ORIGINAL ARTICLE – HEALTH SERVICES RESEARCH AND GLOBAL ONCOLOGY

Evaluation of Surgical Disparities Between African American and European American Women Treated for Breast Cancer Within an Equal-Access Military Hospital

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ABSTRACT

Background. Survival disparities between African American women (AAW) and European American women (EAW) with invasive breast cancer may be attributable, in part, to access to or quality of medical care. In this study, we evaluated surgical disparities between AAW and EAW treated within an equal-access military treatment facility (MTF).

Methods. All AAW ($N = 271$) and EAW ($N = 628$) with Stage I–III breast cancer who had their initial diagnosis performed at Murtha Cancer Center at Walter Reed National Military Medical Center were identified. Differences in surgical interval (time between diagnosis and definitive breast surgery) and surgical procedures were evaluated using χ^2 and Student t-tests while survival was analyzed using Kaplan–Meier survival estimates and log-rank tests. A P value < 0.05 was used to define significance.

Results. Surgical intervals did not differ significantly between populations with an average of 36.3 days in AAW and 33.9 days in EAW. Frequency of the percentage of women undergoing reexcision, mastectomy, and prophylactic removal of the contralateral breast did not differ significantly between populations. Likewise, frequency of

sentinel lymph node biopsy and 5-year survival were not significantly different between AAW compared to EAW.

Discussion. Surgical intervals and procedures were similar between AAW and EAW treated within an equal-access MTF. These data demonstrate that the availability of quality surgical care to all patients with stage I–III breast cancer may eliminate survival disparities between AAW and EAW, emphasizing the importance of equalizing access to breast care.

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Recent increases in the number of African American women (AAW) diagnosed with breast cancer has resulted in a convergence of incidence (135/100,000) between AAW and European American women (EAW).[1] While overall mortality rates have been declining, the mortality rate for AAW in 2012 was 42% higher than for EAW and this disparity is predicted to continue over time. Factors contributing to this survival disparity vary widely and may include biological differences, such as a higher incidence of basal-like/triple-negative breast cancers in AAW coupled with higher PAM50 recurrence scores in AAW with non-basal-like/triple-negative breast cancer (TNBC), as well as nonbiological factors, such as comorbidity/obesity, education, oral contraceptive use, and access to health care.[2,3]

Differences in breast healthcare have been noted across a number of modalities. Although mammography rates do not differ significantly between AAW and EAW, a study of 6722 women with abnormal mammograms in New York found that time to diagnostic follow-up was significantly longer for AAW.[4,5] AAW were more likely to have

treatment delays, and once initiated, adjuvant chemotherapy was more likely to be nonguideline concordant in AAW.[6,7] Evaluation of surgical disparities has led to mixed results. Women diagnosed in urban areas, such as Washington, DC, Detroit, MI, and New York City, demonstrated significantly longer delays between diagnosis and definitive surgery, whereas studies within Medicare or under/uninsured populations found no significant differences.[8–11] Significantly higher frequencies of breast-conserving surgery (BCS) have been detected in some studies but not others.[12–15] Contralateral prophylactic mastectomies were significantly less common in AAW (18%) compared with EAW (33%).[16]

Variability in the results of the above studies may reflect the different populations (e.g., general population, Medicare, safety-net) evaluated. Walter Reed National Military Medical Center (WRNMMC) is a military health facility of the United States Department of Defense's (DoD) Military Healthcare System (MHS), providing quality healthcare to all active-duty personnel, retirees, and beneficiaries, regardless of race/ethnicity and socioeconomic status. The Clinical Breast Care Project (CBCP) of the Murtha Cancer Center (MCC) at WRNMMC therefore can serve as a unique resource to investigate whether surgical disparities exist within an equal-access healthcare system. In this study, we evaluated whether surgical intervals or procedures differ between AAW and EAW with stage I-III breast cancer treated at a single DoD hospital.

METHODS

All patients enrolled in the CBCP met the following eligibility criteria: (1) adult older than age 18 years, (2) mentally competent and willing to provide informed consent, and (3) presenting to the breast center with evidence of breast disease. Tissue and blood samples were collected with approval from the WRNMMC Human Use Committee and Institutional Review Board (WRNMMC IRB #20704). All subjects voluntarily agreed to participate and gave written, informed consent.

Surgical procedures recorded within the CBCP Data Tracking System included core needle biopsy, excisional biopsy, reexcision, mastectomy (for tumor), mastectomy (prophylactic), skin biopsy, sentinel lymph node biopsy (SLNB), axillary lymph node dissection (ALND), lymph node biopsy (other), fine needle aspirate (FNA), body fluid or other. The database was searched to identify all AAW and EAW diagnosed at MCC/WRNMMC with stage I-III breast cancer between 2001 and 2018, with staging assigned using AJCC *Cancer Staging Manual* seventh edition guidelines.[17] Only those patients who had both diagnostic (core needle, skin or excisional biopsy, or FNA)

and definitive surgical procedures (excisional biopsy, reexcision, and/or mastectomy) performed at WRNMMC were included in this study. Patients who underwent neoadjuvant hormone, chemotherapy, or radiation therapy (N = 78) were excluded from analysis.

Surgical interval was defined as the time between diagnostic biopsy and definitive breast operation (excisional biopsy, reexcision, or mastectomy). Factors that may affect timing and choice of surgery and/or patient survival, including education levels, comorbidities, marital status, obesity, and age at diagnosis, were evaluated by population.[18–23] Comorbidity was classified using the Charlson Comorbidity Index (CCI).[24] Because treatment delays of > 3 months have been associated with a 12% lower 5-year survival than shorter treatment times and the National Breast and Cervical Cancer Early Detection Program recommends initiation of treatment within 60 days of diagnosis as a measure of quality of care, we classified surgical intervals as ≤ 60, 61–90, or > 90 days.[25,26] Differences in surgical procedures and intervals were evaluated using χ^2 analysis. Kaplan–Meier product-limit survival estimates were generated with a Log-Rank test for homogeneity of the survival estimates across AAW and EAW to assess differences in breast cancer-specific survival. Cox proportional hazards regression estimated hazards ratios (HRs) and 95% confidence intervals (CIs) for risk of breast cancer-specific death in univariable and multivariable models. A *P* value of 0.05 was used to determine significance.

RESULTS

Of the 899 patients eligible for this study, 271 (30%) were self-described non-Hispanic AAW and the other 628 (70%) were non-Hispanic EAW. Average age at diagnosis was 57.1 years in AAW and 59.1 years in EAW (*P* = 0.032); the frequency of young women (diagnosed < 40 years of age) did not differ significantly (Table 1). Education levels and CCI scores did not differ significantly between populations. Neither tumor size nor lymph node status differed significantly by population; however, tumors from AAW were significantly more likely to be poorly differentiated (36.5% AAW, 22.8% EAW; *P* < 0.001) and TNBC (20.3% AAW, 11.8% EAW; *P* = 0.010).

Surgical intervals did not differ significantly (*P* = 0.083) between AAW and EAW with an average time between biopsy and definitive surgery of 36.3 days in AAW and 33.9 days in EAW. Surgical interval of > 90 days was ∼ 1% in both populations (Fig. 1). The frequency of reexcision and BCS did not differ significantly between populations (Table 2). Within the group of women who

TABLE 1 Demographic and pathological characteristics of AAW and EAW with surgical treatment performed at WRNMMC

	AAW (N = 271) %	EAW (N = 628) %	P value
Age at diagnosis (year)			0.199
< 40	7.7	4.8	
40–49	23.6	23.4	
≥ 50	68.6	71.8	
Education			0.725
≥ College	43.5	46.3	
< College	39.8	38.4	
Unknown	16.6	15.3	
Marital status			< 0.001
Married	63.5	82.0	
Not married	36.5	18.0	
Charlson comorbidity index			0.126
0	25.8	25.5	
1	24.3	18.3	
2	16.2	21.8	
≥ 3	32.1	31.7	
Unknown	1.5	2.7	
BMI at diagnosis			0.015
< 25	23.6	30.7	
25–29.9	27.3	32.0	
≥ 30	36.5	23.7	
Unknown	12.5	13.5	
AJCC pathologic stage			0.240
I	53.9	59.9	
II	36.9	31.7	
III	9.2	8.4	
Tumor size			0.128
T1	64.6	72.0	
T2	28.8	23.4	
T3	4.4	3.5	
Unknown	2.2	1.1	
Tumor grade			< 0.001
Well-differentiated	24.5	38.7	
Moderately differentiated	32.8	36.9	
Poorly differentiated	36.5	22.8	
Undetermined	5.2	1.6	
Lymph node status			0.636
Positive	67.2	68.8	
Negative	31.7	29.5	
Unknown	1.1	1.7	
ER/HER2			0.010
ER+/HER2−	64.9	74.5	
ER+/HER2+	5.5	7.0	
ER−/HER2+	7.4	5.4	
ER−/HER2−	20.3	11.8	
Unknown	1.8	1.3	
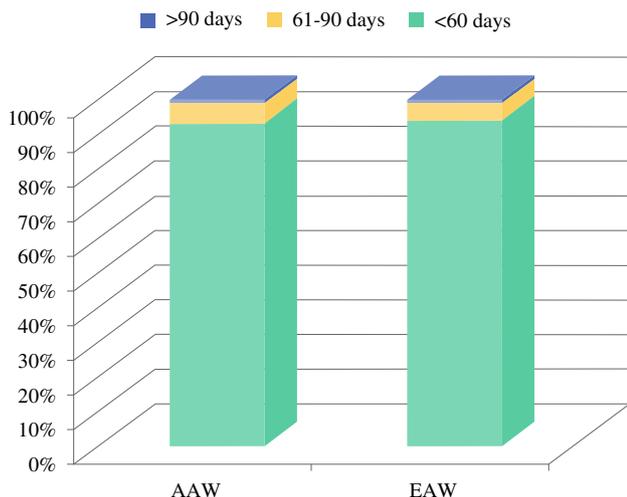
FIG. 1 Time between diagnosis and definitive breast surgery by population. The frequency of time to surgical treatment of < 60 days, 61–90 days, and > 90 days were 93% versus 94%, 6% versus 5%, and 1% versus 1% in AAW and EAW, respectively

had a mastectomy, the frequency of unilateral mastectomy compared with prophylactic removal of the contralateral breast did not differ significantly (64.9% AAW, 60.4 EAW; $P = 0.411$).

The use of SLNB did not differ significantly by population (AAW 82.7%, EAW 85.5%; $P = 0.184$). Evaluation of use of SLNB over time revealed the largest utilization difference (12%) in the earliest (2001–2002) period of enrollment into the CBCP; however, at no time point were the differences significant (Fig. 2).

Overall, the average length of follow-up across the 899 patients was 6.4 (standard deviation [SD] 4.4) years. Breast cancer mortality rates were 4.4% in AAW and 3.8% in EAW ($P = 0.670$). The average time to death was 3.6 (SD

2.1) years in AAW and 5.5 (SD 3.0) years in EAW ($P = 0.054$). Stage at diagnosis (Stage I 16.7% AAW, 29.2% EAW; Stage II 50.0% AAW, 25.0% EAW; Stage III 33.3% AAW, 45.8% EAW) and hormone receptor and HER2 − status (ER + HER2 − 33.3% AAW, 58.3% EAW; ER + HER2 + 8.3% AAW, 0% EAW; ER-HER2 + 8.4% AAW, 4.2% EAW; ER-HER2 − 50% AAW, 37.5% EAW) did not differ significantly within those patients who died of disease ($P = 0.317$ and $P = 0.314$, respectively). In contrast, tumors from AAW (91%) who died of disease were significantly more likely ($P = 0.006$) to be poorly differentiated than those from EAW (33.3%). Five-year breast cancer-specific survival was 96.3% in AAW and 98.6% in EAW ($P = 0.031$); however, there were no significant differences in breast cancer-specific survival probability during the entire study period (Fig. 3) or in risk of breast cancer-specific death between AAW and EAW (Table 3) after adjusting for demographic and cancer characteristics.

DISCUSSION

A number of studies have found that differences in surgical care can degrade quality of life (QOL) and increase morbidity/mortality in AAW. For example, although breast reconstruction after mastectomy has been associated with improved psychological outcomes, numerous studies found that AAW with public (OR 0.64; 95% CI 0.45–0.91) or private (OR 0.54; 95% CI 0.47–0.63) health insurance undergo reconstruction significantly less frequently than EAW.[27] Methods by which lymph node status is determined may also affect QOL by increasing morbidity.[28] An evaluation of the SEER-Medicare database revealed that AAW demonstrated a 12% lower use of

TABLE 2 Surgical utilization in AAW and EAW treated at Murtha Cancer Center, WRNMMC	AAW (N = 271) %	EAW (N = 628) %	P value
Reexcision			0.716
Yes	29.5	30.7	
No	70.5	69.3	
Breast surgery			0.746
BCS	59.0	60.2	
Mastectomy	41.0	39.8	
Mastectomy			0.411
Unilateral	64.9	60.4	
Prophylactic bilateral	27.9	34.4	
Double (bilateral)	7.2	5.2	
LN evaluation			0.184
SLNB	82.7	85.5	
ALND	15.8	11.9	
Not reported	1.5	2.6	
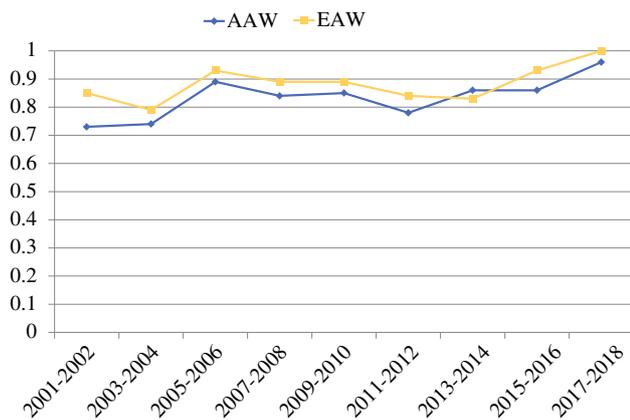
FIG. 2 Frequency of SLNB in 2 year increments from 2001 to 2018 by population
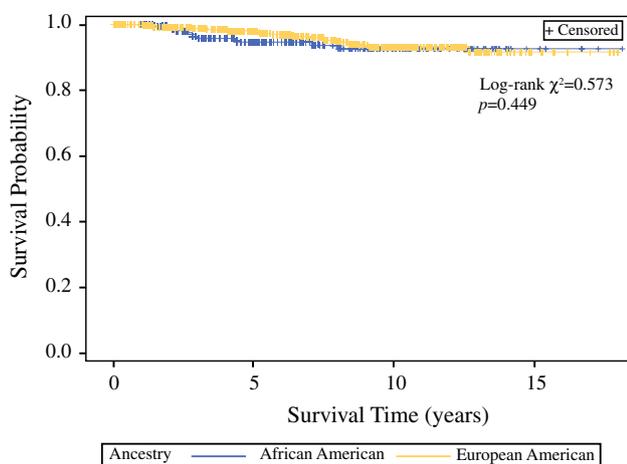
FIG. 3 Product-limit breast cancer-specific survival estimates for European American and African American women treated at Murtha Cancer Center, WRNMMC

SLNB compared to ALND and a correspondingly higher risk of lymphedema compared with EAW.[29] Beyond QOL, treatment delays may affect patient survival. Evaluation of ~ 100,000 women from the SEER database found that breast cancer-specific mortality increased for every 60 day interval.[30] Delays in time to treatment have been detected between AAW and EAW; a recent study from the James

Cancer Hospital in Ohio found that time to treatment was significantly ($P < 0.0001$) longer in AAW (62.0 days) compared with EAW (35.5 days) and 8.5% and 23.1% of AAW had times to treatments of 61–90 days and > 90 days, respectively, compared with 7.8% and 14.8% in EAW.[31] Together, the reported lower rates of breast reconstruction and SLNB and longer times to treatment detected in AAW within the general population may contribute to survival disparities. In contrast to these studies, we observed that AAW and EAW diagnosed and treated within a single equal-access hospital from the DoD healthcare system did not differ significantly in terms of surgical interval, surgical treatment, and survival.

Differences in insurance status and access to healthcare may affect breast cancer survival. For example, within the National Cancer Database, which captures 70% of newly diagnosed breast cancer cases in the United States, uninsured (2.6%) and women with Medicaid (4.3%) had significantly lower breast cancer survival than did those with Medicare or private insurance.[32] While the wide variety of types of insurance available in the United States may confound disparities research within the general population, evaluation of treatment disparities within equal-access healthcare systems may minimize the effects of variable access. Two studies of AAW and EAW treated within safety-net healthcare systems found no difference in surgical interval, although breast cancer survival was lower in AAW.[11,33] In contrast, a third study identified 23% longer wait times between diagnosis and mastectomy for AAW, but 48% longer wait times for women treated within safety net compared with nonsafety net systems.[34]

Because the quality of care provided in the safety net system may be lower than in other settings, survival results from these settings may not reflect those in the general population.[34] In contrast, the DoD Military Healthcare System (MHS) provides clinical care, including annual screening mammography and multimodality cancer care, regardless of ethnicity or socioeconomic status. Evaluation of data from the DoD MHS found that the surgical interval for AAW was 30.8 days compared with 27.3 days in EAW; this 3.5-day difference was found to be not clinically significant. In addition, overall survival did not differ

TABLE 3 Cox proportional hazard regression estimated hazards ratios (HRs) and 95% confidence intervals (CI) for breast cancer-specific death for women treated at Murtha Cancer Center, WRNMMC

	N	Person-years	Deaths	HR (95% CI)	Adjusted HR[a] (95% CI)	Adjusted HR[b] (95% CI)
European American	628	4147	24	1.00 (reference)	1.00 (reference)	1.00 (reference)
African American	271	1578	12	1.31 (0.65, 2.61)	1.30 (0.62, 2.74)	0.82 (0.35, 1.93)
P value				0.451	0.485	0.662

[a]Model adjusted for age at diagnosis, marital status, education, body mass index, and comorbidities

[b]Model adjusted for variables in (a) and tumor stage, tumor grade, invasive size, lymph node evaluation, lymph node status, breast surgery type, time to surgery, and reexcision surgery

by population.[35] A second study utilizing data from the DoD MHS found no difference in BCS in AAW compared with EAW.[36]

One limitation of this study was that to capture a complete set of surgical data, women with Stage IV breast cancer were excluded. Because distant tumors are associated with the lowest 5-year relative survival rates (23%) compared with localized (99%) or regional (85%) disease, exclusion of patients with stage IV disease may have contributed, in part, to the lack of survival disparities detected within this study. Lower 5-year relative survival rates for AAW in the general population, however, also have been reported for stage I, II, and III breast tumors or when breast carcinomas are classified as localized or regional disease.[37,38] In contrast, these disparate outcomes were not detected within our population of women treated at MCC/WRNMMC. A second limitation was the inability to analyze differences in breast reconstruction, which may affect QOL. A previous study utilizing data from the DoD MHS database, however, revealed that across the military health system, breast reconstruction surgery did not differ between populations.[39] Finally, adjuvant treatment information was not routinely collected, thus we could not evaluate whether disparities in adjuvant treatment were present within the CBCP. Enewold et al. reported that within DOD beneficiaries with breast cancer, chemotherapy, and hormonal therapy did not differ in women with local stage tumors.[36] However, in those with regional stage tumors, AAW were significantly less likely to receive chemotherapy (OR 0.4; 95% CI 0.2–0.7) and hormonal therapy (OR 0.5; 95% CI 0.3–0.8). Given the favorable survival of AAW in our study, future studies should evaluate whether provision of adjuvant treatment is also equivalent within the MCC/WRNMMC.

A number of factors may contribute to the lack of surgical and survival disparities detected within the MCC/WRNMMC. Within this study population, AAW were more likely to have ≥ college education (43.5%) than AAW in the general population (22.5%; https://www.census.gov/content/dam/Census/library/publications/2016/demo/p20-578.pdf). Higher education levels have been linked to improved patient-provider communication;[40] thus, higher education levels of AAW treated within MCC/WRNMMC may have influenced surgical decision making and downstream survival. In addition, compared with data from the general population, no differences for comorbidities were detected in this study.[9] Because mastectomy is a more invasive procedure than BCS, higher levels of comorbidities in the general population of AAW may explain the higher rates of BCS in studies from national databases compared with military studies.[41] In addition, comorbidities have been associated with reduced overall survival in breast cancer patients.[42] Access to primary care providers within the military may have improved the overall health of our study populations, thus reducing the effect of comorbidities. As part of the preventative medicine approach of the DoD healthcare system, AAW were more likely than EAW to have screening mammograms, which may account for the lack differences in stage, lymph node status, and tumor size—factors often associated with delayed diagnosis.[43]

CONCLUSIONS

Within a DoD military treatment facility, no differences in surgical interval or procedures were detected between AAW and EAW with stage I-III breast cancer. Despite having tumors with more aggressive phenotypes (higher grade and TNBC), survival did not differ significantly, suggesting that the care received with this MTF was equivalent regardless of ethnicity. These data highlight the importance of the providing quality breast care to reduce survival disparities seen in the general population.

REFERENCES

1. DeSantis CE, Fedewa SA, Goding Sauer A, Kramer JL, Smith RA, Jemal A. Breast cancer statistics, 2015: convergence of incidence rates between black and white women. *CA Cancer J Clin.* 2016;66(1):31–42.

2. Huo D, Hu H, Rhie SK, et al. Comparison of breast cancer molecular features and survival by African and European Ancestry in The Cancer Genome Atlas. *JAMA Oncol.* 2017;3(12):1654–62.

3. Danforth DN Jr. Disparities in breast cancer outcomes between Caucasian and African American women: a model for describing the relationship of biological and nonbiological factors. *Breast Cancer Res.* 2013;15(3):208.

4. DeLancey JO, Thun MJ, Jemal A, Ward EM. Recent trends in black-white disparities in cancer mortality. *Cancer Epidemiol Biomarker Prev.* 2008;17(11):2908–12.

5. Press R, Carrasquillo O, Sciacca RR, Giardina EG. Racial/ethnic disparities in time to follow-up after an abnormal mammogram. *J Womens Health (Larchmt).* 2008;17(6):923–30.

6. Silber JH, Rosenbaum PR, Clark AS, et al. Characteristics associated with differences in survival among black and white women with breast cancer. *JAMA.* 2013;310(4):389–97.

7. Griggs JJ, Culakova E, Sorbero ME, Poniewierski MS, Wolff DA, Crawford J, Dale DC, Lyman GH. Social and racial differences in selection of breast cancer adjuvant chemotherapy regimens. *J Clin Oncol.* 2007;25(18):2522–7.

8. Bustami RT, Shulkin DB, O'Donnell N, Whitman ED. Variations in time to receiving first surgical treatment for breast cancer as a function of racial/ethnic background: a cohort study. *JRSM Open.* 2014;5(7):2042533313515863.

9. Sheppard VB, Oppong BA, Hampton R, et al. Disparities in breast cancer surgery delay: the lingering effect of race. *Ann Surg Oncol.* 2015;22(9):2902–11.

10. Selove R, Kilbourne B, Fadden MK, et al. Time from screening mammography to biopsy and from biopsy to breast cancer treatment among black and white, women medicare beneficiaries not participating in a health maintenance organization. *Womens Health Issues.* 2016;26(6):642–7.

11. Smith ER, Adams SA, Das IP, Bottai M, Fulton J, Hebert JR. Breast cancer survival among economically disadvantaged women: the influences of delayed diagnosis and treatment on mortality. *Cancer Epidemiol Biomarker Prev.* 2008;17(10):2882–90.

12. Akinyemiju TF, Vin-Raviv N, Chavez-Yenter D, Zhao X, Budhwani H. Race/ethnicity and socio-economic differences in breast cancer surgery outcomes. *Cancer Epidemiol.* 2015;39(5):745–51.

13. Thomas P, Killelea BK, Horowitz N, Chagpar AB, Lannin DR. Racial differences in utilization of breast conservation surgery: results from the National Cancer Data Base (NCDB). *Ann Surg Oncol.* 2016;23(10):3272–83.

14. Shen Y, Dong W, Esteva FJ, Kau SW, Theriault RL, Bevers TB. Are there racial differences in breast cancer treatments and clinical outcomes for women treated at M.D. Anderson Cancer Center? *Breast Cancer Res Treat.* 2007;102(3):347–56.

15. Banerjee M, George J, Yee C, Hryniuk W, Schwartz K. Disentangling the effects of race on breast cancer treatment. *Cancer.* 2007;110(10):2169–77.

16. Sabel MS, Kraft CT, Griffith KA, Bensenhaver JM, Newman LA, Hawley ST, Momoh AO. Differences between breast conservation-eligible patients and unilateral mastectomy patients in choosing contralateral prophylactic mastectomies. *Breast J.* 2016;22(6):607–15.

17. American Joint Committee on Cacner. AJCC Cancer Staging Manual, vol. 7th edn. New York: Springer; 2010.

18. Albano JD, Ward E, Jemal A, Anderson R, Cokkinides VE, Murray T, Henley J, Liff J, Thun MJ. Cancer mortality in the United States by education level and race. *J Natl Cancer Inst.* 2007;99(18):1384–94.

19. Bates T, Evans T, Lagord C, Monypenny I, Kearins O, Lawrence G. A population based study of variations in operation rates for breast cancer, of comorbidity and prognosis at diagnosis: failure to operate for early breast cancer in older women. *Eur J Surg Oncol.* 2014;40(10):1230–6.

20. Polverini AC, Nelson RA, Marcinkowski E, Jones VC, Lai L, Mortimer JE, Taylor L, Vito C, Yim J, Kruper L. Time to treatment: measuring quality breast cancer care. *Ann Surg Oncol.* 2016;23(10):3392–402.

21. Martinez ME, Unkart JT, Tao L, Kroenke CH, Schwab R, Komenaka I, Gomez SL. Prognostic significance of marital status in breast cancer survival: a population-based study. *PLoS One.* 2017;12(5):e0175515.

22. Lee K, Kruper L, Dieli-Conwright CM, Mortimer JE. The impact of obesity on breast cancer diagnosis and treatment. *Curr Oncol Rep.* 2019;21(5):41.

23. Anders CK, Johnson R, Litton J, Phillips M, Bleyer A. Breast cancer before age 40 years. *Semin Oncol.* 2009;36(3):237–49.

24. Charlson M, Szatrowski TP, Peterson J, Gold J. Validation of a combined comorbidity index. *J Clin Epidemiol.* 1994;47(11):1245–51.

25. Richards MA, Westcombe AM, Love SB, Littlejohns P, Ramirez AJ. Influence of delay on survival in patients with breast cancer: a systematic review. *Lancet.* 1999;353(9159):1119–26.

26. Richardson LC, Royalty J, Howe W, Helsel W, Kammerer W, Benard VB. Timeliness of breast cancer diagnosis and initiation of treatment in the National Breast and Cervical Cancer Early Detection Program, 1996–2005. *Am J Public Health.* 2010;100(9):1769–76.

27. Shippee TP, Kozhimannil KB, Rowan K, Virnig BA. Health insurance coverage and racial disparities in breast reconstruction after mastectomy. *Womens Health Issues.* 2014;24(3):e261–9.

28. Ashikaga T, Krag DN, Land SE, et al. Morbidity results from the NSABP B-32 trial comparing sentinel lymph node dissection versus axillary dissection. *J Surg Oncol.* 2010;102:111–8.

29. Black DM, Jiang J, Kuerer HM, Buchholz TA, Smith BD. Racial disparities in adoption of axillary sentinel lymph node biopsy and lymphedema risk in women with breast cancer. *JAMA Surg.* 2014;149(8):788–96.

30. Bleicher RJ, Ruth K, Sigurdson ER, et al. Time to surgery and breast cancer survival in the United States. *JAMA Oncol.* 2016;2(3):330–9.

31. Foy KC, Fisher JL, Lustberg MB, Gray DM, DeGraffinreid CR, Paskett ED. Disparities in breast cancer tumor characteristics, treatment, time to treatment, and survival probability among African American and white women. *NPJ Breast Cancer.* 2018;4:7.

32. Shi R, Taylor H, McLarty J, Liu L, Mills G, Burton G. Effects of payer status on breast cancer survival: a retrospective study. *BMC Cancer.* 2015;15:211.

33. Komenaka IK, Martinez ME, Pennington RE Jr, Hsu CH, Clare SE, Thompson PA, Murphy C, Zork NM, Goulet RJ Jr. Race and ethnicity and breast cancer outcomes in an underinsured population. *J Natl Cancer Inst.* 2010;102(15):1178–87.

34. Bradley CJ, Dahman B, Shickle LM, Lee W. Surgery wait times and specialty services for insured and uninsured breast cancer patients: does hospital safety net status matter? *Health Serv Res.* 2012;47(2):677–97.

35. Rizzo JA, Sherman WE, Arciero CA. Racial disparity in survival from early breast cancer in the department of defense healthcare system. *J Surg Oncol.* 2015;111(7):819–23.

36. Enewold L, Zhou J, McGlynn KA, Anderson WF, Shriver CD, Potter JF, Zahm SH, Zhu K. Racial variation in breast cancer treatment among Department of Defense beneficiaries. *Cancer.* 2012;118(3):812–20.

37. American Cancer Society: Breast Cancer Facts and Figures 2017–2018. Atlanta; 2017.

38. Deshpande AD, Jeffe DB, Gnerlich J, Iqbal AZ, Thummalakunta A, Margenthaler JA. Racial disparities in breast cancer survival: an analysis by age and stage. *J Surg Res.* 2009;153(1):105–13.

39. Enewold LR, McGlynn KA, Zahm SH, Poudrier J, Anderson WF, Shriver CD, Zhu K. Breast reconstruction after mastectomy among Department of Defense beneficiaries by race. *Cancer.* 2014;120(19):3033–9.

40. Smith SK, Dixon A, Trevena L, Nutbeam D, McCaffery KJ. Exploring patient involvement in healthcare decision making across different education and functional health literacy groups. *Social Sci Med.* 2009;69(12):1805–12.

41. Akinyemiju T, Meng Q, Vin-Raviv N. Race/ethnicity and socio-economic differences in colorectal cancer surgery outcomes: analysis of the nationwide inpatient sample. *BMC Cancer*. 2016;16:715.

42. Tammemagi CM, Nerenz D, Neslund-Dudas C, Feldkamp C, Nathanson D. Comorbidity and survival disparities among black and white patients with breast cancer. *JAMA*. 2005;294(14): 1765–72.

43. Enewold L, McGlynn KA, Shriver CD, Zhu K. Mammography screening by race/ethnicity among US servicewomen, 2009–2010. *Mil Med*. 2012;177(12):1513–8.

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