Cancer Epidemiology 39 (2015) 745–751

Contents lists available at ScienceDirect

Cancer Epidemiology

The International Journal of Cancer Epidemiology, Detection, and Prevention

journal homepage: www.cancerepidemiology.net

Race/ethnicity and socio-economic differences in breast cancer surgery outcomes

Tomi F. Akinyemiju[a,*], Neomi Vin-Raviv[b], Daniel Chavez-Yenter[c], Xueyan Zhao[a], Henna Budhwani[c]

[a] Department of Epidemiology, University of Alabama at Birmingham, Birmingham AL, United States
[b] Rocky Mountain Cancer Rehabilitation Institute, School of Sport and Exercise Science, University of Northern Colorado, Greeley, CO, United States
[c] Department of Health Care Organization and Policy, University of Alabama at Birmingham, Birmingham AL, United States

ARTICLE INFO

Article history:
Received 20 April 2015
Received in revised form 4 July 2015
Accepted 21 July 2015
Available online 29 July 2015

Keywords:
Breast cancer
Surgery
Disparities
Socio-economic status
Race/ethnicity
Mortality

ABSTRACT

Background: The purpose of this study is to evaluate racial and socio-economic differences in breast cancer surgery treatment, post-surgical complications, hospital length of stay and mortality among hospitalized breast cancer patients.
Methods: We examined the association between race/ethnicity and socio-economic status with treatment and outcomes after surgery among 71,156 women hospitalized with a primary diagnosis of breast cancer using the Nationwide Inpatient Sample database from 2007 to 2011. Multivariable regression models were used to compute estimates, odds ratios and 95% confidence intervals adjusting for age, comorbidities, stage at diagnosis, insurance, and residential region.
Results: Black women were more likely to receive breast conserving surgery but less likely to receive mastectomies compared with white women. They also experienced significantly longer hospital stays ($\beta = 0.31$, 95% CI: 0.24, 0.39), post-surgical complications (OR = 1.21, 95% CI: 1.04–1.42) and in-hospital mortality (OR = 1.26, 95% CI: 1.07–1.50) compared with Whites, after adjusting for other factors including the number of comorbidities and treatment type.
Conclusion: Among patients hospitalized for breast cancer, there were racial differences observed in treatment and outcomes. Further studies are needed to fully characterize whether these differences are due to individual, provider level or hospital level factors, and to highlight areas for targeted approaches to eliminate these disparities.

© 2015 Elsevier Ltd. All rights reserved.

1. Introduction

Disparities in breast cancer treatment and outcomes have been documented among Black and White women in the U.S over the past several decades [1–6]. Although Black women are less likely to develop breast cancer compared with Whites, once diagnosed, Black women are less likely to receive guideline-adherent treatment [7–10] and have significantly lower 5-year survival rates [11–13]. These differences may be due to racial differences in tumor biology and disease aggressiveness [14–16], socio-economic factors and accessibility of healthcare that limit access to high quality treatment [17–20], presence of comorbid conditions [9,21,22], and psychosocial factors [23,24] that may influence responses to treatment. However, despite these explanations, Black–White differences in breast cancer survival have persisted and actually widened in recent decades.

Variations in cancer treatment and treatment outcomes may partially account for the observed racial and socio-economic disparities in breast cancer mortality [2–11]. A growing number of studies indicate that African-American women are less likely to undergo breast-conserving surgery (BCS) compared with White women [2,12–14] whereas other studies either reported no difference [15,16] or observed opposite findings [17,18]. Many of these previous studies were conducted among Medicare recipients, [2,10,12,19,21] a population group aged 65 years and older, with limited data on socio-economic and health care access variables (beyond having Medicare insurance) in the Medicare dataset. Although overall survival rates are similar among women receiving BCS and mastectomy [25], it is not clear if there are significant differences in outcome by race/ethnicity and socio-economic status (SES) among women receiving surgery. In particular, it is unclear if Black and/or low SES women experience

* Corresponding author at: Department of Epidemiology, University of Alabama at Birmingham Birmingham, AL 35294-0022, United States. Fax: +1 205 934 8665.
E-mail address: tomiakin@uab.edu (T.F. Akinyemiju).

http://dx.doi.org/10.1016/j.canep.2015.07.010
1877-7821/© 2015 Elsevier Ltd. All rights reserved.

worse outcomes due to the higher prevalence of advanced disease and comorbidities; factors that are both associated with type of surgical treatment received and treatment outcome.

The aim of this analysis was to examine treatment differences and clinical outcomes among Black and White women hospitalized with a primary diagnosis of breast cancer. By utilizing data from the large Nationwide Inpatient Sample database and focusing on inpatients that had theoretically accessed the healthcare system successfully, we were able to control for differences in access to healthcare. Determining the influence of race/ethnicity and SES on the type of breast cancer treatment received, and associated cancer outcomes may help to further shed light on the persistent disparities in breast cancer outcomes between Black and White women in the U.S, highlighting areas where targeted efforts may be focused to improve survival for all women with breast cancer.

2. Methods

We conducted a cross-sectional study of female patients, ages 40 years and older, admitted to the hospital between 2007 and 2011 with a primary diagnosis of breast cancer. Inpatient data was obtained from the Healthcare Cost and Utilization Project Nationwide Inpatient Sample (HCUP-NIS). The HCUP-NIS is a large all-payer inpatient care database covering over 1000 hospitals in the U.S., with data on over seven million hospital stays [26]. The dataset includes detailed clinical variables relating to all diagnoses and procedures performed during the admission, including ICD-9 codes. It also includes non-clinical variables such as median household income in the patient's zip code, rural/urban residence, hospital location, etc. Further details about the NIS can be obtained from: http://www.hcup-us.ahrq.gov/nisoverview.jsp.

2.1. Clinical variables

Breast cancer diagnosis was identified using the International Classification of Disease, ninth edition ICD-9 codes (174.0–174.9,). Since the HCUP-NIS does not include cancer stage variables, we created a proxy breast cancer stage variable using the clinical criteria of disease staging. We assigned metastatic stage when the ICD-9 code indicated metastatic disease to other organs (196.0), non-metastatic stage when those specific codes were absent, and in-situ when ICD-9 code 2330 was assigned. These staging criteria have been validated in previous studies, including in the HCUP-NIS database [22,27]. We created a modified Deyo comorbidity index

Table 1
Distribution of baseline characteristics by race among breast cancer patients, nationwide inpatient sample, 2007–2011.

	Race				
	White (N = 52,055) N (%)/mean (SD)	Black (N = 9,060) N (%)/mean (SD)	Hispanic (N = 5,372) N (%)/mean (SD)	Other (N = 4,669) N (%)/mean (SD)	P-value
Age at admission–years	62.6 (13.1)	59.8 (12.4)	57.9 (12.2)	59.0 (12.2)	<.0001
Length of stay–days	2.4 (3.4)	3.3 (4.7)	2.7 (4.0)	2.5(4.3)	<.0001
Number of Co-morbidities	0.233 (0.52)	0.289(0.58)	0.169 (0.44)	0.161 (0.43)	<.0001
Residential income					
First Quartile-Lowest	9,265 (18.13)	4,061 (46.37)	1,691 (32.45)	683 (15.33)	<.0001
Second Quartile	11,760 (23.01)	1,853 (21.16)	1,187 (22.78)	806 (18.09)	
Third Quartile	12,713 (24.88)	1,515 (17.30)	1,298 (24.91)	1,114 (25.00)	
Fourth Quartile-Highest	17,361 (33.98)	1,328 (15.17)	1,035 (19.86)	1, 853 (41.58)	
Insurance type					
Medicare	21,767 (41.64)	3,230 (35.65)	1,414 (26.32)	1,314 (28.14)	<.0001
Medicaid	2,821 (5.42)	1,592 (17.57)	1,264 (23.53)	662 (14.18)	
Private	25,907 (49.77)	3,591 (39.64)	2,145 (39.93)	2,403 (51.47)	
Other	1,651 (3.17)	647 (7.14)	549 (10.22)	290 (6.21)	
Residential region					
Large metro	26,958 (51.79)	6,407 (70.72)	3,941 (73.36)	3,446 (73.81)	<.0001
Small metro	13,873 (26.65)	1,540 (17.00)	988 (18.39)	694 (14.86)	
Micropolitan	5,324 (10.23)	573 (6.32)	216 (4.02)	253 (5.42)	
Stage at presentation					
In-situ	6,715 (12.90)	997 (11.00)	630 (11.73)	717 (15.36)	<.0001
Non-metastatic	30,252 (58.12)	4,834 (53.36)	3,004 (55.92)	2,571 (55.07)	
Metastatic	15,088 (28.98)	3,229 (35.64)	1,738 (32.35)	1,381 (29.58)	
Mastectomy					
No	24,641 (47.34)	4,585 (50.61)	2,621 (48.79)	2,154 (46.13)	<.0001
Yes	27,414 (52.66)	4,475 (49.39)	2,751 (51.21)	2,515 (53.87)	
Breast conserving					
No	50,071 (96.19)	8,619 (95.13)	5,101 (94.96)	4, 442 (95.14)	<.0001
Yes	1,984 (3.81)	441 (4.87)	271 (5.04)	227 (4.86)	
Complications					
0	49,813 (95.69)	8,626 (95.21)	5,171 (96.26)	4,482 (95.99)	0.06
1	2,091 (4.02)	407 (4.49)	183 (3.41)	172 (3.68)	
>=2	151 (0.29)	27 (0.30)	18 (0.32)	15 (0.29)	
Died during Hospitalization					
No	51,116 (98.38)	8,800 (97.24)	5,264 (98.04)	4,600 (98.65)	<.0001
Yes	842 (1.62)	250 (2.76)	105 (1.96)	63 (1.35)	

using ICD-9 codes for major comorbid conditions. The conditions included cerebrovascular disease, congestive heart failure, chronic pulmonary disease, diabetes mellitus with or without chronic complications, dementia, myocardial infarctions, peripheral vascular disease, rheumatic disease, peptic ulcer disease, mild liver disease, hemiplegia or paraplegia, renal disease, moderate or severe liver disease, and HIV/AIDS. We identified the presence of each condition within each patient, and summed up the number of conditions per patient into a single comorbidity score.

2.2. Individual variables

Our main predictors were race/ethnicity (White, Black, Hispanic, Other) and residential income (based on median household income at the zip-code level, divided into quartiles ranging from lowest income zip-code to the highest income zip-code). We additionally adjusted for *a priori* specified confounders including age; residential region and insurance type. Residential region was categorized as: large metropolitan areas (metropolitan areas with 1 million residents or more), small metropolitan areas (metropolitan areas with less than 1 million residents), micropolitan areas (Non-metropolitan areas adjacent to metropolitan areas) and non-metropolitan or micropolitan areas (noncore areas with or without its own town) using the 2003 version of the Urban Influence Codes [28]. HCUP-NIS insurance status was classified as: Medicaid, Medicare, private (includes Blue Cross, commercial carriers, private HMOs and PPOs, and self-insured) and other (includes Worker's Compensation, Title V, and other government programs) [29].

2.3. Outcome measures

We were interested in two sets of outcomes: first, whether patients received Breast Conserving Surgery (BCS) or mastectomy and the associated in-patient mortality; and second, post-surgical complications and length of stay among patients who received BCS versus mastectomy. Therefore we created two analytic datasets, the full dataset with all breast cancer patients, and a restricted dataset with only patients who received BCS or mastectomy. We identified patients who received BCS or mastectomy based on ICD-9 diagnoses and procedure codes. A clinical diagnosis of BCS included ICD-9 codes for breast lumpectomy, quadrantectomy, and subtotal mastectomy or mastectomy (codes 85.21, 85.22, 85.23); and mastectomy which included codes 85.41–85.48 [22]. We calculated hospital length of stay by subtracting the admission date from the discharge date, with same-day stays coded as 0. Mortality was based on deaths occurring during hospitalization. We determined the presence of post-surgical complications by using ICD-9 codes to identify mechanical wounds, infections, urinary, pulmonary, gastrointestinal, cardiovascular and intra-operative complications. However the HCUP-NIS does not include information on patient outcomes after discharge, therefore complications and mortality occurring after hospital discharge were not included in our analysis. In addition, since the dataset includes only de-identified patient records, it was not possible to exclude duplicate records if the same patient was admitted multiple times in the same year [30].

2.4. Statistical analysis

We conducted descriptive statistics to examine differences in study characteristics by race/ethnicity using chi-square tests for categorical variables and ANOVA for continuous variables. We used logistic regression analysis to determine the association between

Table 2
Multivariable logistic regression models of breast cancer surgery and in-hospital mortality, nationwide inpatient sample, 2007–2011.

	n	BCS [a] OR (95% CI)	*n*	Mastectomy [a] OR (95% CI)	*n*	In-Hospital Mortality [b] OR (95% CI)
Race/ethnicity						
White	1984	Ref.	27414	Ref.	842	Ref.
Black	441	**1.18 (1.06–1.33)**	4475	**0.94 (0.90–0.99)**	250	**1.26 (1.07–1.50)**
Hispanic	271	**1.25 (1.09–1.43)**	2751	1.02 (0.96–1.08)	105	1.15 (0.91–1.44)
Other	227	**1.22 (1.06–1.42)**	2515	**1.12 (1.05–1.19)**	63	0.94 (0.71–1.24)
Residential income						
Q4-Highest	963	Ref.	12960	Ref.	286	Ref.
Q3	792	1.03 (0.93–1.19)	10506	0.99 (0.95–1.03)	343	**1.30 (1.09–1.55)**
Q2	838	1.19 (1.06–1.33)	10261	1.01 (0.97–1.06)	364	1.14 (0.94–1.38)
Q1-Lowest	777	1.06 (0.94–1.19)	10107	1.03 (0.98–1.08)	449	**1.29 (1.06–1.56)**
Stage						
Non-metastatic	2026	Ref.	26627	Ref.	205	Ref.
In-situ	367	0.89 (0.79, 1.01)	6032	**1.10 (1.05, 1.15)**	3	**0.09 (0.03, 0.28)**
Metastatic	1054	1.00 (0.92-1.09)	12162	**0.78 (0.76, 0.81)**	1272	**10.6 (9.00, 12.5)**
Insurance type						
Private	1380	Ref.	21152	Ref.	620	Ref.
Medicare	1512	1.01 (0.90–1.14)	18095	1.01 (0.96–1.06)	461	**0.41 (0.34–0.48)**
Medicaid	370	**1.34 (1.17–1.54)**	3894	**1.10 (1.04–1.17)**	179	1.01 (0.82–1.23)
Other	185	**1.37 (1.15–1.63)**	1680	**0.79 (0.73–0.85)**	220	**2.07 (1.63–2.58)**
Residential region						
Large metro	2132	Ref.	24122	Ref.	739	Ref.
Small metro	748	**0.75 (0.68–0.83)**	10850	**1.09 (1.05–1.13)**	378	1.18 (1.01–1.38)
Micropolitan	299	**0.76 (0.65–0.88)**	4799	**1.25 (1.18–1.33)**	179	**1.50 (1.21–1.87)**
Not metro or micro	165	**0.56 (0.46–0.69)**	3203	**1.21 (1.13–1.30)**	157	**2.05 (1.63–2.58)**
Number of comorbidities	**3447**	**1.13 (1.06–1.21)**	**44821**	**0.90 (0.87–0.93)**	**1480**	**1.47 (1.34–1.62)**

[a] Model includes age, race, residential income, stage, insurance, residential region and comorbidities.
[b] Model includes age, race, residential income, stage, insurance, residential region, comorbidities and surgical treatment (BCS or mastectomy).

race/ethnicity and residential income with receipt of BCS or mastectomy, and with in-hospital mortality adjusting for stage at presentation, insurance type, residential region and comorbidities. We then restricted the analysis to patients who received BCS or mastectomy, and used logistic regression to compute associations between race/ethnicity and residential income with post-operative complications. We conducted similar analysis using linear regression models to examine associations with hospital length of stay. All statistical analyses were conducted in SAS 9.4.

3. Results

We identified 71,156 women aged 40 years and older admitted with a primary diagnosis of breast cancer between 2007 and 2011. Of these, 40,078 received BCS or mastectomy and 1260 (1.8%) died during hospitalization. About 73% of women were White, 13% Black, 8% Hispanic and 7% were classified as other racial groups. The distributions of study characteristics by race are presented in Table 1. White women were older at the time of admission compared to women of other racial groups, and the majority of Black women lived in lower residential income area compared to other racial groups (46% of Blacks, 32% of Hispanics, and 18% of Whites). Black (36%) and Hispanic (26%) women were more likely to have Medicaid insurance, while White women (50%) and women of other races (51%) were more likely to have private insurance. About 36% of Black women presented with metastatic disease, compared with 33% of Hispanic, and 29% of White women. In addition, Black women presented with a higher number of comorbidities at the time of admission compared to women of other racial groups. Black women received mastectomies less often (p-values <0.001), experienced significantly more post-surgical complications (p-value = 0.06), had longer hospital stays on average (p-value <0.001), and experienced more in-hospital deaths compared with women of other racial groups (p-value <0.001).

Table 2 presents results of multivariable analysis evaluating the association between race/ethnicity and residential income with receipt of BCS, mastectomy and in-hospital mortality. After adjusting for age, disease stage, insurance, residential region and number of comorbidities, odds of BCS receipt was significantly higher among Hispanics (OR = 1.25, 95% CI: 1.09–1.43), women of other races (OR = 1.22, 95% CI: 1.06–1.42), and Blacks (OR = 1.18, 95% CI: 1.06–1.33) compared with White women. In addition, odds of BCS were higher among patients with Medicaid (OR = 1.34, 95% CI: 1.17–1.54), and Other insurance types (OR = 1.37, 95% CI: 1.15–1.63) compared with patients with private insurance. Women residing outside of a large metropolitan area had lower odds of BCS (OR = 0.56, 95% CI = 0.46–0.69) compared with women residing in large metropolitan areas. In contrast, women residing outside of large metropolitan areas had higher odds of mastectomy (OR = 1.21, 95% CI = 1.13-1.30) compared with women residing in large metropolitan areas, and Black women had lower odds of mastectomy (OR = 0.94, 95% CI: 0.90–0.99) compared with White women. While women with a higher number of comorbidities had lower odds of mastectomy (OR = 0.90, 95% CI = 0.87–0.93), they had higher odds of BCS (OR = 1.13, 95% CI: 1.06–1.21). There were no SES differences in treatment type.

Black women (OR = 1.26, 95% CI: 1.07–1.50) had significantly higher odds of in-hospital deaths compared with White women after adjusting for age, residential income, disease stage, insurance type, residential region and surgical treatment (Table 2). Compared with highest residential income, residents of low residential income areas (OR = 1.29, 95% CI: 1.06–1.56) and residents in third quartile residential income areas also had higher odds of in-hospital deaths (OR = 1.30, 95% CI: 1.09–1.55). In addition, patients with other insurance types had significantly higher odds of

Table 3
Multivariable regression analysis of outcomes after breast cancer surgery, nationwide inpatient sample, 2007–2011.

	N (%)	Complications[a] OR (95% CI)	Hospital length of stay[a] β(95% CI)
Race/ethnicity			
White	29,398 (73.35)	Ref.	Ref.
Black	4,916 (12.27)	1.21 (1.04–1.42)	0.31 (0.24, 0.39)
Hispanic	3,022 (7.54)	1.00 (0.81–1.22)	0.06 (-0.03, 0.15)
Other	2,742 (6.84)	0.89 (0.72–1.11)	−0.01 (−0.10, 0.09)
Residential income			
Q4-Highest	13,923 (29.50)	Ref.	Ref.
Q3	11,298 (23.93)	1.12 (0.97–1.28)	−0.06 (−0.13, −0.001)
Q2	11,099 (23.51)	1.01 (0.87–1.17)	−0.08 (−0.15, −0.01)
Q1-Lowest	10,884 (23.06)	0.89 (0.75–1.05)	−0.04 (−0.11, 0.03)
Stage			
Non-metastatic	13,216 (27.38)	Ref.	Ref.
In-situ	6,399 (13.26)	1.13 (0.98, 1.31)	0.10 (0.03, 0.17)
Metastatic	28,653 (59.36)	0.93 (0.83, 1.05)	0.15 (0.10, 0.21)
Insurance type			
Private	22,532 (54.39)	Ref.	Ref.
Medicare	19,607 (40.62)	0.90 (0.77–1.05)	−0.09 (−0.16, −0.02)
Medicaid	4,264 (8.83)	0.93 (0.76–1.14)	−0.03 (−0.12, 0.06)
Other	1,865 (3.86)	0.98 (0.74–1.29)	−0.01 (−0.13, 0.12)
Residential region			
Large metro	26,254 (54.39)	Ref.	Ref.
Small metro	11,598 (24.03)	0.95 (0.84–1.08)	−0.14 (−0.20, −0.08)
Micropolitan	5,098 (10.56)	1.06 (0.88–1.28)	−0.06 (−0.15, 0.02)
Not metro or micro	3,368 (6.98)	1.11 (0.89–1.40)	−0.15 (−0.25, −0.05)
Number of comorbidities		1.40 (1.29–1.52)	0.46 (0.42–0.51)

[a] Adjusted for age, stage, insurance, residential region, comorbidities, treatment type (BCS or mastectomy).

in-hospital deaths compared with those with private insurance (OR = 2.07, 95% CI: 1.63–2.58), and residents of areas outside of large metropolitan areas had higher odds of in-hospital death rates compared with residents of large metro areas (non-metro/micropolitan residence OR = 2.05, 95% CI: 1.63–2.58). Women with a higher number of comorbidities (OR = 1.47, 95% CI: 1.34–1.62) had significantly higher odds of in-hospital deaths.

Table 3 presents the results of multivariable regression analysis of the association between race/ethnicity and residential income with post-surgical complications and hospital length of stay. After adjusting for age, residential income, disease stage, insurance type, residential region and treatment type, Black women (OR = 1.21, 95% CI: 1.04–1.42) and women with more comorbidities (OR = 1.40, 95% CI: 1.29–1.52) had higher odds of post-surgical complications. Black women also experienced longer hospital length of stay ($\beta = 0.31$, 95% CI: 0.24–0.39) compared with White women. In addition, women with a higher number of comorbidities ($\beta = 0.46$, 95% CI: 0.42, 0.51), and women with metastatic disease compared with those with non-metastatic disease, ($\beta = 0.15$, 95% CI: 0.10, 0.21) had significantly longer hospital length of stays. On the other hand, residents outside of large metropolitan areas (small metropolitan area $\beta = -0.14$, 95% CI: −0.20, −0.08; not metro/micropolitan $\beta = -0.15$, 95% CI: −0.25, −0.05) experienced shorter hospital length of stays compared with residents of large metropolitan areas.

4. Discussion

We examined the receipt of breast cancer surgery and post-surgical outcomes by race/ethnicity and SES among hospitalized patients in the large HCUP dataset representative of hospitalized patients in the U.S. We found significant racial and socio-economic disparities in breast cancer treatment and outcomes. Black patients received more BCS, but fewer mastectomies than other racial groups, and experienced more in-hospital deaths, post-surgical complications and longer hospital stays compared with White women regardless of treatment received and number of comorbidities. There were no SES differences in the type of breast cancer surgery received, post-surgical complications or length of stay. However, women in lower SES groups experienced higher in-hospital mortality compared to the highest SES group.

Since the 1990 National Institutes of Health (NIH) consensus development conference on the treatment of early stage breast carcinoma, breast conservation therapy plus radiation in lieu of mastectomy has been the preferable treatment option for the majority of women with early stage breast cancer [25]. However, because both treatment modalities are associated with similar survival rates, the decision to have BCS versus mastectomy likely reflects a combination of individual and physician preference based on various factors. For instance, BCS is less invasive, and associated with less physical disfiguration and with superior quality of life outcomes related to body image and sexual functioning [25,31–33]. As a result, BCS has become the most common surgical treatment for early stage breast cancer [34].

In contrast to previous studies [35,36,37] we observed an inverse association between number of comorbidities and receipt of mastectomy. One possible explanation is that our study population was comprised of hospitalized women with breast cancer, who may have been experiencing more severe, acute disease-related events compared with non-admitted survivors [33]. Since mastectomy is a generally more invasive procedure, this finding may indicate that physicians discourage patients with more comorbid conditions from undergoing this specific surgery. Taken together with our observation that Black women present with more comorbid conditions compared with Whites, this may explain why Black women are more likely to receive BCS compared with mastectomies. Similarly, we observed an inverse association between disease stage and receipt of mastectomy, with women with metastatic disease less likely to receive mastectomies compared with women with non-metastatic disease. This may also be explained by the higher prevalence of metastatic disease among Black women compared with other racial groups, suggesting that regardless of disease stage, Black women still receive BCS more often. Further studies are needed to determine if this reflects personal preferences among Black women for BCS or reflects physician recommendations.

We also observed that although BCS was more common among Black women compared with Whites, Black women were still more likely to experience in-hospital mortality, longer length of stay and more post-surgical complications compared with other racial groups, even after adjusting for comorbidities and disease stage. This suggests that the even though BCS is a 'less-invasive' procedure compared with mastectomy, the higher prevalence of BCS among Black women does not necessarily improve clinical outcome. Nevertheless, adjusting for treatment received slightly attenuated the racial differences in in-hospital mortality. These findings, if replicated in other clinical studies, highlight the need for better clinical strategies to clarify the relative benefits of BCS and mastectomies especially among Black women, women of lower SES and those with more comorbid conditions on admission. For instance, recent studies suggest that surgery does not confer a survival advantage among women with early stage cancer [25], and the likelihood of significant post-surgical complications and in-hospital mortality [22] likely outweighs the benefit of surgery at an early disease stage.

The association between race and in-hospital deaths was expected, as previous studies have demonstrated that Black women experience higher mortality than White women [38]. Several studies have found that Black women are less likely to receive guideline-adherent breast cancer treatment- including radiation and chemotherapy- compared with White women [9,39,40]. Moreover, relative to the highest SES group, women in lower SES groups experienced higher in-hospital mortality. This may be partially explained by the observation that Black women tend to belong to lower SES groups on average and reside in lower SES neighborhoods compared with Whites. In addition, regardless of race/ethnicity, there are likely significant financial and structural barriers to receiving care at high quality hospitals for low SES residents. Second, lack of access to high quality healthcare likely complicates both the breast cancer disease as well as other supportive healthcare needs. For instance, lack of healthcare access may limit treatment and follow-up options for comorbid conditions such as diabetes, obesity or heart disease, and may negatively impact both a physician's decision on treatment and treatment outcomes. These are potentially important factors among both blacks and low SES patients. Third, several studies have shown that even in equal access healthcare settings, and in clinical trials where treatment and care are standardized, significant racial disparities still exist [41–43]. Also, there may be other non-clinical factors influencing treatment and outcome such as cultural beliefs and perceptions about treatment, and/or perceived racism or discrimination that vary by race/ethnicity and SES.

A major strength of our study is the focus on a large sample of hospitalized women who have presumably been seen by a physician prior to admission. In addition, we were able to examine racial differences among a large sample of women in each racial group. However, there were also some important limitations to this study. We could not discern whether there were racial differences in treatment preferences that may contribute to our observed results, and future studies are needed to fully examine this possibility. We were unable to assess other non-surgical forms of

treatment such as chemotherapy and hormonal therapy as those are not readily available in HCUP. Also, although we were able to adjust for cancer stage, we were unable to adjust for tumor sub-types due to lack of data. Certain sub-types of breast cancer, specifically the basal or triple-negative sub-type, have been shown to be more prevalent and also more aggressive among Blacks [44].

Furthermore, previous studies have shown that hospitalized breast cancer patients present with slightly different characteristics compared with the general inpatient population, and may have different patterns of admission such as shorter lengths of stay, fewer diagnoses, more procedures on average, and significantly lower total hospital charges [30]. This raises the possibility that breast cancer patients are being admitted for specific, targeted purposes, such as surgery, and therefore minor complications may be underreported, potentially resulting in an underestimation of the associations observed in this study. Finally, due to patient privacy concerns, residential level SES was only provided at the zip-code level. This may likely lead to an underestimation of our SES estimates, as several studies have documented that smaller geographic levels such as the census tract or census block are more effective at capturing socioeconomic gradients in cancer outcomes [45].

5. Conclusions

Breast cancer is a severe chronic disease that exerts significant physical, emotional, financial and mental burdens on individuals, families, and communities. Racial disparities in breast cancer treatments and outcomes represent an unnecessarily high burden among specific population groups, and efforts must be intensified to eliminate the mortality gaps between Blacks and Whites. Future research efforts should be focused on identifying specific causes of racial differences in breast cancer outcomes and in the receipt of guideline-adherent treatment, and interventions must be developed to address those causes.

Conflict of interest

None

Author contribution

TA conceived of the study, participated in the design and coordination of the study, performed the statistical analysis and led the writing of the manuscript. HB, NV, XZ and DC contributed to design, statistical analysis and revision of the manuscript. All authors read and approved the final manuscript.

References

[1] R.T. Bustami, D.B. Shulkin, N. O'Donnell, E.D. Whitman, Variations in time to receiving first surgical treatment for breast cancer as a function of racial/ethnic background: a cohort study, JRSM Open 5 (2014) 2042533313515863.
[2] S. Shariff-Marco, J. Yang, E.M. John, M. Sangaramoorthy, A. Hertz, J. Koo, et al., Impact of neighborhood and individual socioeconomic status on survival after breast cancer varies by race/ethnicity: the neighborhood and breast cancer study, Cancer Epidemiol. Biomarkers Prev. 23 (2014) 793–811.
[3] Y.N. Flores, P.L. Davidson, T.T. Nakazono, D.C. Carreon, C.M. Mojica, R. Bastani, Neighborhood socio-economic disadvantage and race/ethnicity as predictors of breast cancer stage at diagnosis, BMC Public Health 13 (2013) 1061.
[4] R. McBride, D. Hershman, W.Y. Tsai, J.S. Jacobson, V. Grann, A.I. Neugut, Within-stage racial differences in tumor size and number of positive lymph nodes in women with breast cancer, Cancer 110 (2007) 1201–1208.
[5] V. Grann, A.B. Troxel, N. Zojwalla, D. Hershman, S.A. Glied, J.S. Jacobson, Regional and racial disparities in breast cancer-specific mortality, Soc. Sci. Med. 62 (2006) 337–347.
[6] N. Krieger, S.K. van den Eeden, D. Zava, A. Okamoto, Race/ethnicity, social class, and prevalence of breast cancer prognostic biomarkers: a study of white, black, and Asian women in the San Francisco bay area, Ethn. Dis. 7 (1997) 137–149.
[7] P. George, S. Chandwani, M. Gabel, C.B. Ambrosone, G. Rhoads, E.V. Bandera, et al., Diagnosis and surgical delays in African American and white women with early-stage breast cancer, J. Womens Health (Larchmt) 24 (2015) 209–217.
[8] A. White, L.C. Richardson, H. Krontiras, M. Pisu, Socioeconomic disparities in breast cancer treatment among older women, J. Womens Health (Larchmt) 23 (2014) 335–341.
[9] K. Sail, L. Franzini, D. Lairson, X. Du, Differences in treatment and survival among African-American and Caucasian women with early stage operable breast cancer, Ethn. Health 17 (2012) 309–323.
[10] K. Gwyn, M.L. Bondy, D.S. Cohen, M.J. Lund, J.M. Liff, E.W. Flagg, et al., Racial differences in diagnosis, treatment, and clinical delays in a population-based study of patients with newly diagnosed breast carcinoma, Cancer 100 (2004) 1595–1604.
[11] T.H. Keegan, A.W. Kurian, K. Gali, L. Tao, D.Y. Lichtensztajn, D.L. Hershman, et al., Racial/ethnic and socioeconomic differences in short-term breast cancer survival among women in an integrated health system, Am. J. Public Health 105 (2015) 938–946.
[12] J. Iqbal, O. Ginsburg, P.A. Rochon, P. Sun, S.A. Narod, Differences in breast cancer stage at diagnosis and cancer-specific survival by race and ethnicity in the United States, JAMA 313 (2015) 165–173.
[13] J.K. Kish, M. Yu, A. Percy-Laurry, S.F. Altekruse, Racial and ethnic disparities in cancer survival by neighborhood socioeconomic status in Surveillance, Epidemiology, and End Results (SEER) Registries, J. Natl. Cancer Inst. Monogr. 2014 (2014) 236–243.
[14] L. Vona-Davis, D.P. Rose, The influence of socioeconomic disparities on breast cancer tumor biology and prognosis: a review, J. Womens Health (Larchmt) 18 (2009) 883–893.
[15] R. Demicheli, M.W. Retsky, W.J. Hrushesky, M. Baum, I.D. Gukas, I. Jatoi, Racial disparities in breast cancer outcome: insights into host-tumor interactions, Cancer 110 (2007) 1880–1888.
[16] K. Amend, D. Hicks, C.B. Ambrosone, Breast cancer in African–American women: differences in tumor biology from European–American women, Cancer Res. 66 (2006) 8327–8330.
[17] S.B. Wheeler, K.E. Reeder-Hayes, L.A. Carey, Disparities in breast cancer treatment and outcomes: biological, social, and health system determinants and opportunities for research, Oncologist 18 (2013) 986–993.
[18] S.A. McGee, D.D. Durham, C.K. Tse, R.C. Millikan, Determinants of breast cancer treatment delay differ for African American and White women, Cancer Epidemiol. Biomarkers Prev. 22 (2013) 1227–1238.
[19] T.F. Akinyemiju, A.S. Soliman, N.J. Johnson, S.F. Altekruse, K. Welch, M. Banerjee, et al., Individual and neighborhood socioeconomic status and healthcare resources in relation to black-white breast cancer survival disparities, J. Cancer Epidemiol. 2013 (2013) 490472.
[20] T.P. Shippee, K.B. Kozhimannil, K. Rowan, B.A. Virnig, Health insurance coverage and racial disparities in breast reconstruction after mastectomy, Womens Health Issues 24 (2014) e261–e269.
[21] S. Yasmeen, G. Xing, C. Morris, R.T. Chlebowski, P.S. Romano, Comorbidities and mammography use interact to explain racial/ethnic disparities in breast cancer stage at diagnosis, Cancer 117 (2011) 3252–3261.
[22] A. Dehal, A. Abbas, S. Johna, Comorbidity and outcomes after surgery among women with breast cancer: analysis of nationwide in-patient sample database, Breast Cancer Res. Treat 139 (2013) 469–476.
[23] E.A. Jacobs, P.J. Rathouz, K. Karavolos, S.A. Everson-Rose, I. Janssen, H.M. Kravitz, et al., Perceived discrimination is associated with reduced breast and cervical cancer screening: the Study of Women's Health Across the Nation (SWAN), J. Womens Health (Larchmt) 23 (2014) 138–145.
[24] C.J. Bradley, A. Wilk, Racial differences in quality of life and employment outcomes in insured women with breast cancer, J. Cancer Surviv. 8 (2014) 49–59.
[25] National Institutes of Health, Treatment of early-stage breast cancer, JAMA 265 (1991) 391–395.
[26] HCUP Databases, Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality, Rockville, MD, 2011.
[27] L.I. Iezzoni, A.S. Ash, M. Shwartz, J. Daley, J.S. Hughes, Y.D. Mackiernan, Predicting who dies depends on how severity is measured: implications for evaluating patient outcomes, Ann. Intern. Med. 123 (1995) 763–770.
[28] United States Department of Agricultural Economic Research Service. Urban influence Code. Washington D.C., 2013.
[29] HCUP. Healthcare cost and utilization project. In: Agency for Healthcare Research and Quality, editor. Rockville, MD. 2011.
[30] S. Zhang, J.S. Ivy, F.C. Payton, K.M. Diehl, Modeling the impact of comorbidity on breast cancer patient outcomes, Health Care Manage. Sci. 13 (2010) 137–154.
[31] L. Koch, L. Jansen, A. Herrmann, C. Stegmaier, B. Holleczek, S. Singer, et al., Quality of life in long-term breast cancer survivors—a 10-year longitudinal population-based study, Acta Oncol. 52 (2013) 1119–1128.
[32] Y. Sun, S.W. Kim, C.Y. Heo, D. Kim, Y. Hwang, C.K. Yom, et al., Comparison of quality of life based on surgical technique in patients with breast cancer, Jpn. J. Clin. Oncol. 44 (2014) 22–27.
[33] J. Han, D. Grothuesmann, M. Neises, U. Hille, P. Hillemanns, Quality of life and satisfaction after breast cancer operation, Arch. Gynecol. Obstet. 282 (2010) 75–82.

[34] A.K. Alderman, J. Bynum, J. Sutherland, N. Birkmeyer, E.D. Collins, J. Birkmeyer, Surgical treatment of breast cancer among the elderly in the United States, Cancer 117 (2011) 698–704.
[35] J.S. Mandelblatt, J.F. Kerner, J. Hadley, Y.T. Hwang, L. Eggert, L.E. Johnson, et al., Variations in breast carcinoma treatment in older medicare beneficiaries: is it black or white, Cancer 95 (2002) 1401–1414.
[36] B. Thompson, P. Baade, M. Coory, P. Carriere, L. Fritschi, Patterns of surgical treatment for women diagnosed with early breast cancer in Queensland, Ann. Surg. Oncol. 15 (2008) 443–451.
[37] J. Zhou, L. Enewold, S.H. Zahm, I. Jatoi, C. Shriver, W.F. Anderson, et al., Breast conserving surgery versus mastectomy: the influence of comorbidities on choice of surgical operation in the Department of Defense health care system, Am. J. Surg. 206 (2013) 393–399.
[38] U.S. Cancer Statistics Working Group United States Cancer Statistics: 1999–2009. Incidence and Mortality Web-based Report. 2013.
[39] C.P. Gross, B.D. Smith, E. Wolf, M. Andersen, Racial disparities in cancer therapy: did the gap narrow between 1992 and 2002? Cancer 112 (2008) 900–908.
[40] N.L. Keating, E. Kouri, Y. He, J.C. Weeks, E.P. Winer, Racial differences in definitive breast cancer therapy in older women: are they explained by the hospitals where patients undergo surgery? Med. Care 47 (2009) 765–773.
[41] K.S. Albain, J.M. Unger, J.J. Crowley, C.A. Coltman Jr., D.L. Hershman, Racial disparities in cancer survival among randomized clinical trials patients of the Southwest Oncology Group, J. Natl. Cancer Inst. 101 (2009) 984–992.
[42] I. Jatoi, H. Becher, C.R. Leake, Widening disparity in survival between white and African–American patients with breast carcinoma treated in the U.S. Department of Defense Healthcare system, Cancer 98 (2003) 894–899.
[43] T.H. Keegan, A.W. Kurian, K. Gali, L. Tao, D.Y. Lichtensztajn, D.L. Hershman, et al., Racial/ethnic and socioeconomic differences in short-term breast cancer survival among women in an integrated health system, Am. J. Public Health (2015) e 1–e9.
[44] T. Agurs-Collins, B.K. Dunn, D. Browne, K.A. Johnson, R. Lubet, Epidemiology of health disparities in relation to the biology of estrogen receptor-negative breast cancer, Semin Oncol. 37 (2010) 384–401.
[45] N. Krieger, J.T. Chen, P.D. Waterman, M.J. Soobader, S.V. Subramanian, R. Carson, 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. 156 (2002) 471–482.