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Time to Surgical Treatment and Facility Characteristics as Potential Drivers of Racial Disparities in Breast Cancer Mortality

Lindsay J. Collin, PhD¹, Katie Ross-Driscoll, PhD², Rebecca Nash, MPH³, Jasmine M. Miller-Kleinhenz, PhD³, Leah Moubadder, MPH³, Catherine Osborn, MPH³, Preeti D. Subhedar, MD², Sheryl G. A. Gabram-Mendola, MD^{4,5}, Jeffrey M. Switchenko, PhD⁶, Kevin C. Ward, PhD³, Lauren E. McCullough, PhD³

¹Department of Population Health Sciences, Huntsman Cancer Institute, University of Utah, Salt Lake City, UT

²Department of Surgery, Emory University School of Medicine, Atlanta, Georgia

³Department of Epidemiology, Rollins School of Public Health, Emory University, Atlanta, GA

⁴Emory University, Atlanta, GA

⁵Georgia Center for Oncology Research and Education, Atlanta, GA

⁶Department of Biostatistics, Rollins School of Public Health, Emory University, Atlanta, GA

Abstract

Background.—Black women are more likely to die of breast cancer than White women. This study evaluated the contribution of time to primary surgical management and surgical facility characteristics to racial disparities in breast cancer mortality among both Black and White women.

Methods.—The study identified 2224 Black and 3787 White women with a diagnosis with stages I to III breast cancer (2010–2014). Outcomes included time to surgical treatment (> 30 days from diagnosis) and breast cancer mortality. Odds ratios (ORs) and 95% confidence intervals (CIs) associating surgical facility characteristics with surgical delay were computed, and Cox proportional hazards regression was used to compute hazard ratios (HRs) and 95% CIs associating delay and facility characteristics with breast cancer mortality.

Results.—Black women were two times more likely to have a surgical delay (OR, 2.15; 95% CI, 1.92–2.41) than White women. Racial disparity in surgical delay was least pronounced among women treated at a non-profit facility (OR, 1.95; 95% CI, 1.70–2.25). The estimated mortality rate for Black women was two times that for White women (HR, 2.00; 95% CI, 1.83–2.46). Racial disparities in breast cancer mortality were least pronounced among women who experienced no surgical delay (HR, 1.81; 95% CI, 1.28–2.56), received surgery at a government facility (HR, 1.31; 95% CI, 0.76–2.27), or underwent treatment at a Commission on Cancer-accredited facility (HR, 1.82; 95% CI, 1.38–2.40).

L. J. Collin, PhD, lindsay.collin@hci.utah.edu.

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Conclusions.—Black women were more likely to experience a surgical delay and breast cancer death. Persistent racial disparities in breast cancer mortality were observed across facility characteristics except for government facilities.

In the United States, despite similar screening prevalence and incidence rates of breast cancer,¹ Black women experience persistent disparities in breast cancer mortality compared with White women.^{1–4} These racial disparities in mortality are most pronounced for breast cancers with effective treatment regimens, such as early-stage or estrogen receptor-positive disease.⁵ The observed disparities are complex and multifactorial, but the potential mechanisms underlying these inequities may include differential access to and quality of care. Black women are more likely to experience delays in receiving their initial breast cancer diagnosis^{6–8} and more likely to experience delays in receipt of surgery after diagnosis.^{7,9–11} Delays in time to surgical treatment have been associated with poor postoperative outcomes, including reduced survival.^{9,12} This association is more pronounced among Black women.⁹

Delay in upfront surgery may vary by characteristics of the treating facility, but has been explored limitedly as a potential explanation of racial disparities in breast cancer mortality. One previous study reported that community hospitals had shorter surgical delays, whereas National Cancer Institute (NCI)-designed Comprehensive Cancer Centers and Veterans Administration hospitals had longer wait times.¹¹

In addition to surgical delay, other facility characteristics related to quality of care have been associated with breast cancer outcomes, including surgical volume, a possible proxy for institutional capacity and more comprehensive care, availability of specialty and health services, and breast cancer-related accreditations.^{13,14} Black women also are less likely to receive care at higher-quality hospitals,^{14,15} which may contribute to differences in mortality. However, it remains unclear what role facility characteristics play in time to surgical treatment and whether delays in upfront surgery contribute to overall outcomes or outcome disparities.

This study was the first to evaluate associations between facility characteristics, time to surgical treatment, and breast cancer mortality overall and the racial disparities of the associations.

METHODS

Study Population

Using the Georgia Cancer Registry (GCR), we identified women with breast cancer diagnosed between 2010 and 2014 while residing in metropolitan Atlanta. Breast cancer patients were included if they had a diagnosis of stages I to III primary breast tumor and were classified as non-Hispanic Black (NHB) or non-Hispanic White (NHW). Race was abstracted from the medical abstracts pertaining to the breast cancer diagnosis by Certified Tumor Registrars based on U.S. Census Bureau definitions, and Hispanic ethnicity was determined by the North American Association of Central Cancer Registries Hispanic Identification Algorithm.¹⁶ Patients who did not receive surgery whose surgery date was

equal to the date of diagnosis, those who underwent neoadjuvant therapy, and those whose surgical facility could not be identified were excluded from the study.

Exposure Assessment: Facility Characteristics

Characteristics of the facility where each patient received breast surgery were obtained from the NCI Hospital File for the same year the patient received surgery.¹⁷ Information in the NCI Hospital Files is derived from several sources, including the Healthcare Cost Report and the Provider of Service survey conducted by the Center for Medicare and Medicaid Services.¹⁸ The GCR captures the facility performing the patient surgery. The GCR personnel linked facility variables to the patient-level dataset, keeping facility names and locations confidential.

The facility characteristics of interest were annual patient volume (high vs low), facility type (non-profit, proprietary, government), medical school affiliation, accreditation by the Commission on Cancer (COC), and participation in the National Surgical Adjuvant Breast and Bowel Project (NSABP) as of 2005. Accreditations that applied to only one hospital (e.g., NCI comprehensive center status) were not included in the analysis. Annual patient volume was defined based on the breast cancer surgical counts for the state of Georgia for the study period and facilities were categorized as high- versus low-volume facilities based on a cut point at the 10th percentile of the distribution of breast cancer surgeries. The top 10% of facilities performing breast cancer surgeries accounted for approximately 50% of all the patients.

Outcome Assessment

The primary outcomes of interest were time to upfront surgery and breast cancer mortality. Surgical delay was defined as surgery received more than 30 days after diagnosis versus 30 days or less after diagnosis. This cutoff was determined based on literature review and clinical input.¹⁹ However, because no standard exists currently, we also defined surgical delay as more than 60 days versus 60 days or less after diagnosis in a sensitivity analysis for comparability with prior studies. The date of initial surgery and the date of diagnosis were available from the GCR. Breast cancer mortality (ICD10-C50) was determined from death certificate data. The GCR links annually with both state vital records and the National Death Index. The follow-up period was defined as time in months from the date of surgery until death, last date of contact in registry, 31 December 2019, or end of the study follow-up period.

Covariates

We collected information on age at diagnosis (continuous), stage (I–III), type of breast cancer surgery (breast-conserving surgery, mastectomy, mastectomy with reconstruction or removal of the contralateral breast), derived breast cancer subtype based on hormone receptor (HR) and human epidermal growth factor receptor-2 (HER2) expression (HR+/HER2–, HR+/HER2+, HR–/HER2+, or HR–/HER2–), marital status (single, married—including domestic partner, divorced/separated/other), insurance status (private, Medicare, Medicaid, military/other, or uninsured), and a Census-derived area-based measure of socioeconomic status [SES] (0 % to <5 %, 5 % to <10 %, 10 % to <20 %, 20 % to 100 %

below poverty). The SES was based on Census tract-level poverty data published annually from the American Community Survey.^{20,21}

Statistical Methods

Descriptive statistics were calculated as mean values with standard deviation or frequency and percentage for covariates of interest across categories of surgical delay. We additionally report descriptive statistics across categories of race and ethnicity. We used multivariable-adjusted logistic regression models to compute the odds ratios (ORs) and 95% confidence intervals (CIs) associating facility characteristics with surgical delay and multivariable-adjusted Cox proportional hazards regression to compute the hazard ratios (HRs) and 95% CIs associating surgical delay and facility characteristics with breast cancer mortality.

We assessed the impact of racial disparities on surgical delay and breast cancer mortality and whether these associations were modified by facility characteristics. Interaction describes differences in the effect of one exposure across the strata of another exposure, which depends on the scale. The presence of interaction between race and facility characteristics and its effect on surgical delay was estimated with the common referent approach to calculate the relative excess risk due to interaction (RERI), evaluating the departure of the effect on the additive scale.^{22,23}

We computed the 95% CI for the RERI using the delta method.²⁴ The presence of multiplicative interactions, indicating whether the combined effect of race and facility characteristics or surgical delay is greater than the product of the individual effects, was assessed by comparing stratum-specific effect estimates.^{22,25} To evaluate the contribution of delay and facility characteristics to racial disparities in breast cancer outcomes, we considered the distribution of delay and facility characteristics among NHB and NHW women, as well as the presence of additive/multiplicative interaction.²⁶

Potential confounders included in the models were based on a priori knowledge and graphic-based methods (DAG).²⁷ For the association between facility characteristics and surgical delay, the potential confounders were age at diagnosis and type of breast cancer surgery. For the association between facility characteristics and breast cancer mortality, the confounders were age at diagnosis, disease stage, tumor subtype, SES, and insurance status. In a sensitivity analysis, we excluded women whose breast cancer diagnosis was the first of two or more primaries ($n = 623$, 10%). No hypothesis testing was performed.^{28,29} All analyses were conducted using SAS v9.4 (SAS, Cary, NC, USA).

RESULTS

Among the 6011 breast cancer patients in the study, 3516 (58%) experienced a delay of more than 30 days to primary surgical management (Table 1). NHB women were more likely to experience a delay than NHW women (69% vs 52%, respectively). Women who received mastectomy or mastectomy with reconstruction/removal of the contralateral breast as part of their surgical management were more likely to have a delay in surgery (64% and 74% respectively) than the women who received breast-conserving surgery (51%). Surgical delay also was more common among the patients who received surgery at non-profit

hospitals (63%), facilities with a medical school affiliation (64%), and facilities without COC accreditation (61%). Surgical delay was least likely among breast cancer patients treated at a government facility (41%).

Table 2 presents the distribution of facility characteristics by race. In the total study population, 3787 (63%) of the patients were NHW and 2224 (37%) were NHB. The NHB women were less likely to receive surgery at a high-volume facility (69% vs 85%), a non-profit facility (68% vs 76%), a COC-accredited facility (50% vs 68%), or an NSABP-affiliated facility (70% vs 82%) than the NHW women. However, the NHB women were more likely to receive surgery at a facility with a medical school affiliation (37% vs 21%) than the NHW women.

Facility Characteristics and Surgical Delay

Table 3 presents the multivariable-adjusted associations between facility characteristics and surgical delay overall as well as racial disparities in surgical delay by facility characteristics. Compared with the breast cancer patients treated at non-profit facilities, surgical delay was less likely among those treated at government facilities (OR, 0.40; 95% CI, 0.34–0.47) and those treated at for-profit centers (OR, 0.71; 95% CI, 0.61–0.82). The patients who received surgical management at a non-COC-accredited facility were 1.24 times more likely to experience a delay in surgery than the breast cancer patients who received surgery at a COC-accredited facility (95% CI, 1.11–1.38).

Overall, the NHB women were 2.15 times more likely to experience a delay in surgical management (95% CI, 1.92–2.41) than the NHW women. This disparity in surgical delay persisted across facility characteristics, although the magnitude of the disparity varied. Among the patients who received surgery at a government facility, the NHB women were 4.72 times more likely to experience a surgical delay (95% CI, 3.41–6.52) than the NHW women. The NHB women treated at a for-profit facility were 2.72 times more likely to experience a surgical delay than their NHW counterparts (95% CI, 2.04–3.64). We observed evidence of additive interaction for the NHB women treated at for-profit centers (RERI, 2.13; 95% CI, 1.87–2.40). The racial disparity in delay was least pronounced, but still present, among the women treated at a non-profit facility (OR, 1.95; 95% CI, 1.70–2.25).

Facility Characteristics and Breast Cancer Mortality

Table 4 illustrates the multivariable associations between surgical delay, facility characteristics, and breast cancer mortality overall, and the racial disparities in breast cancer mortality by delay and facility characteristics. We observed a slight increase in the hazard of breast cancer mortality among the breast cancer patients who experienced more than a 30-day delay in surgical management (HR, 1.11; 95% CI, 0.88–1.38) compared with those who did not. The breast cancer patients who received surgery more than 60 days after diagnosis had breast cancer mortality rate 1.28 times greater (95% CI: 0.99, 1.66) than those who received surgery 60 days or less after diagnosis. The patients who received surgery at a low-volume facility versus a high-volume facility had a hazard of breast cancer mortality rate 1.14 times higher (HR, 1.14; 95% CI, 0.89–1.47). Surgery received at a for-profit

facility was associated with higher mortality than surgery received at a non-profit facility (HR, 1.25; 95% CI, 0.94–1.66).

Overall, the NHB breast cancer patients had an estimated mortality rate two times higher than the NHW women (HR, 2.00; 95% CI, 1.63–2.46). Even after restriction of the analysis to women who experienced a surgical delay (> 30 days), the NHB women a mortality rate two times higher than the NHW women (HR, 2.05; 95% CI, 1.57–2.68). The racial disparity in breast cancer mortality was less pronounced among the women who did not experience a surgical delay (HR, 1.81; 95% CI, 1.28–2.56), those who received surgery at a government facility (HR, 1.31; 95% CI, 0.76–2.27), and those treated at a COC-accredited facility (HR, 1.82; 95% CI, 1.38–2.40). Racial disparities in breast cancer mortality were most pronounced among the women who received surgery at a facility with a medical affiliation (HR, 2.61; 95% CI, 1.72–3.95), at a non-profit facility (HR, 2.11; 95% CI, 1.64–2.72), or at a non-COC-accredited facility (HR, 2.29; 95% CI, 1.64–3.20).

In our sensitivity analysis that excluded women whose breast cancer diagnosis was the first of multiple primaries, the results were similar, although less precise (data not shown).

DISCUSSION

To our knowledge, this is the first study to examine the associations between facility characteristics, surgical delay, and breast cancer mortality, as well as the potential impact of facility characteristics and surgical delay on racial disparities in breast cancer mortality. We found that breast cancer patients who received surgery at government facilities, non-profit facilities, and facilities with COC accreditation were less likely to experience a surgical delay. The NHB women were more likely to experience a surgical delay than the NHW women, and racial disparities in surgical delay were largely consistent across facility characteristics. The patients who experienced a surgical delay longer than 60 days had a higher hazard of breast cancer mortality. However, irrespective of surgical delay, the NHB women had a hazard of breast cancer mortality nearly two times greater than the NHW women. Similarly, racial disparities in breast cancer mortality persisted across facility characteristics, although they were least pronounced among the patients who received surgery at government facilities.

Variation in the timeliness of surgical care has been noted in previous publications. A study using data from the National Cancer Database reported that patients with Medicaid or no insurance and patients attending academic/research facilities or high-volume facilities were more likely to experience a delay in surgery.³⁰ Moreover, the authors noted that throughout the study period (2003–2011), the average wait time for surgical care increased by approximately 1 week.³⁰

In the current study, we found slight surgical delays among the patients treated in high-volume facilities. However, we also found that the patients receiving surgery at government and for-profit facilities were less likely to experience surgical delays than the patients treated at non-profit facilities. This may have been due to standardized care protocols at government

facilities. For-profit facilities may have additional diagnostic workups, such as tumor boards, that may lead to delays relative to government facilities.

Racial disparities in receipt of surgery also have been documented.³¹ In a clinic-based study among insured Black and White women, the Black women had an average 47-day delay between diagnosis and surgery compared with the White women, who had an average 33-day delay between diagnosis and surgery. A study that defined surgical delay as 60 days or longer after diagnosis reported that Black women were three times more likely to experience a surgical delay.⁶ Our results were consistent with these previous studies, but these studies did not examine racial disparities in surgical delay by facility characteristics.

Surgical delays among women with early-stage disease may lead to axillary upstaging and are associated with breast cancer mortality.^{32,33} A study using Surveillance, Epidemiology, and End Results (SEER)-Medicare data and the National Cancer Database reported that women who received surgery more than 60 days after diagnosis have an estimated mortality rate 1.26 times higher than women who received surgery 60 days or less after diagnosis.³⁴

In our analyses, we defined surgical delay as more than 30 days after diagnosis based on clinical input, but in our sensitivity analysis defining surgical delay as a delay longer than 60 days, we observed comparable results, highlighting the importance of timeliness of surgery. In our study, Black women were more likely to experience a surgical delay, which may contribute to racial disparities in breast cancer mortality and highlights that timeliness of surgical care may be especially important among vulnerable populations. We did not explore the interaction between stage, race, and delay, but future studies may benefit from an investigation into the role of treatment delays in upstaging in the context of racial disparities in breast cancer outcomes.

To date, literature on surgical facility characteristics in breast cancer mortality and racial disparities in breast cancer mortality is limited. Increasing hospital volume—a possible proxy for institutional capacity and more comprehensive care—also is reported to be associated with a lower breast cancer mortality rate.³⁵ Greenup et al.³⁵ used the National Cancer Database to examine the association between hospital volume and breast cancer mortality, comparing high- and low-volume facilities (HR, 0.89; 95% CI, 0.73–0.83). We observed similar, albeit less precise, results. In our study, the NHB women were more likely to receive surgery at a low-volume facility (31% vs 14%), suggesting that quality of care may be a factor contributing to racial disparities in breast cancer mortality, but would not eliminate the disparities because disparities persisted within strata of facility volume. This also was suggested by the racial disparities in COC facilities, with reduced disparities observed among patients who received surgery at COC-accredited facilities (HR, 1.82 vs 2.29), but Black women were less likely to receive surgery at a COC-accredited facility (50% vs 68%).

This study, although the first to explore race differences in surgical delay and breast cancer mortality by facility characteristics, had limitations to consider. First, even though we had information on surgical facility characteristics, we did not have information on surgical teams or demographic information of physicians at the surgical facilities, which

may influence care.³⁶ Previous studies have suggested, especially in maternal health, that concordance between physician and patient race may influence care and outcomes, which may be important to explore.^{36,37} However, breast cancer treatment is complex and involves multiple specialties. Therefore, understanding the care facility characteristics may be more relevant.

Second, although we examined facility characteristics of the surgical facility for women with a diagnosis of breast cancer in Atlanta, we did not have information on the facility where they received other adjuvant therapies or whether they received other standard-of-care treatment, which also may influence mortality. However, by restricting our study population to women residing in the metropolitan Atlanta area, it is likely that most of the women received adjuvant therapies at the same care facility where they received their surgery.

Third, we did not have information on comorbid conditions, which have been suggested previously as important for surgical delays because patients with more underlying health conditions may require more complex procedures.^{38,39} Finally, where a woman chooses to receive care may be influenced by distance, insurance, SES, and education, which reduce the exchangeability of patients across facility types.¹⁵ We controlled for neighborhood SES and insurance in our analyses to mitigate confounding by these known factors. However, unknown and unmeasured reasons exist to explain why women may choose certain care facilities to receive surgery.

In conclusion, we observed pronounced racial disparities in surgical delay and breast cancer mortality. Surgical delay, hospital volume, and facility accreditations may partially contribute to racial disparities in mortality. Women treated at government care facilities had the lowest racial disparities in breast cancer mortality, although we observed racial disparities in surgical delay at government facilities. Future research may benefit from more comprehensive studies investigating quality of care, delays and completion of care, and breast cancer mortality to further our understanding of racial disparities in breast cancer mortality.

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Patient demographic, tumor, and facility characteristics by surgical delay among 6011 patients with breast cancer diagnosed in the metropolitan Atlanta area (2010–2014)

TABLE 1

	30 Days from diagnosis 2495 (42 %)	> 30 Days from diagnosis 3516 (58 %)
<i>Patient characteristics</i>	Mean ± SD	Mean ± SD
Age at diagnosis (years)	60 ± 13	59 ± 12
Follow-up (years)	7.0 ± 2.2	6.7 ± 2.1
	<i>n</i> (%)	<i>n</i> (%)
<i>Race</i>		
White	1808 (48)	1979 (52)
Black	687 (31)	1537 (69)
Breast cancer-specific death	136 (5.5)	226 (6.4)
<i>Insurance type</i>		
Private	1498 (41)	2193 (59)
Uninsured	30 (33)	60 (67)
Medicaid	130 (38)	212 (55)
Medicare	788 (45)	964 (55)
Military	21 (34)	41 (66)
Unknown	28 (40)	42 (60)
<i>Socioeconomic status</i>		
0 to < 5%	603 (45)	741 (55)
5 to < 10%	674 (45)	833 (55)
10 to < 20%	734 (43)	989 (57)
20% +	484 (36)	953 (66)
<i>Cancer stage</i>		
I	1609 (44)	2083 (56)
II	726 (38)	1168 (62)
III	160 (38)	265 (62)
<i>ER status</i>		
ER+	2140 (41)	3045 (59)
ER-	335 (42)	460 (58)

	30 Days from diagnosis 2495 (42 %)	> 30 Days from diagnosis 3516 (58 %)
Unknown	20	11
<i>Tumor molecular subtype</i>		
Luminal A	1782 (41)	2566 (59)
Luminal B	234 (39)	361 (61)
HER2	70 (40)	105 (60)
TNBC	223 (42)	302 (58)
Unknown	186	182
<i>Surgery type</i>		
Conserving	1714 (49)	1752 (51)
Mastectomy	376 (36)	681 (64)
Mastectomy with reconstruction or removal of the contralateral breast	339 (26)	964 (74)
<i>Facility characteristics</i>		
<i>Annual patient discharge</i>		
High	1994 (42)	2796 (58)
Low	501 (41)	720 (59)
<i>Medical school affiliation</i>		
Yes	580 (37)	1009 (64)
No	1911 (43)	2498 (57)
Unknown	4	9
<i>Facility type</i>		
Non-profit	1639 (37)	2750 (63)
For-profit	400 (47)	448 (53)
Government	452 (59)	309 (41)
Unknown	4	9
<i>Accreditations or affiliations</i>		
<i>COC-accredited</i>		
Yes	1587 (43)	2093 (57)
No	908 (39)	1423 (61)
<i>NSABP affiliation</i>		
Yes	1894 (41)	2750 (59)
No	601 (44)	766 (56)

SD, standard deviation; *ER*, estrogen receptor; *HER2*, human epidermal growth factor receptor-2; *TNBC*, triple-negative breast cancer; *COC*, Commission on Cancer; *NSABP*, National Surgical Adjuvant Breast and Bowel Project

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Patient demographic, time-to-surgery, and facility characteristics by race among 6011 patients with breast cancer diagnosed in the metropolitan Atlanta area (2010–2014)

TABLE 2

	NHW	NHB
Patient characteristics	3787 (63 %)	2224 (37 %)
Age at diagnosis (years)	Mean ± SD 60 ± 13	Mean ± SD 57 ± 12
Follow-up (years)	6.9 ± 2.1	6.8 ± 2.2
Breast cancer-specific death	n (%) 173 (4.6)	n (%) 189 (3.1)
<i>Surgical delay (days)</i>		
Delay (>30)	1979 (52)	1537 (69)
No delay (≤ 30)	1808 (48)	687 (31)
<i>Surgical delay</i>		
Delay (>60)	448 (12)	553 (25)
No delay (≤ 60)	3339 (88)	1671 (75)
<i>Surgery type</i>		
Conserving	2173 (59)	1293 (60)
Mastectomy	614 (17)	443 (21)
Mastectomy with reconstruction or removal of the contralateral breast	885 (24)	418 (19)
<i>Facility characteristics</i>		
<i>Annual patient discharge</i>		
High	3266 (86)	1524 (69)
Low	521 (14)	700 (31)
<i>Medical school affiliation</i>		
Yes	779 (21)	810 (37)
No	3008 (79)	1401 (63)
<i>Facility type</i>		
Non-profit	2882 (76)	1507 (68)
For-profit	454 (12)	394 (18)
Government	451 (12)	310 (14)

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	NHW	NHB
Unknown		13 (0.6)
<i>Accreditations or affiliations</i>		
<i>COC-accredited</i>		
Yes	2572 (68)	1108 (50)
No	1215 (32)	1116 (50)
<i>NSABP affiliation</i>		
Yes	3091 (82)	1553 (70)
No	696 (18)	671 (30)

NHW, non-Hispanic White; NHB, non-Hispanic Black; SD, standard deviation; COC, Commission on Cancer; NSABP, National Surgical Adjuvant Breast and Bowel Project

TABLE 3

Multivariable-adjusted odds ratios associating facility characteristics with surgical treatment delays overall, and racial disparities in delay by facility characteristics among 6011 women with breast cancer diagnosed in the metropolitan Atlanta area (2010–2014)

	Delay (n)	Overall OR (95% CI) ¹	Delay n (%)			Common referent OR (95% CI) ¹			Stratified effects OR (95% CI) ^a
			NHW	NHB	NHW	NHB	RERI		
Racial disparity			1979	1537	–	–	–	–	2.15 (1.92–2.41)
<i>Annual patient discharge</i>									
Low	2796	1.06 (0.93 to 1.21)	236	484	0.73 (0.60 to 0.89)	2.11 (1.76 to 2.53)	0.32 (–0.11 to 0.75)		2.89 (2.25 to 3.70)
High	720	Referent	1743	1053	Referent	2.04 (1.79 to 2.33)	Referent		2.04 (1.79 to 2.33)
<i>Medical school affiliation</i>									
No	2498	0.72 (0.64 to 0.81)	1541	957	0.79 (0.67 to 0.93)	1.70 (1.41 to 2.40)	–0.06 (–0.45 to 0.34)		2.15 (1.87 to 2.48)
Yes	1009	Referent	438	571	Referent	1.94 (1.57 to 2.40)	Referent		1.94 (1.57 to 2.40)
<i>Facility type</i>									
Government	309	0.40 (0.34 to 0.47)	120	189	0.25 (0.20 to 0.32)	1.20 (0.94 to 1.54)	0.23 (–0.19 to 0.66)		4.72 (3.41 to 6.52)
For-profit	448	0.71 (0.61 to 0.82)	190	258	0.54 (0.44 to 0.67)	1.49 (1.19 to 1.87)	2.13 (1.87 to 2.40)		2.72 (2.04 to 3.64)
Non-profit	2750	Referent	1669	1081	Referent	1.95 (1.70 to 2.25)	Referent		1.95 (1.70 to 2.25)
<i>Accreditations or affiliations</i>									
<i>COC-accredited</i>									
No	1423	1.24 (1.11 to 1.38)	643	780	1.10 (0.95 to 1.27)	2.28 (1.95 to 2.66)	0.08 (–0.34 to 0.50)		2.07 (1.74 to 2.47)
Yes	2093	Referent	1336	757	Referent	2.16 (1.85 to 2.52)	Referent		2.16 (1.85 to 2.52)
<i>NSABP affiliation</i>									
No	2750	0.93 (0.82 to 1.06)	1675	1075	0.69 (0.58 to 0.83)	2.03 (1.69 to 2.43)	0.33 (–0.8 to 0.74)		2.92 (2.32 to 3.68)
Yes	766	Referent	304	462	Referent	2.01 (1.76 to 2.30)	Referent		2.01 (1.76 to 2.30)

^a Adjusted for age at diagnosis and type of surgery

OR, odds ratio; CI, confidence interval; RERI, relative excess risk due to interaction; NHW, non-Hispanic White; NHB, non-Hispanic Black; COC, commission on cancer; NSABP, National Surgical Adjuvant Breast and Bowel Project

Multivariable-adjusted hazard ratios (HRs) and 95 % confidence intervals (CIs) associating delay, facility characteristics with breast cancer mortality as well as overall and racial disparities by facility characteristics among 6011 women with breast cancer diagnosed in the metropolitan Atlanta area (2010–2014)

TABLE 4

	Deaths (n)	Overall HR (95 % CI) ^a	Deaths (n)		Common referent HR (95 % CI) ^a		RERI (95 % CI)	Stratified effects HR (95 % CI) ^b
			NHW	NHB	NHW	NHB		
Overall disparity			173	189	–	–		2.00 (1.63 to 2.46)
<i>Dx to surgery</i>								
Delay (>30 days)	226	1.11 (0.88 to 1.38)	90	136	0.98 (0.73 to 1.34)	1.46 (1.07 to 1.99)	0.19 (–0.33 to 0.71)	2.05 (1.57 to 2.68)
No delay (≤ 30 days)	136	Referent	83	53	Referent	1.27 (0.87 to 1.85)	Referent	1.81 (1.28 to 2.56)
<i>Dx to surgery</i>								
Delay (>60 days)	82	1.28 (0.99 to 1.66)	28	54	1.31 (0.87 to 1.99)	1.58 (1.10 to 2.26)	–0.19 (–0.93 to 0.55)	1.62 (1.02 to 2.55)
No delay (≤ 60 days)	280	Referent	145	135	Referent	1.46 (1.11 to 1.91)	Referent	1.98 (1.56 to 2.51)
<i>Annual patient volume</i>								
Low	94	1.14 (0.89 to 1.47)	29	65	1.18 (0.78 to 1.8)	1.50 (1.07 to 2.12)	–0.09 (–0.76 to 0.58)	1.87 (1.20 to 2.90)
High	268	Referent	144	124	Referent	1.43 (1.08 to 1.89)	Referent	1.95 (1.53 to 2.48)
<i>Medical school affiliation</i>								
Yes	108	Referent	31	99	Referent	1.80 (1.12 to 2.89)	Referent	2.61 (1.72 to 3.95)
No	253	1.10 (0.86 to 1.40)	142	111	1.37 (0.91 to 2.08)	1.85 (1.19 to 2.86)	–0.34 (–1.13 to 0.46)	1.81 (1.41 to 2.32)
<i>Facility type</i>								
Government	51	1.06 (0.78 to 1.45)	27	24	1.29 (0.84 to 1.98)	1.27 (0.80 to 2.10)	–0.74 (–1.76 to 0.27)	1.31 (0.76 to 2.27)
For-profit	67	1.25 (0.94 to 1.66)	26	41	1.15 (0.74 to 1.80)	1.88 (1.27 to 2.78)	0.04 (–0.72 to 0.80)	2.04 (1.24 to 3.34)
Non-profit	243	Referent	120	123	Referent	1.46 (1.09 to 1.96)	Referent	2.11 (1.64 to 2.72)
<i>Accreditations or affiliations</i>								
<i>COC-accredited</i>								
Yes	207	Referent	120	87	Referent	1.27 (0.94 to 1.73)	Referent	1.82 (1.38 to 2.40)
No	155	0.98 (0.79 to 1.22)	53	102	0.82 (0.58 to 1.14)	1.36 (1.00 to 1.86)	0.27 (–0.21 to 0.75)	2.29 (1.64 to 3.20)
<i>NSABP affiliation</i>								
Yes	267	Referent	135	132	Referent	1.41 (1.06 to 1.88)	Referent	2.08 (1.63 to 2.64)
No	95	1.11 (0.87 to 1.42)	38	57	1.11 (0.76 to 1.62)	1.52 (1.07 to 2.15)	0.29 (–0.76 to 1.34)	1.72 (1.14 to 2.60)

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Dx, diagnosis; *HR*, hazards ratio; *CI*, confidence interval; *RERI*, relative excess risk due to interaction; *NHW*, non-Hispanic White; *NHB*, non-Hispanic Black; *COC*, Commission on Cancer; *NSABP*, National Surgical Adjuvant Breast and Bowel Project

^a Adjusted for age at diagnosis, insurance, subtype, stage, and SES

^b Adjusted for age at diagnosis