Patient characteristics and health system factors associated with adjuvant radiation therapy receipt in older women with early-stage endometrial cancer

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ABSTRACT

Introduction: Among women with early-stage endometrial cancer (EC), age, stage, grade, and histology are used to determine fitness for adjuvant radiation therapy (RT) administration. We examined non-cancer factors associated with adjuvant RT receipt in older women with early-stage EC.
Materials & methods: Using data from the Surveillance Epidemiology and End Results cancer registry program linked with Medicare claims, we identified 25,654 women (aged ≥66 years) diagnosed with first primary stage I-II EC during 2004–2017 who underwent a hysterectomy. Diagnosis and procedure codes were used to identify adjuvant RT claims filed for the seven-month period post-hysterectomy. Multivariable log-binomial regression was used to estimate adjuvant RT prevalence associated with patient characteristics and health system factors after adjustment for age, frailty, and endometrial factors.
Results: Adjuvant RT was less commonly administered to Asian American and Pacific Islander patients than non-Hispanic White patients (Prevalence ratio [PR], 0.84; 95% confidence interval [CI], 0.73 to 0.97). Compared to women treated in the Northeast region, women treated other regions of the US were less likely to undergo adjuvant RT (PR, 0.75; 95% CI, 0.71 to 0.79). Residing in rural or high neighborhood-poverty counties was associated with lower adjuvant RT administration. Higher comorbidity score was not associated with reduced prevalence of adjuvant RT receipt; however, women with high probability of predicted probability of frailty were less likely to undergo adjuvant RT (PR, 0.67; 95% CI, 0.55 to 0.81) compared to women with low probability of frailty. Women who received lymph node assessment were more likely to undergo adjuvant RT compared to women who did not (PR, 1.43; 95% CI, 1.34 to 1.51). Women treated by a gynecologic oncologist were more likely to undergo adjuvant RT compared to women treated by a non-gynecologic oncologist (PR 1.09; 95% CI, 1.04 to 1.14). Adjuvant RT was more commonly administered to women treated in larger academic hospitals.
Discussion: Findings suggest that various non-cancer factors affect the delivery of adjuvant RT to older women with early-stage EC in real-world oncology practice. Advancing our understanding of factors associated with adjuvant RT administration may help expand equitable access to RT.

1. Introduction

Endometrial cancer (EC) is the fourth most common cancer among American women and one of the few in which incidence and mortality rates continue to rise [1]. In 2022, an estimated 65,950 new cases will be diagnosed and 12,550 women will die of this disease [2]. Women are diagnosed with EC at a median age of 63 years [1,3], and nearly 45% of diagnoses are made among those aged 65 or older [3].

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About 67% of EC patients are diagnosed at an early stage [3], and the majority are treated with surgical intervention alone [4]. Adjuvant radiation therapy (RT) improves locoregional control in early-stage patients with a high risk of recurrence [5,6]. Clinical trials have established prognostic factors (i.e., age, stage, grade, histology) that should be considered in adjuvant RT decision-making for early-stage patients [4–6]; however, non-cancer factors that may contribute to RT administration are not well-understood.

Although several U.S. population-based studies have attempted to identify patient and health system factors associated with RT receipt [7–14], most have assessed the distribution of the factors by RT receipt using descriptive statistics without any adjustment for known endometrial factors. National guidelines recommend that for older patients, underlying functional reserve should be considered when offering RT, but older age need not necessarily be a barrier to RT [15]. However, data on the impact of peri-diagnostic frailty on RT receipt for older patients with early-stage EC has been largely lacking. Moreover, it is unclear whether chronologic age by itself is an independent contributor to the delivery of RT to this patient population, even after accounting for the patient's tumor characteristics.

In this study, using a large U.S. population-based registry resource linked to Medicare claims, we examined factors associated with adjuvant RT application among older women with early-stage EC who underwent hysterectomy. The objective of this study was to identify patient and health system factors associated with the application of RT after adjustment for endometrial factors.

2. Materials and Methods

2.1. Data source and Study Population

We used data from a linkage of the Surveillance Epidemiology and End Results cancer registry program and Medicare enrollment and claims data (SEER–Medicare). The SEER registries of the National Cancer Institute (NCI) include approximately 97% of all incident cancer cases from tumor registries in nineteen U.S. geographic areas that cover 34.6% of the U.S. population [16,17]. Data collected by SEER include demographics, dates of diagnosis, cancer characteristics, first course of treatment, follow-up of vital status, and cause of death. Medicare is the primary health insurer for 97% of the U.S. population $\geq$ 65 years [18]. The Medicare claims database includes billed claims and services data on patients with Medicare Parts A (inpatient) and B (outpatient). Part A covers inpatient hospitalizations and skilled nursing facilities, home health, and hospice care utilization. Part B covers physician services, outpatient care, durable medical equipment, and home health use. Information about each beneficiary's enrollment and entitlement, demographics, and health maintenance organization (HMO) membership is maintained by Medicare in the Enrollment Database. The SEER–Medicare linked database was developed by matching the records of the persons aged $\geq$65 years in the SEER registry to the Medicare claims database [16,19]. SEER–Medicare data provides the identification of incident first primary EC cases with longitudinal data on diagnosis and procedures during the peri- and post-diagnostic periods. The Medicare data also includes the unique provider number for either the physician or hospital providing oncologic services [16]. For our analyses, we used SEER data from 2004 to 2017 linked to Medicare claims files from 2003 to 2018. The study was determined to be exempted from full review by the Institutional Review Board at the University of North Carolina at Chapel Hill.

Older women (aged $\geq$66 years) with a pathologically confirmed diagnosis of first primary International Federation of Gynecology and Obstetrics stage I-II EC (SEER Site Recode using the International Classification of Diseases for Oncology, third edition [ICD-O-3]; 27,020 and 27,030) during 2004–2017 who underwent a hysterectomy in four-month period post-diagnosis and had continuous Medicare Parts A and B (and no HMO) coverage for the same four-month period were included (n = 27,228) (Fig. 1). Diagnosis and procedure codes in Medicare claims files were used to identify hysterectomy receipt (see Supplementary Table 1 for the codes). Women who either did not have full Medicare Parts A and B coverage or had HMO enrollment from twelve months pre-hysterectomy and seven months post-hysterectomy were then excluded (n = 1441). Women who underwent any neoadjuvant therapy were also excluded (n = 133). The final analytical sample included 25,654 women.

2.2. Patient-Level Factors and Health System Measures

Cancer prognostic factors including age at diagnosis, tumor stage, grade, and histologic subtype, as well as patient characteristics including year of diagnosis, and race/ethnicity, were identified from SEER. Using the ICD-O-3 histology codes, we categorized histologic subtype in to three categories: endometrioid tumors, non-endometrioid tumors, and other, as done in previous literature [20]. Geographic region defined by SEER registries in eighteen U.S. geographic areas, census track-level neighborhood poverty defined by percentage of residents in a census tract living below poverty, and rural-metropolitan county residence defined by Rural-Urban Continuum Codes [21] were also identified from SEER.

Initial surgical intervention and baseline health-related variables were identified from Medicare claims. Hysterectomy surgical approach (minimally invasive hysterectomy/total abdominal hysterectomy/other approach) and lymph node assessment status (yes/no) were measured using the diagnosis and procedure codes in Medicare claims files in the four months following diagnosis (see Supplementary Table 1 for the codes).

Charlson Comorbidity Index (CCI) [22] score was measured using diagnosis and procedure codes in Medicare claims files for the twelve month period prior to hysterectomy. We first identified individual comorbidities, including myocardial infarction, heart failure, cerebrovascular disease, chronic obstructive pulmonary disease, diabetes, renal disease, liver disease, and rheumatologic disease. Any malignancy and metastatic solid tumor were excluded. We then applied weights tailored for each condition to create the CCI score (range: 0–6) and collapsed into three categories: 0, 1, or $\geq$ 2. Using the same twelve-month period, we estimated each patient's predicted probability of frailty based on an externally validated Medicare claims-based model, using 20 unique indicators (e.g., hip fracture diagnosis, home oxygen claim, wheelchair claim) [23,24]. The predicted probabilities of frailty were categorized as low (0–<10%), low-intermediate (10–<20%), intermediate-high (20–<50%), and high (≥50%) [25].

Health system factors including provider specialty, hospital volume, hospital teaching status, NCI Cancer Center designation status, and hospital bed size were also identified. Provider specialty was measured using the Centers for Medicare & Medicaid Services specialty codes from Medicare claims submitted by providers. Using the Current Procedural Terminology code submitted for hysterectomy, we identified whether a patient was treated by a gynecologic oncologist. Hospital procedural volume was measured using encrypted hospital identifiers from the Medicare Provider Analysis and Review claims files matching with the year of hysterectomy procedure. We then computed the number of patients treated by each hospital per year and dichotomized the variable (low vs high volume) using the median value as a cut-off. Because the hospital procedural volume data captured in centers located outside of SEER areas are considered incomplete, we further limited the volume data to centers located in the SEER areas, resulting the inclusion of 15,065 women in the analyses. Hospital teaching status, NCI Cancer Center designation status, and hospital bed size were measured using the hospital file created by NCI matching the year of hysterectomy procedure.

2.3. Adjuvant Radiation Therapy Measures

Adjuvant RT receipt (including both external beam radiation and

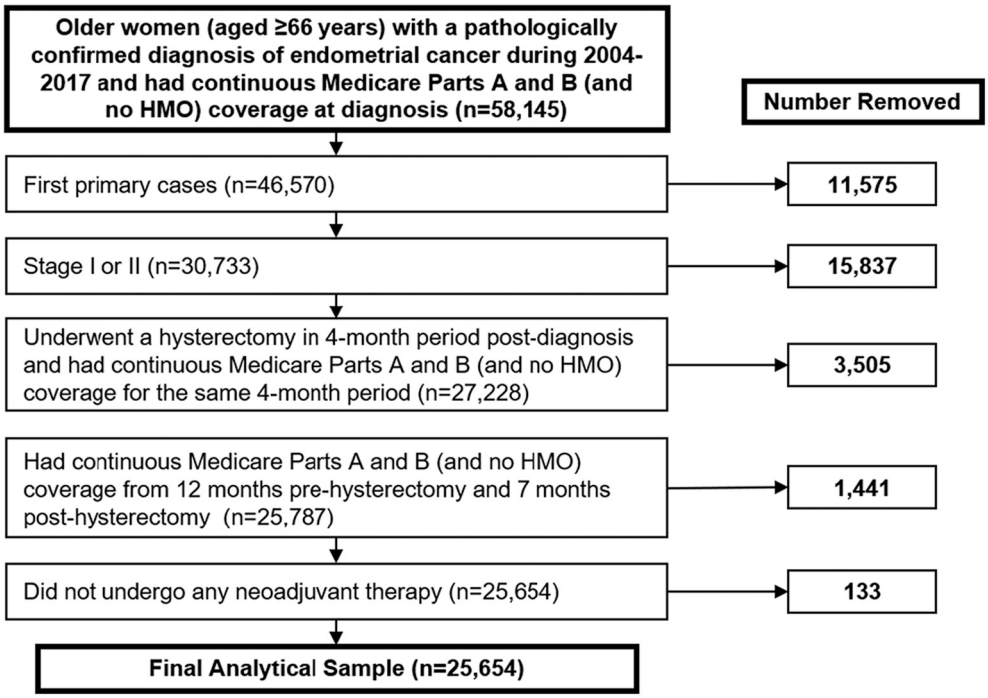

Fig. 1. Flow diagram shows selection of study cohort.

vaginal brachytherapy; dichotomized as yes or no) was measured using the diagnosis and procedure codes in Medicare claims files for the seven-month period post-hysterectomy, which are listed in the Supplementary Table 1. In secondary analyses, adjuvant RT modality was stratified into three categories: external beam radiation therapy (EBRT), vaginal brachytherapy (VBT), or EBRT+VBT.

2.4. Statistical Analysis

Descriptive statistics were used to summarize the distribution of age at diagnosis, tumor characteristics, sociodemographic variables, baseline health variable (CCI and frailty), initial surgical approach, and health system factors for the entire cohort and by RT receipt. Multivariable log-binomial regression models were used to estimate associations between the factors and RT receipt after adjustment for age at diagnosis, frailty, stage, grade, and histologic subtype. We calculated crude and adjusted prevalence ratios (PRs) with 95% confidence intervals (CIs). In secondary analyses, we estimated the associations with the factors by adjuvant RT modality: [1] adjuvant EBRT vs hysterectomy alone, [2] adjuvant VBT vs hysterectomy alone, [3] adjuvant EBRT+VBT vs hysterectomy alone. All tests were two-sided at $\alpha = 0.05$ with $P < .05$ considered statistically significant. All analyses were conducted using SAS version 9.4 (SAS Inc., Cary, NC). R software (version 3.6.3) was used for generating figures.

3. Results

A total of 25,654 women with a diagnosis of first primary stage I-II EC were included. The median age at diagnosis was 73 years (interquartile range [IQR]: 69, 78) (Table 1); Most women had stage I disease (93%) and endometrioid histologic subtype (79%); Most (72%) had grade 1 or 2 disease. Fifty five percent of women received minimally invasive hysterectomy and 45% underwent total abdominal hysterectomy. Median time from diagnosis to hysterectomy (within the four-month eligibility window) was 44 days (IQR: 29, 60). In the same period, 67% had received lymph node assessment.

The majority were non-Hispanic White women (86%). Nearly half resided in the Northeast census region (46%) and 29% were from the West. Most women resided in affluent metro counties (86%), with <20% neighborhood poverty. About 65% had at least one comorbidity, and 88% were estimated to have low probability of being frail.

In our cohort, 37% were treated by a gynecologic oncologist for their initial hysterectomy procedure. Of the 15,065 women with available data on hospital identifiers from inpatient claims, 50% were estimated to be treated at high volume hospitals, 73% were treated at teaching hospitals, 14% were treated at NCI designated cancer centers, and 86% were treated at hospitals with bed size ≥200.

Within the cohort, adjuvant RT was administered in 8748 of 25,654 women (34%), whereas 16,906 (66%) underwent hysterectomy alone. Among women who received adjuvant RT, median time from diagnosis to RT initiation was 102 days (IQR: 80, 133); median time from hysterectomy to RT was 53 days (IQR: 39, 76).

In a multivariate model assessing associations between age, frailty, and adjuvant RT receipt after adjustments for endometrial factors (Fig. 2), both age and frailty were independently associated with RT receipt. Compared to women aged 66–69 years, women aged 70–74 years and women aged 75–79 years were more likely to undergo adjuvant RT (aPR, 1.09; 95% CI, 1.03 to 1.15 and aPR, 1.07; 95% CI, 1.01 to 1.14). In contrast, women aged ≥80 years were less likely to receive the treatment (aPR, 0.88; 95% CI, 0.82 to 0.93). Higher probability of predicted probability of frailty were statistically significantly associated with reduced prevalence of adjuvant RT receipt. In further breakdown by RT modality, overall, similar patterns were observed; however, the associations were particularly strong for adjuvant VBT receipt compared to adjuvant EBRT or EBRT+VBT receipt (Supplementary Fig. 1). The crude and adjusted PRs and 95% CIs for associations between endometrial factors and receipt of adjuvant RT are shown in Table 2. Women with stage IB tumors were more likely to undergo adjuvant RT than those with stage IA tumors (aPR, 2.60; 95% CI, 2.46 to 2.74). Women with stage II tumors were also more likely to undergo adjuvant RT than those with stage IA tumors (aPR, 2.61; 95% CI, 2.46 to 2.77). With respect to histologic subtype, women with other subtype were slightly less likely to undergo adjuvant RT than women with endometrioid type tumor (aPR, 0.94; 95% CI, 0.89 to 0.99).

In multivariable models assessing association between patient sociodemographics, initial surgical intervention, and receipt of adjuvant

Table 1
Characteristics of older women diagnosed with stage I-II endometrial cancer during 2004–2017 who underwent hysterectomy in SEER-Medicare database (n = 25,654).

	N (%)	
Age at diagnosis, years		
Median (SD), IQR	73 (6.3), 69–78	
66–69 years	6976	(27)
70–74 years	7956	(31)
75–79 years	5399	(21)
80+ years	5323	(21)
FIGO 2009 stage		
IA	9650	(38)
IB	3664	(14)
I NOS	10,651	(42)
II	1689	(7)
Tumor grade		
G1, Well differentiated	8989	(42)
G2, Moderately differentiated	6804	(32)
G3 or G4, Poorly differentiated or Undifferentiated/ anaplastic	5492	(26)
Unknown	4369	
Histologic subtype		
Type I (endometrioid type)	20,331	(79)
Type II (non-endometrioid type)	2871	(11)
Other subtype	2452	(10)
Race/Ethnicity		
Non-Hispanic White	21,965	(86)
Non-Hispanic Black	1530	(6)
Non-Hispanic AI/AN	78	(0)
Non-Hispanic AANHPI	752	(3)
Hispanic	1239	(5)
Other (Mixed race)	90	(0)
Geographic region		
Northeast	11,735	(46)
Midwest	2525	(10)
West	7556	(29)
South	3651	(14)
Hawaii	187	(1)
Neighborhood poverty		
0% - <5%	7263	(30)
5% - <10%	6915	(29)
10% - <20%	6420	(27)
20% - 100%	3438	(14)
Unknown	1618	
Rural-metropolitan residence		
Rural counties	<3590*	(14)
Metro counties	>22,053*	(86)
Unknown	<11*	
Charlson Comorbidity Index		
0	8961	(35)
1	6595	(26)
2+	10,098	(39)
Predicted probability of frailty		
Low probability (0- < 10%)	22,688	(88)
Low-intermediate probability (10- < 20%)	1561	(6)
Intermediate-high probability (20- < 50%)	1001	(4)
High probability (50%+)	404	(2)
Lymph node assessment		
No	8486	(33)
Yes	17,168	(67)
Hysterectomy surgical approach		
Minimally invasive hysterectomy	14,141	(55)
Total abdominal hysterectomy	11,457	(45)
Other approach	56	(0)
Provider specialty		
Non- gynecologic oncologist	15,630	(63)
Gynecologic oncologist	8990	(37)
Unknown	1034	
Hospital volume[a]		
Low	7522	(50)
High	7543	(50)
Hospital teaching status[a]		
No	<4065*	(27)
Yes	>10,989*	(73)
Unknown	<11*	
NCI designated cancer center status[a]		
No	12,956	(86)
Yes	2042	(14)
Unknown	67	
Hospital bed size[a]		
<200	>2108*	(14)
200-399	<5118*	(34)
400-599	>4366*	(29)
600+	<3462*	(23)
Unknown	<11*	

AI/AN: American Indian/Alaskan Native, AANHPI: Asian American, Native Hawaiian, and Pacific Islander.

[a] Analyses restricted to 15,065 women with complete data on hospital identifiers from the MedPAR claims and treated in hospitals located in the SEER areas.

[*] To protect the privacy rights of beneficiaries, cell sizes <11 are suppressed.

therapy (Table 3), race/ethnicity, geographic region, neighborhood poverty, rural residence, and lymph node assessment were associated with adjuvant RT receipt. Adjuvant RT was less commonly used among Non-Hispanic Asian American, Native Hawaiian, and Pacific Islander (AANHPI) patients (aPR, 0.84; 95% CI, 0.73 to 0.97) compared to non-Hispanic White patients. Compared to women treated in the Northeast region, women treated in other regions of the US were less likely to undergo adjuvant RT (aPR, 0.75; 95% CI, 0.71 to 0.79). Women residing in an area with ≥20% neighborhood poverty were less likely to undergo adjuvant RT compared to women residing in an area < 5% neighborhood poverty (aPR, 0.94; 95% CI, 0.89 to 0.96). Women residing in metropolitan counties were more likely to undergo adjuvant RT than women residing in rural counties (aPR, 1.09; 95% CI, 1.01 to 1.16). Higher CCI score was not statistically significantly associated with reduced prevalence of adjuvant RT receipt. Women who received lymph node assessment were more likely to undergo adjuvant RT than women who did not (aPR, 1.43; 95% CI, 1.34 to 1.51). Hysterectomy surgical approach was not statistically significantly associated with adjuvant RT.

Likewise, in multivariable models assessing association between health system factors and receipt of adjuvant therapy (Table 4), provider specialty, hospital teaching status, and hospital bed size were associated with adjuvant RT receipt. Women treated by a gynecologic oncologist were slightly more likely to receive adjuvant RT compared to women treated by a non- gynecologic oncologist (aPR, 1.09; 95% CI, 1.04 to 1.14). Among women with available data on hospital identifiers from inpatient claims, being treated in teaching hospitals was associated with higher prevalence of adjuvant RT receipt (aPR, 1.13; 95% CI, 1.05 to 1.21). Furthermore, women treated at hospitals with bed size 400–599 were more likely to undergo adjuvant RT compared to women treated at hospitals with bed size <200 (aPR, 1.16; 95% CI, 1.06 to 1.28).

In secondary analyses, we observed varying associations with the factors by RT modality, particularly with socio-demographics and health system factors (Supplementary Table 1). Women treated by a gynecologic oncologist in larger academic hospitals located in metropolitan areas were less likely to undergo adjuvant EBRT vs hysterectomy alone, but more likely to undergo adjuvant VBT. Moreover, adjuvant VBT receipt was less commonly used in women who identified as non-Hispanic Black, AANHPI, and mixed race, residing in non-Northeast region with ≥5% neighborhood poverty.

4. Discussion

In this large U.S. population-based cohort of older women with early-stage EC, we found that lower prevalence of adjuvant RT receipt was associated with oldest old age, increased peri-diagnostic frailty, AANHPI race, residing in the West, South, Midwest, or Hawaii, residing in areas with higher neighborhood poverty, and residing in rural counties. We

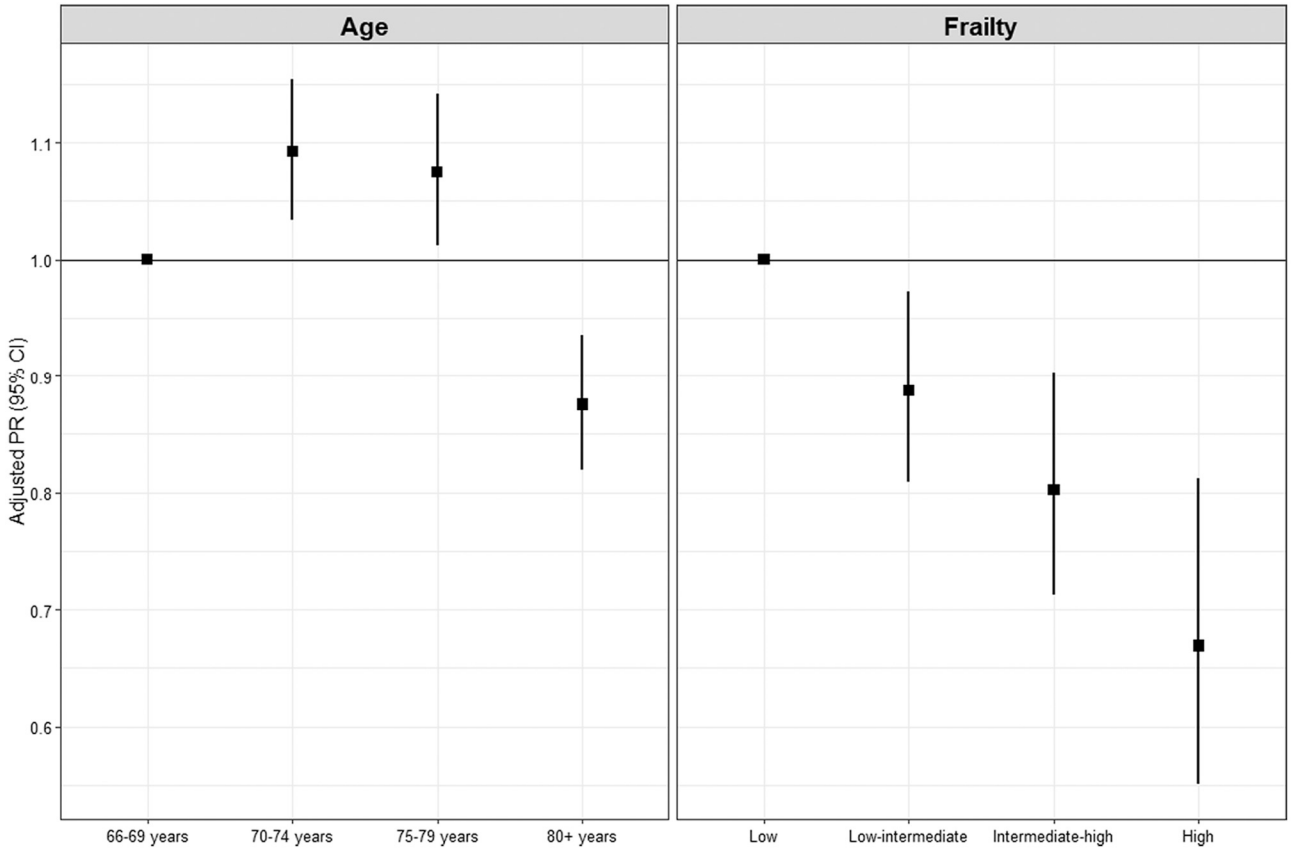

Fig. 2. Association between age, frailty, and adjuvant radiation therapy receipt. Adjusted for age at diagnosis, frailty, stage, grade, and histologic subtype.

Table 2
Association between endometrial factors and adjuvant radiation therapy receipt.

	Adjuvant RT, n (%)		Hysterectomy alone, n (%)		Crude PR (95% CI)	Adjusted PR (95% CI)[a]
FIGO 2009 stage						
IA	1801	(21)	7849	(46)	Reference	Reference
IB	2175	(25)	1489	(9)	3.18 (3.03, 3.34)	2.60 (2.46, 2.74)
I NOS	3712	(42)	6939	(41)	1.87 (1.78, 1.96)	1.77 (1.68, 1.86)
II	1060	(12)	629	(4)	3.36 (3.18, 3.55)	2.61 (2.46, 2.77)
Tumor grade						
G1, Well differentiated	1624	(22)	7365	(53)	Reference	Reference
G2, Moderately differentiated	2623	(36)	4181	(30)	2.13 (2.02, 2.25)	1.95 (1.85, 2.05)
G3 or G4, Poorly differentiated or Undifferentiated/anaplastic	3048	(42)	2444	(17)	3.07 (2.92, 3.23)	2.53 (2.40, 2.67)
Histologic subtype						
Type I (endometrioid type)	6311	(72)	14,020	(83)	Reference	Reference
Type II (non-endometrioid type)	1403	(16)	1468	(9)	1.57 (1.51, 1.64)	0.99 (0.95, 1.03)
Other subtype	1034	(12)	1418	(8)	1.36 (1.29, 1.43)	0.94 (0.89, 0.99)

[a] Adjusted for age at diagnosis, frailty, stage, grade, and histologic subtype.

also found that higher prevalence of adjuvant RT receipt was associated with lymph node assessment, being treated by a gynecologic oncologist, and being treated at larger teaching hospitals.

This study matches many of the findings from prior research. A previous analysis of the SEER-Medicare linkage by Suidan et al. [7] reported similar findings, but with no adjustment of patients' tumor prognostic index or frailty. The study reported that women aged ≥81 years, residing in non-Northeast region or rural area were less likely to undergo RT than women aged <81 years, residing in Northeast or metropolitan area. Several studies have also reported that adjuvant RT was more commonly administered in patients who underwent lymph node assessment [7,11].

Prior studies reported that Black women were more frequently treated with adjuvant RT than White women due, in part, to aggressive tumor features [8,12]. In our study, after adjusting for age, stage, grade, and histology, there was no difference in RT receipt between non-Hispanic Black and non-Hispanic White women, but women who identified as AANHPI had a lower prevalence of adjuvant RT than non-Hispanic White women. This result is consistent with findings from a SEER study [26], in which adjuvant RT therapy was delivered to a lower proportion of Asian and American Indian/Alaskan Native patients than non-Hispanic White patients. This could be explained by a higher proportion of AANHPI people residing in the West or Hawaii compared to non-Hispanic White people (76 vs 28%). Frailty occurs in a significant subset of older adults (40% of aged ≥80 years had a high probability of being frail) [27], and those patients are less likely to receive RT than

Table 3
Association between patient socio-demographics, initial surgical intervention, and adjuvant radiation therapy receipt.

	Adjuvant RT, n (%)		Hysterectomy alone, n (%)		Crude PR (95% CI)	Adjusted PR (95% CI)[a]
Race/Ethnicity						
Non-Hispanic White	7431	(85)	14,534	(86)	Reference	Reference
Non-Hispanic Black	585	(7)	945	(6)	1.13 (1.06, 1.21)	0.95 (0.86, 1.05)
Non-Hispanic AI/AN	28	(0)	50	(0)	1.06 (0.79, 1.43)	1.10 (0.72, 1.69)
Non-Hispanic AANHPI	229	(3)	523	(3)	0.90 (0.81, 1.00)	0.84 (0.73, 0.97)
Hispanic	457	(5)	782	(5)	1.09 (1.01, 1.18)	1.02 (0.92, 1.13)
Other (Mixed race)	18	(0)	72	(0)	0.59 (0.39, 0.89)	0.64 (0.38, 1.09)
Geographic region						
Northeast	4525	(52)	7210	(43)	Reference	Reference
Midwest	803	(9)	1722	(10)	0.82 (0.78, 0.88)	0.80 (0.73, 0.87)
West	2167	(25)	5389	(32)	0.74 (0.71, 0.78)	0.73 (0.68, 0.77)
South	1225	(14)	2426	(14)	0.87 (0.83, 0.92)	0.77 (0.71, 0.83)
Hawaii	28	(0)	159	(1)	0.39 (0.28, 0.55)	0.38 (0.26, 0.56)
Census track based neighborhood poverty level						
0% - <5% poverty	2588	(31)	4675	(30)	Reference	Reference
5% - <10% poverty	2334	(28)	4581	(29)	0.95 (0.91, 0.99)	0.96 (0.90, 1.02)
10% - <20% poverty	2164	(26)	4256	(27)	0.95 (0.90, 0.99)	0.94 (0.89, 1.01)
20% - 100% poverty	1185	(14)	2253	(14)	0.97 (0.92, 1.02)	0.89 (0.83, 0.96)
Unknown	477		1141			
Census track based rural-metropolitan residence						
Rural counties	>1136*	(13)	>2365*	(14)	Reference	Reference
Metro counties	>7601*	(87)	<14,530*	(86)	1.09 (1.03, 1.14)	1.09 (1.01, 1.16)
Unknown	<11*		<11*			
Charlson Comorbidity Index						
0	2948	(34)	6013	(36)	Reference	Reference
1	2275	(26)	4320	(26)	1.05 (1.00, 1.10)	1.03 (0.97, 1.10)
2+	3525	(40)	6573	(39)	1.06 (1.02, 1.10)	1.01 (0.95, 1.06)
Lymph node assessment						
No	1735	(20)	6751	(40)	Reference	Reference
Yes	7013	(80)	10,155	(60)	2.00 (1.91, 2.09)	1.43 (1.34, 1.51)
Hysterectomy surgical approach						
Minimally invasive hysterectomy	4673	(53)	9468	(56)	‘Reference	Reference
Total abdominal hysterectomy	4056	(46)	7401	(44)	1.07 (1.04, 1.11)	0.97 (0.92, 1.01)
Other approach	19	(0)	37	(0)	1.03 (0.71, 1.48)	0.97 (0.61, 1.55)

AI/AN: American Indian/Alaskan Native, AANHPI: Asian American, Native Hawaiian, and Pacific Islander.
[a] Adjusted for age at diagnosis, frailty, stage, grade, and histologic subtype.
* To protect the privacy rights of beneficiaries, cell sizes <11 are suppressed.

their non-frail counterparts due to its association with radiation-induced toxicity [28]. To our knowledge, our study is one of the first to report a lower prevalence of adjuvant RT receipt associated with higher probability of peri-diagnostic frailty among older women with early-stage EC. Our findings suggest that older patients' baseline frailty is an independent contributor to the delivery of RT, reinforcing the utility of geriatric assessment in radiation treatment considerations. Future studies could expand our research by evaluating its association with radiation toxicities that impact treatment compliance, mortality, and quality of life. Higher peri-diagnostic comorbidity score for EC has been associated with decreased odds of receiving adjuvant RT in prior studies [10,14]; conversely, in our study, the use of adjuvant RT was not associated with comorbidity score. Our differing results could be due to the adjustment for tumor characteristics. In our sample, women with higher stage and more aggressive histologic subtypes were more likely to have higher comorbidity scores.

As in prior studies, we observed a number of disparities in access to adjuvant RT in women with EC [7,10,29]. In our study, adjuvant RT was more commonly administered in patients residing in more affluent areas and in larger teaching hospitals, especially adjuvant VBT. This is consistent with findings from an analysis of the National Cancer Database by Luo et al. [29] that have shown disparities in access to adjuvant RT associated with socioeconomic status, type of treatment facilities, and location of residence. Additionally, we found that adjuvant VBT was more commonly administered in patients treated by a gynecologic oncologist. The size/type of hospitals appear to be deriving factors of this association as gynecologic oncologists were more likely to be at larger and academic practice settings.

Overall, our results suggest that adjuvant RT was less commonly administered in women who identified as AANHPI, were treated in non-Northeast regions of the US, and resided in rural counties with higher neighborhood poverty. Conversely, adjuvant RT was more commonly administered in women treated by gynecologic oncologists in larger academic hospitals. The clinical implication is that we now have identified the priority groups for improvement in expanding equitable access to RT. Importantly, our work highlights inequities in access to VBT for non-White minorities and socioeconomically disadvantaged patients, as well as disparities in VBT utilization for patients residing in non-Northeast region and receiving oncologic therapy in smaller non-academic hospitals. Although additional research is needed for deeper understanding of the determinants of access to care (e.g., geographic issues, distance to facilities, transportation barriers, socioeconomic factors), findings from our study may help motivate closing the gaps in cancer care disparities and access to care issues.

A strength of this study was the utilization of large U.S. national population-based cancer data from SEER linked to claims data files from Medicare. Leveraging this data linkage provided an efficient, large-scale opportunity to identify factors associated with the treatment in a group of older women treated for early-stage EC in real-world oncology practice. We used Medicare claims to capture all diagnoses and procedures during the peri-diagnostic period. This allowed us to clearly define the treatment timeline and measure pre-diagnostic frailty and medical comorbidities. Using hospital identifiers and specialty codes in Medicare claims files enabled us to ascertain information on provider specialty, hospital volume, and hospital characteristics. However, our study had several limitations. Because SEER–Medicare does not contain data on Medicare beneficiaries enrolled in Medicare Advantage health plans [30], our results may not be generalizable to the entire Medicare

Table 4
Association between health system factors and adjuvant radiation therapy receipt.

	Adjuvant RT, n (%)		Hysterectomy alone, n (%)		Crude PR (95% CI)	Adjusted PR (95% CI)[a]
Provider specialty						
Non-gynecologic oncologist	5043	(60)	10,587	(65)	Reference	Reference
Gynecologic oncologist	3332	(40)	5658	(35)	1.15 (1.11, 1.19)	1.09 (1.04, 1.14)
Hospital volume[b]	373		661			
Low	2554	(49)	4968	(51)	Reference	Reference
High	2701	(51)	4842	(49)	1.05 (1.01, 1.10)	1.02 (0.96, 1.08)
Hospital teaching status[b]						
No	<1259*	(24)	<2842*	(29)	Reference	Reference
Yes	>3985*	(76)	>6957*	(71)	1.2 (1.14, 1.26)	1.13 (1.05, 1.21)
NCI designated cancer center status[b]	<11*		<11*			
No	4400	(84)	8556	(88)	Reference	Reference
Yes	822	(16)	1220	(12)	1.19 (1.12, 1.26)	1.08 (0.99, 1.17)
Hospital bed size[b]	33		34			
<200	<682*	(13)	<1470*	(15)	Reference	Reference
200–399	<1678*	(32)	<3430*	(35)	1.06 (0.98, 1.14)	1.05 (0.96, 1.16)
400–599	>1678*	(32)	>2744*	(28)	1.24 (1.15, 1.33)	1.16 (1.06, 1.28)
600+	<1259*	(24)	<2156*	(22)	1.17 (1.08, 1.27)	1.07 (0.97, 1.19)
	<11*		<11*			

[a] Adjusted for age at diagnosis, frailty, stage, grade, and histologic subtype.
[b] Analyses restricted to 15,065 women with complete data on hospital identifiers from the MedPAR claims and treated in hospitals located in the SEER areas.

population. There was also an inherent lack of information about the cancer care decision-making process, which limited our ability to evaluate planned treatment compared to treatments received. Further, specific clinicopathological data used for selecting patients with high-risk profiles were not available, including data on lymphovascular space involvement and depth of myometrial invasion, and thus our estimates may have been affected by residual confounding.

Our study contributes to currently limited evidence on factors associated with adjuvant RT receipt and suggests that various non-cancer factors, from those relating directly to the patient to those attributable to the health care system, may affect the application of adjuvant RT to older women with early-stage EC. This information may help expand equitable access to RT for EC patients.

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Disclaimer

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Author Contributions

Jihye Park: Conceptualization, Methodology, Investigation, Formal analysis, Visualization, Writing – original draft, Writing – review & editing. **Jennifer L. Lund:** Methodology, Funding acquisition, Writing - review & editing. **Erin E. Kent:** Methodology, Writing – review & editing. **Chelsea Anderson:** Methodology, Writing – review & editing. **Wendy R. Brewster:** Methodology, Writing – review & editing. **Andrew F. Olshan:** Methodology, Writing - review & editing. **Hazel B. Nichols:** Methodology, Supervision, Writing - review & editing.

Declaration of Competing Interest

Jennifer L. Lund receives salary support to the University of North Carolina at Chapel Hill from the Center for Pharmacoepidemiology (current members: GlaxoSmithKline, UCB BioSciences, Takeda, AbbVie, Boehringer Ingelheim) and from other pharmaceutical companies (AbbVie, Roche). Her spouse was formerly employed by GlaxoSmithKline and previously owned stock in the company. Jihye Park, Erin E. Kent, Chelsea Anderson, Andrew F. Olshan, Wendy R. Brewster, and Hazel B. Nichols have no conflicts of interest to disclose.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jgo.2022.08.020.

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