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# Prevalence of self-reported falls, balance or walking problems in older cancer survivors from Surveillance, Epidemiology and End Results—Medicare Health Outcomes Survey

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ABSTRACT

*Objective:* To determine the prevalence of falls and balance/walking problems in the past 12 months among older cancer survivors before and after cancer diagnosis.
*Materials and Methods:* We analyzed cross-sectional data from individuals aged ≥65 years with first primary cancer from the Surveillance, Epidemiology, and End Results and Medicare Health Outcomes Survey (SEER-MHOS) linkage (n = 12,659). The first MHOS completed by each survivor from 0 to 2 years before cancer diagnosis to 1–4 years after cancer diagnosis were included. We estimated unadjusted and demographic-adjusted prevalence of falls and balance/walking problems for each type of cancer during five one-year time periods before and after cancer diagnosis.
*Results:* Adjusted prevalence of falls was significantly higher post-diagnosis than pre-diagnosis in prostate (12% during years 1–2 pre-diagnosis vs. 17%–20% during years 1–4 post-diagnosis)($p = 0.01$) and lung cancer (17% during years 1–2 pre-diagnosis vs. 28% during years 1–2 post-diagnosis)($p = 0.019$). Adjusted prevalence of balance/walking problems were significantly higher post-diagnosis than pre-diagnosis in non-Hodgkin's lymphoma (26% during years 1–2 pre-diagnosis vs. 45% during years 1–2 post-diagnosis)($p = 0.012$), breast (32% during years 1–2 pre-diagnosis vs. 41% during years 3–4 post-diagnosis)($p = 0.001$), prostate (22% during years 1–2 pre-diagnosis vs. 28%–29% during years 1–4 post-diagnosis)($p = 0.012$), and lung cancer (33% during years 1–2 pre-diagnosis vs. 40% during year 0–1 pre-diagnosis and 46% during years 1–2 post-diagnosis)($p = 0.018$). Prevalence did not differ across time periods in other cancers.
*Conclusions:* Falls and balance/walking problems may become more frequent after the diagnosis of some cancers. Screening, surveillance, and interventions need to consider functional deficits and cancer diagnosis.


## 1. Introduction

Cancer is a chronic condition of older adults. About 53% of new cancers are diagnosed in people 65 years and older [1,2]. With recent advances in medical care, people are living longer after cancer treatments. The 5-year survival rate after the age of 65 years is 59% [3]. The number of cancer survivors is projected to reach 19 million by 2024 [4]. National expenditures for cancer care totaled nearly $125 billion in 2010, and are estimated to cost $156 billion in 2020 [5]. In light of the aging population and the increasing cost of care, developing strategies to optimize function along the trajectory of survivorship for older cancer survivors has become a significant challenge [6–9].

In older adults, falls are common occurrences with serious consequences, including increased cost of health care, mortality, poor quality of life, fears of falling, and restricted mobility [10–17]. Additionally, difficulty with balance or walking is associated with falls, dependence in activities of daily living, and lower quality of life [18–22]. A loss of balance contributed to more than 50% of falls among cancer survivors receiving neurotoxic chemotherapy [23]. Slow walking speed and impaired ability to walk 1/4 mile have been linked to heightened mortality and disability among older cancer survivors [24,25]. Cancer and its treatment impact multiple body systems and present unique health risks [4,23,26–29]. Accelerated aging is evidenced by greater declines in health outcomes over time after cancer diagnosis [30–33]. Significantly higher fall rates among older cancer survivors compared to those without cancer have been documented in population-based studies, with one reporting 33% vs. 30% (OR = 1.16, 95%CI, 1.01 to 1.33, n = 9481) [34] and another reporting 26% vs. 22% (OR = 1.17, 95%CI, 1.04 to 1.32, n = 12,480) [35]. Fall rates of older cancer survivors from previous studies ranged from 20% to 30% over 3 to 12 months

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across different practice settings [29]. Difficulty with balance and walking were identified by cancer survivors as the most frequent functional problems, with prevalence of 19% and 24%, respectively [36]. While the sequelae vary with time and type of cancer [4,23,26–29], whether the prevalence of falls and balance/walking problems vary with time post-cancer diagnosis remains poorly understood. Such information is key for developing survivorship care plans to improve health outcomes and costs, satisfaction with treatment, and caregiver burden.

The aims of this study were to (1) determine unadjusted and demographic-adjusted prevalence of self-reported falls and balance/walking problems in the past 12 months among older cancer survivors from pre- to post-cancer diagnosis, and (2) investigate whether prevalence during initial and later time periods post-cancer diagnosis may be higher in comparison with prevalence during 1–2 years pre-cancer diagnosis. Using population-based data and a cross-sectional design, prevalence among survivors during five one-year time periods before and after cancer diagnosis were estimated for each of the eight common cancers.

## 2. Materials and Methods

### 2.1. Design

This was a cross-sectional study analyzing 2006–2013 data from the Surveillance, Epidemiology and End Results Program and the Medicare Health Outcomes Survey (SEER-MHOS) linkage [37]. The SEER collects information about all newly diagnosed cancer cases from 16 cancer registries that cover about 26% of the U.S. population. The SEER-MHOS linkage includes data from 14 cancer registries, including cancer type, stage, time of diagnosis, cancer histology, initial cancer treatment, such as surgery and radiation, survival time, and cause of death [37]. The MHOS is a 95-item questionnaire that gathers valid, reliable, clinically meaningful, and patient-reported outcomes, including demographics, socioeconomic status, health habits and problems, chronic conditions, functional status, symptoms, health-related quality of life, and respondent characteristics, to monitor the quality of care of Medicare Advantage organizations [37,38]. Beneficiaries in participating Medicare Advantage organizations (managed care health plans) are randomly sampled annually by mail or telephone, and then resurveyed 2 years later [37,38]. The response rates of the baseline survey ranged from 64.1% in 1998 to 71.6% in 2000 [37]. The follow-up response rates ranged from 76.3% to 84.9% [37]. The extent of potential nonresponse bias of the MHOS was reported to be minimal and does not adversely affect estimates of health status for this population [39].

### 2.2. Setting

Population-based.

### 2.3. Participants

Fig. 1 shows the inclusion of the study sample. The sample was comprised of individuals age ≥65 years from SEER-MHOS cohort 9–14, beginning on January 1st in 2006 and ending on December 31st in 2013. Data from survivors of non-Hodgkin's lymphoma (NHL), breast, prostate, colorectal, lung, kidney, bladder, or uterine cancers were extracted. These cancers are highly prevalent in older adults [1,40]. Inclusion criteria were: first primary cancer, availability of cancer staging information, and MHOS administered from years 0–2 before cancer diagnosis to years 1–4 after diagnosis. Because the MHOS asked about falls and balance/walking problems in the past 12 months, survivors completing the MHOS within the first year after cancer diagnosis could have fallen or experienced balance/walking problems before diagnosis. Therefore, these survivors were excluded. We included the first MHOS completed by each individual in the analyses.

### 2.4. Main Outcomes and Measures

Primary outcomes were falls and balance/walking problems based on two MHOS questions with responses of "yes" (coded as 1) or "no" (coded as 2): (1) "A fall is when your body goes to the ground without being pushed. Did you fall in the past 12 months?" (2) "In the past 12 months, have you had a problem with balance or walking?" The prevalence estimates of falls or balance/walking problems, respectively, were defined as the number of survivors responding "yes" to these two questions.

The difference in time from MHOS administration to cancer diagnosis was calculated to create a categorical "time period" variable (coded as 1: >1 year and ≤2 years pre-diagnosis, 2: ≤1 year pre-diagnosis, 3: >1 year and ≤2 years post-diagnosis, 4: >2 years and ≤3 years post-diagnosis, and 5: >3 years and ≤4 years post-diagnosis). Survivors were classified into these five "time period groups" within each cancer diagnosis based on when they completed the MHOS relative to the time of cancer diagnosis. We compared the prevalence estimates between different time periods for each cancer.

Demographics variables included age at MHOS survey, gender (male, female), race (white, black, other/unknown), marital status (married, not married), education (<high school, high school or some college, ≥4-year college), and household income (<$30,000, $30,000–$50,000, >$50,000, unknown).

Health-related variables included calculated body mass index (BMI) and comorbidity index. Thirteen chronic conditions were identified from the MHOS (arthritis, osteoporosis, chronic obstructive pulmonary condition, angina, congestive heart failure, myocardial infarct, stroke, hypertension, diabetes types I and II, visual impairment, hearing impairment, low back pain, and depression). Each was scored as 1 (with the condition) or 0 (without the condition). The sum of scores from all conditions was the comorbidity index.

Cancer-related variables included age at diagnosis, type of cancer, stage of cancer (in situ, localized, regional, distant) [41], time to diagnosis, radiation (yes, no/unknown), surgery (yes, no/unknown), and surgery with radiation (yes, no/unknown). The SEER-MHOS does not include chemotherapy or hormonal therapy information.

### 2.5. Statistical Analysis

Descriptive statistics were calculated for sample characteristics. Using Poisson regression with robust error variance [42–44], we included the "time period" variable as covariate to estimate the unadjusted and adjusted prevalence of falls and balance/walking problems during each of the five time periods from pre- to post-cancer diagnosis. Separate regression models were constructed for each cancer. In the adjusted analyses, an a priori selection of demographic variables (age at survey, race, marital status, education, and household income) was added to the models as covariates based on previous research evidence [45,46]. Gender was also included in these models, except in breast, prostate, and uterine cancer. We used simple contrast coding for the "time period" variable to compare the prevalence during a time period with the prevalence during 1–2 years pre-diagnosis, i.e. the reference prevalence. Bonferroni adjustments were applied for post-hoc comparisons of the prevalence during each time period with the reference prevalence. All analyses were performed with IBM-SPSS® Version 22 (Armonk, NY). All tests were 2-sided. The level of significance was set at 0.05.

## 3. Results

### 3.1. Sample Characteristics

As shown in Table 1, the mean age at the administration of MHOS ranged from 74.2 (SD = 5.8) years in prostate cancer to 77.5 (SD = 6.6) years in bladder cancer. The majority were white, married, and

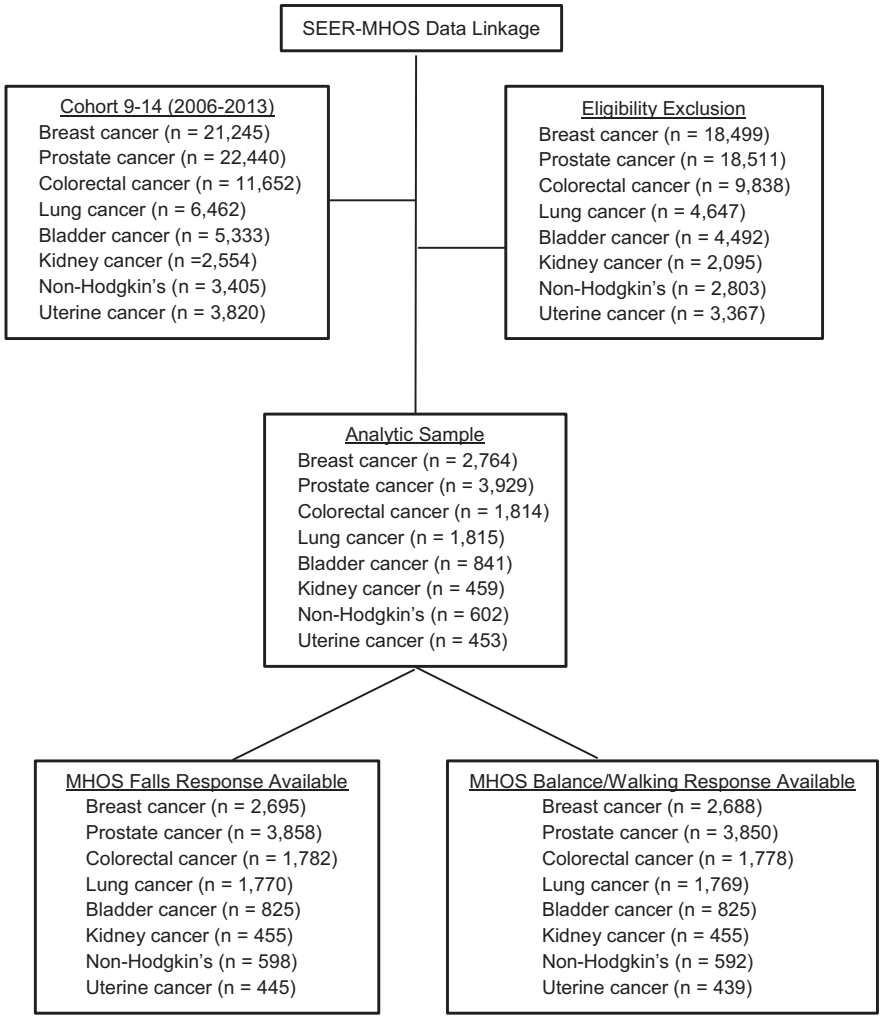


**Fig. 1.** Flowchart of study population. The sample composed of individuals age ≥65 years from cohorts nine to fourteen (year 2006 to 2013) of the Surveillance, Epidemiology and End Results Program and the Medicare Health Outcomes Survey (SEER-MHOS) linkage. Inclusion criteria were: first, primary cancer (non-Hodgkin's lymphoma, breast, prostate, colorectal, lung, bladder, kidney, or uterine cancer), availability of cancer staging information, and first MHOS administered from 0 to 2 years before cancer diagnosis to 1–4 years after diagnosis. Data from the first MHOS completed by each individual were extracted. Responses to two MHOS questions about falls and balance/walking problems were analyzed to obtain prevalence estimates.

with high school or some college education. Most survivors (41.9% to 54.4%) had household incomes of less than $30,000. Women accounted for 26.5% of survivors of bladder cancer. Approximately half of the survivors of NHL, colorectal, lung, and kidney cancer were men. Mean body mass index ranged from 25.9 (SD = 5.4) in lung cancer to 30.4 (SD = 7.6) in uterine cancer. Mean age at diagnosis ranged from 72.5 (SD = 6.0) years in prostate cancer to 76.2 (SD = 6.9) years in bladder cancer. Localized or regional cancer stage was the most frequent in breast, prostate, colorectal, bladder, kidney, and uterine cancer. About 46% and 51% of survivors with lung cancer and NHL, respectively, were at the advanced stage. The rates for radiation or surgery varied across cancers. Breast (47.8%) and uterine cancer (32.1%) had the highest rates of treatment with both radiation and surgery.

### 3.2. Prevalence of Falls in the Past 12 Months

As shown in Table 2, prevalence of falls differed significantly across time periods for lung ($p = 0.038$ for unadjusted; $p = 0.019$ for adjusted) and prostate cancer ($p = 0.001$ for unadjusted; $p = 0.01$ for adjusted). In lung cancer, survivors had a significantly higher adjusted prevalence of falls 1–2 years after diagnosis (28%, 95%CI, 21%–37%)($p = 0.008$) compared to survivors 1–2 years before diagnosis (17%, 95%CI, 13%–21%). Adjusted fall prevalence for prostate cancer survivors was significantly higher during years 1–2 (20%, 95%CI, 17%–24%)($p < 0.001$), years 2–3 (19%, 95%CI, 16%–23%)($p < 0.001$), and years 3–4 after diagnosis (17%, 95%CI, 14%–21%)($p = 0.002$) in comparison with survivors during years 1–2 before diagnosis (12%, 95%CI, 10%–16%). Unadjusted and adjusted prevalence of falls did not differ significantly across time periods for other cancers.

### 3.3. Prevalence of Balance/Walking Problems in the Past 12 Months

As shown in Table 3, prevalence of balance/walking problems differed significantly across time periods in NHL ($p = 0.043$ for unadjusted; $p = 0.012$ for adjusted), breast ($p < 0.001$ for unadjusted; $p = 0.001$ for adjusted), lung ($p = 0.022$ for unadjusted; $p = 0.018$ for adjusted), and prostate cancer ($p < 0.001$ for unadjusted; $p = 0.012$ for adjusted). In breast cancer, adjusted prevalence of balance/walking problems was significantly higher during years 3–4 post-cancer diagnosis (41%, 95%CI, 36%–47%)($p = 0.007$) than during years 1–2 pre-diagnosis (32%, 95%CI, 27%–38%). In lung cancer, adjusted prevalence was significantly higher within one year before cancer diagnosis (40%, 95%CI, 36%–46%)($p = 0.006$) and during years 1–2 post-diagnosis (46%, 95%CI, 38%–56%)($p = 0.005$) compared to during years 1–2 pre-diagnosis (33%, 95%CI, 28%–38%). Survivors of prostate cancer had significantly higher adjusted prevalence of balance/walking problems

**Table 1**
Characteristics of sample by cancer diagnosis.

| Variables | Breast | Colorectal | Lung | Prostate | Bladder | Kidney | NHL | Uterine |
|---|---|---|---|---|---|---|---|---|
| Age at MHOS administration, mean (SD), y | 75.4 (6.6) | 77.3 (7.1) | 75.9 (6.1) | 74.2 (5.8) | 77.5 (6.6) | 75.3 (6.2) | 76.8 (6.8) | 75.0 (6.5) |
| Women, no. (%) | 2268 (100) | 773 (52.8) | 760 (50.4) | 0 (0) | 176 (26.5) | 180 (48.3) | 252 (50.8) | 359 (100) |
| Race, no. (%) | | | | | | | | |
| White | 1694 (74.7) | 1086 (73.1) | 1198 (78.3) | 2312 (71.4) | 594 (87.7) | 281 (75.1) | 415 (82.3) | 297 (80.1) |
| Black | 289 (12.7) | 176 (11.8) | 158 (10.3) | 507 (15.7) | 35 (5.2) | 36 (9.6) | 32 (6.3) | 42 (11.3) |
| Other | 285 (12.6) | 224 (15.1) | 174 (11.4) | 418 (12.9) | 48 (7.1) | 57 (15.2) | 57 (11.3) | 32 (8.6) |
| Married, no. (%) | 941 (42.0) | 699 (48.1) | 778 (51.9) | 2328 (73.2) | 392 (59.2) | 217 (58.8) | 272 (55.5) | 150 (42.0) |
| Education, no. (%) | | | | | | | | |
| <High school | 517 (23.2) | 467 (32.5) | 510 (34.1) | 785 (24.9) | 170 (26.0) | 96 (26.2) | 139 (28.4) | 86 (24.4) |
| High school | 1366 (61.3) | 743 (51.8) | 823 (55.1) | 1557 (49.4) | 364 (55.7) | 210 (57.4) | 261 (53.3) | 219 (62.0) |
| ≥4 year college | 345 (15.5) | 225 (15.7) | 161 (10.8) | 809 (25.7) | 120 (18.3) | 60 (16.4) | 90 (18.4) | 48 (13.6) |
| Household income, no. (%) | | | | | | | | |
| <$30,000 | 1125 (49.6) | 792 (53.3) | 832 (54.4) | 1355 (41.9) | 309 (45.6) | 178 (47.6) | 246 (48.8) | 177 (47.7) |
| $30,000–50,000 | 365 (16.1) | 209 (14.1) | 249 (16.3) | 711 (22.0) | 146 (21.6) | 61 (16.3) | 96 (19.0) | 54 (14.6) |
| >$50,000 | 295 (13.0) | 177 (11.9) | 160 (10.5) | 673 (20.8) | 94 (13.9) | 56 (15.0) | 62 (12.3) | 39 (10.5) |
| Unknown | 483 (21.3) | 308 (20.7) | 289 (18.9) | 498 (15.3) | 128 (18.9) | 79 (21.1) | 100 (19.8) | 101 (27.2) |
| Body mass index, mean (SD) | 27.6 (6.0) | 26.9 (5.5) | 25.9 (5.4) | 27.5 (4.5) | 27.0 (4.8) | 28.6 (6.1) | 26.8 (5.1) | 30.4 (7.6) |
| Comorbidity index, mean (SD) | 3.1 (2.0) | 3.0 (2.0) | 3.5 (2.2) | 2.6 (1.9) | 3.1 (2.3) | 3.3 (2.0) | 3.1 (2.0) | 2.8 (1.9) |
| Age at cancer diagnosis, mean (SD), y | 73.9 (6.7) | 75.9 (7.5) | 75.5 (6.4) | 72.5 (6.0) | 76.2 (6.9) | 73.9 (6.6) | 75.7 (7.3) | 73.5 (6.8) |
| Cancer stage, no. (%) | | | | | | | | |
| In situ | 420 (18.5) | 78 (5.2) | a | a | 375 (55.4) | 6 (1.6) | a | a |
| Localized | 1298 (57.2) | 687 (46.2) | 402 (26.3) | 2845 (87.9) | 257 (38.0) | 256 (68.4) | 161 (31.9) | 268 (72.2) |
| Regional | 491 (21.6) | 565 (38.0) | 420 (27.5) | 288 (8.9) | 34 (5.0) | 69 (18.4) | 86 (17.1) | 76 (20.5) |
| Distant | 59 (2.6) | 156 (10.5) | 707 (46.2) | 103 (3.2) | 11 (1.6) | 43 (11.5) | 257 (51.0) | 25 (6.7) |
| Time of MHOS administration to cancer diagnosis, no. (%) | | | | | | | | |
| 1–2 year pre-diagnosis | 391 (17.2) | 293 (19.7) | 463 (30.3) | 491 (15.2) | 138 (20.4) | 66 (17.6) | 112 (22.2) | 66 (17.8) |
| 0–1 year pre-diagnosis | 636 (28.0) | 409 (27.5) | 691 (45.2) | 767 (23.7) | 202 (29.8) | 124 (33.2) | 167 (33.1) | 99 (26.7) |
| 1–2 year post-diagnosis | 425 (18.7) | 292 (19.7) | 164 (10.7) | 648 (20.0) | 121 (17.9) | 59 (15.8) | 93 (18.5) | 73 (19.7) |
| 2–3 year post-diagnosis | 425 (18.7) | 246 (16.6) | 127 (8.3) | 672 (20.8) | 111 (16.4) | 60 (16.0) | 63 (12.5) | 69 (18.6) |
| 3–4 year post-diagnosis | 391 (17.2) | 246 (16.6) | 85 (5.6) | 659 (20.4) | 105 (15.5) | 65 (17.4) | 69 (13.7) | 64 (17.3) |
| Radiation, no. (%) | 1096 (49.5) | 141 (9.6) | 490 (32.5) | 1397 (43.9) | 21 (3.1) | 13 (3.5) | 96 (19.3) | 124 (34.0) |
| Surgery, no. (%) | 2150 (94.9) | 1360 (91.7) | 438 (28.7) | 930 (29.1) | 639 (94.7) | 309 (83.1) | 153 (31.2) | 353 (95.1) |
| Radiation & surgery, no. (%) | 1084 (47.8) | 114 (7.7) | 82 (5.4) | 75 (2.3) | 18 (2.7) | a | 36 (7.1) | 119 (32.1) |

Abbreviations: MHOS, Medicare Health Outcomes Survey; NHL, Non-Hodgkin's lymphoma; a indicates cell number <11.

during years 1–2 (29%, 95%CI, 26%–33%)($p = 0.004$), years 2–3 (28%, 95%CI, 25%–32%)($p = 0.012$), and years 3–4 post-cancer diagnosis (29%, 95%CI, 25%–33%)($p = 0.006$) than during years 1–2 pre-diagnosis (22%, 95%CI, 18%–26%). In NHL, adjusted prevalence were significantly higher within the second year after cancer diagnosis (45%, 95%CI, 34%–59%)($p = 0.005$) compared to during years 1–2 pre-diagnosis

**Table 2**
Unadjusted and adjusted[c] prevalence of survivors with falls in the past 12 months by time to cancer diagnosis.

| Diagnosis | No. of survivors | Unadjusted prevalence of survivors with falls, % (95%CI) | | | | | p-Value[a] |
|---|---|---|---|---|---|---|---|
| | | 1–2 year pre-diagnosis [Reference] | 0–1 year pre-diagnosis | 1–2 year post-diagnosis | 2–3 year post-diagnosis | 3–4 year post-diagnosis | |
| Breast | 2223 | 23 (19–27) | 23 (20–27) | 25 (21–30) | 26 (25–30) | 29 (25–34) | 0.219 |
| Colorectal | 1463 | 25 (20–30) | 24 (20–28) | 27 (22–33) | 26 (21–32) | 20 (16–26) | 0.446 |
| Lung | 1489 | 18 (15–22) | 23 (20–27) | 29 (23–37)[b] | 25 (18–34) | 27 (19–39) | 0.038 |
| Prostate | 3183 | 13 (10–16) | 16 (14–19) | 22 (19–25)[b] | 21 (18–24)[b] | 19 (17–23)[b] | 0.001 |
| Bladder | 664 | 26 (20–35) | 25 (20–32) | 26 (19–36) | 28 (21–38) | 23 (16–33) | 0.944 |
| Kidney | 370 | 26 (17–39) | 18 (12–16) | 24 (15–38) | 17 (10–30) | 22 (14–35) | 0.622 |
| NHL | 502 | 21 (14–30) | 24 (18–31) | 26 (18–36) | 27 (18–41) | 23 (15–36) | 0.885 |
| Uterine | 364 | 31 (22–45) | 25 (18–35) | 24 (16–36) | 22 (14–35) | 27 (18–41) | 0.788 |
| Diagnosis | No. of survivors | Adjusted prevalence of survivors with falls, % (95%CI) | | | | | p-Value[a] |
| | | 1-2 year pre-diagnosis [Reference] | 0–1 year pre-diagnosis | 1–2 year post-diagnosis | 2–3 year post-diagnosis | 3–4 year post-diagnosis | |
| Breast | 2181 | 20 (16–25) | 21 (18–25) | 23 (19–27) | 23 (19–27) | 25 (21–31) | 0.392 |
| Colorectal | 1405 | 22 (17–27) | 21 (17–26) | 25 (20–31) | 25 (20–31) | 17 (13–23) | 0.189 |
| Lung | 1452 | 17 (13–21) | 21 (18–26) | 28 (21–37)[b] | 24 (17–33) | 25 (17–36) | 0.019 |
| Prostate | 3095 | 12 (10–16) | 16 (13–19) | 20 (17–24)[b] | 19 (16–23)[b] | 17 (14–21)[b] | 0.010 |
| Bladder | 640 | 23 (16–34) | 23 (16–32) | 24 (16–36) | 25 (17–37) | 19 (12–30) | 0.835 |
| Kidney | 362 | 19 (11–33) | 12 (7–20) | 19 (12–31) | 12 (6–24) | 18 (11–31) | 0.303 |
| NHL | 482 | 19 (12–29) | 21 (14–31) | 25 (16–38) | 25 (16–41) | 21 (12–36) | 0.789 |
| Uterine | 345 | 28 (16–47) | 24 (15–38) | 22 (14–35) | 21 (13–35) | 26 (15–45) | 0.900 |

Abbreviation: NHL, non-Hodgkin's lymphoma.

[a] *p*-Values are for the main effect of time periods in the regression model for each cancer diagnosis.

[b] Each superscript letter indicates that the prevalence during a time period differed significantly from the reference prevalence during 1–2 years pre-diagnosis. Bonferroni adjustment was applied for multiple comparisons of time periods with significance level at $p < 0.0125$.

[c] Model for adjusted prevalence estimates included time periods and demographics covariates (age at survey, race, education, marital status, and household income). Gender was also included in the models for colorectal, lung, bladder and kidney cancer, and NHL.

**Table 3**
Unadjusted and adjusted[c] prevalence of survivors with balance or walking problems in the past 12 months by time to cancer diagnosis.

| Diagnosis | No. of survivors | Unadjusted prevalence of survivors with balance or walking problems, % (95%CI) | | | | | *p*-Value[a] |
|---|---|---|---|---|---|---|---|
| | | 1–2 year pre-diagnosis [Reference] | 0–1 year pre-diagnosis | 1–2 year post-diagnosis | 2–3 year post-diagnosis | 3–4 year post-diagnosis | |
| Breast | 2215 | 33 (29–38) | 30 (27–34) | 39 (34–44) | 39 (34–43) | 43 (39–49)[b] | <0.001 |
| Colorectal | 1463 | 36 (31–42) | 34 (30–39) | 36 (31–42) | 38 (32–45) | 37 (31–43) | 0.864 |
| Lung | 1489 | 33 (29–37) | 41 (38–45)[b] | 45 (38–54)[b] | 42 (34–52) | 42 (32–54) | 0.022 |
| Prostate | 3176 | 20 (17–24) | 23 (20–26) | 29 (26–33)[b] | 29 (26–32)[b] | 30 (26–33)[b] | <0.001 |
| Bladder | 663 | 33 (26–42) | 34 (28–42) | 27 (20–36) | 39 (31–50) | 34 (26–44) | 0.421 |
| Kidney | 370 | 30 (21–44) | 35 (28–45) | 42 (31–57) | 40 (29–54) | 46 (35–60) | 0.377 |
| NHL | 498 | 27 (20–37) | 34 (28–42) | 47 (38–58)[b] | 39 (29–54) | 43 (33–57) | 0.043 |
| Uterine | 350 | 37 (27–51) | 31 (23–42) | 44 (34–58) | 34 (25–48) | 48 (37–62) | 0.209 |
| Diagnosis | No. of survivors | Adjusted prevalence of survivors with balance or walking problems, % (95%CI) | | | | | *p*-Value[a] |
| | | 1-2 year pre-diagnosis [Reference] | 0–1 year pre-diagnosis | 1–2 year post-diagnosis | 2–3 year post-diagnosis | 3–4 year post-diagnosis | |
| Breast | 2174 | 32 (27–38) | 30 (26–34) | 38 (33–43) | 36 (31–42) | 41 (36–47)[b] | 0.001 |
| Colorectal | 1404 | 33 (28–39) | 29 (25–34) | 34 (29–40) | 35 (29–42) | 35 (29–42) | 0.383 |
| Lung | 1452 | 33 (28–38) | 40 (36–46)[b] | 46 (38–56)[b] | 43 (34–53) | 43 (33–55) | 0.018 |
| Prostate | 3088 | 22 (18–26) | 24 (21–28) | 29 (26–33)[b] | 28 (25–32)[b] | 29 (25–33)[b] | 0.012 |
| Bladder | 639 | 40 (30–52) | 41 (32–52) | 31 (23–43) | 44 (33–57) | 39 (28–53) | 0.461 |
| Kidney | 362 | 35 (23–51) | 37 (28–48) | 46 (33–63) | 42 (30–60) | 52 (39–69) | 0.280 |
| NHL | 479 | 26 (19–37) | 30 (22–39) | 45 (34–59)[b] | 41 (29–57) | 42 (30–59) | 0.012 |
| Uterine | 340 | 37 (25–53) | 30 (21–44) | 46 (34–62) | 33 (23–49) | 49 (34–68) | 0.127 |

Abbreviation: NHL, non-Hodgkin's lymphoma.
[a] *p*-Values are for the main effect of time periods in the regression model for each cancer diagnosis.
[b] Each superscript letter indicates that the prevalence during a time period differed significantly from the reference prevalence during 1–2 years pre-diagnosis. Bonferroni adjustment was applied for multiple comparisons of time periods with significance level at $p < 0.0125$.
[c] Model for adjusted prevalence estimates included time periods and demographics covariates (age at survey, race, education, marital status, and household income). Gender was also included in the models for colorectal, lung, bladder and kidney cancer, and NHL.

(26%, 95%CI, 19%–37%). For all other cancers, unadjusted and adjusted prevalence of balance/walking problems did not differ significantly across time periods.

## 4. Discussion

This study is the first to examine the prevalence of self-reported falls and balance/walking problems in the past 12 months from pre- to post-cancer diagnosis among older survivors of eight common cancers using population-based data and a cross-sectional design. Current findings indicated that prevalence increased post-diagnosis compared to 1–2 years pre-diagnosis in some but not all cancers. To address falls and balance/walking problems, particularly in survivors of cancers with increased prevalence post-diagnosis, clinicians may integrate rehabilitation services in survivorship care planning.

Findings from this study contribute to knowledge gaps in important ways. First, by analyzing nationally representative data, we demonstrated time-variant prevalence of falls and balance/walking problems before and after cancer diagnosis in non-Hodgkin's lymphoma, breast, prostate, and lung cancer. Previous research grouped different types of cancer together [17,46,47], combined data from individuals who had survived cancer for any length of time [17,35,36,46–48], or included only post-diagnosis data; [17,35,36,46–48] thus, differences in prevalence by time to cancer diagnosis within each cancer were likely masked. In a study of fall rates among older cancer survivors using the SEER-MHOS data, long-term (≥5 years) survivors accounted for 68% of the sample [17]. In contrast, we estimated the prevalence with each cancer using cross-sectional data across six time periods, from 2 years before cancer diagnosis to 4 years after diagnosis. Because the MHOS asked about falls and balance/walking problems in the past 12 months, survivors in the time period of 0–1 year post-diagnosis could have fallen or experienced balance/walking problems before the diagnosis. For example, a survivor completed the MHOS at 6 months post-diagnosis could have fallen 6 months before diagnosis. However, according to the fall prevention guidelines by the American Geriatric Society, clinicians should ask all older adults about falls in the past year and difficulty with balance or walking [19]. Moreover, a history of falls is a significant risk factor for future falls among older cancer survivors [46]. In this context, current findings are relevant to the recommended practice by American Geriatric Society, and support the need to ask these same questions when treating older cancer survivors, particularly those with cancers demonstrating higher prevalence during initial time periods post-diagnosis. The extent to which symptoms and changes in body functions associated with cancer impact falls and balance/walking performance before a clinical diagnosis of cancer was confirmed remains to be investigated.

Second, prevalence of falls was higher post-cancer diagnosis in lung and prostate cancer while balance/walking problems were more prevalent after diagnosis among survivors of breast, prostate, lung cancer, and NHL. Therefore, the screening, surveillance, and interventions to reduce falls and balance/walking problems could be different depending on the type of problems and the cancer diagnosis. Research evidence has revealed a lack of awareness about falls and balance/walking problems among oncology providers. According to the American Geriatrics Society [19], healthcare providers should ask older adults during all encounters whether they have had falls or difficulty with balance or walking [19]. However, a study reviewing medical records showed that only 10% of older cancer survivors with one or more falls in the past 6 months had appropriate medical documentation about their falls [49]. In another study in an oncology outpatient setting, no referrals to rehabilitation specialists were made to address difficulty with balance or walking, the most frequent functional problem identified by cancer survivors being treated at the clinic [36]. Our findings inform the development of a prospective surveillance model (PSM) that specifies time points to provide patient education, detect and treat impairments associated with cancer and its treatment, and enhance awareness and access to rehabilitation [50,51]. The PSM has been proposed for rehabilitation of women with breast cancer to improve physical and functional outcomes [50–52]. Similarly, a PSM may guide clinicians to provide interventions to prevent falls, and improve balance or walking ability among older cancer survivors.

Prevalence of falls among cancer survivors reported previously varied widely [53]. Percentages of cancer survivors with falls were

18%–27% during inpatient stay and 18%–65% in outpatient settings [54–56]. In population-based studies, falls occurred in 25%–33% of older cancer survivors over 3 to 12 months [57–59]. Divergent fall rates reported in the literature may be associated with study design, sample characteristics, follow-up durations, and assessment methods of falls [36]. Overall, in this study, prevalence estimates of falls are in line with previous findings. Additionally, except for lung and prostate cancer, prevalence of falls for other cancers remained unchanged over time. Previous research of older survivors of any cancer reported no differences in fall rates with time since cancer diagnosis [34]. In older adults, lung cancer has a poor prognosis, with an estimated 5-year survival rate of 16% [60], in contrast to 62% in NHL, 99% in prostate, and 89% in breast cancer [60]. Current findings likely reflect the disease burden and the impact of cancer treatment on survivors of lung cancer and NHL, who were mostly diagnosed at a more advanced stage. Moreover, survivors' functional status may influence treatment choice [61] and vice versa [62]. Prostate cancer survivors with radiotherapy had significant declines in physical function between 12 and 52 months after treatment, whereas those with prostatectomy improved slightly [62]. Whether variations in prevalence across different time periods after cancer diagnosis are linked to the effects of cancer treatment or disease progression cannot be directly assessed in this study. The SEER-MHOS linkage does not have information on chemotherapy, hormonal treatment, or other prescription drugs, although more advanced cancer is likely to be treated with chemotherapy [37]. The time when a condition developed cannot be ascertained from MHOS data [37]. Future research is needed to delineate the influence of cancer-related factors on falls.

Research of self-reported difficulty with balance or walking in cancer survivors is limited. In a population-based study, about 37% of older cancer survivors reported “yes” to the question “How often do you have difficulty with balance?” [46]. The recovery of walking ability over time was reported in another population-based study of older cancer survivors. Difficulty with walking 1/2 mile was most prevalent in recent older cancer survivors (<2 years post-cancer diagnosis) (32%), compared to short-term survivors (2–5 years post-diagnosis) (28%), long-term survivors (≥5 years post-diagnosis) (26%), or non-cancer controls (19%) [63]. We found that adjusted prevalence of balance/walking problems across time periods post-diagnosis was greater than 30% in all cancers, except for prostate cancer. Balance/walking problems became evident within one year before diagnosis of lung cancer, suggesting that these functional problems predated the clinical diagnosis and treatment. In breast cancer, balance/walking problems were most prevalent during years 3–4 post-diagnosis. Longer-term surveillance of these functions is warranted for breast cancer survivors. While survivors of other cancers regained balance or walking ability after cancer diagnosis, current findings reflect the inherent heterogeneity of cancer survivorship across cancers.

In addition to the lack of cancer treatment information, other than surgery and radiation, the SEER-MHOS dataset has other limitations [37,64]. First, falls in the past 12 months were based on self-report, which may be subject to recall bias [65] and underreporting [66,67]. Older adults may not recognize the severity or the definition of a fall, or may not remember a fall [66,67]. While a history of falls is a significant predictor of future falls in older cancer survivors [29,68], the SEER-MHOS does not collect the number of falls experienced by each responder. Second, there may be a lack of representativeness in the Medicare program. The medical claims data are not available. The MHOS collects data from the Medicare Advantage enrollees in the SEER regions only and excludes Medicare beneficiaries with fee-for-service coverage, a population that had been found to have more risk factors and lower function [69]. Nevertheless, the SEER-MHOS linkage provides population-based, patient-reported outcomes data that are important to research of cancer survivorship [64].

This study has other weakness. The cross-sectional design makes it difficult to interpret the relationships identified. The prevalence estimates may be biased if characteristics of survivors at the pre-diagnosis time periods were different from those at post-diagnosis time periods. For example, individuals at earlier stages of cancer or higher levels of function before cancer diagnosis may be more likely to survive longer. Cross-sectional data at later time periods post-cancer diagnosis may be comprised of healthier survivors who have lived longer. Further studies using a longitudinal design are necessary to investigate the cause–effect relationships between potential risk factors and falls or balance/walking problems before and after cancer diagnosis among older survivors.

## 5. Conclusions

Among older survivors of eight common cancers, there is a high prevalence of falls and difficulty with balance or walking after cancer diagnosis in some cancers. Current findings underscore the urgency in implementing mechanisms for surveillance, screening, and interventions to prevent and reduce functional problems along the trajectory of cancer survivorship for older adults.

## Disclosures and Conflict of Interest Statements

The authors have no conflicts of interest to disclose.

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Study Concept: MH Huang
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Quality Control of Data and Algorithms: MH Huang, M Godoshian
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Manuscript Preparation: MH Huang, L Pfalzer
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