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Impact of Hospital Volume on Racial Disparities and Outcomes for Endometrial Cancer

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Abstract

Objective—Little is known about the influence of hospital procedural volume on racial disparities for uterine cancer. We examined whether the magnitude of the survival differential between black and white women varied based on hospital procedural volume for endometrial cancer.

Methods—We utilized the National Cancer Data Base to examine women with endometrial cancer from 1998-2012. Annualized hospital procedural volume was calculated and hospitals grouped into volume-based quartiles. Multivariable models were developed to examine differences in two and five-year survival between black and white women across the hospital volume categories. Patients were classified as early or advanced stage and as type I (low grade, endometrioid) or type II (high grade endometrioid, other histologies) cancers.

Results—We identified 243,422 (75.0%) white and 27,764 (8.6%) black women treated at 1059 hospitals. Regardless of hospital volume, black women had decreased survival. For each tumor

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class, the absolute difference in adjusted two-year survival between black and white women decreased with increasing hospital volume. For example, for women with early-stage, type I tumors, the adjusted two-year survival differential between blacks and whites was -1.4% (95%CI, -2.4 to -0.5%) at low volume centers and decreased to -0.5% (95%CI, -0.9 to 0%) at high-volume hospitals ($P<0.0001$). For advanced stage, type I tumors, the adjusted survival differential decreased from -12.4% (95%CI, -24.0 to -0.9%) to 1.2% (95%CI, -2.9 to 5.3%) at high volume hospitals ($P<0.0001$).

Conclusion—Black race is an independent predictor of mortality. The impact of race on mortality is mitigated, albeit not eliminated, by increasing hospital volume.

Introduction

Endometrial cancer is associated with a favorable prognosis overall, however, significant disparities exist in outcomes between black and white women. Compared to white women, black women are nearly twice as likely to die from their disease (7.9 per 100,000 vs 4.1 per 100,000).^{1,2} The 5-year relative survival rate for white women with uterine cancer is 84%, compared to 62% for black women.³ Additionally, the mortality rate from 2005 to 2014 increased by approximately 1% per year for white women compared to 2% per year for black women.³

While some of the disparity in overall mortality can be attributed to a later stage at diagnosis for black women, the survival rate among white women exceeds that for black women at every stage of disease.⁴ Studies have shown that failure to receive cancer-directed therapy following a diagnosis of endometrial cancer is more common among black women (9% vs 4%) and when cancer-directed therapy is initiated, black women are less likely to undergo surgery and less likely to receive adjuvant therapy for advanced stage disease.^{5,6}

Inequality in treatment or in access to medical care is a potentially modifiable cause of disparate outcomes. There is a growing body of evidence that suggests the importance of hospital factors in the outcomes of patients with gynecologic malignancies. A number of studies have suggested that patients treated at high-volume facilities, teaching hospitals and centers with specialty providers have improved outcomes.^{7,8} While the association between outcomes and high volume centers is most pronounced for high risk procedures with significant risk of early mortality⁹, there appears to be at least a modest association between hospital volume and outcomes for endometrial cancer.^{10,11}

Given the influence of hospital factors on outcomes, we hypothesized that hospital characteristics, such as procedural volume, may also impact disparities in care between white and black patients. The objective of our study was to examine the association between hospital volume and racial disparities in women with endometrial cancer. Specifically we explored whether the magnitude of survival differential between black and white patients varied based on hospital volume.

Materials and Methods

Data Source and Patient Selection

The National Cancer Data Base (NCDB) is a nationwide hospital registry of cancer patients sponsored by the American Cancer Society and the American College of Surgeon.¹² NCDB gathers information on approximately 70% of all new invasive cancer diagnoses from more than 1500 Commission on Cancer-affiliated hospitals within the United States. Data captured include hospital factors, patient demographics, stage, first course of treatment, and overall survival. This study was deemed exempt by the Columbia University Institutional Review Board.

Women with uterine cancer diagnosed from 1998-2012 were analyzed. We included women who underwent hysterectomy as part of their initial treatment. Hospitals with less than 50 patients were excluded. Patients of all races (non-Hispanic white, non-Hispanic black, Hispanic, and other) were included in the initial study cohort to allow the estimation of procedural volume at each institution. The original cohort included 324,502 patients from 1059 hospitals. The survival analysis was limited to black and white women treated from 1998 to 2011 who had at least five years of follow-up.

Variables and Outcome

Demographic data included age at diagnosis (<40, 40-49, 50-59, 60-69, 70-79, 80 years), insurance status (private, Medicare, Medicaid, not insured, other, unknown), median zip code household income (<\$30,000, \$30,000-\$35,999, \$36,000-\$45,999, \$46,000, unknown). Each patient's location was determined by matching the patients' state and county five-digit Federal Information Processing Standards code to rural-urban continuum codes from the United States Department of Agriculture Economic Research Service, and classified as urban, rural, and metropolitan. The Deyo classification of the Charlson comorbidity score was used to describe a patient's comorbidity status (0, 1, 2).^{13,14} Year of analysis was aggregated as 1998-2002, 2003-2007, and 2008-2012 in the descriptive analysis, but included as a continuous variable in the multivariable models to avoid collinearity with comorbidity score that was not available prior to 2003.

Each facility reporting cases to the NCDB was classified by the American College of Surgeons Commission on Cancer Accreditation program as a community cancer program, comprehensive community cancer program, academic/research program, or other.¹² Facility type was further aggregated as academic and non-academic. The geographic region of the treating facility was classified as eastern, southern, Midwest, and western. Tumor characteristics included histology (endometrioid, carcinosarcoma, serous, sarcoma, clear cell, other), grade (well, moderately, poorly differentiated, unknown), and stage based on American Joint Committee on Cancer criteria (IA, IB, I NOS, II, III, IV, and unknown). Treatment variables included performance of lymph node examination (yes, no, unknown), whether chemotherapy was given (yes, no, unknown), and what type of radiation was given (none, external beam, vaginal brachytherapy).

Annualized hospital volume was calculated as the total number of patients treated at each hospital divided by the number of years in which a hospital treated at least one uterine

cancer patient.¹⁵ Hospital volume was analyzed as a categorical variable and divided into volume-based quartiles: 10 (low volume), 10.01-20 (medium volume), 20.01-60 (medium high volume), and >60 (high volume) cases per year. Hospital volume was also modeled as a continuous variable in a number of sensitivity analyses.

The primary outcome of the analysis was survival. In NCDB, survival is reported as all-cause mortality and includes death from cancer and other causes.¹² The survival time is estimated as the number of months from diagnosis until death from any cause. For analysis, patients were stratified by stage and risk classification.¹⁶ The early-stage type I patients were defined as women with stage I or II, grade 1 or 2 endometrioid cancers, while the early-stage type II cohort included women with stage I or II, grade 3 endometrioid tumors and those with more aggressive histologic subtypes (clear cell, serous, carcinosarcoma, sarcoma). A similar histologic classification of women with advanced stage (stage III or IV) neoplasms was used.

Statistical Analysis

The clinical and demographic characteristics of study cohort are presented descriptively by hospital volume quartile. Distributions across hospital volume categories were compared using χ^2 tests. Marginal multivariable Cox proportional hazards models were used to determine factors associated with overall mortality, accounting for hospital-level clustering. Results from Cox proportional hazards models are reported as hazard ratios (HR) with 95% confidence intervals (CI). The interaction between hospital volume category and race was tested in marginal multivariable Cox proportional hazards models. Once a significant interaction between race and volume category was confirmed, then the impact of race on mortality by hospital volume was assessed after adjusting for other covariates. Marginal multivariable Cox proportional hazards models were also stratified by hospital volume quartile and race to examine survival within each volume strata. Scaled Schoenfeld residuals for each variable in the Cox model were plotted to visually test the assumption of proportionality.^{17,18}

Kaplan-Meier curves stratified by hospital volume quartile were used to determine unadjusted 2- and 5-year survival rates. Direct adjusted survival curves based on hospital volume were used to estimate adjusted survival rates and to obtain pairwise comparisons between black and white women.^{19,20} Analysis of variance (ANOVA) was used to examine the difference in unadjusted and adjusted survival based on race across hospital volume categories. All hypothesis tests were two-sided. A P-value of <0.05 was considered statistically significant. All analyses were conducted using SAS version 9.4 (SAS Institute Inc, Cary, North Carolina).

Results

We identified a total of 324,502 women including 243,422 (75.0%) non-Hispanic white and 27,764 (8.6%) non-Hispanic black women treated at 1059 hospitals. The majority of patients had endometrioid histology (61.8%) and stage I disease (59.7%) at the time of diagnosis. Patients in the cohort primarily had private insurance (51.8%) or Medicare (36.8%) (Table 1).

Of the 1059 hospitals, 41.9% (n=444) were low volume, 23.2% (n=246) were medium, 28.2% (n=299) were medium-high, and 6.6% (n=70) were high volume centers. Volume was found to be associated with facility type, with high volume centers more frequently described as academic/research facilities (65.3%). Geographically, a disproportionately large number of women in the Midwest were treated at low volume centers (40.7%) and a disproportionately low number of women in the west were treated at high volume centers (10.0%). Compared to white women, black women were more likely to receive care at a high-volume center. Of the 27,764 black patients, 75.6% were treated at medium high or high volume hospitals versus 71.6% of white patients ($P<0.0001$) (Table 1, Supplemental Table 1). High volume centers were more likely to perform lymphadenectomy for patients with advanced stage disease and more likely to utilize chemotherapy in these women (Supplemental Table 2)

For all of the disease classification groups, black race was an independent predictor of increased mortality (Table 2). Black women with early-stage, type I tumors had a hazard ratio for death of 1.23 (95%CI 1.13,1.34) for mortality, a hazard ratio of 1.31 (95%CI 1.22, 1.41) for early-stage type II tumors, 1.30 (95% CI 1.08, 1.57) for advanced stage type I and 1.12 (95% CI 1.06,1.19) for advanced stage type II disease compared to white women. Advanced age, non-commercial insurance, increased comorbidity, histology, and grade were also associated with increased mortality. In a series of sensitivity analysis in which hospital volume was modeled as a continuous variable, our results were largely unchanged (Supplemental Table 3) .

The association between race and mortality was then examined within each volume stratum. After adjustment for known covariates, black race remained an independent predictor of increased mortality for the majority of disease classification groups (Table 3). For example, for women with early-stage, type I tumors, black women treated at low volume hospitals were 48% (HR=1.48; 95% CI, 1.16-1.88) more likely to die than white women at low volume hospitals. Similarly, for women with early-stage, type I tumors treated at high-volume hospitals, black women were 19% (HR=1.19; 95% CI, 1.03-1.38) more likely to die than white women treated at similar hospitals.

We then examined the survival differential between black and white women for each tumor classification group stratified by hospital volume (Table 4). For each tumor grouping, we noted that the absolute difference in adjusted two-year survival decreased with increasing hospital volume. For example, for women with early-stage, type I tumors, the adjusted two-year survival differential between blacks and whites was -1.4% (95% CI, -2.4 to -0.5%) at low volume centers and decreased to -0.5% (95% CI, -0.9 to 0%) at high-volume hospitals ($P<0.0001$). For advanced stage, type I tumors, the adjusted survival differential decreased from -12.4% (95% CI, -24.0 to -0.9%) at low to 1.2% (95% CI, -2.9 to 5.3%) at high volume hospitals ($P<0.0001$).

Similar findings were noted for five-year survival (Table 5). For each tumor classification group, the adjusted survival differential between blacks and whites decreased with increasing volume. For early-stage, type I tumors the survival differential for black compared to white women was -3.6% (95% CI, -5.9 to -1.4%) at low compared to -1.4%

(95% CI, -2.7 to 0%) at high volume hospitals ($P<0.0001$). For advanced stage, type I neoplasms the differential decreased from -17.1% (95% CI, -31.7 to -2.6%) to 2.2% (95% CI, -5.4% to 9.7%) ($P<0.0001$). The consistent decrease in the absolute survival difference between black and white women with increasing hospital volume was found to be significant within each tumor classification at both two and five-years.

Comment

Our findings suggest that receipt of treatment at high volume hospitals decreases the absolute survival disparity between black and white women with endometrial cancer. While our study confirmed that black race continues to be an independent predictor of mortality, the impact of race on mortality appears to be mitigated, albeit not eliminated, by increasing hospital volume.

The importance of hospital characteristics as a contributor to patient outcomes has been shown for a variety of diseases and procedures.^{7,9,21,22} Birkmeyer and colleagues, using a sample of 2.5 million patients, demonstrated that patients undergoing six different types of cardiovascular procedures or eight different types of major cancer resections had decreased operative mortality when treatment was rendered at high volume centers. In addition to short term outcomes, increased hospital volume has been associated with improved 5-year survival for patients with lung, pancreas, stomach and esophageal cancers.²³ The most pronounced association between volume and outcomes for gynecologic cancers appears to be for ovarian cancer.²⁴ In a report of women with ovarian cancer, higher volume centers had both increased adherence to National Comprehensive Care Network guidelines and increased overall survival rates.^{24,25}

Data describing the association between hospital characteristics and outcomes for endometrial cancer has been conflicting.^{11,26,27,28,29} Brookfield and colleagues found that, while high volume centers were independently associated with decreased 30 day and 90 day surgical morbidity, there was no improvement in 5 year overall survival or risk of death for endometrial cancer patients treated at high volume versus low volume centers.³⁰ One report of 6,015 patients found that hospital volume had little independent effect on acute surgical outcomes, most notably perioperative mortality, for endometrial cancer patients.¹¹ When evaluating long term outcomes, a study of 9133 women from the Netherlands did not show a difference in survival in women at high vs low volume centers even when stratified by high grade histology or complexity of surgery.²⁹

While the relationship between hospital volume and outcomes has been well described, there was been relatively little study to directly explore the effect of hospital volume on racial disparities for surgical procedures. One report of 16,195 patients with locally advanced cervical cancer noted that, while high volume hospitals had increased adherence to guideline based care, the increase was significantly greater for white women as compared to black or Hispanic women.³¹ Our study however, demonstrated that the survival differential between black and white women is reduced at high compared to low-volume centers. The reduced survival differential was noted for both early and advanced stage tumors. As high volume hospitals more frequently performed lymph node sampling and utilized adjuvant

chemotherapy for high grade advanced stage disease, at least a portion of the improved outcomes may be a reflection of increased adherence to guideline based care.

We recognize a number of important limitations. First, only women who underwent a hysterectomy for treatment of their endometrial cancer were included in this study. While this represents the vast majority of women with endometrial cancer, we could potentially have missed some of the disparity associated with pretreatment decision making which may vary by race. Second, analysis of procedural volume is associated with a number of technical challenges. We utilized annualized hospital volume which has been commonly reported in the past and used relatively standard volume cut points. While we acknowledge that classification of volume as a categorical variable may overestimate volume-based disparities, our findings were validated through sensitivity analyses with hospital volume as a continuous variable. Additionally, we recognize that there could be significant variation in outcomes between the high end and low end hospitals within each hospital quartile.¹⁵ We were unable to take into account the contribution of physician characteristics, which could play a major role in the quality of treatment patients receive or have effects on hospital referral sites. Finally, we acknowledge that the use of all cause mortality as opposed to disease specific mortality, may introduce a survival difference that may not be related to cancer treatment. However within our model we were able to account for the major contributors to all cause mortality, including co-morbidities, and sociodemographic characteristics, which should mitigate this limitation.

While our study demonstrated that increased hospital volume was associated with decreased survival disparities based on race, the factors underlying this association remain undefined. Prior work has shown that high volume hospitals and surgeons are more likely to deliver evidence-based care, to appropriately recognize and treat complications, and may have greater technical proficiency.^{9,32,33} However, why there would be a difference in any of these factors between black and white women across hospital volumes is unclear. From a policy perspective, these data suggest that referral of black woman to higher volume centers may be particularly beneficial. Further efforts to reduce racial disparities, particularly at low-volume centers, are clearly an imperative.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Research Highlights

- Black race is an independent predictor of mortality for women with endometrial cancer.
- Black women with endometrial cancer are more likely to receive treatment at a high volume hospital.
- The impact of race on mortality is mitigated, albeit not eliminated, by increasing hospital volume.

Table 1

Clinical and characteristics of study cohort stratified by hospital volume quartile.

	Total		Hospital volume 10		Hospital volume 10,01-20		Hospital volume 20,01-60		Hospital volume >60		P-value
	n	%	n	%	n	%	n	%	n	%	
<i>Number of patients</i>	324502	(100.0)	40639	(12.5)	48981	(15.1)	149512	(46.1)	85370	(26.3)	
<i>Number of hospitals</i>	1059	(100.0)	444	(41.9)	246	(23.2)	299	(28.2)	70	(6.6)	
<i>Age of diagnosis</i>											<0.0001
<40	11348	(3.5)	1,391	(3.4)	1,706	(3.5)	5,250	(3.5)	3,001	(3.5)	
40-49	35148	(10.8)	4,752	(11.7)	5,500	(11.2)	15,980	(10.7)	8,916	(10.4)	
50-59	94979	(29.3)	11,383	(28.0)	14,186	(29)	43,874	(29.3)	25,536	(29.9)	
60-69	99200	(30.6)	11,830	(29.1)	14,580	(29.8)	45,930	(30.7)	26,860	(31.5)	
70-79	58753	(18.1)	7,735	(19.0)	9,080	(18.5)	27,032	(18.1)	14,906	(17.5)	
80	25074	(7.7)	3,548	(8.7)	3,929	(8.0)	11,446	(7.7)	6,151	(7.2)	
<i>Race</i>											<0.0001
White	243422	(75.0)	32,349	(79.6)	37,385	(76.3)	108,816	(72.8)	64,872	(76.0)	
Black	27764	(8.6)	2,850	(7.0)	3,936	(8.0)	13,956	(9.3)	7,022	(8.2)	
Hispanic	16266	(5.0)	1,618	(4.0)	2,650	(5.4)	9,010	(6.0)	2,988	(3.5)	
Other	9918	(3.1)	986	(2.4)	1,358	(2.8)	4,576	(3.1)	2,998	(3.5)	
Unknown	27132	(8.4)	2,836	(7.0)	3,652	(7.5)	13,154	(8.8)	7,490	(8.8)	
<i>Insurance</i>											<0.0001
Private Insurance	167967	(51.8)	20,140	(49.6)	25,607	(52.3)	77,976	(52.2)	44,244	(51.8)	
Medicaid	14481	(4.5)	1,880	(4.6)	2,238	(4.6)	6,631	(4.4)	3,732	(4.4)	
Medicare	119474	(36.8)	16,016	(39.4)	17,961	(36.7)	54,813	(36.7)	30,684	(35.9)	
Not Insured	11919	(3.7)	1,429	(3.5)	1,955	(4)	5,712	(3.8)	2,823	(3.3)	
Other Government	2637	(0.8)	313	(0.8)	313	(0.6)	1,336	(0.9)	675	(0.8)	
Unknown	8024	(2.5)	861	(2.1)	907	(1.9)	3,044	(2.0)	3,212	(3.8)	
<i>Median household income</i>											<0.0001
< \$30,000	39185	(12.1)	5,088	(12.5)	5,428	(11.1)	18,649	(12.5)	10,020	(11.7)	
\$30,000 - \$35,999	54517	(16.8)	8,081	(19.9)	8,259	(16.9)	24,049	(16.1)	14,128	(16.5)	
\$36,000 - \$45,999	87606	(27.0)	11,660	(28.7)	13,885	(28.3)	38,973	(26.1)	23,088	(27.0)	
\$46,000 +	129889	(40.0)	14,191	(34.9)	19,319	(39.4)	61,864	(41.4)	34,515	(40.4)	

	Total			Hospital volume 10			Hospital volume 10.01-20			Hospital volume 20.01-60			Hospital volume >60			P-value
	n	%		n	%		n	%		n	%		n	%		
Unknown	13305	(4.1)		1,619	(4.0)		2,090	(4.3)		5,977	(4.0)		3,619	(4.2)		<0.0001
Patient's residence area																
Metropolitan	256437	(79.0)		29,392	(72.3)		39,949	(81.6)		122,896	(82.2)		64,200	(75.2)		
Urban	48323	(14.9)		8,456	(20.8)		6,243	(12.7)		18,743	(12.5)		14,881	(17.4)		
Rural	6329	(2.0)		1,052	(2.6)		768	(1.6)		2,642	(1.8)		1,867	(2.2)		
Unknown	13413	(4.1)		1,739	(4.3)		2,021	(4.1)		5,231	(3.5)		4,422	(5.2)		<0.0001
Comorbidity score																
0	185128	(57.0)		20,936	(51.5)		27,914	(57.0)		86,309	(57.7)		49,969	(58.5)		
1	48521	(15.0)		4,706	(11.6)		6,305	(12.9)		23,312	(15.6)		14,198	(16.6)		
2	10728	(3.3)		1,025	(2.5)		1,255	(2.6)		5,313	(3.6)		3,135	(3.7)		
Unknown	80125	(24.7)		13,972	(34.4)		13,507	(27.6)		34,578	(23.1)		18,068	(21.2)		<0.0001
Year of diagnosis																
1998-2002	80125	(24.7)		13972	(34.4)		13507	(27.6)		34578	(23.1)		18068	(21.2)		
2003-2007	105551	(32.5)		14067	(34.6)		16060	(32.8)		47734	(31.9)		27690	(32.4)		
2008-2012	138826	(42.8)		12600	(31.0)		19414	(60.4)		67200	(45.0)		39612	(46.4)		
Facility location																
Eastern	74469	(22.9)		8,811	(21.7)		12,252	(25.0)		30,539	(20.4)		22,867	(26.8)		
South	84459	(26.0)		8,575	(21.1)		12,200	(24.9)		38,392	(25.7)		25,292	(29.6)		
Midwest	111795	(34.5)		16,537	(40.7)		15,543	(31.7)		51,011	(34.1)		28,704	(33.6)		
West	53779	(16.6)		6,716	(16.5)		8,986	(18.3)		29,570	(19.8)		8,507	(10.0)		<0.0001
Facility Type																
Community cancer program	18093	(5.6)		13,759	(33.9)		3,328	(6.8)		649	(0.4)		357	(0.4)		
Comprehensive community cancer program	172627	(53.2)		25,308	(62.3)		37,133	(75.8)		81,466	(54.5)		28,720	(33.6)		
Academic program	133230	(41.1)		1,572	(3.9)		8,520	(17.4)		67,397	(45.1)		55,741	(65.3)		
Other	552	(0.2)		0	(0.0)		0	(0.0)		0	(0.0)		552	(0.6)		<0.0001
Histology																
Endometrioid	200698	(61.8)		22,851	(56.2)		28,871	(58.9)		94,098	(62.9)		54,878	(64.3)		
Serous	16990	(5.2)		1,604	(3.9)		2,255	(4.6)		8,200	(5.5)		4,931	(5.8)		
Carcinosarcoma	14771	(4.6)		1,554	(3.8)		2,042	(4.2)		6,993	(4.7)		4,182	(4.9)		
Sarcoma	12992	(4.0)		1,765	(4.3)		2,002	(4.1)		5,926	(4)		3,299	(3.9)		

	Total			Hospital volume 10			Hospital volume 10.01-20			Hospital volume 20.01-60			Hospital volume >60			P-value
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	
Clear cell	4251	(1.3)	434	(1.1)	583	(1.2)	2,012	(1.3)	1,222	(1.4)	1,222	(1.4)	1,222	(1.4)	1,222	<0.0001
Other	74800	(23.0)	12431	(30.6)	13228	(27.0)	32283	(21.6)	16858	(19.8)	16858	(19.8)	16858	(19.8)	16858	
<i>Stage</i>																
IA	145442	(44.8)	16,471	(40.5)	20,485	(41.8)	67,624	(45.2)	40,862	(47.9)	40,862	(47.9)	40,862	(47.9)	40,862	<0.0001
IB	35439	(10.9)	4,690	(11.5)	5,453	(11.1)	16,496	(11.1)	8,800	(10.3)	8,800	(10.3)	8,800	(10.3)	8,800	
I NOS	12871	(4.0)	1,968	(4.8)	2,365	(4.8)	5,713	(3.8)	2,825	(3.3)	2,825	(3.3)	2,825	(3.3)	2,825	<0.0001
II	19583	(6.0)	2,456	(6.0)	2,986	(6.1)	9,164	(6.1)	4,977	(5.8)	4,977	(5.8)	4,977	(5.8)	4,977	
III	25256	(7.8)	2,712	(6.7)	3,528	(7.2)	11,919	(8.0)	7,097	(8.3)	7,097	(8.3)	7,097	(8.3)	7,097	<0.0001
IV	12655	(3.9)	1,290	(3.2)	1,711	(3.5)	5,971	(4.0)	3,683	(4.3)	3,683	(4.3)	3,683	(4.3)	3,683	
Unknown	73256	(22.6)	11,052	(27.2)	12,453	(25.4)	32,625	(21.8)	17,126	(20.1)	17,126	(20.1)	17,126	(20.1)	17,126	<0.0001
<i>Grade</i>																
Well	127371	(39.3)	17,439	(42.9)	20,365	(41.6)	57,830	(38.7)	31,737	(37.2)	31,737	(37.2)	31,737	(37.2)	31,737	<0.0001
Moderate	88910	(27.4)	11,331	(27.9)	13,160	(26.9)	40,887	(27.3)	23,532	(27.6)	23,532	(27.6)	23,532	(27.6)	23,532	
Poorly	71141	(21.9)	7,693	(18.9)	9,908	(20.2)	33,465	(22.4)	20,075	(23.5)	20,075	(23.5)	20,075	(23.5)	20,075	<0.0001
Unknown	37080	(11.4)	4,176	(10.3)	5,548	(11.3)	17,330	(11.6)	10,026	(11.7)	10,026	(11.7)	10,026	(11.7)	10,026	
<i>Lymph Nodes Examination</i>																
Yes	205257	(63.3)	19,141	(47.1)	27,133	(55.3)	97,999	(65.5)	60,984	(71.4)	60,984	(71.4)	60,984	(71.4)	60,984	<0.0001
No	115382	(35.6)	20,537	(50.5)	21,204	(43.3)	50,183	(33.6)	23,458	(27.5)	23,458	(27.5)	23,458	(27.5)	23,458	
Unknown	3863	(1.2)	961	(2.4)	644	(1.3)	1,330	(0.9)	928	(1.1)	928	(1.1)	928	(1.1)	928	<0.0001
<i>Radiation</i>																
No radiation	242639	(74.8)	29,021	(71.4)	35,657	(72.8)	113,038	(75.6)	64,923	(76.0)	64,923	(76.0)	64,923	(76.0)	64,923	<0.0001
External Beam	45658	(14.1)	8,159	(20.1)	8,199	(16.7)	20,061	(13.4)	9,239	(10.8)	9,239	(10.8)	9,239	(10.8)	9,239	
Brachytherapy	30896	(9.5)	2,790	(6.9)	4,306	(8.8)	14,152	(9.5)	9,648	(11.3)	9,648	(11.3)	9,648	(11.3)	9,648	<0.0001
Unknown	5309	(1.6)	669	(1.6)	819	(1.7)	2,261	(1.5)	1,560	(1.8)	1,560	(1.8)	1,560	(1.8)	1,560	
<i>Chemotherapy</i>																
None	272813	(84.1)	35,164	(86.5)	42,063	(85.9)	125,595	(84.0)	69,991	(82.0)	69,991	(82.0)	69,991	(82.0)	69,991	<0.0001
Yes	45722	(14.1)	4,555	(11.2)	5,965	(12.2)	21,004	(14)	14,198	(16.6)	14,198	(16.6)	14,198	(16.6)	14,198	
Unknown	5967	(1.8)	920	(2.3)	953	(1.9)	2,913	(1.9)	1,181	(1.4)	1,181	(1.4)	1,181	(1.4)	1,181	<0.0001

Table 2

Multivariable Cox proportional hazard models of mortality.

	Early-stage type I (n=90,601) Hazard Ratio (95%CI)	Early-stage type II (n=24,031) Hazard Ratio (95%CI)	Advanced-stage type I (n=6,290) Hazard Ratio (95%CI)	Advanced-stage type II (n=13,860) Hazard Ratio 95%CI)
<i>Age of diagnosis</i>				
<40	Referent	Referent	Referent	Referent
40-49	1.37 (1.09, 1.73)*	1.24 (0.83, 1.83)	1.21 (0.80, 1.83)	1.04 (0.84, 1.31)
50-59	2.01 (1.62, 2.49)**	1.95 (1.33, 2.85)*	1.57 (1.07, 2.29)*	1.31 (1.07, 1.61)*
60-69	3.12 (2.51, 3.89)**	3.05 (2.10, 4.43)**	2.02 (1.37, 2.96)*	1.41 (1.15, 1.73)*
70-79	6.16 (4.94, 7.69)**	4.67 (3.21, 6.79)**	2.81 (1.89, 4.17)**	1.65 (1.35, 2.03)**
80	15.59 (12.45, 19.53)**	8.39 (5.76, 12.23)**	4.06 (2.72, 6.04)**	2.00 (1.62, 2.47)**
<i>Race</i>				
White	Referent	Referent	Referent	Referent
Black	1.23 (1.13, 1.34)**	1.31 (1.22, 1.41)**	1.30 (1.08, 1.57)*	1.12 (1.06, 1.19)*
<i>Insurance Status</i>				
Private	Referent	Referent	Referent	Referent
Medicaid	2.45 (2.19, 2.74)**	1.72 (1.50, 1.99)**	1.57 (1.28, 1.93)**	1.23 (1.10, 1.37)*
Medicare	1.19 (0.90, 1.57)	1.23 (0.98, 1.55)	0.86 (0.65, 1.14)	0.89 (0.76, 1.05)
Not Insured	1.56 (1.45, 1.67)**	1.29 (1.20, 1.39)**	1.33 (1.17, 1.50)**	1.07 (1.02, 1.13)*
Other Government	1.48 (1.27, 1.72)**	1.34 (1.12, 1.60)*	1.45 (1.15, 1.82)*	1.03 (0.90, 1.18)
Unknown	1.10 (0.83, 1.46)	1.06 (0.75, 1.50)	0.66 (0.34, 1.30)	0.90 (0.68, 1.20)
<i>Median household income</i>				
<\$30,000	Referent	Referent	Referent	Referent
\$30,000 - \$35,999	0.95 (0.88, 1.02)	0.96 (0.88, 1.05)	0.95 (0.79, 1.14)	0.98 (0.90, 1.06)
\$36,000 - \$45,999	0.91 (0.84, 0.98)*	0.92 (0.85, 1.00)	1.03 (0.88, 1.22)	1.01 (0.93, 1.08)
\$46,000 +	0.74 (0.68, 0.80)**	0.88 (0.80, 0.96)*	1.02 (0.86, 1.21)	0.95 (0.88, 1.02)
Unknown	0.99 (0.87, 1.13)	1.08 (0.92, 1.25)	1.18 (0.90, 1.56)	1.11 (0.96, 1.28)
<i>Patient's residence area</i>				
Metropolitan	Referent	Referent	Referent	Referent
Urban	1.03 (0.97, 1.08)	1.03 (0.96, 1.11)	1.10 (0.95, 1.26)	1.00 (0.94, 1.06)
Rural	0.84 (0.73, 0.97)*	0.90 (0.78, 1.04)	1.05 (0.74, 1.47)	1.15 (1.01, 1.32)*
Unknown	1.38 (1.21, 1.58)**	1.19 (1.04, 1.37)*	1.26 (0.98, 1.61)	1.00 (0.88, 1.13)
<i>Comorbidity score</i>				
0	Referent	Referent	Referent	Referent
1	1.49 (1.39, 1.59)**	1.19 (1.11, 1.28)**	1.12 (0.98, 1.28)	1.12 (1.06, 1.19)*
2	2.89 (2.65, 3.15)**	1.60 (1.42, 1.80)**	1.73 (1.38, 2.17)**	1.18 (1.05, 1.33)*
Unknown	1.08 (1.00, 1.17)*	1.04 (0.94, 1.14)	0.93 (0.79, 1.11)	0.99 (0.91, 1.08)
<i>Year of Diagnosis</i>	0.99 (0.98, 1.01)	0.99 (0.98, 1.00)	0.96 (0.94, 0.98)**	0.98 (0.97, 0.99)**
<i>Facility location</i>				
Eastern	Referent	Referent	Referent	Referent
Midwest	1.02 (0.95, 1.10)	1.06 (0.98, 1.15)	0.97 (0.87, 1.10)	1.03 (0.96, 1.10)
South	1.11 (1.03, 1.20)*	1.08 (0.99, 1.17)	1.09 (0.96, 1.25)	1.04 (0.97, 1.12)

	Early-stage type I (n=90,601) Hazard Ratio (95%CI)	Early-stage type II (n=24,031) Hazard Ratio (95%CI)	Advanced-stage type I (n=6,290) Hazard Ratio (95%CI)	Advanced-stage type II (n=13,860) Hazard Ratio 95%CI)
West	0.92 (0.83, 1.03)	1.00 (0.91, 1.10)	0.91 (0.78, 1.07)	0.97 (0.89, 1.05)
<i>Facility Type</i>				
Non-Academic	Referent	Referent	Referent	Referent
Academic	1.04 (0.99, 1.11)	0.97 (0.91, 1.03)	0.94 (0.85, 1.04)	0.94 (0.90, 0.99)*
<i>Hospital Volume</i>				
10	Referent	Referent	Referent	Referent
10.01-20	0.97 (0.89, 1.05)	1.07 (0.97, 1.17)	0.98 (0.82, 1.16)	0.94 (0.85, 1.03)
20.01-60	0.98 (0.91, 1.06)	1.05 (0.96, 1.15)	0.93 (0.80, 1.08)	0.96 (0.88, 1.03)
>60	0.96 (0.87, 1.06)	0.96 (0.86, 1.06)	0.76 (0.64, 0.90)*	0.97 (0.88, 1.06)
<i>Histology</i>				
Endometrioid	NA	Referent	NA	Referent
Serous	NA	1.12 (1.02, 1.23)*	NA	1.24 (1.13, 1.35)**
Carcinosarcoma	NA	2.32 (2.15, 2.50)**	NA	1.85 (1.72, 1.99)**
Sarcoma	NA	3.68 (3.02, 4.47)**	NA	1.80 (1.51, 2.14)**
Clear cell	NA	1.21 (1.12, 1.30)**	NA	1.25 (1.18, 1.33)**
<i>Grade</i>				
Well	Referent	Referent	Referent	Referent
Moderate	1.42 (1.36, 1.48)**	1.29 (1.03, 1.62)*	1.52 (1.37, 1.69)**	1.31 (0.97, 1.77)
Poorly	NA	1.74 (1.44, 2.10)**	NA	1.81 (1.38, 2.37)**
Unknown	NA	1.53 (1.27, 1.84)**	NA	1.76 (1.34, 2.31)**
<i>Lymph Nodes Examination</i>				
Yes	Referent	Referent	Referent	Referent
No	1.13 (1.08, 1.18)**	1.38 (1.30, 1.47)**	2.18 (1.93, 2.46)**	1.73 (1.65, 1.81)**
Unknown	1.26 (1.05, 1.51)*	1.58 (1.23, 2.02)*	1.83 (1.01, 3.32)*	1.52 (1.28, 1.81)**
<i>Radiation</i>				
No radiation	Referent	Referent	Referent	Referent
External Beam	1.34 (1.26, 1.42)**	1.15 (1.08, 1.22)**	0.61 (0.56, 0.68)**	0.64 (0.61, 0.68)**
Brachytherapy	0.96 (0.89, 1.03)	0.84 (0.77, 0.91)**	0.59 (0.49, 0.71)**	0.58 (0.53, 0.64)**
Unknown	1.29 (1.11, 1.50)*	1.18 (1.03, 1.34)*	0.65 (0.52, 0.82)*	0.63 (0.54, 0.72)**
<i>Chemotherapy</i>				
No	Referent	Referent	Referent	Referent
Yes	1.99 (1.64, 2.41)**	0.92 (0.85, 1.00)*	0.90 (0.82, 1.00)*	0.69 (0.65, 0.73)**
Unknown	0.73 (0.60, 0.90)*	0.83 (0.67, 1.04)	0.70 (0.55, 0.90)*	0.83 (0.72, 0.95)*

Notes: -Early-stage Type I: stage I or II, grade 1 or 2 endometrioid.

-Early-stage Type II: stage I or II, grade 3 endometrioid or aggressive tumor subtype of clear cell, serous, carcinosarcoma, sarcoma

-Advanced-stage Type I: stage III or IV, grade 1 or 2 endometrioid

-Advanced-stage Type II: stage III or IV, grade 3 endometrioid or aggressive tumor subtype of clear cell, serous, carcinosarcoma, sarcoma

-Year of diagnosis is included as a continuous variable in multivariable Cox model to avoid the collinearity with comorbidity score.

-Facility type was aggregated as academic and non-academic hospital. The latter included community cancer program and other.

Table 3

Impact of black race on mortality by hospital volume after adjusting for other covariates.

Hospital volume	Hazard Ratio (95%CI)	Hazard Ratio (95%CI)	Hazard Ratio (95%CI)	Hazard Ratio (95%CI)
10	1.48 (1.16, 1.88) *	1.50 (1.21, 1.86) *	1.91 (1.17, 3.11) *	1.18 (0.97, 1.43)
10.01-20	1.25 (0.97, 1.61)	1.38 (1.12, 1.70) *	1.45 (0.93, 2.27)	1.22 (1.01, 1.46) *
20.01-60	1.17 (1.04, 1.33) *	1.27 (1.14, 1.40) **	1.30 (1.00, 1.69) *	1.13 (1.04, 1.23) *
>60	1.19 (1.03, 1.38) *	1.31 (1.14, 1.52) *	0.91 (0.61, 1.34)	1.07 (0.96, 1.19)

* P<0.05,

** P<0.0001

Model1 adjusted for age of diagnosis, insurance status, median income of zip code residence area, patients' residence area (urban/rural), year of diagnosis, comorbidity score, tumor histology, grade, lymphadenectomy, facility location, facility type, overall radiation, and chemotherapy), and was stratified by hospital volume quartile.

Table 4

Racial difference on two-year survival by hospital volume quartile for each cancer classification.

Hospital volume	Unadjusted			Adjusted*		
	Non-Hispanic: Black 2-yr survival (%)	Non-Hispanic: White 2-yr survival (%)	Survival difference (%)	Non-Hispanic: Black 2-yr survival (%)	Non-Hispanic: White 2-yr survival (%)	Survival difference (%)
Early-stage Type I						
10	93.9 (91.5, 95.6)	96.9 (96.5, 97.2)	-3.0 (-4.8, -1.2)	95.4 (94.3, 96.4)	96.8 (96.3, 97.3)	-1.4 (-2.4, -0.5)
10.01-20	96.4 (94.8, 97.5)	97.3 (97.0, 97.6)	-0.9 (-2.1, 0.3)	96.5 (95.8, 97.3)	97.2 (96.9, 97.5)	-0.7 (-1.4, 0.1)
20.01-60	96.5 (95.8, 97.1)	97.4 (97.2, 97.6)	-0.9 (-1.5, -0.3)	97.0 (96.7, 97.4)	97.4 (97.3, 97.6)	-0.4 (-0.7, -0.1)
>60	96.7 (95.6, 97.5)	97.5 (97.3, 97.7)	-0.8 (-1.6, 0.0)	96.9 (96.4, 97.4)	97.4 (97.2, 97.6)	-0.5 (-0.9, 0.0)
<i>P-value</i>			<0.0001			<0.0001
Early-stage Type II						
10	77.5 (72.6, 81.6)	87.0 (85.5, 88.4)	-9.5 (-13.8, -5.2)	83.5 (80.3, 86.9)	88.5 (86.5, 90.5)	-4.9 (-7.6, -2.2)
10.01-20	79.4 (75.6, 82.6)	87.2 (85.8, 88.5)	-7.8 (-11.3, -4.3)	82.3 (79.8, 84.9)	86.6 (85.2, 88.0)	-4.3 (-7.0, -1.6)
20.01-60	81.0 (79.2, 82.7)	88.0 (87.3, 88.7)	-7.0 (-8.8, -5.2)	84.1 (82.9, 85.3)	87.1 (86.4, 87.7)	-3.0 (-4.2, -1.7)
>60	84.6 (82.3, 86.6)	88.9 (88.1, 89.7)	-4.3 (-6.5, -2.1)	85.1 (83.4, 86.8)	88.3 (87.4, 89.1)	-3.2 (-4.9, -1.5)
<i>P-value</i>			<0.0001			<0.0001
Advanced stage Type I						
10	61.8 (42.4, 76.4)	83.7 (80.6, 86.3)	-21.9 (-36.7, -7.1)	66.9 (55.2, 81.1)	79.3 (72.6, 86.6)	-12.4 (-24.0, -0.9)
10.01-20	73.1 (61.1, 81.9)	83.7 (80.8, 86.1)	-10.6 (-19.8, -1.4)	78.3 (71.7, 85.5)	84.1 (81.4, 86.8)	-5.8 (-12.8, 1.3)
20.01-60	82.1 (76.1, 86.7)	83.8 (82.3, 85.1)	-1.7 (-6.5, 3.1)	79.6 (75.9, 83.6)	83.6 (82.3, 85.0)	-4.0 (-7.8, -0.2)
>60	82.9 (74.1, 88.9)	85.7 (83.9, 87.4)	-2.8 (-9.0, 3.4)	86.9 (82.8, 91.1)	85.7 (83.9, 87.5)	1.2 (-2.9, 5.3)
<i>P-value</i>			<0.0001			<0.0001
Advanced stage Type II						
10	40.6 (34.6, 46.5)	50.7 (47.7, 53.5)	-10.1 (-16.7, -3.5)	45.3 (39.8, 51.5)	50.4 (45.6, 55.7)	-5.1 (-10.6, 0.3)
10.01-20	44.7 (39.8, 49.6)	54.0 (51.3, 56.6)	-9.3 (-14.8, -3.8)	46.7 (42.6, 51.2)	52.7 (49.9, 55.7)	-6.1 (-11.0, -1.1)
20.01-60	44.6 (42.0, 47.1)	52.4 (51.0, 53.8)	-7.8 (-10.7, -4.9)	47.3 (45.1, 49.5)	51.0 (49.8, 52.4)	-3.8 (-6.2, -1.4)
>60	45.7 (42.0, 49.3)	52.8 (51.0, 54.5)	-7.1 (-11.1, -3.1)	48.1 (45.1, 51.3)	50.1 (48.4, 51.9)	-2.0 (-5.3, 1.2)
<i>P-value</i>			<0.0001			<0.0001

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* Notes: Model adjusted for age of diagnosis, insurance status, median income of zip code residence area, patients' residence area (urban/rural), year of diagnosis, comorbidity score, facility location, facility type, tumor histology, grade, lymphadenectomy, overall radiation, and chemotherapy.

Table 5

Racial difference on five-year survival by hospital volume quartile for each cancer classification.

Hospital volume	Unadjusted			Adjusted*		
	Non-Hispanic: Black 5-yr survival (%)	Non-Hispanic: White 5-yr survival (%)	Survival difference (%)	Non-Hispanic: Black 5-yr survival (%)	Non-Hispanic: White 5-yr survival (%)	Survival difference (%)
Early-stage Type I						
10	84.8 (81.1, 87.8)	90.9 (90.3, 91.5)	-6.1 (-9.2, -3.0)	87.4 (85.0, 89.8)	91.0 (89.9, 92.1)	-3.6 (-5.9, -1.4)
10.01-20	87.5 (84.5, 90.0)	91.5 (90.9, 92.0)	-4.0 (-6.6, -1.4)	89.4 (87.4, 91.4)	91.3 (90.6, 92.0)	-1.9 (-3.9, 0.2)
20.01-60	87.9 (86.5, 89.3)	91.5 (91.1, 91.8)	-3.6 (-5.0, -2.2)	90.1 (89.2, 91.1)	91.4 (91.1, 91.7)	-1.3 (-2.2, -0.3)
>60	88.2 (86.1, 90.1)	91.9 (91.5, 92.3)	-3.7 (-5.6, -1.8)	90.4 (89.0, 91.7)	91.8 (91.3, 92.2)	-1.4 (-2.7, 0.0)
<i>P-value</i>			<0.0001			<0.0001
Early-stage Type II						
10	55.7 (49.5, 61.4)	71.4 (69.3, 73.5)	-15.7 (-21.8, -9.6)	65.7 (60.4, 71.4)	74.5 (71.0, 78.3)	-8.9 (-13.5, -4.2)
10.01-20	58.7 (53.5, 63.4)	71.3 (69.3, 73.2)	-12.6 (-17.7, -7.5)	63.4 (59.4, 67.8)	71.0 (68.8, 73.2)	-7.5 (-12.1, -3.0)
20.01-60	62.3 (59.8, 64.6)	73.4 (72.3, 74.4)	-11.1 (-13.7, -8.5)	66.9 (64.9, 68.9)	72.2 (71.2, 73.2)	-5.3 (-7.5, -3.1)
>60	65.5 (62.1, 68.6)	75.7 (74.3, 76.9)	-10.2 (-13.6, -6.8)	68.4 (65.6, 71.3)	74.3 (72.9, 75.7)	-5.9 (-8.8, -2.9)
<i>P-value</i>			<0.0001			<0.0001
Advanced stage Type I						
10	32.1 (14.0, 51.9)	64.1 (59.8, 68.0)	-32.0 (-52.2, -11.8)	40.4 (27.9, 58.6)	57.6 (48.8, 67.9)	-17.1 (-31.7, -2.6)
10.01-20	44.5 (30.4, 57.7)	63.2 (59.2, 67.0)	-18.7 (-32.4, -5.0)	55.9 (46.2, 67.6)	65.4 (61.2, 70.0)	-9.5 (-20.7, 1.6)
20.01-60	52.2 (44.0, 59.8)	65.5 (63.3, 67.6)	-13.3 (-21.2, -5.4)	58.5 (52.7, 65.0)	65.3 (63.3, 67.3)	-6.7 (-13.0, -0.5)
>60	69.8 (58.9, 78.3)	68.2 (65.5, 70.7)	1.6 (-7.3, 10.5)	71.6 (64.5, 79.5)	69.5 (66.8, 72.2)	2.2 (-5.4, 9.7)
<i>P-value</i>			<0.0001			<0.0001
Advanced stage Type II						
10	20.5 (15.2, 26.3)	27.8 (25.0, 30.8)	-7.3 (-13.8, -0.8)	24.2 (19.4, 30.1)	29.0 (24.4, 34.4)	-4.7 (-9.7, 0.3)
10.01-20	20.6 (16.0, 25.5)	31.3 (28.5, 34.0)	-10.7 (-16.4, -5.0)	25.1 (21.4, 29.4)	30.9 (28.1, 34.0)	-5.8 (-10.5, -1.2)
20.01-60	21.6 (19.3, 24.1)	29.4 (28.0, 30.9)	-7.8 (-10.7, -4.9)	25.5 (23.6, 27.7)	29.1 (27.9, 30.5)	-3.6 (-5.9, -1.3)
>60	20.8 (17.5, 24.3)	28.9 (27.1, 30.7)	-8.1 (-12.1, -4.1)	25.5 (22.7, 28.6)	27.4 (25.8, 29.2)	-1.9 (-4.9, 1.1)
<i>P-value</i>			<0.0001			<0.0001

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* Notes: Model adjusted for age of diagnosis, insurance status, median income of zip code residence area, patients' residence area (urban/rural), year of diagnosis, comorbidity score, facility location, facility type, tumor histology, grade, overall radiation, and chemotherapy.