


Falls, walking or balance problems, and limitations in activities of daily living (ADLs) among older endometrial cancer survivors

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Abstract

Purpose Functional status deficits are important quality of life concerns for older cancer survivors. We examined the prevalence of falls, walking/balance problems, and limitations in activities of daily living (ADLs) among older women with a history of endometrial cancer.

Methods Cancer registry records from the Surveillance, Epidemiology, and End Results (SEER) program linked with Medicare Health Outcomes Survey (MHOS) data were used to identify endometrial cancer survivors aged ≥ 65 years who completed a survey ≥ 1 year after their cancer diagnosis ($N=3766$), as well as an age- and race-matched group of women without a cancer history ($N=3766$). We estimated prevalence ratios (PRs) to compare the prevalence of falls, walking or balance problems, and limitations in ADLs (bathing, dressing, eating, getting in/out of chairs, walking, using the toilet) between groups.

Results Difficulty with walking or balance was more common among survivors than the noncancer group (43% vs 36%; $PR=1.19$; 95% CI: 1.10–1.27). Fall prevalence was similar between groups (endometrial cancer: 25%; noncancer: 26%; $PR=0.98$; 95% CI: 0.89–1.08). Nearly half of endometrial cancer survivors (47%) reported at least one ADL limitation, with several activities (getting in/out of a chair, walking, bathing, using the toilet) more often limited among survivors than among women without cancer.

Conclusion Functional impairments, especially problems with walking and/or balance, are common among older endometrial cancer survivors. Our results highlight the importance of addressing functional problems during the ongoing survivorship care of women with a history of endometrial cancer, with referral to rehabilitation or other relevant services when indicated.

Keywords Endometrial cancer · Cancer survivors · Falls · Functional status

Introduction

Endometrial cancer is the fourth most commonly diagnosed cancer among US women, with an estimated 66,570 new cases in the year 2021 [1]. High 5-year survival ($> 80\%$ overall), combined with an increase in incidence of about

1% per year over the past decade [1], has led to a rapidly growing population of US endometrial cancer survivors. By the year 2030, the number of US women with an endometrial cancer history is expected to exceed 1 million [2]. This projected growth underscores the need for survivorship-focused research to improve long-term health after endometrial cancer.

For older cancer survivors, a history of cancer and associated treatments may increase the risk of functional impairments, or hasten their onset to an earlier age, compared to individuals with no prior cancer history [3–5]. These functional impairments can include difficulty performing basic activities of daily living (ADLs), such as dressing, bathing, and eating, as well as problems with ambulation and a greater likelihood of falls, all of which may have a significant impact on quality of life [6–8]. Considerable research

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has investigated the prevalence of functional impairments among older survivors of all cancer types combined [9–11], or of common cancer types such as breast, prostate, and colorectal [12–17]. However, these outcomes have received little attention in research specific to women with a history of endometrial cancer, who have distinct treatment patterns and treatment-related sequelae that may worsen quality of life and physical functioning [18, 19]. In particular, the impacts of surgical procedures and/or radiation to the pelvic area, as part of endometrial cancer treatment, could potentially contribute to long-term problems with ambulation or basic daily activities requiring lower body strength or movement. A better understanding of the burden of functional impairments among older endometrial cancer survivors may help to ensure that these concerns are identified and addressed as part of long-term survivorship care.

In this study, we examined the prevalence of falls, walking or balance problems, and ADL limitations among older women with an endometrial cancer history. Our aims were: (1) to compare the prevalence of these outcomes between endometrial cancer survivors and a matched group of women without a cancer history, and (2) to identify demographic and cancer-related characteristics associated with these outcomes among endometrial cancer survivors. We hypothesized that prevalence of these outcomes would be higher among women with endometrial cancer than women without cancer, and that cancer characteristics such as disease stage and treatment type would be predictors of these outcomes among endometrial cancer survivors.

Methods

Data source and study population

Women with and without an endometrial cancer history were identified using data from a linkage of the Surveillance Epidemiology and End Results (SEER) program and the Medicare Health Outcomes Survey (MHOS) [20, 21]. SEER is a system of population-based cancer registries which captures cancer incidence and survival data and currently covers approximately 35% of the US population [22]. Information collected by SEER includes patient demographics, diagnosis date, tumor site and morphology, stage, first course of treatment, vital status, and cause of death. The MHOS collects information on health-related quality of life and other patient-reported outcomes among Medicare Advantage (MA) (managed care plans) enrollees [23]. Since 1998, a baseline survey has been administered annually to random sample of MA beneficiaries (i.e. a new cohort is surveyed each year), and respondents receive a follow-up survey 2 years after baseline if they are still in the same managed care plan [23].

Participants complete MHOS surveys via mailed questionnaire or telephone-administered interview. For the current analysis, we included data from MHOS cohorts 1 through 18 (1998–2017) linked to SEER data from 1973–2015. MHOS response rates ranged from 44 to 87% across survey years [24, 25]. This study was considered exempt by the University of North Carolina Institutional Review Board.

From the SEER-MHOS data, we identified women with a first malignant primary endometrial cancer who completed at least one MHOS survey after their diagnosis. Data from the first survey completed at least 1 year after diagnosis were used in our analyses. Women were eligible to be selected for the noncancer comparison group if they completed at least one MHOS survey and had never been diagnosed with cancer (i.e., did not link with SEER records and did not self-report a cancer diagnosis). For women without cancer, data from their first MHOS survey were used. Women with and without an endometrial cancer history were required to be residing in a SEER region at the time of survey. We also excluded women whose survey was missing data on all study outcomes. Eligible endometrial cancer survivors were matched 1:1 on age at survey, race/ethnicity (Non-Hispanic White, Non-Hispanic Black, Non-Hispanic Asian, Hispanic, Other/unknown) and survey year to eligible women without cancer. In total, 3766 endometrial cancer survivors and 3766 women without a cancer history contributed to our analyses.

Outcomes

Study outcomes included falls, walking or balance problems, and ADL limitations. Falls were assessed with the following question: “Did you fall in the past 12 months?” Similarly, participants were asked: “In the past 12 months, have you had a problem with balance or walking?” Response options for these questions were either “yes” or “no.” Both falls and walking/balance problems were only collected on MHOS surveys in the year 2006 or later. Therefore, women whose survey was completed prior to 2006 were excluded from all of our analyses of falls and walking/balance problems.

Activities of daily living were assessed on all MHOS surveys and included walking, dressing, bathing, getting in/out of chairs, eating, and toileting. Participants were asked: “Because of a health or physical problem, do you have difficulty doing the following activities without special equipment or help from another person?” Response options included: “No, I do not have difficulty,” “Yes, I have difficulty,” or “I am unable to do this activity.” Consistent with prior research [26], we dichotomized responses for analysis as either limited (have difficulty/unable to do activity) or not limited (no difficulty) for each ADL.

Covariates

Characteristics abstracted from the MHOS data included age at survey, race/ethnicity, education, marital status, body mass index (BMI), and current smoking status. BMI was only collected on MHOS surveys in 2006 and later and was therefore not available for women who completed surveys in prior years. We also used MHOS information on self-reported musculoskeletal conditions and other comorbidities. Musculoskeletal conditions included arthritis of the hand/wrist, arthritis of the hip/knee, low back pain (sciatica), and osteoporosis (2006 and later only). Other comorbidities included cardiovascular disease (angina pectoris/coronary artery disease, congestive heart failure, myocardial infarction, other heart conditions, stroke); hypertension; gastrointestinal conditions (Crohn's disease, ulcerative colitis, inflammatory bowel disease); emphysema, asthma, or chronic obstructive pulmonary disease; and diabetes or low blood sugar. For endometrial cancer survivors, the SEER data was used to abstract information on age at cancer diagnosis, stage, histology, grade, radiation, and surgery. Information on chemotherapy and hormonal therapies was not available for this analysis. We used the following ICD-O-3 codes to define histologic subtypes as endometrioid: 8140, 8210, 8260, 8262, 8380–8384, 8440, 8480–8482, 8560, 8570 [27]. Other histologic types were grouped together as non-endometrioid.

Statistical analysis

To compare the prevalence of falls, walking/balance problems, and ADL limitations between endometrial cancer survivors and women without cancer, we estimated prevalence ratios (PRs) and 95% confidence intervals (CIs) using Poisson regression models with robust error variance [28]. In addition to adjustment for the matching factors (age, race/ethnicity, and survey year), multivariable models were further adjusted for marital status and education. In sensitivity analyses, we assessed the impact of additional adjustment for covariates with a high proportion of missing data (> 5%), including BMI, smoking status, number of musculoskeletal conditions, and number of other comorbidities. These analyses were restricted to participants who completed surveys in 2006–2017 because information on BMI and osteoporosis (a musculoskeletal comorbidity) was not available in prior survey years. Among endometrial cancer survivors, we also used PRs to investigate associations between demographic and cancer-related characteristics and study outcomes. Multivariable models among survivors were adjusted for age, race/ethnicity, survey year, marital status, and education. All analyses were conducted using SAS version 9.4 (SAS Inc., Cary, NC, USA).

Results

Among both endometrial cancer survivors and the matched noncancer group, most women were non-Hispanic White (84%), and the median age at MHOS survey was 75 years (IQR: 70, 81) (Table 1). Most women had at least a high school education (endometrial cancer: 79%; noncancer: 73%), while fewer than half were currently married at survey (endometrial cancer: 40%; noncancer: 39%). Endometrial cancer survivors were more likely to be overweight or obese (BMI ≥ 25 kg/m²) (69% vs 58%) and less likely to be current smokers (5% vs 8%) than women without cancer.

Cancer-related characteristics among endometrial cancer survivors are shown in Table 2. Most women were age 60 years or older at endometrial cancer diagnosis (72%) and more than half were 1–< 10 years post-diagnosis at the time of survey (52%). Most had localized stage disease (78%), endometrioid histology (90%), and grade 1 or 2 disease (83%). Nearly all received surgery (96%), while only 28% received radiation.

Walking/balance problems and falls were common among endometrial cancer survivors, reported by 43% and 25%, respectively. In multivariable adjusted models, endometrial cancer survivors were more likely than matched women without cancer to report problems with walking or balance (PR: 1.19; 95% CI: 1.10–1.27) (Table 3). However, the prevalence of falls was similar between the two groups.

The mean number of ADL limitations (out of 6) was 1.22 (SD = 1.70) among endometrial cancer survivors and 1.11 (SD = 1.69) among the matched comparison women. Overall, 47% of endometrial cancer survivors reported at least one ADL limitation (Table 3). Relative to women without cancer, endometrial cancer survivors were significantly more likely to report at least one ADL limitation (PR = 1.15; 95% CI: 1.09–1.21). Across the six individual ADLs, the most commonly reported limitations among endometrial cancer survivors included difficulty with walking (42%), getting in/out of a chair (30%), and bathing (19%). The activity that was least often limited among survivors was eating (6%). Limitations in four of the six ADLs were significantly more common among survivors than women without cancer: getting in/out of a chair (30% vs 27%; PR = 1.15; 95% CI: 1.07–1.24), walking (42% vs 36%; PR = 1.19; 95% CI: 1.12–1.26), bathing (19% vs 18%; PR = 1.14; 95% CI: 1.03–1.25), and using the toilet (12% vs 11%; PR = 1.16; 95% CI: 1.02–1.32). Limitations in dressing and eating were similarly prevalent in both groups. In sensitivity analyses with additional adjustment for BMI, smoking status, musculoskeletal conditions, and other comorbidities among women who completed surveys in 2006–2017, PR estimates were not meaningfully different from those in primary analyses (Supplementary Table 1).

Table 1 Characteristics of endometrial cancer survivors (N=3766) and matched women without cancer (N=3766)

	Women without cancer		Endometrial cancer survivors	
	N	%	N	%
Age at survey				
65–69	860	23%	860	23%
70–74	897	24%	897	24%
75–79	832	22%	832	22%
80–84	651	17%	651	17%
85 +	526	14%	526	14%
Median (IQR)	75	(70, 81)	75	(70, 81)
Race				
Non-Hispanic White	3178	84%	3178	84%
Non-Hispanic Black	222	6%	222	6%
Non-Hispanic Asian	157	4%	157	4%
Hispanic	59	2%	59	2%
Other/unknown	150	4%	150	4%
Education				
Less than high school graduate	1002	27%	758	21%
High school graduate	1331	36%	1334	37%
Some college	856	23%	946	26%
College graduate	471	13%	613	17%
Missing	106		115	
Marital status				
Married	1481	40%	1449	39%
Divorced/separated	537	15%	526	14%
Widowed	1535	42%	1498	41%
Never married	126	3%	208	6%
Missing	87		85	
Body mass index (kg/m²)^a				
Underweight (< 18.5)	86	4%	58	3%
Normal weight (18.5–< 25)	900	39%	647	28%
Overweight (25–< 30)	728	31%	646	28%
Obese (30+)	614	26%	953	41%
Missing	1438		1462	
Current smoker				
No	2973	92%	3042	95%
Yes	258	8%	160	5%
Missing	535		564	
Musculoskeletal conditions				
Arthritis of the hand/wrist	1575	43%	1537	42%
Arthritis of the hip/knee	1665	45%	1819	49%
Low back pain (sciatica)	860	23%	928	25%
Osteoporosis ^a	765	32%	661	28%
Other comorbidities				
Cardiovascular disease ^b	1237	34%	1204	33%
Hypertension	2418	65%	2536	68%
Gastrointestinal condition ^c	191	5%	234	6%
Emphysema, asthma, or COPD	550	15%	465	13%
Diabetes or high blood sugar	767	21%	1028	28%

^aOnly included on surveys in 2006 and later

^bCoronary artery disease, congestive heart failure, myocardial infarction, other heart condition or stroke

^cCrohn's disease, ulcerative colitis or inflammatory bowel disease

Table 2 Cancer characteristics among endometrial cancer survivors (N=3766)

	N	%
Age at endometrial cancer diagnosis		
< 50	198	5%
50–59	867	23%
60–69	1578	42%
70–79	906	24%
80+	217	6%
Time between endometrial cancer diagnosis and survey, years		
1–< 5	1063	28%
5–< 10	895	24%
10–< 20	1217	32%
20+	591	16%
Stage		
Localized	2695	78%
Regional	385	11%
Distant	89	3%
Unstaged	274	8%
Missing	323	
Histology		
Endometrioid	3378	90%
Non-endometrioid	388	10%
Grade		
1	1676	50%
2	1118	33%
3	470	14%
Undifferentiated	88	3%
Not applicable or missing	414	
Radiation		
No	2617	72%
Yes	1043	28%
External beam radiation	506	49%
Vaginal brachytherapy	185	18%
Both	261	25%
Other/unknown	91	9%
Missing	106	
Surgery		
No	156	4%
Yes	3595	96%
Missing	15	

Tables 4 and 5 show associations between demographic and cancer-related characteristics and functional impairments among endometrial cancer survivors. Among endometrial cancer survivors, the prevalence of all study outcomes tended to increase with age at survey (Table 4). Compared to non-Hispanic White survivors, non-Hispanic Black survivors were less likely to report falls (PR=0.53; 95% CI: 0.36–0.78), but more likely to report a limitation

Table 3 Prevalence of falls, walking or balance problems, and limitations in activities of daily living (ADLs) among endometrial cancer survivors compared to matched women without cancer

	Women with- out cancer		Endometrial cancer survi- vors		PR (95% CI) ^{a,b}	PR (95% CI) ^{a,c}
	N	%	N	%		
Balance or walking problems ^d	874	36%	1024	43%	1.18 (1.10, 1.27)	1.19 (1.10, 1.27)
Falls ^d	627	26%	608	25%	0.97 (0.88, 1.07)	0.98 (0.89, 1.08)
Limitations in activities of daily living (ADLs)						
Getting in/out of a chair	1005	27%	1118	30%	1.11 (1.03, 1.19)	1.15 (1.07, 1.24)
Walking	1338	36%	1547	42%	1.15 (1.09, 1.22)	1.19 (1.12, 1.26)
Bathing	659	18%	713	19%	1.08 (0.98, 1.19)	1.14 (1.03, 1.25)
Dressing	507	14%	520	14%	1.03 (0.92, 1.15)	1.09 (0.97, 1.23)
Eating	240	6%	221	6%	0.92 (0.77, 1.10)	0.96 (0.80, 1.15)
Using the toilet	395	11%	439	12%	1.11 (0.98, 1.26)	1.16 (1.02, 1.32)
≥ 1 ADL limitation	1577	42%	1778	47%	1.13 (1.07, 1.19)	1.15 (1.09, 1.21)

Note: N(%)s may not sum to total due to missing responses

^aPrevalence ratios (PRs) estimated using Poisson regression models with robust error variance

^bAdjusted for age at survey, race, and survey year

^cAdjusted for age at survey, race, survey year, marital status, and education

^dOnly included on surveys in 2006 and later

in bathing (PR = 1.48; 95% CI: 1.18–1.85). Other ADL limitations did not significantly differ according to race/ethnicity. ADL limitations were generally more common among women with a lower education level, those not currently married at the time of survey, and those who were obese (BMI ≥ 30 kg/m²). Notably, obese endometrial cancer survivors were nearly twice as likely to report at least one ADL limitation than women with a BMI of 18.5–< 25 kg/m² (PR = 1.97; 95% CI: 1.76, 2.22). Musculoskeletal conditions (arthritis of the hand/wrist; arthritis of the hip/knee; low back pain; osteoporosis) were strongly associated with all study outcomes. The prevalence of falls, balance/walking problems, and ADL limitations also generally increased with the number of other reported comorbidities. Balance problems were strongly associated with the prevalence of falls among endometrial cancer survivors (PR = 3.91; 95% CI: 3.29–4.64).

In general, outcomes were not strongly associated with cancer-related characteristics, other than older age at endometrial cancer diagnosis (Table 5). Difficulties with toileting were also significantly more common among women with non-endometrioid histology (vs. endometrioid), while those who had surgery (vs. no surgery) were less likely to report difficulties with bathing, dressing, and toileting. Additionally, women who had radiation (vs. no radiation) were more likely to report problems associated with walking (PR = 1.11; 95% CI: 1.02, 1.20). In analyses according to radiation receipt/type, women who received external beam radiation were more likely to report walking/balance problems than those who did not have radiation (PR = 1.18; 95% CI: 1.04–1.34).

Discussion

Using population-based cancer registry data from SEER linked with survey data from MHOS, we examined the prevalence of several functional impairments, including ADL limitations, falls, and walking/balance problems, among older women with an endometrial cancer history. Overall, difficulty with walking or balance was the most commonly reported problem among endometrial cancer survivors, and the prevalence of this impairment among survivors significantly exceeded that in the matched noncancer comparison group. Nearly half of endometrial cancer survivors reported at least one ADL limitation, with several activities (getting in/out of chair, walking, bathing, using the toilet) more often limited among survivors than among women without cancer.

The health care needs of older cancer survivors are often complex, involving the assessment and management of both cancer-specific concerns, such as cancer symptoms and treatment sequelae, and the effects of age-related declines in physiological and functional status that are common to the general population. Recognition of this complexity has led to calls for the incorporation of geriatric assessment—an interdisciplinary process that examines multiple domains to characterize an older person's health and well-being [29]—into geriatric oncology practice and the routine care of older patients with a cancer history [29–32]. Limitations in activities of daily living, mobility or walking problems, and falls are all among the aging-related deficits that may be captured as part of a geriatric assessment [29]. Emerging evidence suggests that deficits such as these may have significant utility, beyond the use

Table 4 Associations between demographic characteristics and comorbidities and falls, walking or balance problems and limitations in activities of daily living (ADLs) among endometrial cancer survivors

	Activities of daily living									
	Falls ^a	Balance/walking problems ^a	Bathing	Dressing	Eating	Getting in/out of chair	Walking	Using the toilet	≥1 ADL limitation	
	PR (95% CI) ^b	PR (95% CI) ^b	PR (95% CI) ^b	PR (95% CI) ^b	PR (95% CI) ^b	PR (95% CI) ^b	PR (95% CI) ^b	PR (95% CI) ^b	PR (95% CI) ^b	
Age at survey										
65–69	1	1	1	1	1	1	1	1	1	1
70–74	0.84 (0.67, 1.06)	0.96 (0.82, 1.13)	0.97 (0.76, 1.23)	0.97 (0.72, 1.30)	1.12 (0.67, 1.86)	0.96 (0.81, 1.13)	1.06 (0.93, 1.22)	1.04 (0.75, 1.45)	1.04 (0.92, 1.17)	
75–79	1.01 (0.81, 1.26)	1.11 (0.95, 1.30)	1.27 (1.01, 1.60)	1.36 (1.03, 1.79)	1.66 (1.02, 2.70)	1.10 (0.93, 1.29)	1.26 (1.11, 1.44)	1.58 (1.15, 2.15)	1.18 (1.06, 1.33)	
80–84	1.01 (0.80, 1.27)	1.33 (1.14, 1.56)	1.50 (1.19, 1.89)	1.51 (1.14, 2.02)	2.07 (1.28, 3.35)	1.18 (0.99, 1.40)	1.37 (1.20, 1.57)	1.76 (1.28, 2.43)	1.31 (1.16, 1.47)	
85 +	1.44 (1.16, 1.77)	1.72 (1.49, 1.98)	2.67 (2.15, 3.30)	2.91 (2.24, 3.79)	4.20 (2.65, 6.67)	1.89 (1.62, 2.21)	1.80 (1.58, 2.04)	3.15 (2.33, 4.27)	1.66 (1.48, 1.85)	
Race										
Non-Hispanic White	1	1	1	1	1	1	1	1	1	1
Non-Hispanic Black	0.53 (0.36, 0.78)	1.00 (0.84, 1.21)	1.48 (1.18, 1.85)	1.11 (0.81, 1.53)	0.95 (0.52, 1.74)	1.01 (0.84, 1.27)	1.13 (0.98, 1.32)	1.35 (0.96, 1.89)	1.09 (0.96, 1.25)	
Non-Hispanic Asian	0.98 (0.69, 1.40)	0.82 (0.62, 1.07)	1.01 (0.73, 1.41)	0.98 (0.66, 1.47)	1.54 (0.88, 2.68)	0.75 (0.56, 1.01)	0.99 (0.82, 1.19)	1.15 (0.75, 1.77)	0.93 (0.78, 1.11)	
Hispanic	1.07 (0.67, 1.72)	1.00 (0.73, 1.36)	0.93 (0.57, 1.52)	1.17 (0.69, 1.98)	1.42 (0.65, 3.10)	1.02 (0.70, 1.48)	0.93 (0.69, 1.24)	1.19 (0.67, 2.13)	0.92 (0.71, 1.21)	
Other	0.63 (0.39, 1.00)	0.89 (0.68, 1.16)	0.65 (0.41, 1.02)	0.69 (0.41, 1.15)	0.83 (0.38, 1.83)	0.95 (0.73, 1.24)	1.02 (0.83, 1.25)	0.68 (0.37, 1.24)	0.96 (0.80, 1.16)	
Education										
Less than high school graduate	1.20 (0.99, 1.46)	1.14 (1.00, 1.29)	1.41 (1.19, 1.66)	1.41 (1.15, 1.72)	1.44 (1.04, 1.98)	1.19 (1.05, 1.35)	1.19 (1.08, 1.30)	1.41 (1.13, 1.78)	1.21 (1.11, 1.31)	
High school graduate	1	1	1	1	1	1	1	1	1	1
Some college	1.08 (0.90, 1.29)	0.96 (0.85, 1.08)	0.85 (0.71, 1.02)	0.85 (0.68, 1.05)	0.87 (0.61, 1.24)	0.99 (0.87, 1.12)	0.92 (0.83, 1.02)	1.02 (0.81, 1.29)	0.95 (0.87, 1.04)	
College graduate	1.22 (1.00, 1.48)	0.93 (0.81, 1.07)	0.79 (0.64, 0.98)	0.70 (0.53, 0.92)	0.64 (0.40, 1.02)	0.79 (0.67, 0.93)	0.78 (0.69, 0.89)	0.81 (0.61, 1.09)	0.84 (0.75, 0.93)	
Marital status										
Married	1	1	1	1	1	1	1	1	1	1
Divorced/separated	1.25 (1.01, 1.55)	1.46 (1.27, 1.68)	1.52 (1.23, 1.88)	1.29 (1.00, 1.66)	1.09 (0.70, 1.70)	1.38 (1.18, 1.61)	1.30 (1.15, 1.47)	1.41 (1.06, 1.87)	1.28 (1.15, 1.43)	

Table 4 (continued)

		Activities of daily living								
		Falls ^a	Balance/walking problems ^a	Bathing	Dressing	Eating	Getting in/out of chair	Walking	Using the toilet	≥1 ADL limitation
		PR (95% CI) ^b	PR (95% CI) ^b	PR (95% CI) ^b	PR (95% CI) ^b	PR (95% CI) ^b	PR (95% CI) ^b	PR (95% CI) ^b	PR (95% CI) ^b	PR (95% CI) ^b
1		1.45 (1.13, 1.85)	1.34 (1.13, 1.59)	1.17 (0.88, 1.55)	1.02 (0.71, 1.45)	1.17 (0.70, 1.95)	1.41 (1.11, 1.79)	1.39 (1.17, 1.65)	1.10 (0.75, 1.62)	1.33 (1.14, 1.56)
2+		2.38 (1.94, 2.93)	2.16 (1.88, 2.48)	2.43 (1.94, 3.04)	2.45 (1.87, 3.21)	2.03 (1.34, 3.05)	2.79 (2.29, 3.39)	2.27 (1.97, 2.62)	2.56 (1.90, 3.45)	2.13 (1.87, 2.42)
Number of other comorbidities (out of 5) ^d										
0	1	1	1	1	1	1	1	1	1	1
1	1	1.48 (1.13, 1.94)	1.69 (1.37, 2.08)	1.35 (1.04, 1.76)	1.25 (0.94, 1.68)	0.88 (0.57, 1.36)	1.52 (1.25, 1.85)	1.76 (1.49, 2.08)	1.47 (1.02, 2.10)	1.58 (1.37, 1.82)
2+	1	2.06 (1.60, 2.66)	2.37 (1.94, 2.89)	2.43 (1.91, 3.10)	2.02 (1.54, 2.64)	1.54 (1.04, 2.27)	2.45 (2.04, 2.94)	2.66 (2.27, 3.12)	2.81 (2.01, 3.92)	2.28 (2.00, 2.60)

^aOnly included on surveys in 2006 and later

^bAdjusted for age at survey, survey year, race, marital status, and education; PRs for age at endometrial cancer diagnosis are not adjusted for age at survey due to nonoverlapping distributions of age at diagnosis and age at survey

^cNumber of the following conditions: arthritis of the hand/wrist, arthritis of the hip/knee, low back pain (sciatica), osteoporosis; analyses restricted to surveys in 2006 and later due to lack of osteoporosis information in prior survey years

^dNumber of the following comorbidities: cardiovascular disease, hypertension, diabetes, gastrointestinal conditions, emphysema/asthma/COPD

of chronological age alone, for predicting hospitalization and mortality in cancer populations [33–37]. For endometrial cancer survivors, however, the prevalence and predictors of functional impairments and other aging-related deficits remain largely unexamined. Our study sought to address this gap, to inform future interventions specific to the growing population of older women with an endometrial cancer history.

Though magnitudes of the prevalence ratios were generally fairly small, it is notable that endometrial cancer survivors in our sample were significantly more likely than women without cancer to report walking and/or balance problems and several of the ADL limitations. Given that we excluded women who completed their MHOS survey within the year after diagnosis, these findings are unlikely to be driven by acute effects of endometrial cancer or its treatments, but rather may reflect long-term impacts of these exposures on the ability to carry out basic daily activities.

Few other studies have examined functional impairments among endometrial cancer survivors compared to women without a cancer history. In a study using data from the National Health Interview Survey, the prevalence of lower-body functional limitations, defined as reporting difficulty/inability to perform at least 1 of 5 activities (walking $\frac{1}{4}$ of a mile; walking up and down 10 steps without rest; standing for 2 h; stooping, crouching, or kneeling; and lifting 10 lbs) among long-term (≥ 5 years) survivors of uterine cancer (67.3%) was 2.41 (95% CI: 1.63–3.58) times that among cancer-free controls [38]. These results, along with those of the current study, suggest the importance of addressing functional problems, as part of a geriatric assessment or other examination, during the ongoing survivorship care of women with an endometrial cancer history, with referral to rehabilitation or other relevant services when indicated.

Whether assessed as either an ADL or along with balance problems, walking appeared to be the most common functional problem among endometrial cancer survivors included in our analyses. Falls, though similar in prevalence to the matched noncancer comparison group, were also fairly common. Prior research suggests that these functional impairments may have significant implications for quality of life [6, 7], but may also be under-recognized and under-documented among cancer patients and survivors [39, 40]. Though further research is warranted to understand the most appropriate intervention strategies for this population, screening for falls and walking problems early in the survivorship trajectory may help to prevent further decline in functional status among longer-term endometrial cancer survivors. Some research also suggests that increasing exercise may help to alleviate physical health limitations after endometrial cancer [41, 42]. Increasing access to exercise and lifestyle interventions may therefore be another strategy to improve functional status and physical quality of life among survivors.

In our sample, comorbidities, higher BMI, and participant demographics (older age, lower education, and being unmarried) were the characteristics most consistently associated with falls, walking or balance problems, and ADL limitations among endometrial cancer survivors. While associations with age and comorbidity were expected, our finding of a higher prevalence of functional impairments among obese women, those with a lower education level, and those who were unmarried may highlight additional groups to target for future screening and intervention efforts. Cancer-related characteristics such as disease stage and treatment were generally not strong predictors in our sample. However, we did not have information on chemotherapy, or specific details of radiation and surgical treatments, and were therefore unable to assess potential associations with these characteristics. We also lacked information on treatment-related adverse effects, such as lower-extremity lymphedema or peripheral neuropathy, which could be key drivers of functional impairments in this population. Examination of associations between specific therapies, their adverse sequelae, and functional status deficits may be an area for future investigation among endometrial cancer survivors.

Although prior reports have examined the long-term impact of an endometrial diagnosis and treatment on overall health-related quality of life [43–45], ours is among the first to investigate specific functional impairments among older endometrial cancer survivors and to include a matched non-cancer group for comparison. However, our analyses have some limitations. We were unable to assess whether functional problems among endometrial cancer survivors arose before or after cancer diagnosis and treatment, or to adjust for pre-diagnosis functional problems in our analyses, since few women in our sample completed surveys both before and after their cancer diagnosis. Additionally, we lacked information on cancer recurrence or cancer treatments other than surgery or radiation. Chemotherapy, in particular, has several potential side effects (e.g. fatigue, dehydration), which could increase risk of falls and other functional impairments, but we were unable to assess this possibility. The functional outcomes that we examined, as well as covariates such as comorbidity and BMI, were all based on self-report, and therefore may be subject to misclassification due to imperfect recall. However, we do not expect that recall of outcomes such as falls or walking/balance difficulties would strongly differ between women with and without an endometrial cancer history. We also did not have information on instrumental activities of daily living (IADLs), which may be important outcomes for cancer populations. Our study sample was also limited to Medicare Advantage enrollees who resided in SEER regions, and therefore our results may not be generalizable to the broader Medicare population. Endometrial cancer survivors who were alive, able, and willing to complete MHOS surveys may also have been

Table 5 Associations between cancer-related characteristics and falls, walking or balance problems and limitations in activities of daily living (ADLs) among endometrial cancer survivors

Activities of daily living																		
	Falls ^a		Balance/walking problems ^a		Bathing		Dressing		Eating		Getting in/out of chair		Walking		Using the toilet		≥1 ADL limitation	
	PR (95% CI) ^b	PR (95% CI) ^b	PR (95% CI) ^b	PR (95% CI) ^b	PR (95% CI) ^b	PR (95% CI) ^b	PR (95% CI) ^b	PR (95% CI) ^b	PR (95% CI) ^b	PR (95% CI) ^b	PR (95% CI) ^b	PR (95% CI) ^b	PR (95% CI) ^b	PR (95% CI) ^b	PR (95% CI) ^b	PR (95% CI) ^b	PR (95% CI) ^b	PR (95% CI) ^b
Age at endometrial cancer diagnosis																		
<50	0.90 (0.64, 1.26)	0.84 (0.66, 1.07)	0.97 (0.69, 1.36)	0.94 (0.63, 1.42)	1.25 (0.68, 2.30)	0.79 (0.59, 1.06)	0.91 (0.74, 1.11)	0.73 (0.43, 1.23)	0.90 (0.75, 1.08)									
50–59	0.95 (0.79, 1.14)	0.92 (0.81, 1.05)	0.87 (0.72, 1.07)	0.83 (0.65, 1.05)	0.84 (0.56, 1.26)	0.97 (0.85, 1.12)	0.88 (0.79, 0.98)	0.88 (0.68, 1.14)	0.94 (0.85, 1.04)									
60–69	1	1	1	1	1	1	1	1	1									
70–79	1.11 (0.93, 1.32)	1.11 (0.99, 1.25)	1.34 (1.14, 1.58)	1.35 (1.11, 1.65)	1.68 (1.22, 2.30)	1.28 (1.13, 1.44)	1.16 (1.06, 1.27)	1.34 (1.08, 1.66)	1.17 (1.07, 1.27)									
80+	1.18 (0.90, 1.54)	1.31 (1.12, 1.53)	1.63 (1.30, 2.04)	1.88 (1.44, 2.47)	2.06 (1.30, 3.27)	1.58 (1.34, 1.88)	1.32 (1.16, 1.51)	1.70 (1.24, 2.32)	1.33 (1.18, 1.49)									
Time between endometrial cancer diagnosis and survey, years																		
1–<5	1	1	1	1	1	1	1	1	1									
5–<10	1.03 (0.84, 1.27)	0.99 (0.86, 1.14)	0.96 (0.79, 1.17)	1.04 (0.82, 1.32)	1.29 (0.88, 1.91)	1.06 (0.92, 1.21)	1.02 (0.92, 1.14)	1.10 (0.85, 1.42)	1.01 (0.92, 1.12)									
10–<20	1.13 (0.95, 1.36)	1.02 (0.90, 1.15)	1.01 (0.85, 1.20)	1.13 (0.92, 1.40)	1.24 (0.87, 1.77)	0.98 (0.86, 1.12)	0.98 (0.88, 1.08)	1.11 (0.87, 1.41)	1.00 (0.91, 1.09)									
20+	0.99 (0.79, 1.24)	0.97 (0.84, 1.12)	1.05 (0.86, 1.29)	1.02 (0.79, 1.32)	1.06 (0.69, 1.62)	0.90 (0.77, 1.05)	0.99 (0.88, 1.11)	1.09 (0.83, 1.44)	0.97 (0.87, 1.08)									
Stage																		
Localized	1	1	1	1	1	1	1	1	1									
Regional	1.01 (0.81, 1.27)	0.96 (0.82, 1.13)	0.99 (0.78, 1.24)	0.95 (0.71, 1.27)	0.89 (0.55, 1.42)	0.94 (0.78, 1.12)	1.03 (0.91, 1.18)	0.88 (0.64, 1.21)	0.97 (0.86, 1.09)									
Distant	0.87 (0.51, 1.48)	1.21 (0.93, 1.58)	1.16 (0.76, 1.78)	1.33 (0.81, 2.19)	1.12 (0.47, 2.67)	1.10 (0.79, 1.52)	1.13 (0.89, 1.43)	1.31 (0.77, 2.22)	1.06 (0.86, 1.32)									
Histology																		
Endometrioid	1	1	1	1	1	1	1	1	1									
Non-endometrioid	1.00 (0.80, 1.25)	1.04 (0.90, 1.20)	1.17 (0.96, 1.43)	1.25 (0.97, 1.59)	1.44 (0.98, 2.12)	0.98 (0.83, 1.17)	1.04 (0.91, 1.18)	1.37 (1.05, 1.77)	1.04 (0.93, 1.17)									
Grade																		
1	1	1	1	1	1	1	1	1	1									
2	1.03 (0.88, 1.21)	1.02 (0.91, 1.13)	0.96 (0.82, 1.12)	0.98 (0.81, 1.18)	0.83 (0.60, 1.15)	0.99 (0.88, 1.11)	0.99 (0.90, 1.08)	0.81 (0.65, 1.01)	0.98 (0.91, 1.07)									
3	1.01 (0.81, 1.25)	1.10 (0.96, 1.26)	1.08 (0.89, 1.32)	1.15 (0.91, 1.47)	1.02 (0.68, 1.52)	0.99 (0.85, 1.15)	1.00 (0.88, 1.12)	1.13 (0.88, 1.46)	1.00 (0.90, 1.11)									
Undifferentiated	0.99 (0.64, 1.54)	1.01 (0.75, 1.37)	0.96 (0.61, 1.53)	0.87 (0.48, 1.59)	0.83 (0.31, 2.20)	1.00 (0.71, 1.40)	1.01 (0.79, 1.30)	0.89 (0.47, 1.67)	1.07 (0.86, 1.32)									

Table 5 (continued)

Activities of daily living									
	Falls ^a	Balance/walking problems ^a	Bathing	Dressing	Eating	Getting in/out of chair	Walking	Using the toilet	≥1 ADL limitation
Radiation									
No	1	1	1	1	1	1	1	1	1
Yes	1.04 (0.89, 1.21)	1.10 (0.99, 1.21)	1.09 (0.95, 1.26)	1.02 (0.85, 1.22)	0.98 (0.73, 1.32)	0.99 (0.88, 1.10)	1.11 (1.02, 1.20)	1.07 (0.88, 1.30)	1.05 (0.98, 1.13)
Radiation type									
No radiation	1	1	1	1	1	1	1	1	1
External beam	1.07 (0.87, 1.31)	1.18 (1.04, 1.34)	1.17 (0.98, 1.41)	1.10 (0.87, 1.38)	1.04 (0.71, 1.52)	0.92 (0.80, 1.07)	1.10 (0.99, 1.22)	1.04 (0.80, 1.35)	1.04 (0.95, 1.15)
Vaginal brachy-therapy	1.05 (0.80, 1.38)	0.98 (0.80, 1.19)	0.89 (0.64, 1.25)	0.84 (0.56, 1.27)	0.59 (0.26, 1.34)	1.20 (0.97, 1.48)	1.08 (0.91, 1.28)	0.88 (0.56, 1.38)	1.05 (0.90, 1.23)
Both	1.01 (0.77, 1.34)	1.13 (0.95, 1.35)	1.10 (0.84, 1.43)	0.96 (0.69, 1.33)	1.08 (0.65, 1.79)	0.98 (0.80, 1.19)	1.15 (1.00, 1.32)	1.26 (0.91, 1.74)	1.07 (0.94, 1.22)
Other/unknown	0.90 (0.51, 1.62)	0.90 (0.64, 1.28)	1.07 (0.73, 1.58)	1.12 (0.70, 1.79)	1.15 (0.56, 2.35)	0.98 (0.72, 1.33)	1.08 (0.86, 1.36)	1.09 (0.64, 1.86)	1.04 (0.85, 1.27)
Surgery									
No	1	1	1	1	1	1	1	1	1
Yes	1.61 (0.96, 2.72)	1.07 (0.82, 1.40)	0.71 (0.56, 0.92)	0.60 (0.45, 0.80)	0.85 (0.46, 1.56)	1.00 (0.79, 1.26)	1.05 (0.87, 1.27)	0.69 (0.48, 0.97)	0.97 (0.83, 1.14)

^aOnly included on surveys in 2006 and later

^bAdjusted for age at survey, survey year, race, marital status, and education; PRs for age at endometrial cancer diagnosis are not adjusted for age at survey due to nonoverlapping distributions of age at diagnosis and age at survey

healthier, on average, than the overall population of older women with an endometrial cancer history.

Our results suggest that some functional impairments, particularly difficulty with walking and/or balance, are common among older endometrial cancer survivors. Assessment of these concerns as part of long-term survivorship care, using geriatric assessment or other tools early in the survivorship trajectory, may be critical for improving and maintaining quality of life in this population.

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Data availability Not applicable.

Code availability Not applicable.

Declarations

Ethics approval and consent to participate This study was considered exempt by the University of North Carolina Institutional Review Board.

Consent for publication Not applicable.

Conflict of interest The authors declare no competing interests.

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