1042.
24. Simon MS, Banerjee M, Crossley-May H, et al. Racial differences in breast cancer survival in the Detroit Metropolitan area. *Breast Cancer Res Treat*. (2006);97: 149-155.
25. Bastiaannet E, de Craen AJ, Kuppen PJ, et al. Socioeconomic differences in survival among breast cancer patients in the Netherlands not explained by tumor size. *Breast Cancer Res Treat*. (2010).
26. Harper S, Lynch J, Meersman SC, et al. Trends in area-socioeconomic and race-ethnic disparities in breast cancer incidence, stage at diagnosis, screening, mortality, and survival among women ages 50 years and over (1987-2005). *Cancer Epidemiol Biomarkers Prev*. (2009);18: 121-131.
27. Hunter CP Epidemiology, stage at diagnosis, and tumor biology of breast carcinoma in multiracial and multiethnic populations. *Cancer*. (2000);88: 1193-1202.
28. Worthington J, Waterbor JW, Funkhouser E, et al. Receipt of standard breast cancer treatment by African American and White women. *Int J Med Sci*. (2008);5: 181-188.
29. Du Xianglin L, Gor BJ Racial disparities and trends in radiation therapy after breast-conserving surgery for early-stage breast cancer in women, 1992 to 2002. *Ethn Dis*. (2007);17: 122-128.
30. Gross CP, Smith BD, Wolf E, Andersen M Racial disparities in cancer therapy: did the gap narrow between 1992 and 2002? *Cancer*. (2008);112: 900-908.
31. College PaFoH (2004)The Public Health Disparities Geocoding Project, Harvard School of Public Health, Department of Society, Human Development, and Health,
32. Krieger N, Chen JT, Waterman PD, et al. Geocoding and monitoring of US socioeconomic inequalities in mortality and cancer incidence: does the choice of area-based measure and geographic level matter?: the Public Health Disparities Geocoding Project. *Am J Epidemiol*. (2002);156: 471-482.
33. Krieger N, Williams DR, Moss NE Measuring social class in US public health research: concepts, methodologies, and guidelines. *Annu Rev Public Health*. (1997);18: 341-378.
34. Geronimus AT, Bound J Use of census-based aggregate variables to proxy for socioeconomic group: evidence from national samples. *Am J Epidemiol*. (1998);148: 475-486.
35. Jolliffe I (2005) Principal Component Analysis: John Wiley & Sons, Ltd.
36. Messer L, Laraia B, Kaufman J, et al. The Development of a Standardized Neighborhood Deprivation Index. (2006): 1041-1062.
37. Rural-Urban Commuting Area Codes, ER Services, August 16, 2005 http://www.ers.usda.gov/Data/RuralUrbanCommutingAreaCodes/

38. Health WSDo Guidelines for using rural-urban classification systerms for public health assessment, February 3, 2010 http://www.doh.wa.gov/Guidelines/RuralUrban.htm#suggested
39. Types of Breast Cancer, National Cancer Institute, http://training.seer.cancer.gov/breast/intro/types.html
40. Zack M SJ, Satterwhite C (2004) collinearity_macro.
41. 2020 Topics & Objectives Social Determinants of Health, U.S. Department of Health and Human Services, http://www.healthypeople.gov/2020/topicsobjectives2020/default.aspx
42. Clegg LX, Reichman ME, Miller BA, et al. Impact of socioeconomic status on cancer incidence and stage at diagnosis: selected findings from the surveillance, epidemiology, and end results: National Longitudinal Mortality Study. *Cancer Causes Control*. (2009);20: 417-435.

Tables

List of Tables

List of Figures

Table 1. Demographics and clinical features of study population by SES measure

	Measures of Socio-economic Status													
	Deprivation Index (SES)							% Poverty						
	Low SES		Mid SES		High SES			Low SES		Mid SES		High SES		
Outcome and Covariates	n	%	n	%	n	%	**p-value**	n	%	n	%	n	%	**p-value**
Number (%)	2159	28.7	2580	34.3	2776	36.9	**<.0001***	1564	20.8	2432	32.4	3519	46.8	**<.0001***
% Reciept of Radation Therapy							**<.0001***							**<.0001***
Yes	1603	74.3	2093	81.1	2303	83.0		1115	71.3	1956	80.4	2928	83.2	
No	556	25.7	487	18.9	473	17.0		449	28.7	476	19.6	591	16.8	
Rurality							**<.0001***							**<.0001***
Urban Core Areas	1374	63.6	2042	79.2	2701	97.3		1007	64.4	1753	72.1	3357	95.4	
Suburban Areas	328	15.2	287	11.1	48	1.7		253	16.2	313	12.9	97	2.8	
Large Town Areas	106	4.9	74	2.9	11	0.4		39	2.5	124	5.1	28	0.8	
Small Town/Isolated	351	16.3	177	6.9	16	0.6		265	16.9	242	10.0	37	1.1	
Race							**<.0001***							**<.0001***
White	1138	52.7	1852	71.8	2400	86.5		792	50.6	1659	68.2	2939	83.5	
Black	992	46.0	696	27.0	294	10.6		752	48.1	735	30.2	495	14.1	
Other	29	1.3	32	1.2	82	3.0		20	1.3	38	1.6	85	2.4	
Hispanic Origin							0.9964							0.6925
Hispanic Origin	49	2.3	58	2.3	62	2.2		31	2.0	58	2.4	80	2.3	
Other	2110	97.7	2520	97.7	2714	97.8		1532	98.0	2373	97.6	3439	97.7	
Marital Status							**<.0001***							**<.0001***
Single	406	18.8	316	12.3	258	9.3		317	20.3	323	13.3	340	9.7	
Married	1132	52.4	1692	65.6	2017	72.7		785	50.2	1520	62.5	2536	72.1	
Separated	34	1.6	28	1.1	13	0.5		22	1.4	33	1.4	20	0.6	
Divorced	355	16.4	311	12.1	318	11.5		258	16.5	340	14.0	386	11.0	
Widowed	183	8.5	179	6.9	117	4.2		146	9.3	164	6.7	169	4.8	
Unknown	49	2.3	54	2.1	53	1.9		36	2.3	52	2.1	68	1.9	
Age at Diagnosis (Years)							**0.0376†**							**0.0079†**
mean (std)	54.1	9.5	53.5	9.2	53.5	9.1		54.2	9.6	53.7	9.3	53.3	9.1	
Stage							**<.0001***			.				**<.0001***
I	1208	55.9	1521	59.0	1782	64.2		868	55.5	1429	58.8	2214	62.9	
IIA	590	27.3	665	25.8	678	24.4		428	27.4	627	25.8	878	25.0	
IIB	219	10.1	234	9.1	195	7.0		161	10.3	224	9.2	263	7.5	
III	142	6.6	160	6.2	121	4.4		107	6.8	152	6.3	164	4.7	
Collaborative Stage							**<.0001***							**<.0001***
ER	1465	67.9	1830	70.9	2140	77.1		1072	68.5	1694	69.9	2669	75.8	
ER other$^{\phi}$	694	32.1	750	29.1	636	22.9		492	31.5	738	30.4	850	24.3	
							<.0001*							**<.0001***
PR	1290	59.7	1574	61.0	1904	68.6		947	60.5	1460	60.0	2361	67.1	
PR other$^{\phi}$	869	40.3	1006	39.0	872	31.4		617	39.5	972	40.0	1158	32.9	

Table 1. Demographics and clinical features of study population by SES measure

	Measures of Socio-economic Status													
	Deprivation Index (SES)							% Poverty						
	Low SES		Mid SES		High SES			Low SES		Mid SES		High SES		
Outcome and Covariates	n	%	n	%	n	%	**p-value**	n	%	n	%	n	%	**p-value**
Histology							0.0733							0.5067
Ductal	1726	79.9	2085	80.8	2182	78.6		1251	80.0	1944	79.9	2798	79.5	
Lobular	94	4.4	124	4.8	158	5.7		69	4.4	124	5.1	183	5.2	
Medullary	30	1.4	33	1.3	22	0.8		19	1.2	33	1.4	33	0.9	
Mixed	181	8.4	197	7.6	230	8.3		126	8.1	202	8.3	280	8.0	
Other	128	5.9	141	5.5	184	6.6		99	6.3	129	5.3	225	6.4	
Laterality							0.7332							0.9784
Right	1055	48.9	1262	48.9	1404	50.6		769	49.2	1210	49.8	1742	49.5	
Left	1103	51.1	1317	51.1	1371	49.4		794	50.8	1221	50.2	1776	50.5	
Subsite							**<.0001***							**0.0011***
Central	109	5.1	123	4.8	131	4.7		80	5.1	108	4.4	175	5.1	
Inner quadrant	421	19.5	478	18.5	551	19.8		297	19.0	467	19.2	686	19.5	
Outer quadrant	985	45.6	1191	46.2	1351	48.7		722	46.2	1107	45.5	1698	48.2	
Axillary Tail	22	1.0	24	0.9	17	0.6		16	1.0	21	0.9	26	0.7	
Overlapping	401	18.6	527	20.4	560	20.2		288	18.4	501	20.6	699	19.9	
Breast, NOS	221	10.3	237	9.2	166	6.0		161	10.3	228	9.4	235	6.7	
Grade							**<.0001***							**<.0001***
Low	412	19.1	527	20.4	701	25.3		318	20.3	464	19.1	858	24.4	
Intermediate	768	35.6	938	36.4	1093	39.4		563	36.0	878	36.1	1358	38.6	
High	875	40.4	1002	38.8	862	31.0		613	39.2	975	40.1	1151	32.7	
Unknown	104	4.8	113	4.4	120	4.3		70	4.5	115	4.7	152	4.3	

*Significant at a value of 0.05 using a Likelihood Ratio Chi-Square
†Significant at a 0.05 level using an ANOVA test
PR is a progesterone receptor postive assay
ER is an estrogen receptor postive assay
ϕOther is negative, unknown, or discrepant

Table 2. Demographics and clinical features of study population by receipt of radiation therapy

	Receipt of Standard of Care Radiation Therapy				
	Yes		No		
Exposures and Covariates	**n**	**%**	**n**	**%**	**p-value**
Number (%)	5999	79.8	1516	20.2	**<.0001***
% Poverty					**<.0001***
High SES	2928	48.8	591	39.0	
Mid SES	1956	32.6	476	31.4	
Low SES	1115	18.6	449	29.6	
Deprivation Index					**<.0001***
High SES	2303	38.4	473	31.2	
Mid SES	2093	24.9	487	32.1	
Low SES	1603	26.7	556	36.7	
Rurality					**<.0001***
Urban Core Areas	4956	82.6	1161	76.6	
Suburban Areas	501	8.3	162	10.7	
Large Town Areas	163	2.7	28	1.8	
Small Town/Isolated	379	6.3	165	10.9	
Race					**<.0001***
White	4390	73.2	1000	66.0	
Black	1497	24.9	485	32.0	
Other	112	1.9	31	2.0	
Hispanic Origin					0.7146
Hispanic Origin	133	2.2	36	2.4	
Other	5864	97.8	1480	97.6	
Marital Status					**<.0001***
Single	746	12.4	234	15.4	
Married	3956	65.9	885	58.3	
Separated	51	0.9	24	1.6	
Divorced	770	12.8	214	14.1	
Widowed	358	6.0	121	8.0	
Unknown	38	2.5	38	2.5	
Age at Diagnosis (Years)					
mean (std)	53.7	9.2	53.2	9.6	**0.0303†**

Table 2. Demographics and clinical features of study population by receipt of radiation therapy

	Receipt of Standard of Care Radiation Therapy				
	Yes		No		
Exposures and Covariates	**n**	**%**	**n**	**%**	**p-value**
Stage					**<.0001***
I	3800	63.3	711	46.9	
IIA	1439	24.0	494	32.6	
IIB	452	7.5	196	12.9	
III	308	5.1	115	7.6	
Histology					0.1303
Ductal	4810	80.2	1183	78.0	
Lobular	295	4.9	81	5.3	
Medullary	71	1.2	14	0.9	
Mixed	481	8.0	127	8.4	
Other	342	5.7	111	7.3	
Collaborative Stage					**<.0001***
ER	4480	74.7	955	63.0	
ER other	1519	25.3	561	37.0	
					<.0001*
PR	3964	66.1	804	53.0	
PR other	2035	33.9	712	47.0	
Laterality					0.8398
Right	2975	49.6	746	49.2	
Left	3022	50.4	769	50.7	
Subsite					**<.0001***
Central	276	4.6	87	5.7	
Inner quadrant	1191	19.8	259	17.1	
Outer quadrant	2872	47.9	655	43.2	
Axillary Tail	48	0.8	15	1.0	
Overlapping	1189	19.8	299	19.7	
Breast, NOS	423	7.1	201	13.3	
Grade					**<.0001***
Low	1373	22.9	267	17.6	
Intermediate	2282	38.0	517	34.1	
High	2093	42.6	646	42.6	
Unknown	251	4.2	86	5.7	

*Significant at a value of 0.05 using a Likelihood Ratio Chi-Square
†Significant at a value of 0.05 using a Two-Sample Independent T-test
PR is a progesterone receptor positive assay
ER is an estrogen receptor postive assay
ϕOther is negative, unknown, or discrepant

Table 3. Covariate adjusted Odds Ratios (ORs) of not receiving radiation therapy following breast-conserving surgery with 95% confidence interval

	Socioeconomic Status (deprivation index DEP)			Socioeconomic Status (% poverty POV)		
Characteristic	**OR**	**95% CI**		**OR**	**95% CI**	
Socioeconomic Status						
High	1.00	Reference		1.00	Reference	
Mid	0.96	0.83	1.11	1.04	0.90	1.21
Low	1.29*	1.10	1.52	1.61*	1.37	1.89
Rurality						
Urban	1.00	Reference		1.00	Reference	
Suburban	1.22	1.00	1.50	1.17	0.95	1.43
Large Town	0.69	0.46	1.05	0.72	0.47	1.09
Small Town	1.67*	1.35	2.06	1.59*	1.28	1.96
Race						
White	1.00	Reference		1.00	Reference	
Black	1.05	0.91	1.21	1.00	0.87	1.16
Other	1.24	0.82	1.87	1.23	0.81	1.86
Marital Status						
Married	1.00	Reference		1.00	Reference	
Single	1.22*	1.02	1.46	1.19	0.99	1.42
Separated	1.66	1.00	2.78	1.67	1.00	2.80
Divorced	1.13	0.95	1.35	1.12	0.94	1.34
Widowed	1.42*	1.13	1.79	1.42*	1.13	1.80
Unknown	1.41	0.95	2.07	1.39	0.94	2.05
Year of Diagnosis						
2008	1.00	Reference		1.00	Reference	
2007	1.01	0.83	1.22	1.01	0.83	1.22
2006	0.92	0.75	1.12	0.92	0.75	1.12
2005	1.33*	1.10	1.61	1.32*	1.09	1.59
2004	1.20	0.99	1.45	1.19	0.98	1.45
ER						
Other	1.00	Reference		1.00	Reference	
Yes	1.20	0.99	1.44	1.19	0.99	1.44
PR						
Other	1.00	Reference		1.00	Reference	
Yes	1.39*	1.16	1.65	1.39*	1.17	1.66

Table 3. Covariate adjusted Odds Ratios (ORs) of not receiving radiation therapy following breast-conserving surgery with 95% confidence interval

	Socioeconomic Status (deprivation index)			Socioeconomic Status (% poverty)		
Characteristic	**OR**	**95% CI**		**OR**	**95% CI**	
Stage						
III	1.00	Reference		1.00	Reference	
I	0.55	0.44	0.70	0.59*	0.44	0.71
IIA	0.96	0.75	1.22	0.96	0.75	1.23
IIB	1.17	0.88	1.54	1.17	0.88	1.55
Site						
Overlapping	1.00	Reference		1.00	Reference	
Axillary	1.00	0.54	1.84	0.99	0.54	1.84
Breast, NOS	1.67*	1.35	2.08	1.67*	1.34	2.08
Central	1.20	0.90	1.58	1.20	0.91	1.59
Inner Quadrant	0.85	0.70	1.02	0.85	0.70	1.03
Outer Quadrant	0.85	0.73	1.00	0.85	0.73	1.00
Grade						
Low	1.00	Reference		1.00	Reference	
Intermediate	0.98	0.83	1.16	0.98	0.83	1.16
High	0.95	0.79	1.14	0.95	0.79	1.14
Unknown	1.28	0.96	1.72	1.30	0.97	1.74

*Significant at a value of 0.05

Age at diagnosis was included in the model but not displayed in the table since it is continuous

Table 4. Multivariate analysis on receiving radiation therapy among women undergoing breast conserving surgery in Georgia

	Low SES v. High SES		Mid SES v. High SES	
	OR	95% CI	OR	95% CI
Main Exposure: % Poverty				
Model 1 Without adjustment for other factors	1.99	(1.73, 2.30)	1.21	(1.06, 1.38)
Model 2 Fully adjusted model	1.61	(1.40, 1.90)	1.04	(0.90, 1.21)
Main Exposure: Deprivation Index				
Model 3 Without adjustment for other factors	1.69	(1.47, 1.94)	1.13	(0.99, 1.30)
Model 4 Fully adjusted model	1.29	(1.10, 1.52)	0.96	(0.83, 1.11)

*Model 2 adjusted for poverty, rural, race, marital status, age at diagnosis, year at diagnosis, ER, PR, stage, site, grade

**Model 4 adjusted for poverty, rural, race, marital status, year at diagnosis, ER, PR, stage, site, grade

Figures

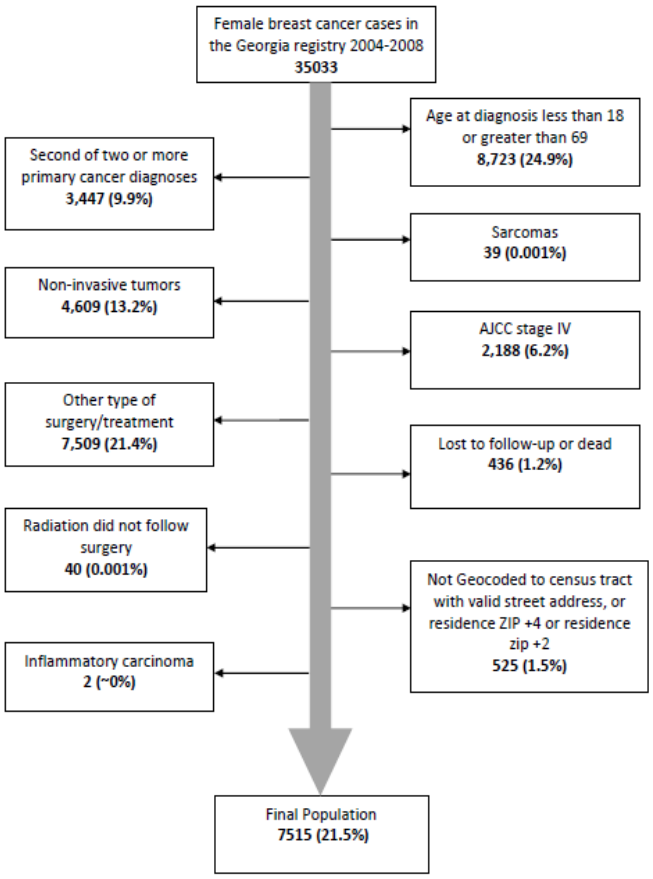

Figure 1. Flow chart of exclusion criteria used to determine the final study population

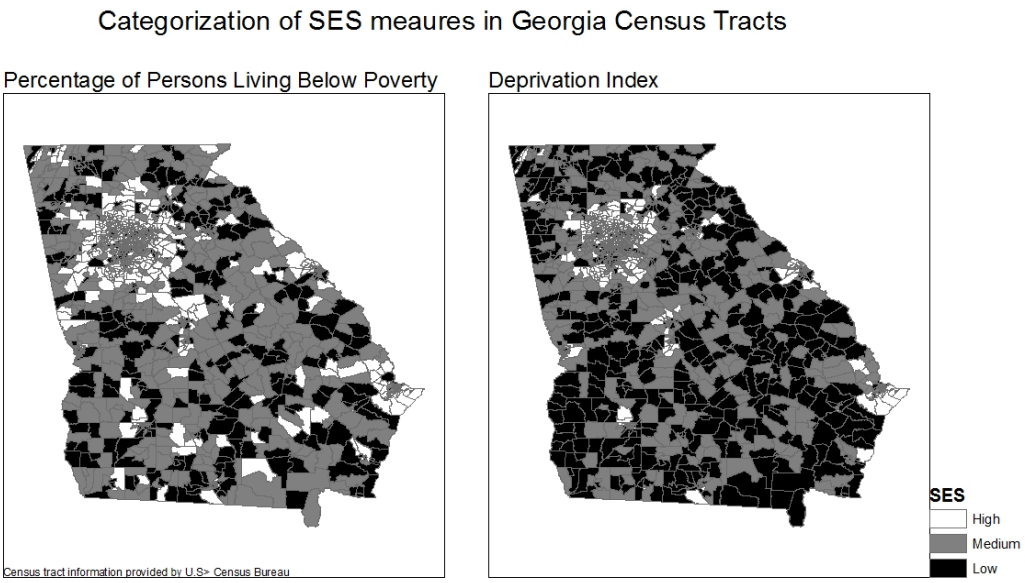

Figure 2. Map of Georgia census tracts by SES measure