Racial Disparities in the Incidence, Breast Conserving Rate and Survival of Breast Cancer Patients Who Underwent Breast Conserving Surgery

Shu Han
University of Science and Technology of China
Jianjun Liu (ljianjun@ustc.edu.cn)
university of scidence and technology of China https://orcid.org/0000-0002-9280-828X
Weifang Tang
University of Science and Technology of China
Shengying Wang
University of Science and Technology of China
Shikai Hong
University of Science and Technology of China

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Abstract

Objective: In the current study, we aimed to provide a clear insight on the racial disparity of breast conserving rate (BCR) and survival in breast cancer after breast conserving surgery (BCS).

Materials and Methods: Using data from the Surveillance, Epidemiology, and End Results program (SEER), we estimated breast cancer incidence rates and the rate of BCS by race in two periods (2000-2004 and 2013-2017). Relative survival analysis was based on patient-level data from 1998 to 2017. To be adjusted for baseline differences for different races, inverse probability weighting (IPW) models were stepwise performed.

Results: From 2000-2004 to 2013-2017, both the breast cancer incidence (from 4.18 to 5.05 per 1000 white women) and the proportion of patients after BCS (from 55.5% to 59.9) were highest in whites than that of other races. Black individuals' incidence (1.20 per 1000 black women or relatives 43.6% increased) and the BCR were increased most rapidly (6%) than other races. Asian or Pacific Islanders (APIs) were less likely to be diagnosed at a later stage and had the best prognosis than those of other races. After baselines fully adjusted, whites had the better Breast Cancer Specific Survival (BCSS) and Overall Survival (OS) than that of minorities (all $p< 0.001$).

Conclusions: We identified the racial disparities of breast cancer incidence, BCR, and survival differences. We found increase trends of breast cancer incidence and BCR in minorities; however, we also identified the worse survival of minorities than that of whites, regardless of age, tumor stage, grade, and Luminal subtype.

Introduction

The incidence of breast cancer has been increasing over the past 30 years. The slightly rise incidence rates of breast cancer have been attributed in part to continued increased obesity and declines in the fertility rate.(1) In 2020, breast cancer became the first leading incidence of cancer and the second leading cause of cancer death. It is estimated that in 2020, 276,480 new cases or 30% of all female cancers were diagnosed as breast cancer and 42,170 cancer-related deaths were caused by breast cancer.(2) Nowadays, given the advent of regular breast cancer screening in recent years, a higher proportion of breast cancer patients were diagnosed at an early stage.(3) Undoubtedly, treatment for early-stage breast cancer will continue to experience a substantial economic burden in the future.

Although increasing studies revealed that breast cancer is a systemic disease, surgery is still a mainstay treatment for early-stage breast cancer patients.(4–9) In the past 50 years, significant progress has been made in the area of breast cancer surgery.(10) Especially, breast conserving therapy, including wide local excision of the cancer followed by irradiation, has become a standard treatment option for early-stage breast cancer.(11) In addition, given the development of molecular mechanism research, increasingly new effective drugs were used in breast cancer. As a result, increasingly patients with locally advanced stages were willing to accept BCS after downstage by neoadjuvant therapy. Although it is still controversial in partial breast cancer whether radiotherapy is required after BCS, it is confirmed that the survival of BCS is not worse than that of total resection, regardless of race. (12–14)

Racial disparities are a major health concern and an area of ongoing research and national funding.(15–17) In fact, substantial racial disparity in tumor incidence and survival continues to exist.(18) For example, due to increased emphasis on early detection in Whites, white patients are more likely to be diagnosed in early stage. As a result, the breast cancer mortality rate of whites has decreased in recent years. Conversely, the overall breast cancer incidence and mortality rates among the black and Hispanic population has still continued to grow.(19–21) BCS has become the main treatment of breast cancer, however, in the population of breast cancer patients after BCS, the BCR and survival of racial disparities remains unclear. In fact, the etiology is considered a multifactor. The clinical characteristics, genetic differences, and socio-economic status differences may be other main factors beyond the tumor stage affecting the BCR and the survival of breast cancer patients after BCS.(22)

To better understand the disparities in different races may provide insight concerning differences in treatment effectiveness and access to care for breast cancer. In the current study, we therefore sought to provide a clear insight on the racial disparity of incidence and survival by using a large multirace dataset. These racial-specific results may help to formulate more tailored public health interventions and policies.

Materials And Methods

Incidence Cohort

We derived breast cancer incidence data by using Surveillance, Epidemiology, and End Results (SEER) program of cancer registries during 2000 to 2017. Data from 18 registries released in Nov 2019 were collected and analyzed. We estimated the women breast cancer incidence and BCR in two periods, 2000 to 2004 and 2013 to 2017. We defined the patients' race into four standard categories. Patient' s race was recorded as white, black, API, or American Indian/Alaska Native (AI). The breast cancer incidence and BCR were accumulated by race, respectively.

Survival Cohort

We used the population-based SEER program to collect survival data for further survival analysis. Female patients with M0 (according to AJCC 7th or 6th M stage classification) from 1998 to 2017 were extracted before analysis. We selected the period 1998 to 2017 because of the breast cancer molecular subtype was only provided after 1998. All breast cancer patients receiving BCS (Therapy. RX sum-Surg Prim Site code: 20–39) were selected. Given the low incidence of breast cancer in AI patients, and the sample of AI breast cancer undergoing BCS is too small for accurate survival analysis, the survival of AI breast cancer patients was excluded to minimize heterogeneity in the current study.

Statistics analysis

The primary outcomes in the current study were OS and BCSS. OS was defined by algorithmic analysis of death certificates. BCSS was defined by death caused by breast cancer. Other cause mortality (OCM) was recorded by death caused by other diseases. OS and BCSS were calculated by Kaplan-Merier method, respectively. Hazard ratios (HRs) were pairwise calculated for each race.

In order to adjust the imbalances of patients' baseline characteristics in different races, stepwise Inverse Probability Weighting (IPW) via propensity models were stepwise made before pairwise comparison.(23) The stepwise IPW models were performed as follows: Step 1, age-adjusted IPW, which only adjusted the imbalance in age at diagnosis. Step 2, age at diagnosis and Luminal subtype adjusted, which both weights the imbalance in age at diagnosis and breast cancer Luminal subtype. Step 3, fully adjusted IPW, which weights fully the potential risk factors we could get from SEER program, including age at diagnosis, Luminal subtype, grade, T stage, N stage. In these propensity IPW models, age at diagnosis was included as a continuous variable and the remaining factors were included as categorical variables.

Two-sided $p < 0.05$ was considered statistically significant. Analyses were performed with R software, version 3.4.3 (R Foundation for Statistical Computing) and Statistical Product and Service Solutions (SPSS) version 22.

Results

Racial disparities in Incidence

As shown in Table 1 and Fig. 1, a total of 159,134 female breast cancer patients from 41,688,010 women were diagnosed during 2000 to 2004. Of those, 86,611 patients received BCS. Compared 2000–2004, in 2013–2017, both the breast cancer incidence and the number of patients who received BCS were increased. A total of 404,302 female breast cancer patients were diagnosed. Of those, 125,880 patients received BCS. In both periods, white women have the highest risk of developing breast cancer in their lifetime (2000–2004: 4.18 per 1000 white women; 2013–2017: 5.05 per 1000 white women). The incidence of breast cancer was a small increase in whites (relative 20.8% increase). Compared with other races, the incidence of breast cancer in black women is the fastest increased (Whites: 0.51 per 1000 white women; Blacks: 1.20 per 1000 black women; APIs: 1.19 per 1000 API women; AIs: 0.45 per 1000 AI women).

Table 1
The incidence of breast cancer and accept rate of BCS by race and time period (2000–2004 versus 2013–2017)

BC incidence in all population	White			Black			API			AI		
	2000–2004	2013–2017	Diff	2000–2004	2013–2017	Diff	2000–2004	2013–2017	Diff	2000–2004	2013–2017	Diff
	3.19	**3.70**	**0.51**	**0.35**	**0.52**	**0.17**	**0.26**	**0.46**	**0.20**	**0.02**	**0.03**	**0.01**
BC incidence in the same race	4.18	5.05	0.87	2.75	3.95	1.20	2.73	3.92	1.19	1.28	1.73	0.45
BCS incidence in all population	1.77	2.21	0.44	0.17	0.29	0.12	0.13	0.24	0.12	0.01	0.02	0.01
BCS incidence in the same race	2.32	3.02	0.71	1.36	2.19	0.83	1.32	2.05	0.73	0.67	0.94	0.27
BCR in the same race	0.555	0.599	0.044	0.494	0.554	0.060	0.485	0.523	0.038	0.524	0.545	0.021

BC: Breast cancer; BCS: Breast conserving surgery; BCR: Breast conserving rate

From 2000–2004 to 2013–2017, the BCR increased from 2.08 to 2.76 per 1000 women (increase relative 44.6%). However, the BCR increased with marked differences in the four races. The overall rate of breast cancer patients receiving BCS was highest among white breast cancer patients, neither in 2000–2004 (2.32 per 1000 white women) or 2013–2017 (3.02 per 1000 white women). Interestingly, compared with other races, blacks had a prominent increase in the proportion of BCS (from 1.35 to 2.18 per 1000 black women or 60.8% relative increase), and followed by APIs (from 1.32 to 2.05 per 1000 API women or 55.3% relative increase). In addition, from 2000–2004 to 2013–2017, the overall BCR was highest increased among black breast cancer patients (Blacks: increased 6.0%; Whites: increased 4.4%; APIs: increased 3.8%; AIs: increased 2.1%).

Racial disparities in Survival

Patients Characteristics

As shown in Table 2, between 2000 to 2017, a total of 130,746 breast cancer patients underwent BCS who meet all the criteria were included in this study. Of note, 106,200 were white patients, 13,693 were black patients, and 10,853 were API patients. Mean age at diagnosed was the youngest among APIs (57.93 years old), and white patients with the oldest age at diagnosed (62.18 years old). Black breast cancer patients receiving BCS were most likely to have poorly differentiated or undifferentiated tumors (43.63 %). Conversely, white patients were most likely to have well differentiated tumors (29.61 %). In addition, black breast cancer patients were most likely to have poorly TNBC or Her-2 enriched tumors (25.28%). Compared with whites and blacks, the API patients were less likely to be diagnosed at T4 stage and N3 stage. In the primary dataset, the 5-year BCSS in whites, blacks, and APIs were 96.9%, 93.1%, and 97.4%, respectively. The 5-year OS in whites, blacks, and APIs were presented similar disparity (95.5%, 88.9%, and 91.9% respectively). In the unadjusted dataset, compared with other races, blacks had significantly worse BCSS and OS (all $p < 0.001$). Conversely, the API breast cancer patients had the best OS and BCSS than that of other races (as shown in Table 3).

Table 2 Description of baseline characteristics by race

	White n=106200		Black n=13693		API n=10853	
	Mean ± SD / NO	Percent (%)	Mean ± SD / NO	Percent (%)	Mean ± SD / NO	Percent (%)
Age (year)	62.18 ± 12.30		59.02 + 12.13		57.93 + 12.42	
Grade						
Well	31444	29.61	2468	18.02	2815	25.94
Moderately	47333	44.57	5251	38.35	4938	45.50
Poorly	27206	25.62	5947	43.43	3072	28.31
Undifferentiated	217	0.20	27	0.20	28	0.26
T stage						
T1	78707	74.11	8720	63.68	7637	70.37
T2	25199	23.73	4470	32.64	2983	27.49
T3	1858	1.75	409	2.99	191	1.76
T4	436	0.41	94	0.69	42	0.39
N stage						
N0	84870	79.92	10052	73.41	8668	79.87
N1	17963	16.91	2938	21.46	1868	17.21
N2	2455	2.31	517	3.78	240	2.21
N3	912	0.86	186	1.36	77	0.71
Luminal Subtype				0.00		0.00
Luminal A	84555	79.62	8860	64.70	8419	77.57
Luminal B	9123	8.59	1372	10.02	1134	10.45
TNBC	9496	8.94	2841	20.75	843	7.77
HER-2 enriched	3026	2.85	620	4.53	457	4.21
Radiation therapy						
Yes	79425	74.79	10141	74.06	8088	74.52
NO/Unknown	26775	25.21	3552	25.94	2765	25.48
Chemotherapy				0.00		
Yes	34033	32.05	6623	48.37	3891	35.85
NO/Unknown	72167	67.95	7070	51.63	6962	64.15
Insurance						
Insured	103567	97.52	13189	96.32	10590	97.58
Uninsured/NA	2633	2.48	504	3.68	263	2.42
Follow up (months)	42.25 ± 21.31		41.31 + 20.98		41.14+ 21.57	

Table 3 Inverse probability weighted (IPTW) estimates of BCSS and OS

	BCSS			OS		
	HR	CIs	P	HR	CIs	P
Un-adjusted						
Whites vs. Black	0.473	0.434 to 0.516	< 0.001	0.674	0.631 to 0.719	< 0.001
Whites vs. API	1.440	1.230 to 1.686	< 0.001	1.892	1.685 to 2.125	< 0.001
Blacks vs. API	3.042	2.564 to 3.611	< 0.001	2.807	2.470 to 3.190	< 0.001
Age-adjusted						
Whites vs. Black	0.457	0.419 to 0.499	< 0.001	0.428	0.398 to 0.46	< 0.001
Whites vs. API	1.373	1.172 to 1.608	< 0.001	1.144	1.013 to 1.292	0.030
Blacks vs. API	3.040	2.562 to 3.607	< 0.001	2.400	2.103 to 2.738	< 0.001
Age and Luminal subtype adjusted						
Whites vs. Black	0.333	0.304 to 0.364	< 0.001	0.358	0.332 to 0.385	< 0.001
Whites vs. API	0.999	0.851 to 1.721	0.987	0.952	0.843 to 1.077	0.436
Blacks vs. API	2.265	1.896 to 2.705	< 0.001	2.051	1.791 to 2.349	< 0.001
Full adjusted						
Whites vs. Black	0.132	0.119 to 0.147	< 0.001	0.254	0.235 to 0.274	< 0.001
Whites vs. API	0.402	0.339 to 0.475	< 0.001	0.689	0.609 to 0.780	< 0.001
Blacks vs. API	0.916	0.749 to 1.121	0.396	1.276	1.106 to 1.473	< 0.001

BCSS: API: Asian or Pacific Islander

Stepwise IPW model in survival analysis

To understand the association between patients' baseline characteristics with survival, we performed stepwise IPW in the primary dataset for sensitivity analysis. Firstly, as shown in Fig. 3, after the weighted imbalance in age at diagnosed, we found that the BCSS sub-distribution hazard ratio (sHR) between whites and APIs decreased 6.7 percent risk (from 1.440 to 1.373). In addition, white patients had a 74.8% relative decreased sub-distribution OS hazard in the OS IPW model (from 1.892 to 1.144). In the age and Luminal subtype adjusted IPW models (Fig. 4), neither BCSS model or OS model, the survival differences between whites and APIs were disappeared (BCSS: HR = 0.999, CIs: 0.851–1.721, p = 0.987; OS: HR = 0.952, CIs: 0.843–1.077, p = 0.436). After adjusted imbalance baseline characteristics, compared with other races, the whites had the best BCSS and OS (Fig. 5). However, the survival advantage of API patients was disappeared, the sub-distribution hazard model demonstrated no significant survival difference in blacks and APIs (BCSS: HR = 0.916, 0.749–1.121, p = 0.396). The detail results of sHR were provided in Table 3 and Fig. 6.

Discussion

In describing cancer disparities by racial have been progressed in the past several years. The focus of racial disparities has been shifted from single dimension models to complex frameworks. Several domains which contain biological, sociocultural, environment, education, and healthcare systems have been incorporated. These frameworks attempt to provide a deep structure which integrates both biology and social dimensions to explore the racial disparities in couples with health problems.(24–26) However, the considerable progress in understanding the mechanisms affecting racial disparities has been relatively slow. Indeed, the incidence, BCR and survival of racial disparities in breast cancer patients who received BCS are continuing to have been variety. In the current study, based on the large multirace dataset, we found great racial disparities in the incidence, BCR and survival of breast cancer patients after BCS. Compared with blacks and APIs, the white race is the race with the consistent highest incidence of breast cancer in the past decade. In addition, white breast cancer patients have the highest acceptance rate of BCS. The breast

cancer incidence in blacks increased fastest than other races. In addition, minorities had a significantly higher increased BCR than whites. After adjusted the imbalance baselines of different races by stepwise IPW, we found white patients have the best prognosis than those of minorities.

The overall cancer incidence rate in women has remained generally stable over the past several decades. However, as the incidence of lung cancer and colorectal cancer declined, breast cancer has become the first leading cancer affecting women health worldwide.(2) Our study found in the age-adjusted breast cancer incidence data, the levels of breast cancer incidence in different races are unequally. Neither 2000–2004 or 2013–2017, white women had the consistent highest risk to suffer from breast cancer in their lifetimes. Moreover, although breast cancer incidence has historically been relatively low among minorities, the breast cancer incidence of minorities women raised rapidly in the past decade. The reason of the racial disparities in breast cancer incidence was complexed.(19, 27) Previous studies identified possible differences in biological properties in different races, such as the levels of hormones and growth factors, reproductive factors, susceptibility loci, BMI, socioeconomic status, breastfeeding and obesity.(20, 28–32) Those above possible differences may have the potential influence on the racial disparities of breast cancer incidence.

In the past century, Halsted's radical mastectomy was regarded as the standard operation for no organ distant metastatic breast cancer patients.(33) However, this operation was too aggressive and low quality of life to patients.(34) This conception was ended in several large randomized clinical trials and the evolution toward less harm had been evidence based.(4, 5, 11) One of most noted study was termed as NSABP B-06.(35) Initial reports of the trial at five, eight, twelve and twenty years follow-up included 1843 enrolled patients, researchers indicated that breast cancer patients received segmental mastectomy regardless of breast irradiation performed, which resulted in BCSS and OS were no worse than that of patients after total mastectomy.(4, 35–37) More surprisingly, BCS plus radiation even exhibited better survival that total mastectomy in a 20-years follow up data.(4) Since then, a lot of clinical trials and long-term follow-up analyses have repeated demonstrated no worse survival outcomes between BCS and total mastectomy.(38–41) In fact, these findings recommend BCS to be a standard treatment option for early-stage breast cancer in the past two decades. Indeed, our findings also demonstrated raised trends of BCS in the population of American, which was consistent with previous studies. Patients select the surgery type can be influenced by several clinical or nonclinical factors, including clinicopathologic factors, physician factors, and individual factors with subgroups of sociodemographic, geographic, and personal beliefs and preferences.(22) This increased BCS rate may contribute to the early breast cancer screening program, which increases the rate of BC patients diagnosed at an early stage.(3) In addition, increasingly locally advanced breast cancer undergoes BCS after neoadjuvant therapy, which further increases the rate of BCS. Several studies have demonstrated that black women were less likely to choose mastectomy procedures than whites, which was consistent with our study, however, our findings point to the situation being changed in the last decade. In fact, blacks have a significant increase of BCS rates, which get increasingly closer to whites.

Although our findings were consistent with previous research, we confirmed that the rising trend of BCS in breast cancer surgery. However, patients after BCS in different races still have a large wide variation in survival regardless of tumor stage and Luminal type. Thus, the racial heterogeneity cannot be ignored. The possible racial heterogeneity affecting the worse prognosis of minorities included younger age at diagnosis, later stage of breast cancer at diagnosis, worse biologic and genetic factors, difficult access to health care and lower socioeconomic status.(42) In current study, after adjusting those imbalance characteristics including age, grade, stage and Luminal subtype, we found the prognosis of black breast cancer patients was still worse than that of white patients. We assumed that biologic and genetic factors, access to health care, and socioeconomic status as racial traits beyond the adjusted factors may play key roles in affect breast cancer patients' survival. Indeed, it was observed that black women were less likely to obtain adequate treatment compared to white women. For example, black women were less likely to receive surgical treatment in tertiary hospitals and were more likely to have delays in receiving adjuvant therapy.(42) Interestingly, since API patients had more strict indications for BCS in the real world, we found their prognosis was better than that of other races in the unadjusted data. This result suggested that, to get a better prognosis, BCS should be only performed in blacks or APIs with more strictly indications.

We acknowledge the inherent limitations in this cancer registry dataset. Firstly, owing to the data availability, we could not collect other important information from the SEER program, such as surgical margins, income, premenopausal endogenous level hormones, breastfeeding, and susceptibility genetic factors, it is hard to adjust all potential bias in the current study.(20, 28–30, 43, 44) Secondly, although our study demonstrated the survival advantage in whites, it may be due to the receipt of adjuvant chemotherapy and radiation therapy after surgery. However, cancer registries do not systematically collect treatment regimens after

surgery. In our study, we found the rates of radiotherapy were received similar in those three races. Moreover, the blacks with the worst survival even received the highest rate of adjuvant chemotherapy than other races. Despite the above limitations, our study included substantial samples, which could offer a deep insight into the racial disparities of breast cancer. Moreover, we have cumulative survival disparities using Fine-Gray regression models in the pairwise IPW adjusted dataset. These methods could reduce the potential cohort bias in a retrospective study, thereby providing more reliable and stable results.

To the best of our knowledge, we first based on a large individual patient-level dataset, which confirmed a comprehensive analysis of racial disparities in the incidence, BCR and survival of breast cancer after BCS. Our study revealed the increased of BCS rate in breast cancer, especially in minorities. However, after adjusting the imbalance between baseline characteristics by IPW, we found that minorities have performed worse survival than that of whites. This survival benefit may be attributed to the special genetic characteristics and socio-economic status of whites. In addition, our study points out that API breast cancer patients after BCS had the best survival in the real world. This survival benefit may be attributed to only API patients with more strict indications receiving BCS. We hypothesized that BCS should be more cautious for minorities for better survival. This significantly increased rate of BCS and worse survival in minorities should be alerted by health management departments and clinicals.

Declarations

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Disclosure of Potential Conflicts of Interest

The authors have no potential conflicts of interest or financial ties to disclose.

Data Availability Statement

The data analyzed in this paper comes from public and open databases, which are freely available.

Author Contribution Statement

Conceptualization, Jianjun Liu and Shikai Hong;

Collection and Assembly of Data, Shuhan Wang and Weifang Tang;

Data Analysis and Interpretation, Jianjun Liu;

Writing, Shuhan Wang, Weifang Tang and Jianjun Liu;

Visualization, Shikai Hong.;

Supervision, Shengying Wang;

Project Administration, Jianjun Liu and Shikai Hong;

Ethics Statement

The SEER database is a public database, this study does not require additional ethical approval.

References

1. Pfeiffer RM, Webb-Vargas Y, Wheeler W, Gail MH (2018) Proportion of U.S. Trends in Breast Cancer Incidence Attributable to Long-term Changes in Risk Factor Distributions. Cancer Epidemiol Biomarkers Prev 27(10):1214–1222. doi:10.1158/1055-9965.Epi-18-0098
2. Siegel RL, Miller KD, Jemal A (2020) Cancer statistics, 2020. CA Cancer J Clin 70(1):7–30. doi:10.3322/caac.21590
3. Welch HG, Prorok PC, O'Malley AJ, Kramer BS (2016) Breast-Cancer Tumor Size, Overdiagnosis, and Mammography Screening Effectiveness. N Engl J Med 375(15):1438–1447. doi:10.1056/NEJMoa1600249
4. Fisher B, Jeong J, Anderson S, Bryant J, Fisher E, Wolmark N (2002) Twenty-five-year follow-up of a randomized trial comparing radical mastectomy, total mastectomy, and total mastectomy followed by irradiation. N Engl J Med 347(8):567–575. doi:10.1056/NEJMoa020128
5. McGuire K, Santillan A, Kaur P, Meade T, Parbhoo J, Mathias M, Shamehdi C, Davis M, Ramos D, Cox C (2009) Are mastectomies on the rise? A 13-year trend analysis of the selection of mastectomy versus breast conservation therapy in 5865 patients. Ann Surg Oncol 16(10):2682–2690. doi:10.1245/s10434-009-0635-x
6. Czajka ML, Pfeifer C: Breast Cancer Surgery. In: StatPearls. StatPearls Publishing
7. Copyright © 2021, StatPearls Publishing LLC., Treasure Island (FL) (2021)
8. Black DM, Mittendorf EA (2013) Landmark trials affecting the surgical management of invasive breast cancer. Surg Clin North Am 93(2):501–518. doi:10.1016/j.suc.2012.12.007
9. B. Fisher, C. Redmond and E. R. Fisher: The contribution of recent NSABP clinical trials of primary breast cancer therapy to an understanding of tumor biology–an overview of findings. Cancer, 46(4 Suppl), 1009–25 (1980) doi:10.1002/1097-0142(19800815)46:4+<1009::aid-cncr2820461326>3.0.co;2-h
10. Fisher B, Fisher ER (1966) Transmigration of lymph nodes by tumor cells. Science 152(3727):1397–1398. doi:10.1126/science.152.3727.1397
11. Matsen CB, Neumayer LA (2013) Breast cancer: a review for the general surgeon. JAMA Surg 148(10):971–979. doi:10.1001/jamasurg.2013.3393
12. Christian MC, McCabe MS, Korn EL, Abrams JS, Kaplan RS, Friedman MA (1995) The National Cancer Institute audit of the National Surgical Adjuvant Breast and Bowel Project Protocol B-06. N Engl J Med 333(22):1469–1474. doi:10.1056/nejm199511303332206
13. Hughes KS, Schnaper LA, Berry D, Cirrincione C, McCormick B, Shank B, Wheeler J, Champion LA, Smith TJ, Smith BL, Shapiro C, Muss HB, Winer E, Hudis C, Wood W, Sugarbaker D, Henderson IC, Norton L (2004) Lumpectomy plus tamoxifen with or without irradiation in women 70 years of age or older with early breast cancer. N Engl J Med 351(10):971–977. doi:10.1056/NEJMoa040587
14. Favourable (2000) and unfavourable effects on long-term survival of radiotherapy for early breast cancer: an overview of the randomised trials. Early Breast Cancer Trialists' Collaborative Group Lancet 355(9217):1757–1770
15. Fisher B, Anderson S (1994) Conservative surgery for the management of invasive and noninvasive carcinoma of the breast: NSABP trials. National Surgical Adjuvant Breast and Bowel Project. World J Surg 18(1):63–69. doi:10.1007/bf00348193
16. Ward E, Jemal V, Fau - A, Cokkinides GK, Cokkinides VF - Singh C Singh Gk Fau - Cardinez, A. Cardinez C Fau - Ghafoor, M. Ghafoor A Fau - Thun and M. Thun: Cancer disparities by race/ethnicity and socioeconomic status(0007-9235 (Print))
17. Fontanarosa PB, Bauchner H (2018) Race, Ancestry, and Medical Research. Jama 320(15):1539–1540. doi:10.1001/jama.2018.14438
18. Bonham VL, Green ED, Pérez-Stable EJ (2018) Examining How Race, Ethnicity, and Ancestry Data Are Used in Biomedical Research. Jama 320(15):1533–1534. doi:10.1001/jama.2018.13609
19. Zavala VA, Bracci PM, Carethers JM, Carvajal-Carmona L, Coggins NB, Cruz-Correa MR, Davis M, de Smith AJ, Dutil J, Figueiredo JC, Fox R, Graves KD, Gomez SL, Llera A, Neuhausen SL, Newman L, Nguyen T, Palmer JR, Palmer NR, Pérez-Stable EJ, Piawah S, Rodriquez EJ, Sanabria-Salas MC, Schmit SL, Serrano-Gomez SJ, Stern MC, Weitzel J, Yang JJ, Zabaleta J, Ziv E, Fejerman L (2021) Cancer health disparities in racial/ethnic minorities in the United States. Br J Cancer 124(2):315–332. doi:10.1038/s41416-020-01038-6
20. Yedjou CG, Sims JN, Miele L, Noubissi F, Lowe L, Fonseca DD, Alo RA, Payton M (2019) and P. B. Tchounwou: Health and Racial Disparity in Breast Cancer. Adv Exp Med Biol 1152:31–49. doi:10.1007/978-3-030-20301-6_3

21. Chlebowski RT, Chen Z, Anderson GL, Rohan T, Aragaki A, Lane D, Dolan NC, Paskett ED, McTiernan A, Hubbell FA, Adams-Campbell LL, Prentice R (2005) Ethnicity and breast cancer: factors influencing differences in incidence and outcome. J Natl Cancer Inst 97(6):439–448. doi:10.1093/jnci/dji064
22. Warner ET, Tamimi RM, Hughes ME, Ottesen RA, Wong YN, Edge SB, Theriault RL, Blayney DW, Niland JC, Winer EP, Weeks JC (2015) and A. H. Partridge: Racial and Ethnic Differences in Breast Cancer Survival: Mediating Effect of Tumor Characteristics and Sociodemographic and Treatment Factors. J Clin Oncol 33(20):2254–2261. doi:10.1200/jco.2014.57.1349
23. Gu J, Groot G, Boden C, Busch A, Holtslander L, Lim H (2018) Review of Factors Influencing Women's Choice of Mastectomy Versus Breast Conserving Therapy in Early Stage Breast Cancer: A Systematic Review. Clin Breast Cancer 18(4):e539–e554. doi:10.1016/j.clbc.2017.12.013
24. Austin PC, Schuster T (2016) The performance of different propensity score methods for estimating absolute effects of treatments on survival outcomes: A simulation study. Stat Methods Med Res 25(5):2214–2237. doi:10.1177/0962280213519716
25. Ward E, Jemal A, Cokkinides V, Singh GK, Cardinez C, Ghafoor A, Thun M (2004) Cancer disparities by race/ethnicity and socioeconomic status. CA Cancer J Clin 54(2):78–93. doi:10.3322/canjclin.54.2.78
26. Alvidrez J, Castille D, Laude-Sharp M, Rosario A, Tabor D (2019) The National Institute on Minority Health and Health Disparities Research Framework. Am J Public Health 109(S1):S16–Ss20. doi:10.2105/ajph.2018.304883
27. Krieger N (2001) Theories for social epidemiology in the 21st century: an ecosocial perspective. Int J Epidemiol 30(4):668–677. doi:10.1093/ije/30.4.668
28. Rojas K, Stuckey A (2016) Breast Cancer Epidemiology and Risk Factors. Clin Obstet Gynecol 59(4):651–672. doi:10.1097/grf.0000000000000239
29. Pinheiro SP, Holmes MD, Pollak MN, Barbieri RL, Hankinson SE (2005) Racial differences in premenopausal endogenous hormones. Cancer Epidemiol Biomarkers Prev 14(9):2147–2153. doi:10.1158/1055-9965.Epi-04-0944
30. Haiman CA, Chen GK, Vachon CM, Canzian F, Dunning A, Millikan RC, Wang X, Ademuyiwa F, Ahmed S, Ambrosone CB, Baglietto L, Balleine R, Bandera EV, Beckmann MW, Berg CD, Bernstein L, Blomqvist C, Blot WJ, Brauch H, Buring JE, Carey LA, Carpenter JE, Chang-Claude J, Chanock SJ, Chasman DI, Clarke CL, Cox A, Cross SS, Deming SL, Diasio RB, Dimopoulos AM, Driver WR, Dünnebier T, Durcan L, Eccles D, Edlund CK, Ekici AB, Fasching PA, Feigelson HS, Flesch-Janys D, Fostira F, Försti A, Fountzilas G, Gerty SM, Giles GG, Godwin AK, Goodfellow P, Graham N, Greco D, Hamann U, Hankinson SE, Hartmann A, Hein R, Heinz J, Holbrook A, Hoover RN, Hu JJ, Hunter DJ, Ingles SA, Irwanto A, Ivanovich J, John EM, Johnson N, Jukkola-Vuorinen A, Kaaks R, Ko YD, Kolonel LN, Konstantopoulou I, Kosma VM, Kulkarni S, Lambrechts D, Lee AM, Marchand LL, Lesnick T, Liu J, Lindstrom S, Mannermaa A, Margolin S, Martin NG, Miron P, Montgomery GW, Nevanlinna H, Nickels S, Nyante S, Olswold C, Palmer J, Pathak H, Pectasides D, Perou CM, Peto J, Pharoah PD, Pooler LC, Press MF, Pylkäs K, Rebbeck TR, Rodriguez-Gil JL, Rosenberg L, Ross E, Rüdiger T, Silva Idos S, Sawyer E, Schmidt MK, Schulz-Wendtland R, Schumacher F, Severi G, Sheng X, Signorello LB, Sinn HP, Stevens KN, Southey MC, Tapper WJ, Tomlinson I, Hogervorst FB, Wauters E, Weaver J, Wildiers H, Winqvist R, Van Den Berg D, Wan P, Xia LY, Yannoukakos D, Zheng W, Ziegler RG, Siddiq A, Slager SL (2011) Nat Genet 43(12):1210–1214. doi:10.1038/ng.985 D. O. Stram, D. Easton, P. Kraft, B. E. Henderson and F. J. Couch: A common variant at the TERT-CLPTM1L locus is associated with estrogen receptor-negative breast cancer.
31. Kato I, Cichon M, Yee CL, Land S, Korczak JF (2009) African American-preponderant single nucleotide polymorphisms (SNPs) and risk of breast cancer. Cancer Epidemiol 33(1):24–30. doi:10.1016/j.canep.2009.04.009
32. Pudrovska T, Anikputa B (2012) The role of early-life socioeconomic status in breast cancer incidence and mortality: unraveling life course mechanisms. J Aging Health 24(2):323–344. doi:10.1177/0898264311422744
33. Jones KM, Power ML, Queenan JT, Schulkin J (2015) Racial and ethnic disparities in breastfeeding. Breastfeed Med 10(4):186–196. doi:10.1089/bfm.2014.0152
34. Halsted WS: I. A Clinical and Histological Study of certain Adenocarcinomata of the Breast: and a Brief Consideration of the Supraclavicular Operation and of the Results of Operations for Cancer of the Breast from 1889 to 1898 at the Johns Hopkins Hospital. Ann Surg, 28(5), 557–76 (1898)
35. Mc WR (1948) The value of simple mastectomy and radiotherapy in the treatment of cancer of the breast. Br J Radiol 21(252):599–610. doi:10.1259/0007-1285-21-252-599

36. Fisher B, Bauer M, Margolese R, Poisson R, Pilch Y, Redmond C, Fisher E, Wolmark N, Deutsch M, Montague E (1985) and et al.: Five-year results of a randomized clinical trial comparing total mastectomy and segmental mastectomy with or without radiation in the treatment of breast cancer. N Engl J Med 312(11):665–673. doi:10.1056/nejm198503143121101
37. Fisher B, Redmond C, Poisson R, Margolese R, Wolmark N, Wickerham L, Fisher E, Deutsch M, Caplan R, Pilch Y (1989) and et al.: Eight-year results of a randomized clinical trial comparing total mastectomy and lumpectomy with or without irradiation in the treatment of breast cancer. N Engl J Med 320(13):822–828. doi:10.1056/nejm198903303201302
38. Fisher B, Anderson S, Redmond CK, Wolmark N, Wickerham DL, Cronin WM (1995) Reanalysis and results after 12 years of follow-up in a randomized clinical trial comparing total mastectomy with lumpectomy with or without irradiation in the treatment of breast cancer. N Engl J Med 333(22):1456–1461. doi:10.1056/nejm199511303332203
39. Maddox WA, Carpenter JT Jr, Laws HL, Soong SJ, Cloud G, Urist MM, Balch CM (1983) A randomized prospective trial of radical (Halsted) mastectomy versus modified radical mastectomy in 311 breast cancer patients. Ann Surg 198(2):207–212. doi:10.1097/00000658-198308000-00016
40. Blichert-Toft M, Nielsen M, Düring M, Møller S, Rank F, Overgaard M, Mouridsen HT (2008) Long-term results of breast conserving surgery vs. mastectomy for early stage invasive breast cancer: 20-year follow-up of the Danish randomized DBCG-82TM protocol. Acta Oncol 47(4):672–681. doi:10.1080/02841860801971439
41. van Dongen JA, Voogd AC, Fentiman IS, Legrand C, Sylvester RJ, Tong D, van der Schueren E, Helle PA, van Zijl K, Bartelink H (2000) Long-term results of a randomized trial comparing breast-conserving therapy with mastectomy: European Organization for Research and Treatment of Cancer 10801 trial. J Natl Cancer Inst 92(14):1143–1150. doi:10.1093/jnci/92.14.1143
42. Poggi MM, Danforth DN, Sciuto LC, Smith SL, Steinberg SM, Liewehr DJ, Menard C, Lippman ME, Lichter AS, Altemus RM (2003) Eighteen-year results in the treatment of early breast carcinoma with mastectomy versus breast conservation therapy: the National Cancer Institute Randomized Trial. Cancer 98(4):697–702. doi:10.1002/cncr.11580
43. Akinyemiju TF, Vin-Raviv N, Chavez-Yenter D, Zhao X, Budhwani H (2015) Race/ethnicity and socio-economic differences in breast cancer surgery outcomes. Cancer Epidemiol 39(5):745–751. doi:10.1016/j.canep.2015.07.010
44. Houssami N, Macaskill P, Marinovich ML, Dixon JM, Irwig L, Brennan ME, Solin LJ (2010) Meta-analysis of the impact of surgical margins on local recurrence in women with early-stage invasive breast cancer treated with breast-conserving therapy. Eur J Cancer 46(18):3219–3232. doi:10.1016/j.ejca.2010.07.043
45. Byun J, Singhal S, Park S, Yi D, Yan T, Caban A, Jones A, Mukhopadhyay P, Gil S, Hewitt S, Newman L, Davis M, Jenkins B, Sepulveda J, De Siervi A, Nápoles A, Vohra N, Gardner K (2020) Racial Differences in the Association Between Luminal Master Regulator Gene Expression Levels and Breast Cancer Survival. Clinical cancer research: an official journal of the American Association for Cancer Research 26(8):1905–1914. doi:10.1158/1078-0432.Ccr-19-0875

Figures

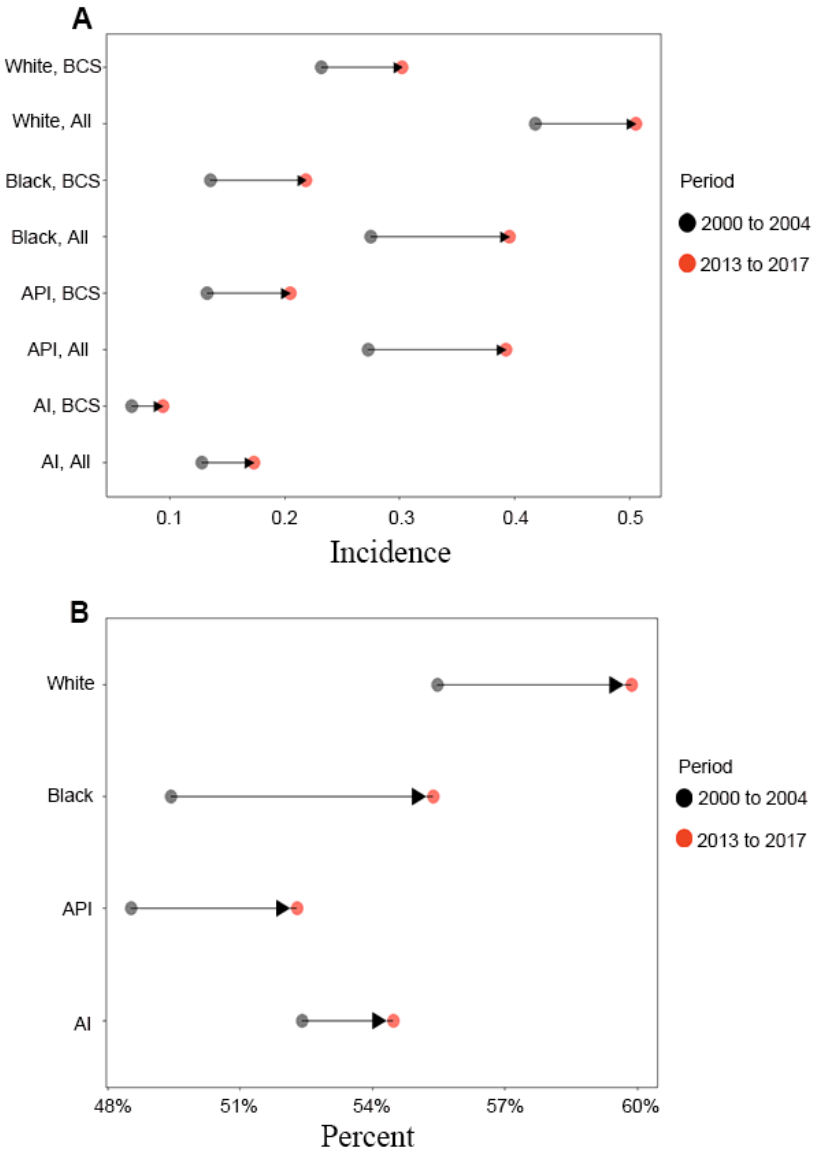

Figure 1 Liu et al.

Figure 1

A. Change in incidence of breast cancer by surgery type and race between 2000-2004 to 2013-2017; B. Change in breast conserving rate by race between 2000-2004 to 2013-2017;

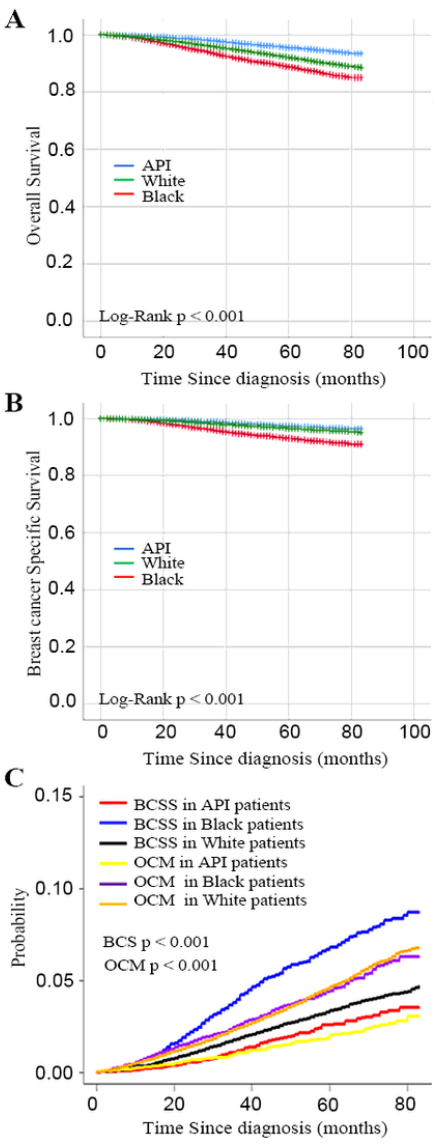

Figure 2 Liu et al.

Figure 2

A. Kaplan-Meier curves of overall survival (A) and breast cancer specific survival (B) between 2000 and 2017 by race; C. The CIF curves for breast cancer specific death and other cause mobility by race.

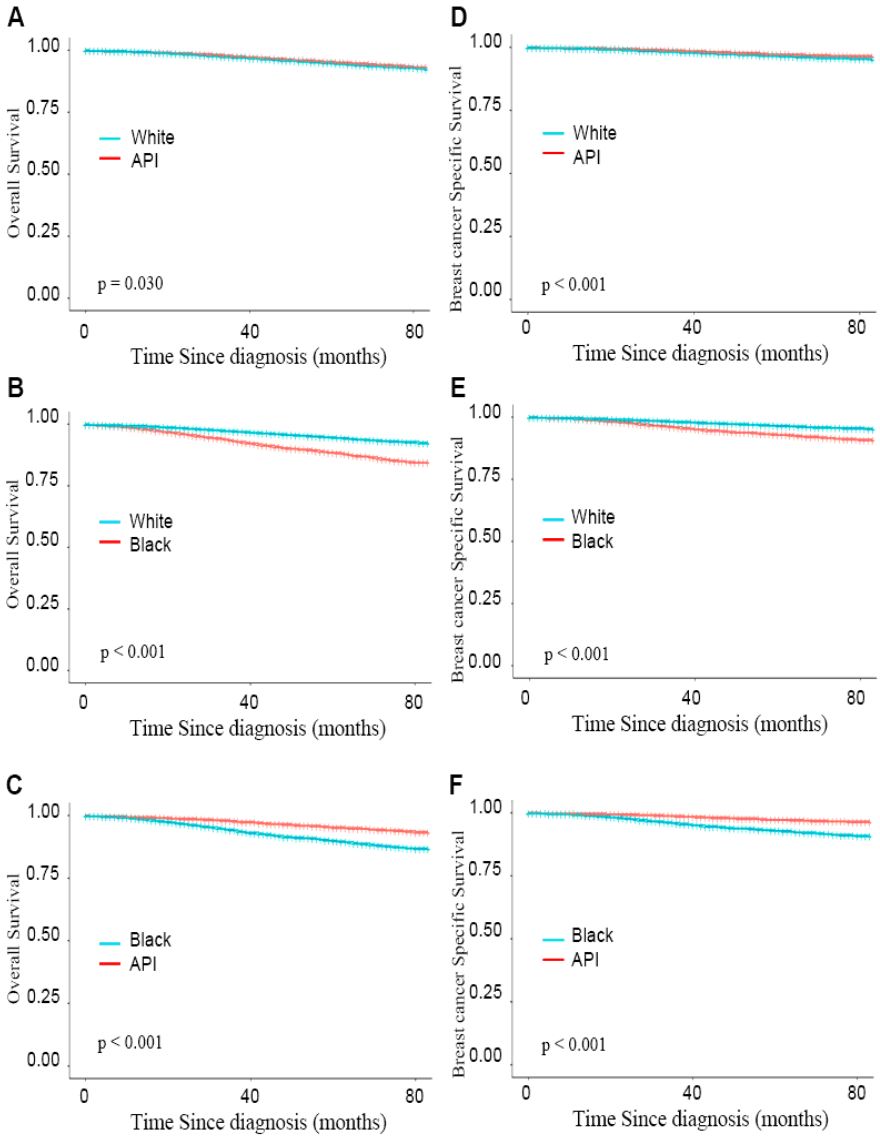

Figure 3 Liu et al.

Figure 3

Kaplan-Meier curves of indicated races' overall survival (A-C) and breast cancer specific survival (D-F) after age inverse probability weighted.

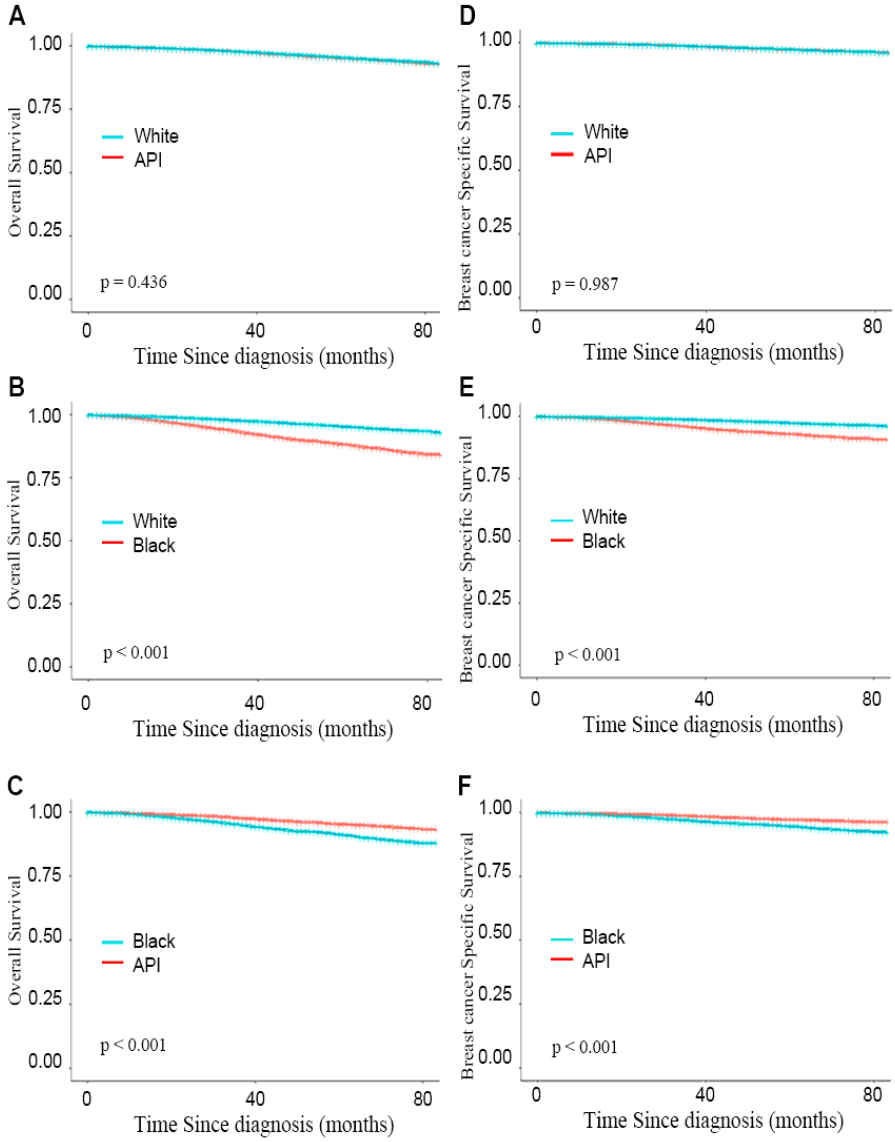

Figure 4 Liu et al.

Figure 4

Kaplan-Meier curves of indicated races' overall survival (A-C) and breast cancer specific survival (D-F) after age and Luminal subtype inverse probability weighted.

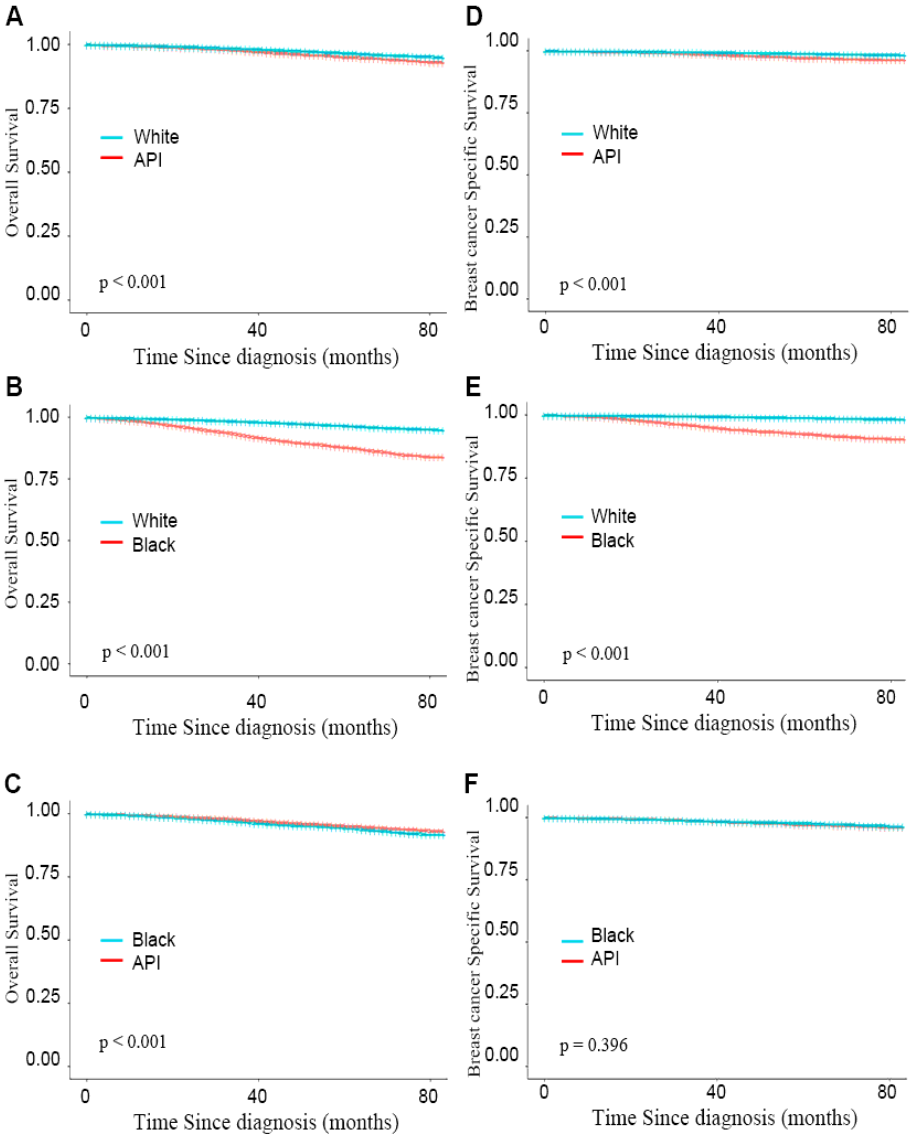

Figure 5 Liu et al.

Figure 5

Kaplan-Meier curves of indicated races' overall survival (A-C) and breast cancer specific survival (D-F) after full factors inverse probability weighted.

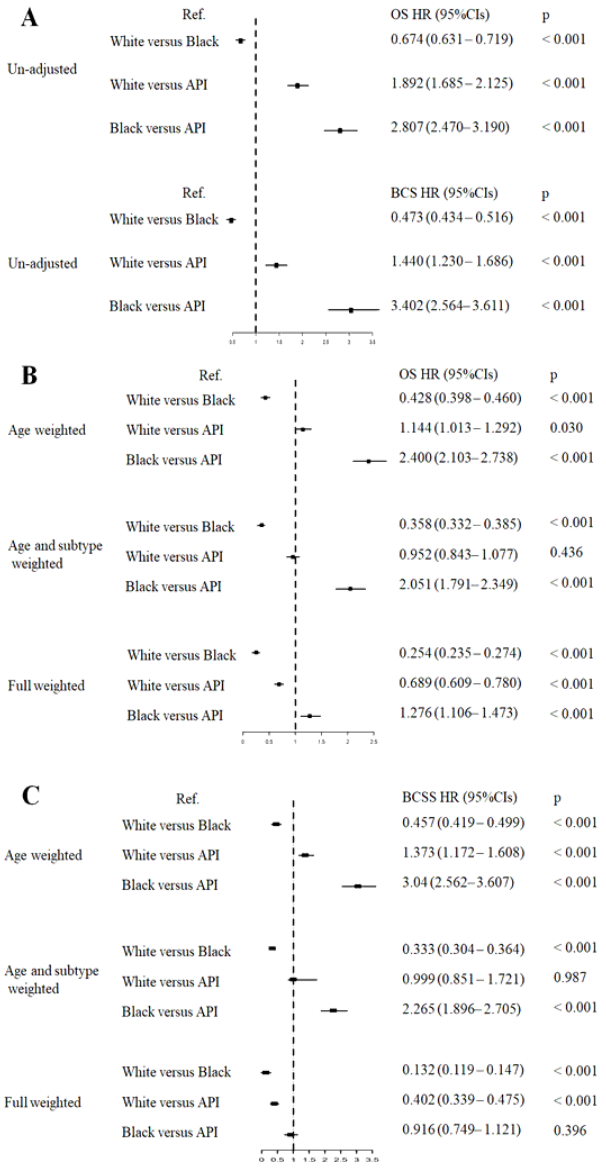

Figure 6 Liu et al.

Figure 6

Forest Plot of Hazard Ratios of overall survival and breast cancer specific survival in un-adjusted dataset (A) and stepwise inverse probability weighted dataset (B-C).