BMC Geriatrics

SYSTEMATIC REVIEW

Open Access

Falls among geriatric cancer patients: a systematic review and meta-analysis of prevalence and risk across cancer types

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Abstract

Background Falls represent a significant health concern among the older adults, particularly geriatric cancer patients, due to their increased susceptibility from both age-related and cancer treatment-related factors. This systematic review and meta-analysis aimed to synthesize global data on the prevalence and risk of falls in this population to inform targeted fall prevention strategies.

Methods Following PRISMA 2020 guidelines, we conducted a comprehensive search of PubMed, Embase, and Web of Science up to October 2024. Articles were screened using Nested Knowledge software by two independent reviewers. Eligible studies included those involving geriatric cancer patients aged 60 years or older reporting on fall prevalence. Quality assessment was performed using a modified Newcastle–Ottawa Scale, and meta-analysis was conducted using random-effects models with R software.

Results From 1,365 identified studies, 86 met the inclusion criteria, encompassing 180,974 participants. The pooled prevalence of falls was 24% (95% CI, 20%–28%), with substantial heterogeneity ($I^2 = 100\%$). Country- and cancer-type-specific analyses revealed variability in fall prevalence, with breast cancer patients showing the highest prevalence. The comparative risk analysis did not show a statistically significant difference in fall risk between cancer patients and non-cancer controls.

Conclusion Falls are a prevalent and concerning issue among geriatric cancer patients, with substantial variability influenced by cancer type and study design. Personalized fall prevention strategies tailored to cancer-specific risk factors are essential. Further research is warranted to explore the complex interplay of cancer treatments, frailty, and fall risk in this vulnerable population.

Keywords Falls, Older adults, Cancer, Prevalence, Risk factors

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Introduction

Falls were a significant and often under-recognized health concern among older adults, contributing to substantial morbidity, mortality, and increased healthcare costs [1]. For older adults, falls were not merely a natural consequence of aging but were frequently indicative of underlying health issues such as frailty, polypharmacy, and neurological or musculoskeletal disorders [2]. Geriatric cancer patients, in particular, presented unique vulnerabilities due to the complex interplay between age-related physiological changes and cancer-specific treatments, which could worsen balance and mobility impairments [3, 4]. Radiotherapy is vital for treating cancer in geriatric patients but can exacerbate frailty through side effects like fatigue and reduced physical function, increasing fall risks. Integrating frailty assessment into radiotherapy could improve treatment outcomes and safety for this vulnerable population [5]. Studies have highlighted the higher fall risk in this group due to factors such as chemotherapy-induced neuropathy, sarcopenia, and impaired physical function [6]. Reported prevalence rates of falls in older cancer patients varied widely, ranging from 15 to 50% depending on cancer type, treatment regimen, and comorbidities, necessitating a comprehensive analysis to clarify these variations [7, 8]. For instance, older adults with multiple myeloma were found to have a significantly higher fall risk due to cancer-related bone disease and treatment-induced weakness [3]. Similarly, pre-treatment falls in older women receiving adjuvant chemotherapy for breast cancer were shown to predict greater hospitalization risks and chemotherapy-related toxicities [4]. Understanding these nuanced impacts on geriatric oncology patients was crucial for developing effective fall-prevention strategies tailored to this vulnerable population.

The confluence of oncological and geriatric syndromes in older cancer patients contributed to a complex clinical concern that keen fall risk through multiple pathways [6, 7]. For example, among older men undergoing androgen deprivation therapy for prostate cancer, the treatment was associated with reduced bone density and increased fracture risk, further elevating their susceptibility to falls [9]. Additionally, the symptom burden and reduced physical function reported in older cancer patients were strongly linked to an increased risk of falls and subsequent physical decline [6]. A population-based study demonstrated that community-dwelling older adults cancer survivors had a higher prevalence of falls compared to their non-cancer counterparts, underscoring the need for tailored interventions targeting this group [7]. Moreover, older Medicare beneficiaries with cancer frequently presented with multiple geriatric syndromes, such as cognitive impairment, incontinence, and mobility disability, which compounded their risk of falling [8]. These findings highlighted the need for a comprehensive approach to fall prevention that accounted for both oncological and geriatric factors.

This study aims to systematically review and analyze the global prevalence and risk of falls among geriatric cancer patients. By synthesizing evidence from diverse settings, it provides a comprehensive understanding of the burden of falls, informing evidence-based guidelines and personalized fall prevention strategies to enhance patient safety, reduce hospitalizations, and improve quality of life in this vulnerable population.

Methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 standards were followed in this systematic review and meta-analysis [10] (Table S1). The review protocol was registered in the International Prospective Register of Systematic Reviews (PROSPERO) with CRD42024596426.

Eligibility criteria

Studies were included if they met the following criteria: (1) the study population consisted of geriatric cancer patients aged 60 years or older, (2) the study reported data on either the prevalence of falls or factors associated with fall risk in this population, (3) the study design was clinical trial and observational (cross-sectional, cohort, or case–control), and (4) the article was published in a peer-reviewed journal in English. Studies were excluded if they were reviews, commentaries, editorials, case reports, or focused on non-cancer-related falls or falls in non-geriatric populations. Articles that did not present original data, provided insufficient fall-related data, or were not accessible in full text were also excluded (Table S2).

Literature search

A systematic literature search was conducted using PubMed, Embase, and Web of Science from their inception to September 2024. The search strategy employed a combination of MeSH terms and keywords to identify studies investigating the prevalence and risk falls among older cancer patients. Additionally, manual searches of reference lists from selected studies and relevant reviews were conducted to ensure no eligible articles were missed (Table S3).

Screening and data extraction

The screening process was performed in two stages using Nested Knowledge software: (1) title and abstract screening, and (2) full-text review. During the second stage, full texts of potentially eligible studies were retrieved and reviewed by the same two independent reviewers to

confirm their inclusion. Any disagreements were resolved through discussion until a consensus was reached.

Data extraction was conducted using Nested Knowledge, a semi-automatic software designed to streamline systematic reviews and meta-analyses. The software facilitates data extraction through its tagging function, allowing reviewers to systematically organize and annotate study characteristics such as author, year, country, participant demographics (age, sex, sample size), cancer type, and fall prevalence. In cases of missing or unclear data, corresponding authors were contacted for clarification. To ensure accuracy and reliability, all extracted data were cross-verified by a third reviewer.

Quality assessment

The quality of the included studies was evaluated using the Modified Newcastle–Ottawa Scale (NOS) modified for geriatric cancer research [11]. The NOS assessed study quality based on three domains: (1) selection of participants (0–4 points), (2) comparability of study groups (0–2 points), and (3) ascertainment of outcomes (0–3 points). Studies scoring 7 to 9 points were considered to have a low risk of bias, scores of 4 to 6 indicated moderate risk, and scores of 0 to 3 were classified as having a high risk of bias. The detailed scoring and assessment are provided in Table S4.

Statistical analysis

All statistical analyses were conducted using R® software (version 4.4.0) with the "meta" and "metafor" packages. Prevalence data were pooled using a random-effects model to account for between-study variability. For pooling prevalence data, the logit-transformed proportions (PLOGIT) were used as the primary summary measure, along with 95% confidence intervals (CI). Heterogeneity across studies was quantified using the I^2 statistic, where values of 25%, 50%, and 75% represented low, moderate, and high heterogeneity, respectively [11]. Publication bias was assessed using Doi plots, and quantified using the Luis Furuya-Kanamori (LFK) index. An LFK index value between −1 and + 1 indicated no asymmetry, values between ± 1 and ± 2 indicated minor asymmetry, and values beyond ± 2 suggested major asymmetry [12, 13]. Leave-one-out sensitivity analyses were performed to test the robustness of the pooled results by excluding one study at a time and observing changes in the overall effect size. All statistical tests were two-tailed, with a significance level set at $p < 0.05$.

Results

Literature search

A total of 1,365 studies were identified through comprehensive database searches. After the excision of 437 duplicates, 928 records remained for title and abstract screening. During this stage, 575 records were excluded for not meeting the relevance criteria. The full texts of 353 articles were then reviewed for eligibility, resulting in the exclusion of 267 articles. In the final selection, 86 studies were included in the quantitative synthesis. The entire process of study selection is outlined in PRISMA flow diagram (Fig. 1).

Summary of study characteristics

A total of 86 studies were included in the systematic review, representing a variety of study designs, cancer types, and geographic regions (Table 1). The majority of these studies were conducted in the United States ($n = 52$), followed by Canada ($n = 10$), Belgium ($n = 4$), and France ($n = 4$), with additional studies from countries such as Denmark, Germany, and Australia. The study designs were diverse, with cross-sectional studies being the most common ($n = 29$), followed by prospective ($n = 25$), retrospective ($n = 22$), and randomized clinical trials ($n = 8$). One study utilized a case–control design. The included studies examined various types of cancer, most notably breast cancer ($n = 12$), colorectal cancer ($n = 7$), prostate cancer ($n = 5$), and gastrointestinal cancers ($n = 6$). Other types, including lymphoma, multiple myeloma, and gynaecologic cancers, were also investigated. Study sample sizes varied widely, ranging from 51 to 60,265 participants. The majority of studies focused on older adults, especially those at heightened risk of falls due to cancer treatments and related comorbidities.

Meta-analysis

Prevalence of falls among geriatric cancer patients

Meta-analysis of 86 studies including 180,974 participants, the pooled prevalence of falls among geriatric cancer patients was estimated at 24% (95% CI, 20%–28%) (Fig. 2). The prediction interval ranged widely, from 4 to 68%, reflecting considerable variability between studies (Table 2). A high degree of heterogeneity was noted ($I^2 = 100\%$, $P < 0.001$). The leave-one-out sensitivity analysis (Figure S1) demonstrated that excluding individual studies had minimal impact on the overall pooled prevalence of falls among geriatric cancer patients, which consistently stayed at around 24% (95% CI: 0.2–0.28). The slight variations observed across duplications of the meta-analysis results. Despite significant heterogeneity ($I^2 = 100\%$), the stability of the pooled estimates suggests that no single study excessively influenced the final outcomes, thereby confirming the reliability of the findings. Following the exclusion of outliers, a reanalysis was performed. This refined analysis resulted in a slightly lower pooled prevalence of 23% (95% CI, 21%–24%). The prediction interval narrowed to 17% to 30%, indicating

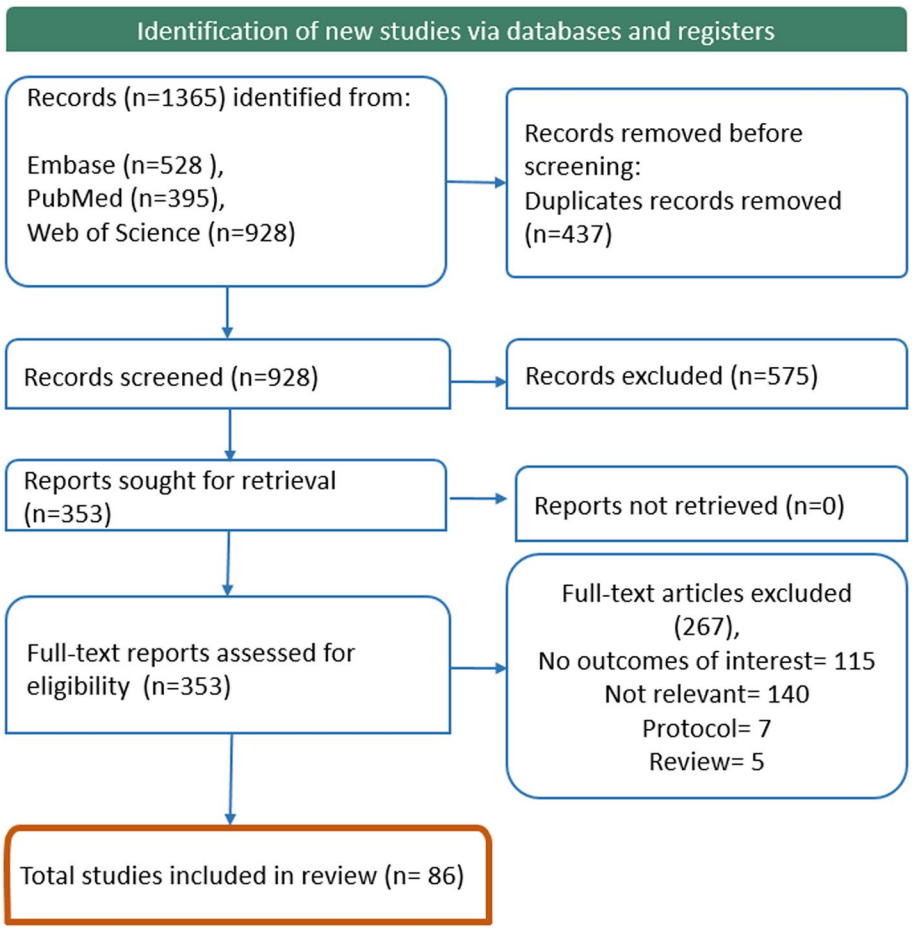

Fig. 1 PRISMA flow diagram

reduced variability between the studies (Fig. 3). Furthermore, the heterogeneity decreased markedly to $I^2 = 75\%$ ($P < 0.001$), suggesting a more consistent pattern among the remaining studies after outliers were removed.

Sub-group analysis The pooled prevalence of falls among older adults cancer patients varied across cancer types, study designs, and countries, as shown in the Table 2. Breast cancer had the highest prevalence at 32% (I2 = 94%), while colorectal and gastrointestinal cancers had prevalence of 15% (I2 = 100%) and 28% (I2 = 98%), respectively. Across all cancer types, the overall pooled prevalence was 24% (95% CI: 0.17–0.33), with substantial heterogeneity (I2 = 99%). Prevalence also differed by study design, with cross-sectional studies reporting the highest prevalence at 30% (I2 = 99%), followed by prospective studies at 24% (I2 = 98%) and retrospective studies at 14% (I2 = 100%). Randomized clinical trials showed a lower prevalence of 18% (I2 = 88%). The pooled prevalence across all study designs was 24% (95% CI: 0.20–0.28, I2 = 100%). Country-specific analysis revealed that the United States had a pooled prevalence of 22% (I2 = 100%) across 33 studies, Canada 23% (I2 = 95%), and France 58% (I2 = 98%). Denmark reported a lower prevalence of 12%, while Spain had a higher rate at 55% (I2 = 98%). In Korea and Japan, the prevalence were 50% and 41%, respectively. Overall, the pooled prevalence across all countries was 23% (95% CI: 0.17–0.30), with significant regional variability.

Risk of falls among geriatric cancer patients

The forest plot (Fig. 4) compares the fall risk between geriatric cancer patients and non-cancer controls, incorporating data from six studies. The pooled risk ratio (RR) was 1.099 (95% CI: 0.558–2.164), indicating no statistically significant difference in fall risk between the groups, although substantial heterogeneity was present (I2 = 96%). Sensitivity analysis showed that excluding individual studies had little impact on the overall pooled risk. For instance, when Wildes et al. [88] was excluded,

Table 1 Characteristics of studies

Study	country	Study design	Age (mean)	N
Abraham_2011 [14]	USA	Retrospective	74.5	60,265
Aburub_2020 [15]	Canada	Cross-sectional	69.3	175
Anderson_2022 [16]	USA	Cross-sectional	75(median)	1024
Arora_2022 [17]	USA	Cross-sectional	70	505
Arrieta_2019 [18]	France	Randomized clinical trial	76.7	301
Bartlett_2020 [19]	USA	Retrospective	75.8	425
Basal_2019 [20]	USA	Prospective	63	667
Bjerre_2019 [21]	Denmark	Randomized clinical trial	68.4	214
Blackwood_2021 [22]	USA	Prospective	72.62	34
Bluethmann_2020 [23]	USA	Cross-sectional	74.4	1203
Bylow_2008 [24]	USA	Prospective	78(median)	50
Chen_2014 [25]	USA	Prospective	75.41	1630
Childs_2021 [26]	USA	Retrospective	62	300
Cobbing_2024 [27]	Canada	Prospective	74	198
Eriksen_2022 [28]	Norway	Prospective	73.6	298
Fagard_2017 [29]	Belgium	Prospective	77(median)	115
Fahimnia_2018 [30]	USA	Retrospective	80(median)	806
Farcet_2016 [31]	France	Cross-sectional	83.2	217
Feliu_2021 [32]	Spain	Prospective	77(median)	493
Gewandter_2015 [33]	USA	Retrospective	80(median)	103
Godby_2021 [34]	USA	Cross-sectional	70.0	355
Grothe_2014 [35]	Germany	Retrospective	70	285
Guerard_2015 [36]	USA	Cross-sectional	71(median)	528
Gupta_2023 [37]	USA	Retrospective	62(median)	1571
Habib_2024 [38]	Canada	Cross-sectional	75.4	320
Hamid_2022 [39]	Ireland	Retrospective	76.49	94
Hines_2024 [40]	USA	Retrospective	71.7	4792
Huang_2017 [41]	USA	Cross-sectional	74.2	12,659
Hurria_2009 [42]	USA	Prospective	73	500
Hussain_2010 [9]	Canada	Prospective	69.6	260
Isleyen_2023 [43]	Turkey	Cross-sectional	73.0	180
Jensen-Battaglia_2022 [44]	USA	Randomized clinical trial	75.88	541
Jespersen_2021 [45]	Denmark	Prospective	75.5(median)	170
Ji_2024 [4]	USA	Prospective	70	497
Jolly_2015 [46]	Canada	Cross-sectional	77	90
Jun_2018 [47]	Korea	Retrospective	62.1	356
Kalariya_2024 [48]	USA	Retrospective	78.1	156
Kenis_2022 [49]	Belgium	Prospective	80.0(median)	3681
Kikuchi_2019 [50]	USA	Retrospective	76	429
Kim_2022 [51]	USA	Randomized clinical trial	68	122
Komatsu_2018 [52]	Japan	Cross-sectional	68	98
Kong_2014 [53]	China	Prospective	Not available	52
Korc-Grodzicki_2015 [54]	USA	Retrospective	80(median)	416
Liu_2023 [55]	China	Cross-sectional	71.29	161
LoConte_2013 [56]	USA	Retrospective	>64	36,781
Loh_2017 [57]	USA	Cross-sectional	81(median)	389
Lund_2024 [58]	Denmark	Prospective	74	238
Mariano_2015 [59]	Canada	Prospective	77	90
Martí-Dillet_2023 [60]	Spain	Prospective	Not available	117

Table 1 (continued)

Study	country	Study design	Age (mean)	N
May_2020 [61]	Ireland	Prospective	77.7	174
Mir_2020 [62]	USA	Cross-sectional	70	264
Mohamed_2024 [63]	USA	Randomized clinical trial	77.2	616
Mohile_2011 [8]	USA	Cross-sectional	76.19	2349
Nassani_2013 [64]	Lebanon	Cross-sectional	76(median)	100
Overcash_2007 [65]	USA	Prospective	77.6	165
Paillaud_2014 [66]	France	Prospective	80.0	519
Pan_2020 [67]	USA	Randomized clinical trial	70	2019
Pandya_2016 [68]	USA	Cross-sectional	78.5	24,271
Patel_2015 [69]	Australia	Retrospective	77(median)	385
Pautex_2008 [70]	Switzerland	Prospective	71.0	198
Peeters_2019 [71]	Belgium	Prospective	> 70	3681
Pergolotti_2014 [72]	USA	Retrospective	71(median)	524
Piper_2024 [73]	Denmark	Cross-sectional	74.4	200
Pollock_2023 [74]	USA	Randomized clinical trial	74.0(median)	803
Rattanakrong_2022 [75]	Thailand	Prospective	Not available	123
Reyes_2023 [76]	USA	Retrospective	67.7	83
Rosko_2019 [77]	USA	Prospective	Not available	100
Saarelainen_2014 [78]	Australia	Prospective	76.7	383
Sattar_2019 [79]	Canada	Cross-sectional	76(median)	100
Spoelstra_2010 [7]	USA	Cross-sectional	79.5	911
Sulicka_2018 [80]	Poland	Cross-sectional	79.4	286
Tennison_2021 [81]	USA	Prospective	Not available	198
Tomczak_2021 [82]	USA	Prospective	72.2	51
Turner_2016 [83]	Australia	Cross-sectional	76.7	385
Vande Walle_2014 [84]	Belgium	Prospective	76	937
Vetrano_2016 [85]	Europe	Retrospective	82.2	802
Villani_2022 [86]	Italy	Cross-sectional	83.4	442
Whittle_2017 [87]	UK	Prospective	73.9	417
Wildes_2018 [3]	USA	Case–control	76.4	234
Wildes_2018 [88]	USA	Cross-sectional	73	498
Williams_2015 [89]	USA	Prospective	73	1172
Williams_2020 [90]	USA	Prospective	70.1(median)	336
Winters-Stone_2011 [91]	USA	Retrospective	Not available	143
Wu_2016 [92]	Taiwan	Retrospective	74.2	1748
Zak_2017 [93]	Poland	Cross-sectional	70.2	102
Zhang_2018 [94]	USA	Retrospective	78.4	304

the pooled risk ratio decreased to 0.9 (95% CI: 0.52–1.57), with I2 remaining at 96%. Conversely, omitting Spoelstra et al. [7] increased the risk ratio to 1.3 (95% CI: 0.6–2.5), reducing heterogeneity to I2 = 83% (Figure S2).

Meta-regression

The bubble plot shows the meta-regression that analysed the impact of sample size on the rate of falls among older adult cancer patients. The meta-regression analysis indicated that changes in the pooled prevalence were not significantly affected by variations in sample size, with a *p*-value of 0.5577 (Fig. 5).

Publication bias

The Doi plot (Figure S3) shows substantial asymmetry, with an LFK index of −4.1, indicating the presence of publication bias. The asymmetry suggests potential issues with the included studies, affecting the consistency of the pooled estimates. This bias may influence the overall reliability of the results.

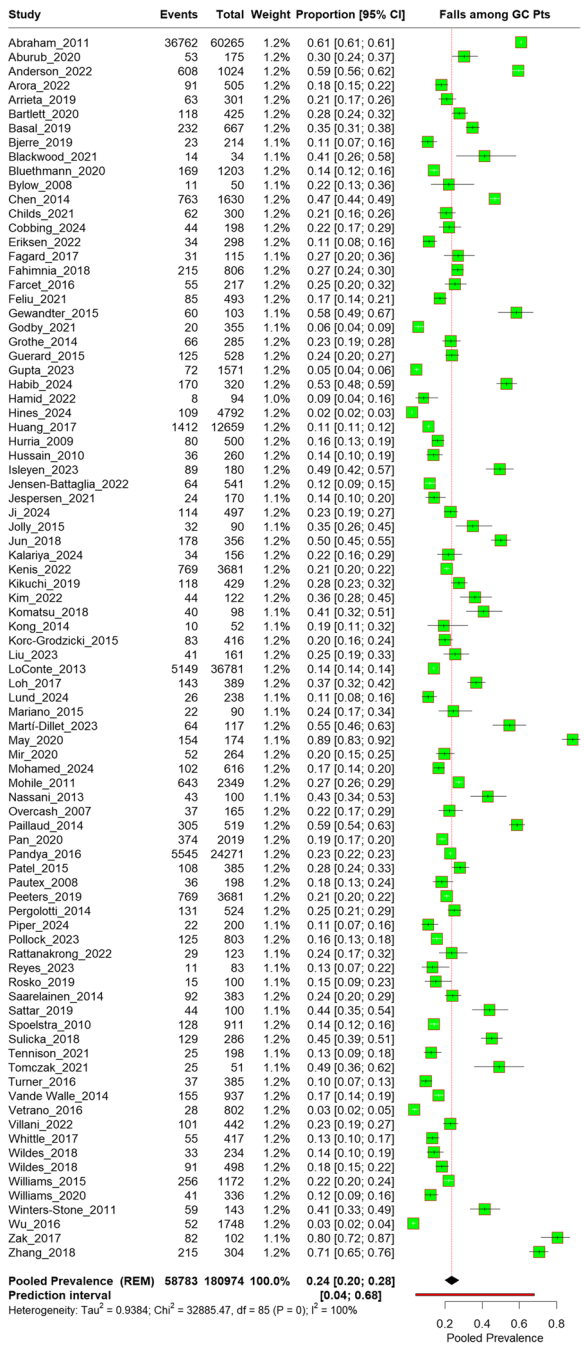

Fig. 2 Forest plot illustrating the pooled prevalence of falls among geriatric cancer patients

Discussion

This meta-analysis identified a pooled fall prevalence of 24% (95% CI: 20%–28%) across 86 studies, highlighting the significant risk faced by geriatric cancer patients. The high heterogeneity observed (I2 = 100%) suggests considerable variability across studies, likely attributable to differences in cancer types, treatments, and study designs. Notably, breast cancer patients exhibited the highest fall prevalence at 32%, while colorectal and gastrointestinal cancer patients had lower rates of 15% and 28%, respectively. These findings underscore the need for cancer-specific considerations when evaluating fall risk in older adults. The analysis also revealed that cross-sectional studies reported a higher fall prevalence (30%) than prospective (24%) and retrospective (14%) studies, emphasizing the influence of study design on reported outcomes. Despite this heterogeneity, sensitivity analyses confirmed the robustness of the pooled estimates, indicating that the overall conclusions remain valid despite individual study differences.

A comparison of fall risk between cancer patients and non-cancer controls revealed no statistically significant difference overall (RR: 1.099, 95% CI: 0.558–2.164). However, individual studies presented mixed findings, such as Spoelstra et al. [7], which reported a reduced fall risk (RR: 0.476) among cancer patients, and Wildes et al. [88], which documented an elevated fall risk (RR: 3.249). These discrepancies likely stem from variations in patient characteristics, study methodologies, and cancer treatments. Nonetheless, the overall analysis suggests that fall risk is not uniformly higher across all cancer subgroups, emphasizing the need for context-specific assessments in clinical practice.

Several factors likely contribute to the increased fall risk observed in geriatric cancer patients. Cancer treatments, including chemotherapy, radiotherapy, and hormone therapy, are associated with well-documented side effects such as fatigue, neuropathy, and muscle weakness, all of which increase fall risk [36]. In breast cancer patients, aromatase inhibitors exacerbate joint pain and mobility limitations, leading to increased falls [23]. Similarly, prostate cancer patients on androgen deprivation therapy (ADT) experience muscle wasting and bone density loss, further elevating their fall risk, as noted in Wildes et al. (2018) [3, 88]. In addition to treatment effects, age-related frailty compounds fall risk, as older adults with cancer often present with comorbid conditions such as osteoporosis, cardiovascular disease, and diabetes, all of which heighten fall susceptibility. The interaction between cancer, its treatment, and underlying frailty underscores the complexity of fall risk management in this population.

Clinically, these findings highlight the critical need for routine fall risk assessments in geriatric oncology care. Given the multifactorial nature of falls in this population, clinicians should adopt multidisciplinary approaches that incorporate physical therapy, balance training, and medication reviews to mitigate fall risk

Table 2 Subgroup analysis based on study design, country-specific, cancer types

Subgroup	Type	No. of studies	Sample size (N)	Pooled prevalence [95% CI]	Heterogeneity (I^2)	*P*-value
Study design	Retrospective	21	110,768	24.5% [19.6%–30.3%]	100%	< 0.01
	Cross-sectional	26	47,677	28.2% [23.1%–33.6%]	99%	< 0.01
	Randomized Clinical Trial	7	4,616	18.0% [12.0%–25.0%]	88%	< 0.01
	Prospective	31	75,444	24.7% [19.6%–31.1%]	98%	< 0.01
	Case–control	1	234	14.0% [10.0%–19.0%]	Not applicable	Not applicable
Country	Australia	3	1,153	19% [4%–37%]	97%	< 0.01
	Belgium	3	8,444	20% [15%–26%]	0%	0.71
	Canada	6	4,003	34% [25%–43%]	95%	< 0.01
	China	2	213	24% [5%–67%]	67%	0.36
	Denmark	4	822	11% [7%–14%]	0%	0.71
	Europe	1	82	3% [2%–5%]	Not applicable	Not applicable
	France	3	1,037	49% [30%–68%]	98%	< 0.01
	Germany	1	285	23% [19%–28%]	Not applicable	Not applicable
	Ireland	2	262	4% [0%–10%]	99%	< 0.01
	Italy	1	442	23% [19%–27%]	Not applicable	Not applicable
	Japan	1	98	41% [32%–51%]	Not applicable	Not applicable
	Korea	1	356	50% [45%–55%]	Not applicable	Not applicable
	Lebanon	1	100	43% [34%–53%]	Not applicable	Not applicable
	Poland	2	383	45% [30%–51%]	97%	< 0.01
	Spain	2	610	36% [5%–63%]	98%	< 0.01
	Switzerland	1	198	18% [13%–24%]	Not applicable	Not applicable
	Taiwan	1	1,748	3% [2%–4%]	Not applicable	Not applicable
	Thailand	1	123	24% [17%–32%]	Not applicable	Not applicable
	Turkey	1	180	49% [42%–57%]	Not applicable	Not applicable
	UK	1	417	14% [10%–17%]	Not applicable	Not applicable
	USA	36	161,654	22% [18%–27%]	95%	< 0.01

Table 2 (continued)

Subgroup	Type	No. of studies	Sample size (N)	Pooled prevalence [95% CI]	Heterogeneity (I^2)	*P*-value
Cancer type	Breast cancer	11	3,056	32% [21%–46%]	94%	< 0.01
	Colorectal cancer	4	67,597	15% [1%–78%]	100%	< 0.01
	Endometrial cancer	1	1,024	59% [56%–62%]	Not applicable	Not applicable
	Esophageal cancer	1	300	21% [16%–26%]	Not applicable	Not applicable
	Gastrointestinal cancer	5	1,019	28% [7%–68%]	98%	< 0.01
	Gynaecologic cancer	1	90	24% [17%–34%]	Not applicable	Not applicable
	Lymphoma	1	301	21% [17%–26%]	Not applicable	Not applicable
	Multiple myeloma	1	234	14% [10%–19%]	Not applicable	Not applicable
	Prostate cancer	4	2,210	11% [2%–41%]	97%	< 0.01

[95]. These interventions are particularly important for high-risk subgroups, such as breast cancer patients on aromatase inhibitors and prostate cancer patients receiving ADT [96]. Moreover, integrating personalized fall prevention strategies into cancer treatment plans could significantly reduce fall-related injuries and hospitalizations, improving overall patient outcomes [97]. From a public health perspective, community-based programs that promote physical activity and home safety modifications could play a key role in reducing fall incidence among older cancer patients. Such initiatives, when coupled with clinical interventions, could lessen the burden of falls and enhance the quality of life for this vulnerable population [98].

Despite the robustness of the findings, the high heterogeneity observed in this analysis indicates that further research is necessary to better understand the factors contributing to fall risk variability. Prospective cohort studies focused on specific cancer types and treatments would be instrumental in elucidating the long-term effects of these therapies on fall risk. For example, studies examining the impact of chemotherapy-induced neuropathy or hormone therapy-induced frailty could provide valuable insights into targeted interventions aimed at reducing fall risk [99]. Moreover, future research should explore the role of sarcopenia and frailty as mediators between cancer treatment and falls. Studies such as Kenis et al. [49] have already begun investigating the potential of geriatric screening to identify patients at high risk of falls, and further work in this area could refine risk stratification in clinical practice [49].

Addressing publication bias, as indicated by the asymmetry observed in the Doi plot, is also critical for enhancing the accuracy of future meta-analyses. Ensuring that smaller or negative studies are adequately represented will help create a more comprehensive understanding of fall risk in geriatric cancer patients. Future research should prioritize efforts to address these gaps, ultimately leading to more effective fall prevention strategies and better patient outcomes in this high-risk population.

Conclusion

This meta-analysis provides a comprehensive assessment of the prevalence of falls among geriatric cancer patients, with an overall estimate of 24%. Significant variability was observed across subgroups, including cancer types, study designs, and geographic regions, indicating the need for tailored interventions. Despite the high heterogeneity, sensitivity analyses confirmed the robustness of the pooled estimates. No statistically significant difference in fall risk was observed when

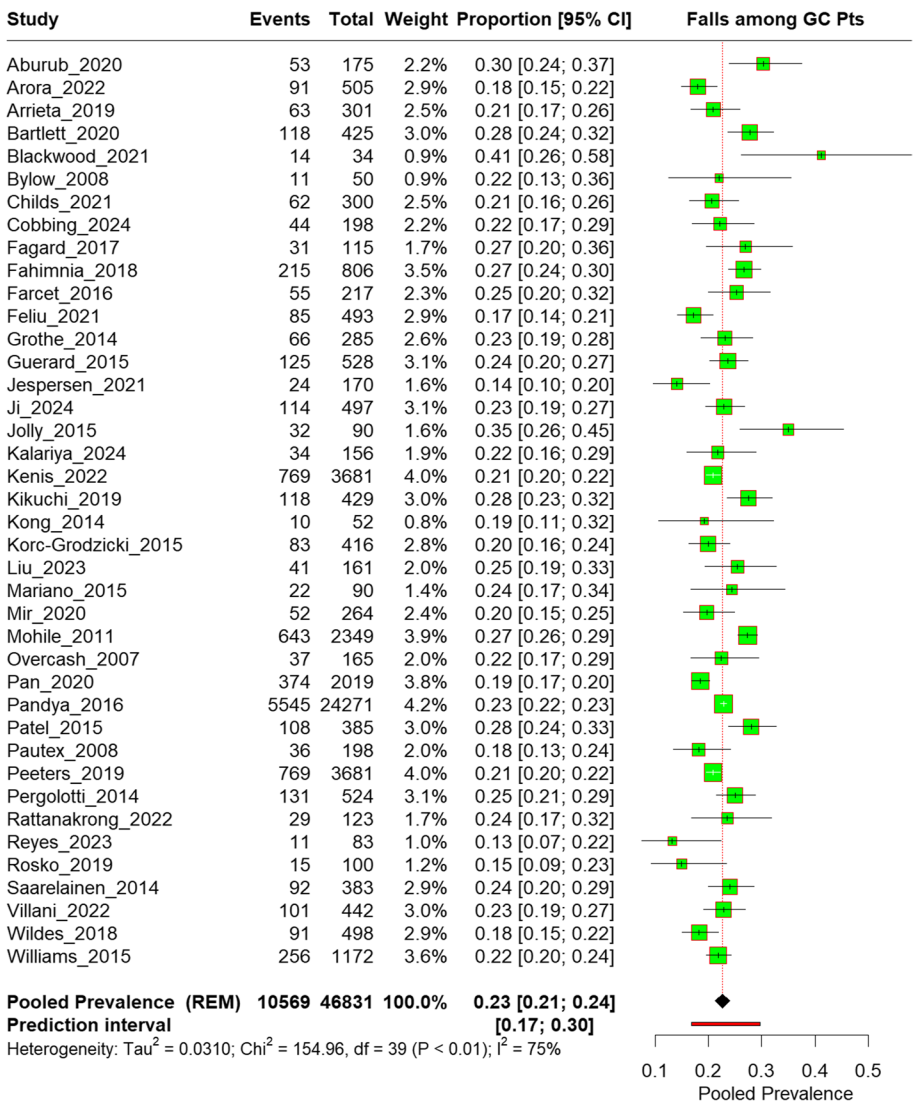

Fig. 3 Forest plot illustrating the pooled prevalence of falls among geriatric cancer patients after the exclusion of outliers

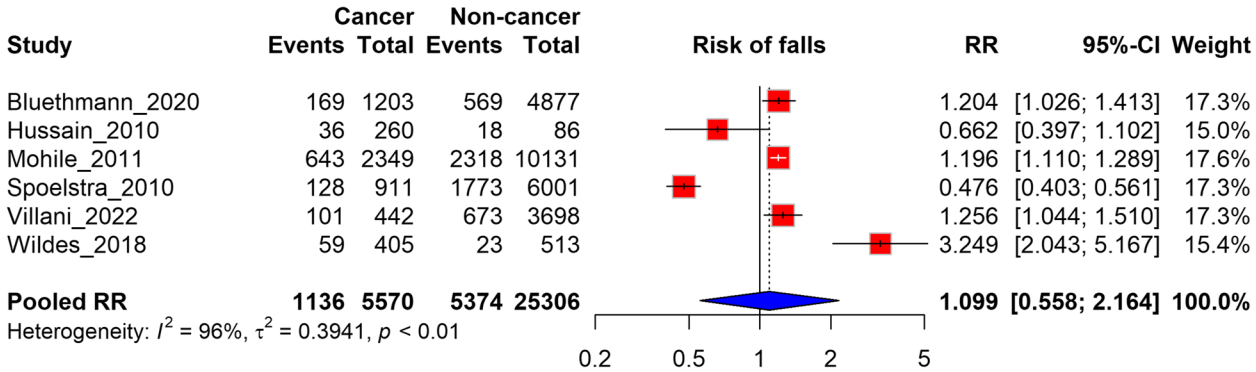

Fig. 4 Forest plot interprets the risk of falls among geriatric cancer patients compared to non-cancer controls

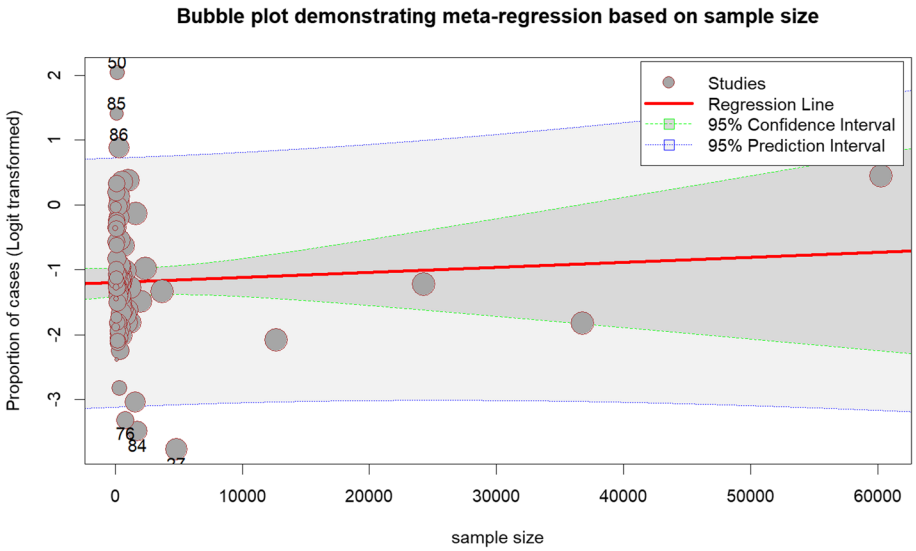

Fig. 5 Bubble plot demonstrating meta-regression based on sample size and its effect on the proportion of falls in geriatric cancer patients

comparing geriatric cancer patients to non-cancer controls. These findings highlight the importance of implementing personalized fall prevention strategies and underscore the need for further research to address the factors contributing to fall risk in this vulnerable population.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12877-025-05722-1.

Supplementary Material 1: Table S1. PRISMA checklist. Table S2. Inclusion and Exclusion criteria. Table S3. The adjusted search terms as per searched electronic databases. Table S4. Modified-Newcastle–Ottawa Scale (NOS). Figure S1. Sensitivity analysis (Leave-one-out) assessing the influence of individual studies on the pooled prevalence of falls. Figure S2. Leave-one-out meta-analysis showing the risk of falls in geriatric cancer versus non-cancer patients. Figure S3. DOI plot with LFK index assessing publication bias in the meta-analysis of falls among geriatric cancer patients.

Acknowledgements
The authors acknowledge Nested-Knowledge, MN, USA for providing access to the software.

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Conceptualization: G.B., D.L., S.G., A.K.B. Data curation: G.P., I.K., M.L., S.I. Formal analysis: G.V.S.P., A.P., T.V., P.M. Investigation: P.S., M.P.S., A.Y., A.P. Methodology: M.J., M.S., R.M., S.S. Project administration: Q.S.Z., G.B., D.L., S.G. Resources: A.K.B., G.P., I.K., M.L. Software: S.I., G.V.S.P., A.P., T.V. Supervision: P.M., P.S., M.P.S., A.Y. Validation: A.P., M.J., M.S., R.M. Visualization: S.S., Q.S.Z., G.B., D.L. Writing – original draft: S.G., A.K.B., G.P., I.K. Writing – review & editing: M.L., S.I., G.V.S.P., A.P.

Funding
This study received no funding.

Data availability
All data generated or analyzed during this study are included in this published article (and its Supplementary information files).

Declarations

Ethics approval and consent to participate
Not applicable, as there were no human participants involved in this study.

Consent for publication
Not applicable, as this study does not involve any individual person's data in any forms.

Competing interests
The authors declare no competing interests.

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Received: 21 October 2024 Accepted: 20 January 2025
Published online: 15 March 2025

References

1. Vaishya R, Vaish A. Falls in older adults are serious. Indian J Orthop. 2020;54(1):69–74.
2. Ambrose AF, Paul G, Hausdorff JM. Risk factors for falls among older adults: a review of the literature. Maturitas. 2013;75(1):51–61.
3. Wildes TM, Fiala MA. Falls in older adults with multiple myeloma. Eur J Haematol. 2018;100(3):273–8.
4. Ji J, Bae M, Sun CL, Wildes TM, Freedman RA, Magnuson A, et al. Falls prechemotherapy and toxicity-related hospitalization during adjuvant chemotherapy for breast cancer in older women: Results from the prospective multicenter HOPE trial. Cancer. 2024;130(6):936–46.
5. Fernández-Camacho E, Ferrer-Ramos C, Morilllo-Macías V, Rodríguez-Cordón M, Sánchez-Iglesias Á, Beato-Tortajada I, et al. The impact of frailty screening on radiation treatment modification. Cancers. 2022;14(4):1072.
6. Pandya C, Magnuson A, Flannery M, Zittel J, Duberstein P, Loh KP, et al. Association between symptom burden and physical function in older patients with cancer. J Am Geriatr Soc. 2019;67(5):998–1004.
7. Spoelstra S, Given B, von Eye A, Given C. Fall risk in community-dwelling elderly cancer survivors: a predictive model for gerontological nurses. J Gerontol Nurs. 2010;36(2):52–60.
8. Mohile SG, Fan L, Reeve E, Jean-Pierre P, Mustian K, Peppone L, et al. Association of cancer with geriatric syndromes in older Medicare beneficiaries. J Clin Oncol. 2011;29(11):1458–64.
9. Hussain S, Breunis H, Timilshina N, Alibhai SM. Falls in men on androgen deprivation therapy for prostate cancer. Journal of Geriatric Oncology. 2010;1(1):32–9.
10. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372.
11. Bushi G, Shabil M, Padhi BK, Ahmed M, Pandey P, Satapathy P, et al. Prevalence of acute kidney injury among dengue cases: a systematic review and meta-analysis. Trans R Soc Trop Med Hyg. 2023;118(1):1–11.
12. Langan D, Higgins JP, Jackson D, Bowden J, Veroniki AA, Kontopantelis E, et al. A comparison of heterogeneity variance estimators in simulated random-effects meta-analyses. Research synthesis methods. 2019;10(1):83–98.
13. Gandhi AP, Shamim MA, Padhi BK. Steps in undertaking meta-analysis and addressing heterogeneity in meta-analysis. The Evidence. 2023;1(1):44–59.
14. Abraham NS, Kunik M, Richardson PA, Castillo DL, Naik AD. Life expectancy of colorectal cancer patients with geriatric syndromes. Gastroenterology. 2011;140(5):S–206.
15. Ala'S A, Phillips SP, Curcio C-L, Guerra RO, Auais M. Fear of falling in community-dwelling older adults diagnosed with cancer: a report from the International Mobility in Aging Study (IMIAS). J Geriatr Oncol. 2020;11(4):603–9.
16. Anderson C, Olshan A, Bae-Jump V, Park J, Brewster W, Kent E, Nichols HB. Falls, walking or balance problems, and limitations in activities of daily living (ADLs) among older endometrial cancer survivors. Support Care Cancer. 2022;30(7):6339–51.
17. Arora S, Fowler ME, Harmon C, Al-Obaidi M, Outlaw D, Hollis R, et al. Differences in pretreatment frailty across gastrointestinal cancers in older adults: Results from the cancer and aging resilience evaluation registry. JCO Oncology Practice. 2022;18(11):e1796–806.
18. Arrieta H, Astrugue C, Regueme S, Durrieu J, Maillard A, Rieger A, et al. Effects of a physical activity programme to prevent physical performance decline in onco-geriatric patients: a randomized multicentre trial. J Cachexia Sarcopenia Muscle. 2019;10(2):287–97.
19. Bartlett DB, Broadwater G, White HK, Shelby R, Zullig LL, Robertson J, et al. Factors associated with falls in older women with breast cancer: the use of a brief geriatric screening tool in clinic. Breast Cancer Res Treat. 2020;184:445–57.
20. Basal C, Vertosick E, Gillis TA, Li Q, Bao T, Vickers A, Mao JJ. Joint pain and falls among women with breast cancer on aromatase inhibitors. Support Care Cancer. 2019;27:2195–202.
21. Bjerre ED, Petersen TH, Jørgensen AB, Johansen C, Krustrup P, Langdahl B, et al. Community-based football in men with prostate cancer: 1-year follow-up on a pragmatic, multicentre randomised controlled trial. PLoS Med. 2019;16(10): e1002936.
22. Blackwood J, Rybicki K. Assessment of gait speed and timed up and go measures as predictors of falls in older breast cancer survivors. Integr Cancer Ther. 2021;20:15347354211006462.
23. Bluethmann SM, Flores E, Campbell G, Klepin HD. Mobility device use and mobility disability in US Medicare beneficiaries with and without cancer history. J Am Geriatr Soc. 2020;68(12):2872–80.
24. Bylow K, Dale W, Mustian K, Stadler WM, Rodin M, Hall W, et al. Falls and physical performance deficits in older patients with prostate cancer undergoing androgen deprivation therapy. Urology. 2008;72(2):422–7.
25. Chen T-Y, Janke MC. Predictors of falls among community-dwelling older adults with cancer: results from the health and retirement study. Support Care Cancer. 2014;22:479–85.
26. Childs DS, Yoon HH, Eiring RA, Jin Z, Jochum JA, Pitot HC, Jatoi A. Falls: descriptive rates and circumstances in age-unspecified patients with locally advanced esophageal cancer. Support Care Cancer. 2021;29:733–9.
27. Cobbing S, Timilshina N, Tomlinson G, Yang H, Kim VS, Emmenegger U, Alibhai SM. Falls in older adults during treatment for metastatic castration-resistant prostate cancer. J Geriatr Oncol. 2024;16:102047.
28. Eriksen GF, Šaltytė Benth J, Grønberg BH, Rostoft S, Kirkhus L, Kirkevold Ø, et al. Geriatric impairments are prevalent and predictive of survival in older patients with cancer receiving radiotherapy: a prospective observational study. Acta Oncol. 2022;61(4):393–402.
29. Fagard K, Casaer J, Wolthuis A, Flamaing J, Milisen K, Lobelle J-P, et al. Value of geriatric screening and assessment in predicting postoperative complications in patients older than 70 years undergoing surgery for colorectal cancer. Journal of geriatric oncology. 2017;8(5):320–7.
30. Fahimnia S, Mirhedayati Roudsari H, Doucette J, Shahrokni A. Falls in older patients with cancer undergoing surgery: prevalence and association with geriatric syndromes and levels of disability assessed in preoperative evaluation. Current gerontology and geriatrics research. 2018;2018(1):5713285.
31. Farcet A, De Decker L, Pauly V, Rousseau F, Bergman H, Molines C, Retornaz F. Frailty markers and treatment decisions in patients seen in onco-geriatric clinics: results from the ASRO pilot study. PLoS ONE. 2016;11(2): e0149732.
32. Feliu J, Espinosa E, Basterretxea L, Paredero I, Llabrés E, Jiménez-Munárriz B, et al. Prediction of unplanned hospitalizations in older patients treated with chemotherapy. Cancers. 2021;13(6):1437.
33. Gewandter JS, Dale W, Magnuson A, Pandya C, Heckler CE, Lemelman T, et al. Associations between a patient-reported outcome (PRO) measure of sarcopenia and falls, functional status, and physical performance in older patients with cancer. Journal of geriatric oncology. 2015;6(6):433–41.
34. Godby RC, Dai C, Al-Obaidi M, Giri S, Young-Smith C, Kenzik K, et al. Depression among older adults with gastrointestinal malignancies. Journal of geriatric oncology. 2021;12(4):599–604.
35. Jahrestagung der Deutschen, Österreichischen und Schweizerischen Gesellschaften für Hämatologie und Medizinische Onkologie, Hamburg, 10.-14. Oktober 2014: Abstracts. Oncol Res Treat. 2014;37(Suppl. 5):1–332.
36. Guerard EJ, Deal AM, Williams GR, Jolly TA, Nyrop KA, Muss HB. Falls in older adults with cancer: Evaluation by oncology providers. Journal of oncology practice. 2015;11(6):470–4.
37. Gupta E, Tennison JM, Shin KY, Fu JB, Rozman de Moraes A, Naqvi SMA, et al. Frequency, characteristics, and risk factors for falls at an inpatient cancer rehabilitation unit. JCO Oncol Pract. 2023;19(9):741–9.
38. Habib MH, Alibhai SM, Puts M. How representative are participants in geriatric oncology clinical trials? The case of the 5C RCT in geriatric oncology: a cross-sectional comparison to a geriatric oncology clinic. Journal of Geriatric Oncology. 2024;15(2): 101703.
39. Hamid M, Hannan M, Myo Oo N, Lynch P, Walsh DJ, Matthews T, et al. Chemotherapy toxicity in older adults optimized by geriatric

assessment and intervention: a non-comparative analysis. Curr Oncol. 2022;29(9):6167–76.
40. Hines RB, Schoborg C, Sumner T, Thiesfeldt DL, Zhang S. The associations of oxaliplatin-induced peripheral neuropathy, sociodemographic characteristics, and clinical characteristics with time to fall in older adults with colorectal cancer. Am J Epidemiol. 2024;193(9):1271–80. https://doi.org/10.1093/aje/kwae067.
41. Huang MH, Blackwood J, Godoshian M, Pfalzer L. Prevalence of self-reported falls, balance or walking problems in older cancer survivors from Surveillance, Epidemiology and End Results—Medicare Health Outcomes Survey. J Geriatr Oncol. 2017;8(4):255–61.
42. Hurria A, Mohile S, Lichtman S, Owusu C, Klepin H, Gross C, et al. Geriatric assessment of older adults with cancer: baseline data from a 500 patient multicenter study. J Clin Oncol. 2009;27(15_suppl):9546.
43. Sucuoglu Isleyen Z, Besiroglu M, Yasin AI, Simsek M, Topcu A, Smith L, et al. The risk of malnutrition and its clinical implications in older patients with cancer. Aging Clin Exp Res. 2023;35(11):2675–83.
44. Jensen-Battaglia M, Lei L, Xu H, Loh KP, Wells M, Tylock R, et al. Communication about fall risk in community oncology practice: the role of geriatric assessment. JCO Oncol Pract. 2022;18(10):e1630–40.
45. Jespersen E, Winther SB, Minet LR, Möller S, Pfeiffer P. Frailty screening for predicting rapid functional decline, rapid progressive disease, and shorter overall survival in older patients with gastrointestinal cancer receiving palliative chemotherapy-a prospective, clinical study. J Geriatr Oncol. 2021;12(4):578–84.
46. Jolly TA, Mariano CJ, Deal AM, Williams GR, Alston SM, Bryant AL, et al. The association of Geriatric Assessment (GA) identified deficits and 30-day re-admission in hospitalized older cancer patients. American Society of Clinical Oncology; 2015.
47. Jun M, Lee K, Park S. Risk factors of falls among inpatients with cancer. Int Nurs Rev. 2018;65(2):254–61.
48. Kalariya NM, Hildebrandt MA, Hansen DK, Sidana S, Khouri J, Ferreri CJ, et al. Clinical outcomes after idecabtagene vicleucel in older patients with multiple myeloma: a multicenter real-world experience. Blood Adv. 2024;8(17):4679–88.
49. Kenis C, Decoster L, Flamaing J, Debruyne PR, De Groof I, Focan C, et al. Incidence of falls and fall-related injuries and their predictive factors in frail older persons with cancer: a multicenter study. BMC Geriatr. 2022;22(1):877.
50. Kikuchi R, Broadwater G, Shelby R, Robertson J, Zullig LL, Maloney B, et al. Detecting geriatric needs in older patients with breast cancer through use of a brief geriatric screening tool. Journal of geriatric oncology. 2019;10(6):968–72.
51. Kim J, Ferrell B, Raz D, Erhunmwunsee L, Teteh D, Dale W, et al. EP10. 01–012 geriatric assessment in patients undergoing lung cancer surgery and their family caregivers. J Thorac Oncol. 2022;17(9):S505.
52. Komatsu H, Yagasaki K, Komatsu Y, Yamauchi H, Yamauchi T, Shimokawa T, Doorenbos AZ. Falls and functional impairments in breast cancer patients with chemotherapy-induced peripheral neuropathy. Asia Pac J Oncol Nurs. 2019;6(3):253–60.
53. Kong QH, Wang Y, Song CG, Liu YS, Qin HY, Feng YD, Li YJ. Prospective analysis of the risk factors for falls in lymphoma patients. Eur J Oncol Nurs. 2014;18(5):540–4.
54. Korc-Grodzicki B, Sun SW, Zhou Q, Iasonos A, Lu B, Root JC, et al. Geriatric assessment as a predictor of delirium and other outcomes in elderly patients with cancer. Ann Surg. 2015;261(6):1085–90.
55. Liu X, Dong C, Zhao R, Gu Z, Sun C. Fall risk in older adults hospitalized with tumours: Contributing factors and prediction model. Nurs Open. 2023;10(10):7084–91.
56. LoConte NK, et al. Severe falls among older adults with resected stage II/III colon cancer receiving chemotherapy. JCO. 2013;31:e14550. https://doi.org/10.1200/jco.2013.31.15_suppl.e14550.
57. Loh KP, Pandya C, Zittel J, Kadambi S, Flannery M, Reizine N, et al. Associations of sleep disturbance with physical function and cognition in older adults with cancer. Support Care Cancer. 2017;25:3161–9.
58. Lund CM, Nielsen DL, Schultz M, Dolin TG. Physical decline, falls, and hospitalization among vulnerable older patients in the trajectory of colorectal cancer treatment. J Geriatr Oncol. 2024;15(7): 101820.
59. Mariano C, Williams G, Deal A, Alston S, Bryant AL, Jolly T, Muss HB. Geriatric assessment of older adults with cancer during unplanned hospitalizations: an opportunity in disguise. Oncologist. 2015;20(7):767–72. https://doi.org/10.1634/theoncologist.2015-0023.
60. Martí-Dillet MM, Fernández-Rodriguez C, Ginesta-Guanter A, Suñer-Soler R. Accumulated incidence of falls in people hospitalised with cancer and related factors. Nurs Open. 2023;10(8):5571–7.
61. May P, Roe L, McGarrigle CA, Kenny RA, Normand C. End-of-life experience for older adults in Ireland: results from the Irish longitudinal study on ageing (TILDA). BMC Health Serv Res. 2020;20:1–10.
62. Mir N, MacLennan P, Al-Obaidi M, Murdaugh D, Kenzik KM, McDonald A, et al. Patient-reported cognitive complaints in older adults with gastrointestinal malignancies at diagnosis–Results from the Cancer & Aging Resilience Evaluation (CARE) study. J Geriatr Oncol. 2020;11(6):982–8.
63. Mohamed MR, Juba K, Awad H, Flannery M, Culakova E, Wells M, et al. Effect of polypharmacy and potentially inappropriate medications on physical functional decline among older adults with advanced cancer receiving systemic treatment. Support Care Cancer. 2024;32(10):1–9.
64. Nassani NA, et al. The ability of physical performance test and Karnofsky performance status to identify elderly cancer patients requiring a comprehensive geriatric assessment: a comparative study. JCO. 2013;31:e20534. https://doi.org/10.1200/jco.2013.31.15_suppl.e20534.
65. Overcash J. Prediction of falls in older adults with cancer: a preliminary study. Oncol Nurs Forum. 2007;34(2):341–6. https://doi.org/10.1188/07.ONF.341-346.
66. Paillaud E, Liuu E, Laurent M, Le Thuaut A, Vincent H, Raynaud-Simon A, et al. Geriatric syndromes increased the nutritional risk in elderly cancer patients independently from tumoursite and metastatic status. The ELCAPA-05 cohort study. Clin Nutr. 2014;33(2):330-5.
67. Pan K, Ray RM, Cauley JA, Shadyab AH, Hurria A, Chlebowski RT. Trajectory of recurrent falls in post-menopausal breast cancer survivors and in matched cancer-free controls. Breast Cancer Res Treat. 2020;180:767–75.
68. Pandya C, Magnuson A, Dale W, Lowenstein L, Fung C, Mohile SG. Association of falls with health-related quality of life (HRQOL) in older cancer survivors: a population based study. J Geriatr Oncol. 2016;7(3):201–10.
69. Abstracts P. Asia Pac J Clin Oncol. 2015;11(S3):50–69.
70. Pautex S, Herrmann FR, Zulian GB. Factors associated with falls in patients with cancer hospitalized for palliative care. J Palliat Med. 2008;11(6):878–84.
71. Peeters L, De Cock J, Kenis C, Wildiers H, Decoster L, Laethem L, et al. Risk factors for falls in older persons with cancer: a multicenter study. J Geriatr Oncol. 2019;10(6):S23.
72. Pergolotti M, et al. The underutilization of occupational and physical therapy for older adults with cancer. JCO. 2014;32:9548. https://doi.org/10.1200/jco.2014.32.15_suppl.9548.
73. Piper KS, Myhre KK, Jensen HE, Madsen K, Mikkelsen MK, Lund C. Dizziness and impaired walking balance in aging patients during chemotherapy. J Geriatr Oncol. 2024;15(8): 102059.
74. Pollock Y, Smith MR, Saad F, Chowdhury S, Oudard S, Hadaschik B, et al. Clinical characteristics associated with falls in patients with non-metastatic castration-resistant prostate cancer treated with apalutamide. Prostate Cancer Prostatic Dis. 2023;26(1):156–61.
75. Rattanakrong N, Siriphorn A, Boonyong S. Incidence and risk factors associated with falls among women with breast cancer during taxane-based chemotherapy. Support Care Cancer. 2022;30(9):7499–508.
76. Reyes KR, Huang C-Y, Lo M, Arora S, Chung A, Wong SW, et al. Safety and efficacy of BCMA CAR-T cell therapy in older patients with multiple myeloma. Transplant Cell Ther. 2023;29(6):350–5.
77. Rosko AE, Huang Y, Benson DM, Efebera YA, Hofmeister C, Jaglowski S, et al. Use of a comprehensive frailty assessment to predict morbidity in patients with multiple myeloma undergoing transplant. J Geriatr Oncol. 2019;10(3):479–85.
78. Saarelainen LK, Turner JP, Shakib S, Singhal N, Hogan-Doran J, Prowse R, et al. Potentially inappropriate medication use in older people with cancer: prevalence and correlates. J Geriatr Oncol. 2014;5(4):439–46.
79. Sattar S, Alibhai SM, Spoelstra SL, Puts MT. The assessment, management, and reporting of falls, and the impact of falls on cancer treatment in community-dwelling older patients receiving cancer treatment: Results from a mixed-methods study. Journal of geriatric oncology. 2019;10(1):98–104.
80. Sulicka J, Pac A, Puzianowska-Kuźnicka M, Zdrojewski T, Chudek J, Tobiasz-Adamczyk B, et al. Health status of older cancer survivors—results of the PolSenior study. J Cancer Surviv. 2018;12:326–33.

81. Tennison JM, Ng AH, Rianon NJ, Liu DD, Bruera E. Patient-reported continuity of care and functional safety concerns after inpatient cancer rehabilitation. Oncologist. 2021;26(10):887–96.
82. Tomczak U, Sattar S, Schoenbeck KL, Cordner T, Wildes TM. Circumstances around falls in older adults with Cancer. J Geriatr Oncol. 2021;12(1):91–5.
83. Turner JP, Jamsen KM, Shakib S, Singhal N, Prowse R, Bell JS. Polypharmacy cut-points in older people with cancer: how many medications are too many? Support Care Cancer. 2016;24:1831–40.
84. Vande Walle N, Kenis C, Heeren P, Van Puyvelde K, Decoster L, Beyer I, et al. Fall predictors in older cancer patients: a multicenter prospective study. BMC Geriatr. 2014;14:1–10.
85. Vetrano DL, Foebel AD, Marengoni A, Brandi V, Collamati A, Heckman GA, et al. Chronic diseases and geriatric syndromes: The different weight of comorbidity. Eur J Intern Med. 2016;27:62–7.
86. Villani ER, Fusco D, Franza L, Onder G, Bernabei R, Colloca GF. Characteristics of patients with cancer in European long-term care facilities. Aging Clin Exp Res. 2022;34:1–8.
87. Whittle A, Kalsi T, Babic-Illman G, Wang Y, Fields P, Ross P, et al. A comprehensive geriatric assessment screening questionnaire (CGA-GOLD) for older people undergoing treatment for cancer. Eur J Cancer Care. 2017;26(5): e12509.
88. Wildes TM, Maggiore RJ, Tew WP, Smith D, Sun C-L, Cohen H, et al. Factors associated with falls in older adults with cancer: a validated model from the Cancer and Aging Research Group. Support Care Cancer. 2018;26:3563–70.
89. Williams GR, Deal AM, Nyrop KA, Pergolotti M, Guerard EJ, Jolly TA, Muss HB. Geriatric assessment as an aide to understanding falls in older adults with cancer. Support Care Cancer. 2015;23:2273–80.
90. Williams GR, Al-Obaidi M, Dai C, Mir N, Challa SA, Daniel M, et al. Association of malnutrition with geriatric assessment impairments and health-related quality of life among older adults with gastrointestinal malignancies. Cancer. 2020;126(23):5147–55.
91. Winters-Stone KM, Torgrimson B, Horak F, Eisner A, Nail L, Leo MC, et al. Identifying factors associated with falls in postmenopausal breast cancer survivors: a multi-disciplinary approach. Arch Phys Med Rehabil. 2011;92(4):646–52.
92. Wu F-J, Sheu S-Y, Lin H-C, Chung S-D. Increased fall risk in patients receiving androgen deprivation therapy for prostate cancer. Urology. 2016;95:145–50.
93. Zak M, Biskup M, Macek P, Krol H, Krupnik S, Opuchlik A. Identifying predictive motor factors for falls in post-menopausal breast cancer survivors. PLoS ONE. 2017;12(3): e0173970.
94. Zhang X, Sun M, Liu S, Leung CH, Pang L, Popat UR, et al. Risk factors for falls in older patients with cancer. BMJ Support Palliat Care. 2018;8(1):34–7.
95. Hopewell S, Adedire O, Copsey BJ, Boniface GJ, Sherrington C, Clemson L, et al. Multifactorial and multiple component interventions for preventing falls in older people living in the community. Cochrane Database Syst Rev. 2018;7(7):Cd012221.
96. Chaput G, Sumar N. Endocrine therapies for breast and prostate cancers: Essentials for primary care. Can Fam Physician. 2022;68(4):271–6.
97. Turner K, Staggs VS, Potter C, Cramer E, Shorr RI, Mion LC. Fall prevention practices and implementation strategies: examining consistency across hospital units. J Patient Saf. 2022;18(1):e236–42.
98. Guo X, Wang Y, Wang L, Yang X, Yang W, Lu Z, He M. Effect of a fall prevention strategy for the older patients: a quasi-experimental study. Nurs Open. 2023;10(2):1116–24.
99. Tofthagen C, Overcash J, Kip K. Falls in persons with chemotherapy-induced peripheral neuropathy. Support Care Cancer. 2012;20(3):583–9.

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