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Rural–urban differences in surgical treatment, regional lymph node examination, and survival in endometrial cancer patients

Whitney E. Zahnd¹, Katherine S. Hyon², Paula Diaz-Sylvester^{2,3}, Sonya R. Izadi⁴, Graham A. Colditz⁴, and Laurent Brard^{2,5}

¹Office of Population Science and Policy, Southern Illinois University School of Medicine, 201 E. Madison St Rm. 235, PO Box 19664, Springfield, IL 62794-9664, USA

²Department of Obstetrics and Gynecology, Southern Illinois University School of Medicine, Springfield, IL, USA

³Center for Clinical Research, Southern Illinois University School of Medicine, Springfield, IL, USA

⁴Division of Public Health Sciences, Department of Surgery, Washington University School of Medicine, St. Louis, MO, USA

⁵Simmons Cancer Institute at SIU, Springfield, IL, USA

Abstract

Purpose—Endometrial cancer (EC) is the most common gynecological malignancy and one of few cancers with an increasing US mortality rate. Rural patients may have less access to specialty care affecting their receipt of surgery and adequate lymphadenectomy (AL). We sought to assess rural–urban differences in EC surgery, lymphadenectomy, and survival.

Methods—We analyzed data from the Surveillance Epidemiology and End Results database on EC patients (2004–2013). We performed univariate analyses to compare rural and urban patients on demographic and clinical characteristics and receipt of nodal examination and AL. We assessed rural–urban differences in trends of receipt of AL, performed logistic regression to evaluate differences in receipt of surgery, nodal examination, and AL, and performed survival analysis.

Results—Rural patients were less likely to have any lymph nodes removed, had a smaller median number removed, and a smaller proportion had AL. Even after controlling for established risk factors, rural patients had lower odds of lymph node examination and adequate AL than urban patients and also had poorer survival.

Conclusions—Future research should continue to assess the association between access to care and disparities in surgical care and the effect of these disparities on survival.

Keywords

Endometrial cancer; Rural health; Disparities; Health services research

Correspondence to: Whitney E. Zahnd.

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Introduction

Endometrial cancer is the most common gynecological malignancy. In 2017, it is expected that 61,380 women will be diagnosed with the disease and 10,920 women will die in the United States [1]. The 2017 Annual Report to the Nation on the Status of Cancer reports that endometrial cancer is one of only a few cancers in the United States where mortality rates are on the rise [2]. As there is no screening modality for endometrial cancer, patients are diagnosed upon presenting with symptoms, most commonly abnormal uterine bleeding and vaginal discharge [3]. The current standard for diagnostic evaluation includes an endometrial biopsy, pelvic ultrasound, or dilation and curettage, with the gold standard being hysteroscopic-guided endometrial sampling [4]. Pathological evaluation of an endometrial biopsy is an effective and accurate approach to detect endometrial cancer, with a reported detection rate of 99.6% [4]. Based on histopathological features, endometrial cancer has traditionally been classified into two subtypes—Type I and Type II. About 80% of endometrial cancers are Type I which have endometrioid histology (grade 1–2). Type I endometrial cancers tend to be estrogen receptor positive, and thus have higher exposure to circulating estrogen as a result of obesity, polycystic ovarian syndrome, nulliparity, and/or other factors [5, 6]. Type II endometrial cancers tend to be papillary serous, clear cell, or grade 3 endometrioid cancers, are more common in older women and African Americans, are more aggressive, and have worse survival than Type I cancers [6].

Despite distinct differences between the two types of endometrial cancer and associations with advanced disease, endometrial biopsies and advanced imaging techniques are neither sufficient, nor cost-effective, in determining endometrial cancer stage [7, 8]. Similarly, there is no definitive evidence to recommend measuring biomarkers preoperatively to evaluate endometrial cancer metastasis [4, 9–11]. The standard practice following an endometrial cancer diagnosis is to proceed with total hysterectomy and bilateral salpingo-oophorectomy to remove the primary tumor. The official International Federation of Gynecology and Obstetrics (FIGO) 2009 recommendation and 2016 National Comprehensive Cancer Network (NCCN) recommendation for comprehensive staging include total hysterectomy, bilateral salpingo-oophorectomy, bilateral pelvic and para-aortic lymph node dissection (or pelvic sentinel lymph node biopsy), and pelvic washings [12, 13]. Both lymphadenectomy and the number of nodes examined have been shown to improve the staging process and influence the choice of therapy used [14–16]. Node assessment is important to identify metastasis, which has almost a sixfold higher likelihood of developing recurrence compared to those without metastasis [17]. As such, extensive randomized controlled trials and systematic reviews have been performed to evaluate the optimal approach for surgical staging and appropriate utilization of lymphadenectomy in order to maximize overall and disease-specific survival, prevent recurrence, and minimize surgical morbidity in endometrial cancer patients [16, 18, 19]. However, the recommended extent of lymphadenectomy (i.e., the number of lymph nodes examined) has not been explicitly stated in either the FIGO or NCCN guidelines.

Further, these efforts are complicated by disparities among different patient populations. Numerous studies have explored racial/ethnic treatment and survival disparities in endometrial cancer [20–24]. Black women are less likely to receive appropriate staging and

guideline-concordant treatment and have poorer survival than their white peers [20–24]. However, there is a paucity of research evaluating disparities between rural and urban populations. It is important to understand rural–urban differences in the receipt of surgical care for endometrial cancer, especially as rural counties lack spatial access to gynecologic oncologist services, which may put them at greater risk of endometrial cancer mortality [25, 26]. Furthermore, multiple studies have shown that rural patients with other cancer types are less likely to have lymph nodes examined and/or to have adequate lymphadenectomy during their surgical treatment [27–29]. This has not been explored for endometrial cancer patients. Therefore, the objective of our study was to assess rural–urban differences in receipt of surgery, regional lymph node examination, and adequate lymphadenectomy and the impact of these procedures on survival.

Materials and methods

Data source

We utilized data from the National Cancer Institute’s Surveillance Epidemiology and End Results (SEER) 18 registries [30]. SEER is a collection of population-based cancer registries that cover 28% of the US population. These registries include data on demographics, tumor characteristics, staging, treatment, and survival outcomes.

Case selection

We selected patients with a diagnosis of endometrial cancer (ICD-O-3 sites C54.0–C54.9 and C 55.9) between 2004 and 2013. Patients with incomplete information on survival status or for whom cancer was only identified on a death certificate or autopsy were excluded. Further exclusions included unknown surgical or nodal examination status, unassessed or in situ cancers, unknown rural–urban status, and unknown tumor size. After exclusions, 58,420 patients were included in our analysis.

Variables

We examined SEER variables on patient demographics, tumor characteristics, surgical characteristics, and survival status. The United States Department of Agriculture’s Rural–Urban Continuum Codes (RUCC), which categorize counties by population size and proximity to metropolitan areas, were used to define patients as rural or urban based upon their county of residence [31]. Patients with a RUCC of 1–3 were considered urban, and those with a RUCC of 4–9 were considered rural. Type I cancers were those with histology codes 8140, 8210–8211, 8260–8263, 8380–8383, 8480–8482, 8560, or 8570–8571 (e.g., grade 1 or 2 endometrioid), and Type II cancers were those with histology codes 8310, 8441, 8313, 8384, or 8460–8461 (e.g., papillary serous) [32]. All other histology codes were categorized as “other” type. While there is no specific recommendation or definition for adequate lymphadenectomy, we defined it as the examination of 10 or more lymph nodes based upon the Gynecologic Oncology Group criteria and criteria use in previous studies [33, 34]. As such, we categorized lymph node examination as none, inadequate (< 10), and adequate ($\geq$ 10). As hysterectomy is the standard of care for endometrial cancer, we dichotomized surgical treatment as either hysterectomy (surgical code of 40–65) or non-hysterectomy care/no surgery.

Statistical analysis

We performed univariate analysis to assess the relationship between demographic and clinical characteristics and rural–urban status among all patients and to evaluate the association between rural–urban status and regional lymph node examination and adequate lymphadenectomy among patients who received a hysterectomy. Chi-square test for independence was performed for categorical variables, and Wilcoxon rank-sum tests were performed for continuous variables, as these variables were non-normally distributed. Analyses were stratified by type, grade, and race/ethnicity (non-Hispanic Whites and non-Hispanic Blacks only). Cochran–Armitage test for trends was performed to assess trends in adequate lymphadenectomy overall and by cancer type. We performed unadjusted and adjusted logistic regression analyses to determine rural–urban differences in odds of receipt of surgery, nodal examination, and adequate lymphadenectomy for all cancers and stratified by type, grade, and race/ethnicity. Adjusted analysis controlled for age, race/ethnicity, marital status, year of diagnosis, and clinical stage. Kaplan–Meier curves were constructed to assess rural–urban differences in survival. Additionally, Cox proportional hazard models were used to further assess rural–urban differences in all-cause mortality accounting for race/ethnicity, marital status, year of diagnosis, clinical stage, receipt of hysterectomy, and receipt of adequate lymphadenectomy. All analyses were performed in SAS 9.4 (SAS Institute, Inc.). All tests were two sided using an alpha level of 0.05.

Results

Of the 58,420 patients in our analysis, 6,087 (10.4%) were from rural counties (Table 1). Rural patients were more racially/ethnically homogeneous than their urban peers (i.e., 85.7% of rural patients were non-Hispanic Whites compared to 70.0% of urban patients). A higher proportion of rural patients were married compared to their urban counterparts (56.9 vs. 50.8%, respectively). A lower percentage of rural patients had well-differentiated grade cancer compared to urban patients (32.5 and 35.3%, respectively). There was no statistically significant difference in stage among rural and urban patients.

Among only patients who had surgery, a lower proportion of rural patients had nodes examined compared to their urban counterparts (65.7 and 67.7%, respectively, $p = 0.002$, Table 2). For those who did have nodes examined, rural surgical patients had fewer nodes examined compared to their urban counterparts (a median of 7 and 8, respectively, $p < 0.001$). Additionally, a smaller proportion of rural surgical patients had adequate lymphadenectomy compared to urban patients (42.9 vs. 45.5%, respectively, $p < 0.001$). Findings were similar when the analysis was stratified by cancer type. Among surgical patients with Type I endometrial cancer, 64.0% of rural patients had nodes examined compared to 65.7% of urban patients ($p = 0.02$). Rural Type I patients also had fewer median nodes examined than their urban counterparts (6 vs. 7, respectively, $p < 0.001$). Among Type II surgical patients, 73.5% of rural patients compared to 78.9% of urban patients had nodes examined ($p = 0.01$). Among those who had nodes examined, Type II rural women had a lower median number of nodes examined compared to urban women (9 vs. 11, respectively, $p = 0.005$). Additionally, 49.1% of rural women with Type II endometrial cancer had adequate lymphadenectomy compared to 54.9% of Type II urban patients ($p = 0.03$).

Analyses stratified by grade indicated rural–urban differences for moderately differentiated and poorly differentiated/undifferentiated grades, but not for well-differentiated cancers. Analyses stratified by race indicated that both non-Hispanic Whites and non-Hispanic Blacks experienced rural–urban differences in lymph node examination. For example, rural non-Hispanic White women had a lower median number of nodes examined compared to their urban peers (7 vs. 8, $p < 0.001$). The rural–urban disparity among non-Hispanic Black women indicated that rural women also had fewer nodes examined than their urban counterparts (3 vs. 7; $p < 0.001$).

For all endometrial cancers, both rural and urban patients showed statistically significant trends in adequate lymphadenectomy between 2004 and 2013. During this time, adequate lymphadenectomy increased from 31.5 to 41.0% ($p < 0.001$) in rural surgical patients and from 39.1 to 45.1% ($p < 0.001$) in urban patients (Fig. 1a). For patients with Type I endometrial cancer, adequate lymphadenectomy increased from 31.1 to 38.6% among rural patients and from 37.1 to 42.6% in urban patients between 2004 and 2013 ($p = 0.01$ and $p < 0.001$ for rural and urban, respectively, Fig. 1b). For patients with Type II, adequate lymphadenectomy increased from 27.8 to 53.9% in rural patients ($p = 0.03$), while urban patients experienced a non-statistically significant ($p = 0.07$) increase during that time period (Fig. 1c).

In unadjusted analysis, there was no difference between rural and urban patients in the receipt of surgery, but rural surgical patients were 9% less likely to have nodes examined (OR 0.91; 95% CI 0.86–0.95, Table 3) and were 10% less likely to have adequate lymphadenectomy (OR 0.90; 95% CI 0.85–0.96). Similar associations were seen when cancers were stratified by type. After adjusting for age, race/ethnicity, marital status, and year of diagnosis, rural women were less likely to have lymph nodes examined (OR 0.91; 95% CI 0.85–0.96) and to have adequate lymphadenectomy (OR 0.88; 95% CI 0.84–0.93) compared to urban patients. In adjusted analysis, women with Type I endometrial cancer who received surgery were less likely than urban women to have lymph nodes examined (OR 0.92; 95% CI 0.86–0.98). Similarly, adjusted analysis found that rural women with Type II endometrial cancer were 30% less likely to have nodes examined (OR 0.70; 95% CI 0.55–0.89) and 25% less likely to have adequate lymphadenectomy (OR 0.75; 95% CI 0.61–0.92). In adjusted analysis, there were no statistically significant differences in receipt of surgery when stratified by cancer type. Similar associations were identified when stratifying by grade or by race/ethnicity; generally, there was no rural–urban difference in receipt of surgery, but statistically significant differences in nodal examination and receipt of adequate lymphadenectomy were identified. Rural non-Hispanic Black women had particular disparities in nodal examination (OR 0.62; 95% CI 0.49–0.79) and receipt of adequate lymphadenectomy (OR 0.63; 95% CI 0.49–0.81) compared to their urban peers, even after accounting for confounders.

Kaplan–Meier curves indicated poorer survival among rural patients (log-rank p value = 0.002)(Fig. 2). Adjusted analysis showed that even after controlling for demographics, tumor characteristics, and receipt of surgery, rural patients were slightly more likely to die than their urban counterparts (HR = 1.08, 95% CI 1.01–1.15) (Table 4). Greater risk of death was also identified among older patients, non-Hispanic Blacks, non-married women, and those

with more advanced stage disease. Receipt of any surgical procedure was protective compared to no surgery: hysterectomy (HR = 0.25; 95% CI 0.23–0.27) and non-hysterectomy procedure (HR = 0.36; 95% CI 0.36–0.41). Similar findings were identified among those who received surgery, with rural patients at greater risk for death (HR = 1.14; 95% CI 1.07–1.22).

Discussion

Our study used population-based cancer registry data on endometrial cancer cases diagnosed between 2004 and 2013 to assess difference in receipt of surgery, examination of lymph nodes, and performance of adequate lymphadenectomy, as well as time trends in adequate lymphadenectomy. We found that, regardless of cancer type, rural patients were less likely to have had any lymph nodes examined. If they did have lymph nodes removed, rural patients had a smaller median number examined and a smaller proportion of them had adequate lymphadenectomy compared to their urban counterparts. While rates of adequate lymphadenectomy increased for both rural and urban patients over time, rates remained higher for urban patients. Further, our findings suggest that, even after controlling for age, race/ethnicity, marital status, and year of diagnosis, rural patients were less likely than their urban counterparts to receive surgery, have lymph nodes examined, and have adequate lymphadenectomy. Further, rural patients were at greater risk for death, even after accounting for potential confounders.

Our study is the first, to our knowledge, to explore rural–urban differences in the extent of lymph node examination. We found that rural women had fewer median number of lymph nodes examined and a smaller proportion of them had adequate lymphadenectomy compared to urban women. Previous disparities research on lymph node examination in endometrial cancer found ethnic disparities, with Hispanic women less likely to have lymph nodes examined compared to non-Hispanic White women [34]. Rodriguez et al. suggested that ethnic differences may be related to physician preference and practice location, rather than patient ethnicity. The same may be true for rural–urban differences, especially in light of the absence of specific recommendations for lymphadenectomy. Rodriguez et al. found that those who had any lymph nodes examined and who had at least 10 lymph nodes examined had improved survival over those who did not have any nodes examined.

Receipt of adequate lymphadenectomy rates increased in both rural and urban women over time. This trend was also noted for cases stratified by cancer type for both rural and urban women. This is consistent with previous research, which found that the use of lymphadenectomy for endometrioid endometrial cancer increased between 1998 and 2007, followed by a decreasing trend in use from 2007 to 2012 [35]. Some of the downward trends in lymphadenectomy in Type I patients may be due to findings of randomized controlled trial studies and changing FIGO recommendations regarding which patients (i.e., low- vs. high-risk patients) may benefit from lymphadenectomy [13, 16]. However, Type II rates experienced a different trend, increasing in the early years and remaining relatively high in the later years. The sustained rate of adequate lymphadenectomy in Type II patients may be due, in part, to the continued call for lymphadenectomy in these high-risk patients [21, 36].

Additionally, for all endometrial cancers, rural women were less likely to have surgery, have lymph nodes examined, and receive adequate lymphadenectomy, even after controlling for confounders. This corroborates a previous study from Kentucky, which found that rural women were more than twice as likely to have no nodal examination or unknown nodal status compared to their urban counterparts [36]. On the other hand, a study using the National Cancer Database (NCDB) clinical surveillance data found that, even after controlling for relevant demographic and clinical factors, there was no difference between rural and urban endometrial cancer patients in receipt of surgery [23]. However, the NCDB only includes data from Commission on Cancer (COC)-accredited hospitals, which are less likely to be located in rural areas [37]. Additionally, rural women may be more likely to have surgery at a low-volume facility (i.e., a facility that performs few surgical procedures for endometrial cancer) [25]. A recent study found that high-grade endometrial cancer cases who received care at moderately high-, intermediate-, or low- volume facilities were less likely to be surgically staged than those who received care at high-volume facilities [21]. Similarly, another study found that endometrial cancer cases who received care at rural, low-volume hospitals were more likely to have open surgery, rather than minimally invasive surgery, which is the recommended surgical procedure [38]. This study also found that open surgeries were less likely to have lymphadenectomy.

We found that rural patients were at greater risk for death than their urban counterparts. Previous studies have shown no rural–urban differences in survival among endometrial cancer patients, but such studies were either singlestate studies or only included Medicare-eligible patients [26, 39, 40]. Limited access to obstetric and gynecologic care in rural areas may play a role in the treatment and mortality disparities that we identified among rural patients in our study. For example, rural patients may be less likely to be treated by a gynecologic oncologist due to travel burden. Women who are treated by gynecologic oncologists have better survival than those who are treated by other providers [41]. A study by Shalowitz et al. found that nearly 15 million women in the United States live in counties of low gynecologic oncologist access, meaning that the closest gynecologic oncologist is at least 50 miles away [25]. Promoting increased access to gynecologic services in rural areas to reduce disparities is a key recommendation of the American College of Obstetricians and Gynecologists [42]. Future efforts and research should focus on elucidating and reducing these disparities.

Strengths and limitations

This study was not without limitations. First, although we know whether a woman resided in a rural or urban area, we know neither where she sought care nor the specialty training of the physician (e.g., gynecologic oncologist, gynecologist, general surgeon, etc.) who treated the patient. Furthermore, SEER does not have information on obesity or other comorbidities that may affect whether or not a woman has surgery and does not specify which lymph nodes were removed (i.e., pelvic and/or para-aortic lymphadenectomy) or the location of the examination. While we used 10 lymph nodes assessed as a cutoff for adequate lymphadenectomy based upon previous studies, there are still no explicit recommendations from professional organizations regarding the optimal number of lymph nodes to be examined. In addition, SEER data do not indicate whether or not patients had pelvic sentinel

lymph node biopsy, which typically would remove < 10 lymph nodes. There is a growing body of literature that suggests that lymph node examination should be performed by sentinel lymph node mapping for apparent uterine-confined disease [12, 43], but sentinel lymph node mapping was not widely used during our chosen study period (2004–2013). Additionally, we were not able to control for insurance status, as it was not included in the SEER database until 2007, and insurance status is unclear for women over the age of 65 (i.e., it is unclear whether or not they are on Medicare or private insurance).

Nonetheless, a major strength of this paper is that it is one of the few studies to assess and identify differences among rural and urban populations in comprehensive staging of endometrial cancer patients. Furthermore, it utilizes a population-based database and is representative of the demographic distribution of the country, while most other studies used non-population-based clinical databases.

Conclusions

We observed rural–urban disparities in surgery, lymph node examination, and adequate lymph node examination in national data for endometrial cancer patients. These disparities may be due to rural patients having surgery at a low-volume hospital or, similarly, having less access to gynecologic oncologists. It has been shown that patients who are cared for by a specialist are more likely to undergo lymph node examination and those who presented with more advanced disease have improved survival when seen by gynecologic oncologists. Future research should focus on the association between access to care and disparities in surgical care and the effect of these disparities on both receipt of adjuvant therapy and survival.

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Fig. 1.

Rural-urban trends in adequate lymphadenectomy in surgical patients: **a** all types; **b** Type I and **c** Type II

Fig. 2. Kaplan–Meier curve of rural–urban differences in survival (log-rank p value = 0.002)

Table 1

Demographic characteristics of endometrial cancer patients in SEER 18 registries, 2004–2013

	All (n = 58,420)	Rural (n = 6,087)	Urban (n = 52,333)	p Value
Race/ethnicity				
Non-Hispanic White	41,841 (71.6%)	5,217 (85.7%)	36,624 (70.0%)	< 0.001
Non-Hispanic Black	4,978 (8.5%)	359 (5.9%)	4,619 (8.8%)	
Hispanic	6,162 (10.6%)	209 (3.4%)	5,953 (11.4%)	
Non-Hispanic Asian	4,883 (8.4%)	197 (3.2%)	4,686 (9.0%)	
American Indian	556 (1.0%)	105 (1.7%)	451 (0.9%)	
Age				
< 50	7,198 (12.3%)	710 (11.7%)	6,488 (12.4%)	0.07
50–70	37,299 (63.9%)	3,866 (63.5%)	33,433 (63.9%)	
71+	12,412 (23.7%)	1,511 (24.8%)	12,412 (23.7%)	
Marital status				
Married	29,915 (51.2%)	3,437 (56.5%)	26,478 (50.6%)	< 0.001
Widowed	6,747 (11.6%)	639 (10.5%)	6,108 (11.7%)	
Divorced/separated	8,637 (14.8%)	999 (16.4%)	7,638 (14.6%)	
Single/domestic partner	10,716 (18.3%)	833 (13.7%)	9,883 (18.9%)	
Unknown	2,405 (4.1%)	179 (2.9%)	2,226 (4.3%)	
Type				
I	47,548 (81.4%)	4,971 (81.7%)	42,577 (81.4%)	0.04
II	4,662 (8.0%)	440 (7.2%)	4,222 (8.1%)	
Other	6,210 (10.6%)	676 (11.1%)	5,534 (10.6%)	
Grade				
Well-differentiated	20,545 (35.2%)	1,975 (32.5%)	18,570 (35.5%)	< 0.001
Moderately differentiated	14,988 (25.7%)	1,765 (29.0%)	13,223 (25.3%)	
Poorly differentiated/undifferentiated	13,686 (23.4%)	1,489 (24.5%)	12,197 (23.1%)	
Unknown	9,201 (15.6%)	858 (14.1%)	8,343 (15.9%)	
Tumor size				
2 cm	16,057 (27.5%)	1,617 (26.6%)	14,440 (27.6%)	0.09
2+ cm	43,463 (72.5%)	4,470 (73.4%)	37,893 (72.5%)	

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	All (n = 58,420)	Rural (n = 6,087)	Urban (n = 52,333)	p Value
Stage				
I	40,936 (70.1%)	4,316 (70.9%)	36,620 (70.0%)	0.38
II	4,736 (8.1%)	489 (8.1%)	4,247 (8.1%)	
III	9,096 (15.6%)	903 (14.8%)	8,193 (15.7%)	
IV	3,652 (6.3%)	379 (6.2%)	3,273 (6.3%)	

Rural–urban differences in node examination among endometrial cancer surgical patients ($n = 56,007$) stratified by type, known grade, and race

Table 2

All surgical patients	Rural ($n = 5,832$)	Urban ($n = 50,175$)	<i>p</i> Value
Nodes examined, yes ^a	3,833 (65.7%)	33,986 (67.7%)	0.002
Number of nodes examined, median ^b (IQR)	7 (0–17)	8 (0–18)	< 0.001
Lymphadenectomy ^a			
None	1,999 (34.3%)	16,189 (32.3%)	< 0.001
Inadequate	1,331 (22.8%)	11,135 (22.2%)	
Adequate	2,502 (42.9%)	22,851 (45.5%)	
Type I	Rural ($n = 4,801$)	Urban ($n = 41,128$)	<i>p</i> Value
Nodes examined, yes ^a	3,071 (64.0%)	27,071 (65.7%)	0.02
Number of nodes examined, median ^b (IQR)	6 (0–16)	7 (0–17)	< 0.001
Lymphadenectomy ^a			
None	1,730 (36.0%)	14,111 (34.3%)	0.003
Inadequate	1,094 (22.8%)	9,071 (21.9%)	
Adequate	1,977 (41.2%)	18,000 (43.8%)	
Type II	Rural ($n = 407$)	Urban ($n = 3,916$)	<i>p</i> Value
Nodes examined, yes ^a	299 (73.5%)	3,091 (78.9%)	0.01
Number of nodes examined, median ^b (IQR)	9 (0–18)	11 (2–20)	0.006
Lymphadenectomy ^a			
None	108 (26.5%)	825 (21.1%)	0.03
Inadequate	99 (24.3%)	941 (24.0%)	
Adequate	200 (49.1%)	2,150 (54.9%)	

Well-differentiated grade	Rural (<i>n</i> = 1,918)	Urban (<i>n</i> = 18,073)	<i>p</i> Value
Nodes examined, yes ^a	1,004 (52.4%)	9,830 (54.4%)	0.09
Number of nodes examined, median (IQR) ^b	2 (0–13)	3 (0–14)	0.08
Lymphadenectomy ^a			
None	914 (47.7%)	8,243 (45.6%)	0.18
Inadequate	370 (19.3%)	3,514 (19.4%)	
Adequate	634 (33.1%)	6,316 (35.0%)	
Moderately differentiated grade	Rural (<i>n</i> = 1,715)	Urban (<i>n</i> = 12,873)	<i>p</i> Value
Nodes examined, yes ^a	1,205 (70.3%)	9,619 (74.7%)	< 0.001
Number of nodes examined, median (IQR) ^b	8 (0–17)	10 (0–19)	< 0.001
Lymphadenectomy ^a			
None	510 (29.7%)	3,254 (25.3%)	< 0.001
Inadequate	454 (26.5%)	3,149 (24.5%)	
Adequate	751 (43.8%)	6,470 (50.3%)	
Poorly differentiated or undifferentiated	Rural (<i>n</i> = 1,416)	Urban (<i>n</i> = 11,519)	<i>p</i> Value
Nodes examined, yes ^a	1,101 (77.8%)	9,389 (81.5%)	< 0.001
Number of nodes examined, median (IQR) ^b	11 (1–19)	12 (3–21)	< 0.001
Lymphadenectomy ^a			
None	315 (22.3%)	2,130 (18.5%)	0.003
Inadequate	343 (24.2%)	2,874 (25.0%)	
Adequate	758 (53.5%)	6,515 (56.5%)	
Non-Hispanic Whites	Rural (<i>n</i> = 5,031)	Urban (<i>n</i> = 35,294)	<i>p</i> Value
Nodes examined, yes ^a	3,331 (65.9%)	23,891 (68.0%)	0.003
Number of nodes examined, median ^b	7 (0–17)	8 (0–18)	< 0.001

Non-Hispanic Whites	Rural (n = 5,031)	Urban (n = 35,294)	p Value
(IQR)			
Lymphadenectomy ^a			
None	1,718 (34.2%)	11,313 (32.1%)	< 0.001
Inadequate	1,146 (22.8%)	7,735 (21.9%)	
Adequate	2,167 (43.1%)	16,246 (46.0%)	
Non-Hispanic Blacks	Rural (n = 308)	Urban (n = 4,285)	p Value
Nodes examined, yes ^a	182 (59.1%)	2,985 (69.7%)	< 0.001
Number of nodes examined, median ^b (IQR)	3 (0–13)	7 (0–17)	< 0.001
Lymphadenectomy ^a			
None	126 (40.9%)	1,300 (30.3%)	< 0.001
Inadequate	83 (27.0%)	1,156 (27.0%)	
Adequate	99 (32.1%)	1,829 (42.7%)	
^a Chi-square analysis			
^b Wilcoxon rank-sum test			

Unadjusted and adjusted odds of surgery, node examination, and adequate lymphadenectomy among endometrial cancer patients (*n* = 58,420) by type and grade

Table 3

	Unadjusted OR (95% CI)	Adjusted OR (95% CI) ^b
All cancers—rural versus urban (reference group)		
Receipt of surgery	0.92 (0.81–1.06)	0.88 (0.77–1.00)
Node examination ^a	0.91 (0.86–0.97)	0.91 (0.85–0.96)
Receipt of adequate lymphadenectomy ^a	0.90 (0.85–0.95)	0.88 (0.84–0.93)
Type I—rural versus urban (reference group)		
Receipt of surgery	0.92 (0.79–1.09)	0.89 (0.76–1.05)
Node examination ^a	0.93 (0.87–0.99)	0.92 (0.86–0.98)
Receipt of adequate lymphadenectomy ^a	0.90 (0.85–0.96)	0.89 (0.83–0.94)
Type II—rural versus urban (reference group)		
Receipt of surgery	0.91 (0.62–1.31)	0.87 (0.60–1.27)
Node examination ^a	0.74 (0.59–0.93)	0.70 (0.55–0.89)
Receipt of adequate lymphadenectomy ^a	0.79 (0.65–0.97)	0.75 (0.61–0.92)
Well-differentiated grade—rural versus urban (reference group)		
Receipt of surgery	0.88 (0.66–1.18)	0.88 (0.65–1.18)
Node examination ^a	0.92 (0.84–1.01)	0.91 (0.82–1.00)
Receipt of adequate lymphadenectomy ^a	0.92 (0.83–1.02)	0.90 (0.81–1.00)
Moderately differentiated grade—rural versus urban (reference group)		
Receipt of surgery	0.88 (0.64–1.19)	0.81 (0.59–1.11)
Node examination ^a	0.80 (0.72–0.89)	0.78 (0.70–0.88)
Receipt of adequate lymphadenectomy ^a	0.77 (0.70–0.85)	0.75 (0.68–0.83)
Poorly differentiated or undifferentiated—rural versus urban (reference group)		
Receipt of surgery	0.90 (0.72–1.14)	0.86 (0.67–1.08)
Node examination ^a	0.79 (0.69–0.91)	0.76 (0.66–0.88)

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	Unadjusted OR (95% CI)	Adjusted OR (95% CI) ^b
Receipt of adequate lymphadenectomy ^a	0.89 (0.79–0.99)	0.84 (0.75–0.94)
Non-Hispanic Whites		
Receipt of surgery	0.91 (0.78–1.06)	0.89 (0.76–1.04)
Node examination ^a	0.91 (0.86–0.97)	0.90 (0.85–0.96)
Receipt of adequate lymphadenectomy ^a	0.89 (0.84–0.94)	0.87 (0.82–0.93)
Non-Hispanic Blacks		
Receipt of surgery	0.69 (0.47–1.00)	0.69 (0.47–1.00)
Node examination ^a	0.63 (0.50–0.80)	0.62 (0.49–0.79)
Receipt of adequate lymphadenectomy ^a	0.64 (0.50–0.81)	0.63 (0.49–0.81)

Urban patients are the reference group;

^a Among those who had surgery

^b Adjusted for age, race/ethnicity, marital status, and year of diagnosis

Table 4

Cox proportional hazard models of rural–urban endometrial cancer patients

Variable	Model 1 ^a Hazard ratio (95% CI)	Model 2 ^b Hazard ratio (95% CI)
Rural–urban status		
Urban	Ref	Ref
Rural	1.08 (1.01–1.15)	1.14 (1.07–1.22)
Age		
< 50	Ref	Ref
50–70	1.73 (1.58–1.89)	1.81 (1.64–1.99)
71 +	3.90 (3.55–4.28)	4.26 (3.84–4.72)
Race/ethnicity		
Non-Hispanic White	Ref	Ref
Non-Hispanic Black	1.51 (1.42–1.60)	1.57 (1.47–1.68)
Hispanic	1.01 (0.94–1.08)	1.01 (0.94–1.10)
Non-Hispanic Asian	0.88 (0.81–0.96)	0.89 (0.82–0.97)
American Indian	0.88 (0.68–1.13)	0.91 (0.69–1.19)
Marital status		
Married	Ref	Ref
Widowed	1.28 (1.19–1.36)	1.27 (1.18–1.36)
Divorced/separated	1.40 (1.32–1.47)	1.41 (1.34–1.49)
Single/domestic partner	1.22 (1.15–1.29)	1.23 (1.16–1.31)
Unknown	1.11 (1.00–1.24)	1.09 (0.97–1.23)
Type		
I	Ref	Ref
II	1.67 (1.58–1.76)	1.73 (1.63–1.84)
Other	1.77 (1.68–1.86)	1.89 (1.78–2.00)
Stage		
I	Ref	Ref
II	1.90 (1.77–2.04)	1.98 (1.73–2.13)
III	3.31 (3.15–3.49)	3.56 (3.38–3.76)
IV	9.42 (8.89–9.98)	9.52 (8.94–10.14)

Variable	Model 1 ^a Hazard ratio (95% CI)	Model 2 ^b Hazard ratio (95% CI)
Surgery		
None	Ref	
Hysterectomy	0.25 (0.23–0.27)	
Non-hysterectomy procedure	0.36 (0.31–0.41)	
Lymphadenectomy		
Inadequate		Ref
Adequate		0.74 (0.71–0.78)
Ref/reference group		
^a Model includes all patients		
^b Model includes all patients who received surgery		