



# Incidence and risk factors for falls among nursing home residents in Italy: a retrospective cohort study

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## Abstract

**Background** Falls are a public health concern among older adults, particularly in nursing home (NH) residents, but in Italy data on fall incidence and risk factors remain limited.

**Aims** To estimate the incidence of falls, identify associated risk factors, and evaluate the predictive value of the Tinetti Performance-Oriented Mobility Assessment (T-POMA) in a large cohort of NH residents.

**Methods** We conducted a retrospective cohort study using electronic health records from 32 NHs managed by Kos Care company across Italy. Residents aged  $\geq 65$  years with at least one functional assessment were included. Fall incidence was calculated per 100 person-years. Cox proportional hazards regression models were used to identify predictors of time to first fall.

**Results** Overall, 754 residents (19.2%) experienced a fall. A T-POMA score  $\leq 18$  was a strong predictor of falls (HR 2.13; 95% CI: 1.61–2.81), along with age  $\geq 85$  years (HR 1.39; 1.02–1.90), male sex (HR 1.47; 1.27–1.71), cognitive impairment (HR 1.30; 1.10–1.53), hearing impairment (HR 1.26; 1.01–1.58), mood and behavioural disorders (HR 1.29; 1.09–1.54), and therapies known to increase fall risk (HR 1.29; 1.09–1.52). Poor general health (HR 0.63; 0.52–0.77) and frequent physical restraint (HR 0.70; 0.58–0.86) use were associated with lower fall risk. Severe fall consequences occurred in 15.9% of fallers and were significantly associated with low T-POMA scores and restraint use.

**Discussion and conclusion** Falls are highly prevalent among Italian NH residents and influenced by multiple clinical and functional factors. These findings support the implementation of multifactorial fall prevention strategies and real-time risk monitoring in NH settings.

**Keywords** Falls · Nursing homes · Older adults · Tinetti score · Functional assessment · Fall prevention

## Introduction

As the population ages, falls among older adults are becoming an increasingly common occurrence and a significant public health challenge, with around one in four adults aged 65 years and older reporting a fall each year—although variability exists across different settings [1]. Falls are also a major cause of injury, with up to 30% of older adults who experience a fall sustaining moderate to severe consequences—such as fractures and head trauma—which can lead to hospitalization, disability, and, in the most severe cases, death [2]. Beyond the physical consequences, falls also have a significant psychological impact. They can lead to a loss of confidence, post-fall anxiety, and fear of falling, which may exacerbate activity limitations and functional

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decline, increase the risk of future falls, and further impair the quality of life in older adults [3].

The NICE quality standard (UK National Institute for Health and Care Excellence) highlights that there are over 400 risk factors associated with falls, with the likelihood of falling increasing as the number of these risk factors rises [4]. Among older adults residing in care facilities, such as nursing homes (NHs), the fall rate exceeds 2.5 falls per person per year, which is approximately three times higher than that observed among community-dwelling older adults [5–7]. According to the US Centers for Disease Control and Prevention, up to one in five NH falls result in serious injuries, and approximately 1,800 NH residents die each year due to fall-related consequences [7].

The increased fall risk in NHs can be attributed to multiple factors, including residents' advanced age, underlying health conditions and multimorbidity (e.g., moderate-to-high disability, neurological diseases, cognitive decline), polypharmacy, limited self-care abilities, use of walking aids, and weakened social support [6, 8]. Furthermore, falling is an independent predictor of future falls [9].

International guidelines emphasize the importance of using standardized tools to quantify fall risk through gait and balance assessments [4, 10], and the Tinetti Performance-Oriented Mobility Assessment (T-POMA) is widely recognized for evaluating balance and gait abnormalities, as well as for predicting fall risk [11, 12–15]. To consolidate the evidence on the predictive validity of the T-POMA in high-risk populations, particularly NH residents, previous studies have highlighted the need for large prospective investigations [13, 16]. Furthermore, comprehensive analyses of NH residents with a history of falls and associated risk factors are essential—particularly in countries such as Italy, where data on falls in long-term care settings remain limited and there is a pressing need to advance the current epidemiological understanding.

Building on this premise, we aimed to estimate the incidence and risk factors of falls in a large population of Italian NH residents, and to evaluate the added value of the T-POMA score in predicting fall risk in this population.

## Methods

### Study design

We conducted a retrospective cohort study using the databases of Kos Care company, an Italian healthcare group that provides socio-health services, rehabilitation, psychiatry, diagnostics, and acute care through a network of NHs across eight regions in Italy. These facilities are characterized by harmonized clinical-care processes, supported by

standardized quality and safety protocols, and a unified electronic health record (EHR) system. The NHs deliver a range of services to older adults with varying levels of functional autonomy and cognitive capacity, offering both short-term and long-term (permanent) care. Ethical approval for the study was obtained from the Ethics Committee of the University of Milan–Bicocca (protocol no. 928/2025), and all data were analysed anonymously.

### Study population

At the time of the study, the Kos Care databases included data from 4,745 residents across 32 NHs in Italy. In these facilities, residents underwent functional assessments (FAs), which evaluate an individual's level of functioning and ability to perform daily tasks. The assessment includes mobility, basic activities of daily living (ADLs)—defined as essential tasks for survival, hygiene, and self-care—and participation in recreational activities. We selected a dynamic cohort of NH residents according to the following criteria: (1) aged 65 years or older; and (2) had at least one comprehensive clinical evaluation recorded at the time of admission or during residency, including physical examination, medical history, and FA. Residents whose FA was recorded after the occurrence of falls and those with a recorded T-POMA score of 0 were excluded from the analysis. For all participants, the index date for the analyses was set as January 1, 2022, and follow-up time was censored at the date of fall occurrence, exit from the cohort, or at the end of the follow-up period on December 31, 2022—whichever occurred first.

### Study endpoints

According to the literature, a fall is defined as “an unexpected event in which an individual comes to rest on the ground, floor, or a lower level” [17]. Fall-related data were collected from daily logs or incident reports maintained by staff, as well as from EHR reviews. Documentation included details on the circumstances surrounding the fall, including location, time, contributing factors (e.g., clinical conditions, medication use), as well as the resident's post-fall condition, such as the level of consciousness and use of mobility aids or restraints. The consequences of falls were also recorded in the Kos database and categorized as either severe (e.g., head trauma, hospitalization, fractures, surgery, or referral to the emergency department) or mild (e.g., bruises, abrasions, lacerations).

### Study variables

Multiple variables were collected and categorized into key groups to assess fall risk and those measured in FAs were

dichotomized from their original four-level categorical distribution for analysis. Demographic characteristics included sex and age, categorized into three groups (65–74, 75–84, and 85+ years). Balance and gait assessment was conducted using the T-POMA, which evaluates both balance (maximum score: 16) and gait (maximum score: 12), with a total possible score of 28. The balance component included tasks such as sitting balance, rising from a chair, and turning, while the gait component assessed step length, height, and symmetry. Scores were interpreted as follows:  $\leq 18$  indicated a high fall risk, 19–24 a moderate risk, and  $\geq 25$  a low fall risk. To assess the effect of long-term residency on fall risk and related outcomes, length of stay was categorized as  $\leq 2$  years or  $> 2$  years. Physical restraint use was recorded based on frequency: less than once per week or one or more times per week/daily. The database includes a global evaluation of general health conditions, performed by NH physicians, which results in a classification of ‘good’, ‘discrete’, or ‘poor’ based on clinical judgment. The presence of moderate or severe visual and hearing impairments, was assessed using standardized clinical evaluations [18]. Cognitive function was assessed using the Mini-Mental State Examination (MMSE), with a cut-off score of 18 to distinguish no or mild cognitive impairment from moderate or severe cognitive impairment [19]. The functional status was evaluated using the Barthel Index [20], dichotomized as  $\geq 75$  (autonomous / mild dependence) and  $< 75$  (moderate / severe dependence). Mood and behavioural disorders were evaluated by NH physicians, and categories were constructed as follows: the none/mild group included individuals with no symptoms or only occasional, minor issues (e.g., mild anxiety, irritability); the moderate/severe group included individuals with more severe symptoms, such as major mood (e.g., depression, mania) or marked behavioural disturbances (e.g., aggression, impulsivity, self-harm), which interfered with daily functioning and often required professional intervention. Comorbidities and therapies influencing fall risk were also considered (listed in Table S1). Comorbidities were classified as: *i*) absent or not relevant, i.e., no active medical conditions were present, or existing conditions did not contribute to fall risk; *ii*) relevant, i.e., at least one active medical condition potentially influencing fall risk was present (e.g., a condition causing postural instability, gait disturbances, or one that had previously led to falls). For medications, the risk categories were defined as follows: *i*) absent, i.e.) fewer than three medications, none associated with increased fall risk; *ii*) mild, i.e., fewer than five medications, none associated with increased fall risk; *iii*) moderate, i.e., fewer than three medications, none associated with increased fall risk, or more than five medications not associated with fall risk; *iv*) severe, i.e., more than three medications known to increase fall risk. Additionally, fall history was documented,

specifically recording whether participants had experienced one or more falls in the previous 180 days.

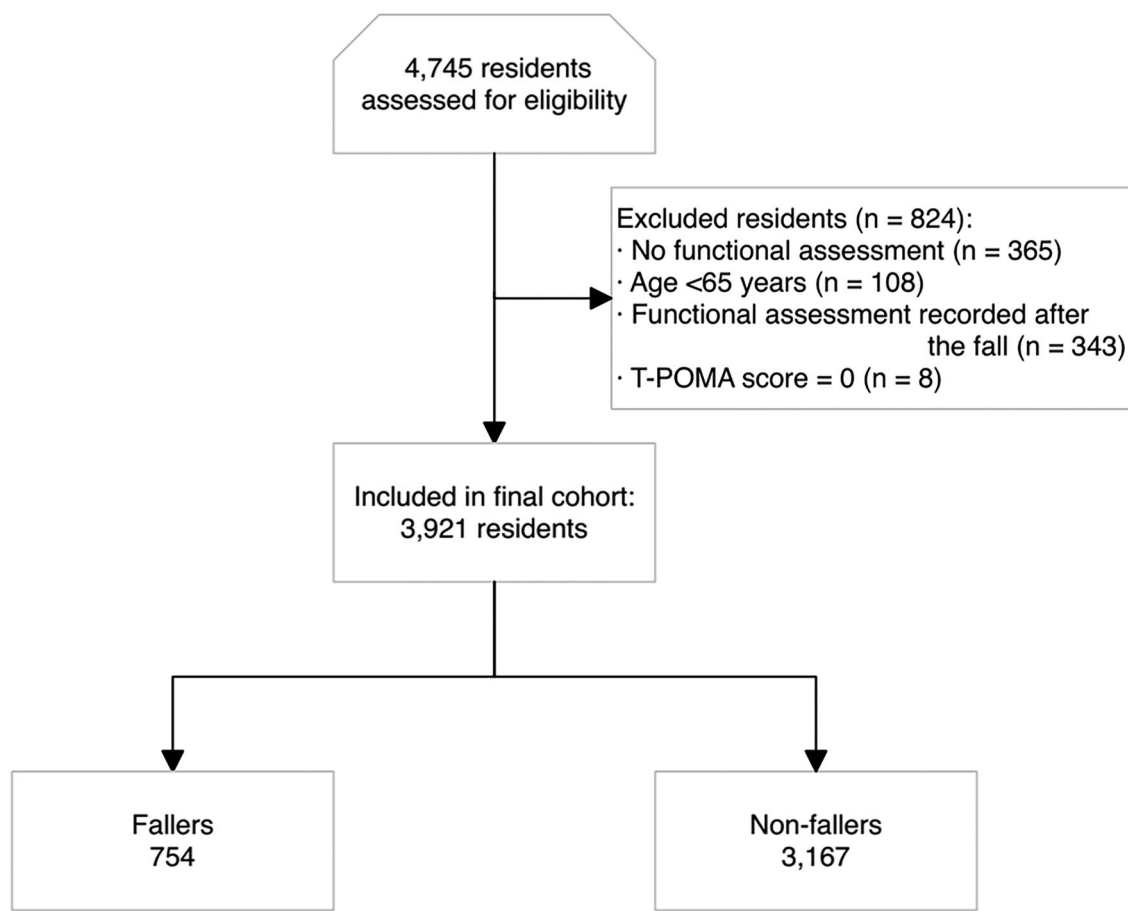
## Statistical analysis

Baseline characteristics were summarized as frequencies and percentages, and median and interquartile range (IQR). To evaluate fall incidence, we estimated the crude yearly incidence rate of first falls, expressed as the number of new fall events per person-year. To account for differences in fall risk stratification, we estimated the incidence of falls across three T-POMA categories: high fall risk ( $\leq 18$ ), moderate fall risk (19–24), and low fall risk ( $\geq 25$ ). Subsequently, we employed Cox proportional hazards regression models, both in univariable and multivariable analyses, to investigate the association between demographic and clinical factors and the time to first fall. Hazard ratios (HRs) with 95% confidence intervals (95% CIs) were reported to quantify the risk of experiencing a fall. The proportional hazards assumption was evaluated by means of martingale residuals and hypothesis testing [21]. Finally, we built a multivariable Poisson regression model to compute incidence rate ratios (IRRs) and 95% CIs of potential risk factors that predicted with the occurrence of severe fall consequences. All statistical analyses were performed using R 4.4.1 (R Foundation for Statistical Computing, Vienna, Austria) and SAS 9.4 (SAS Institute, Cary, North Carolina, USA). Significance level was set at  $p$ -value  $\leq 0.05$ .

## Results

A total of 3,921 individuals were included in the analysis according to the inclusion and exclusion criteria (Fig. 1), of whom 69.5% were female and 66.3% were aged 85 years or older. Of the total cohort, 754 residents experienced falls (19.2%). Table 1 presents the demographic and clinical characteristics of study participants, stratified by fallers and non-fallers. No differences in age distribution or median length of stay were observed between fallers and non-fallers. Fallers had a higher proportion of individuals with a T-POMA score  $\leq 18$  (30.5% vs. 17.5%) and a lower proportion of residents having poor general health conditions (21.8% vs. 36.7%). Frequent or daily use of physical restraints was less common among fallers compared to non-fallers (37.7% vs. 55.5%).

Males experienced falls at an incidence rate of 26.6 per 100 person-years (95% CI: 23.6–29.9), which was higher than that observed in females (18.6/100py; 95% CI: 17.0–20.4). Fall risk was also strongly associated with a T-POMA score  $\leq 18$ , with an incidence rate of 33.6/100py (95% CI: 29.4–38.3), and this association was even more



**Fig. 1** Flowchart of the cohort assembly. Abbreviations: T-POMA, Tinetti Performance-Oriented Mobility Assessment

pronounced in the 85+ age group, where the incidence reached 38.8/100py (95% CI: 32.9–45.5). The highest incidence rates were observed among residents with moderate to severe mood and behavioural disorders (49.6/100py; 95% CI: 37.7–64.1) and those with hearing impairment (44.4/100py; 95% CI: 28.1–66.6), both within the T-POMA score range of 19–24 (Fig. 2 and Table S2, Supplementary material).

Several factors were significantly associated with an increased risk of falls (Table 2). In the adjusted model, residents aged 85 years or older had a 39% higher risk of falling compared to younger (HR 1.39; 95% CI: 1.02–1.90), while male residents exhibited a 47% higher risk compared to females (HR 1.46; 95% CI: 1.27–1.71). A T-POMA score of  $\leq 18$  was strongly linked to an increased fall risk (HR 2.13; 95% CI: 1.61–2.81). An MMSE score indicative of moderate or severe cognitive impairment increased the risk of falling by 30% (HR 1.30; 95% CI: 1.10–1.53). An increased risk of over 25% was also associated with moderate or severe hearing impairment (HR 1.26; 95% CI: 1.01–1.58), the presence of moderate/severe mood and behavioural disorders (HR 1.29; 95% CI: 1.09–1.54), and the use of

therapies influencing the risk of falls (HR 1.29; 95% CI: 1.09–1.52). Conversely, poor general health conditions and physical restraint showed HRs of 0.63 (95% CI: 0.52–0.77) and 0.70 (95% CI: 0.58–0.86), respectively.

The distribution of fall modalities and consequences is presented in Fig. 3. Severe fall consequences occurred in 120 out of 754 fallers, 15.1%. The multivariable analysis (Table S3, Supplementary Material) showed that lower T-POMA scores ( $\leq 18$ ) and frequent or daily use of physical restraints were significant predictors of severe fall consequences, increasing the risk by 2.46 times (IRR, 95% CI: 1.18–5.12) and 2.00 times (IRR, 95% CI: 1.13–3.57), respectively.

## Discussion

Fall incidence among long-term NH residents in Italy was high, with several key demographic and clinical characteristics influencing fall risk. The observed estimates align with previous studies showing that this population experiences falls at significantly higher rates than community-dwelling

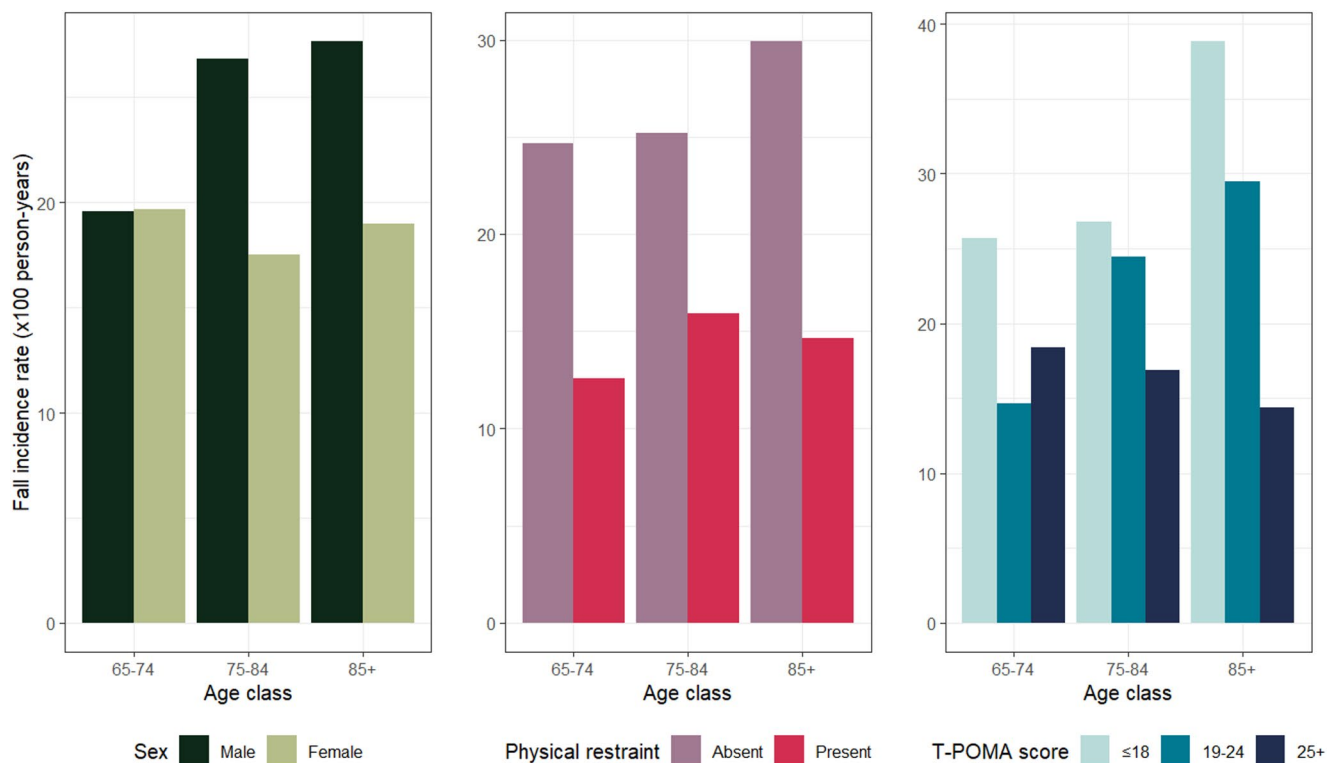
**Table 1** Demographic and clinical characteristics of study participants, overall and stratified by fall status

Residents' characteristics	Total (N=3921)	Fallers (N=754)	Non-fallers (N=3167)
<b>Age class</b>			
65–74	246 (6.3%)	45 (6%)	201 (6.3%)
75–84	1074 (27.4%)	204 (27.1%)	870 (27.5%)
85+	2601 (66.3%)	505 (67%)	2096 (66.2%)
<b>Sex</b>			
Females	2726 (69.5%)	470 (62.3%)	2256 (71.2%)
<b>Time to first fall / censoring</b>			
Median (IQR) days	365.0 (365.0–365.0)	209.0 (132.0–277.8)	365.0 (365.0–365.0)
<b>Length of stay</b>			
Median (IQR)	0.6 (0.4–1.1)	0.7 (0.4–1.3)	0.6 (0.3–1.1)
0–2 years	3332 (85%)	645 (85.5%)	2687 (84.8%)
>2 years	589 (15%)	109 (14.5%)	480 (15.2%)
<b>T-POMA score</b>			
≤18	784 (20%)	230 (30.5%)	554 (17.5%)
19–24	787 (20.1%)	190 (25.2%)	597 (18.9%)
25+	2350 (59.9%)	334 (44.3%)	2016 (63.7%)
<b>Physical restraint</b>			
No / Sporadic	1879 (47.9%)	470 (62.3%)	1409 (44.5%)
Frequent / Daily	2042 (52.1%)	284 (37.7%)	1758 (55.5%)
<b>General health conditions</b>			
Good / Discrete	2596 (66.2%)	590 (78.2%)	2006 (63.3%)
Poor	1325 (33.8%)	164 (21.8%)	1161 (36.7%)
<b>Visual impairment</b>			
No / Mild	3538 (90.2%)	697 (92.4%)	2841 (89.7%)
Moderate / Severe	383 (9.8%)	57 (7.6%)	326 (10.3%)
<b>Hearing impairment</b>			
No / Mild	3465 (88.4%)	660 (87.5%)	2805 (88.6%)
Moderate / Severe	456 (11.6%)	94 (12.5%)	362 (11.4%)
<b>Cognitive impairment (MMSE)</b>			
18+ (No / Mild)	1772 (45.2%)	353 (46.8%)	1419 (44.8%)
<18 (Moderate / Severe)	2149 (54.8%)	401 (53.2%)	1748 (55.2%)
<b>Functional assessment (Barthel Index)</b>			
75+ (Autonomous / Mild Dependence)	402 (10.3%)	118 (15.6%)	284 (9%)
<75 (Moderate / Severe Dependence)	3519 (89.7%)	636 (84.4%)	2883 (91%)
<b>Mood and behaviour disorders</b>			
No / Mild	2842 (72.5%)	520 (69%)	2322 (73.3%)
Moderate / Severe	1079 (27.5%)	234 (31%)	845 (26.7%)
<b>Comorbidities influencing the risk of falls</b>			
No / Not Relevant	964 (24.6%)	206 (27.3%)	758 (23.9%)
Relevant	2957 (75.4%)	548 (72.7%)	2409 (76.1%)
<b>Therapies influencing the risk of falls</b>			
No / Mild Risk	1570 (40%)	286 (37.9%)	1284 (40.5%)
Moderate / Severe Risk	2351 (60%)	468 (62.1%)	1883 (59.5%)
<b>Previous falls within the last 180 days</b>			
No	3365 (85.8%)	643 (85.3%)	2722 (85.9%)
1+	556 (14.2%)	111 (14.7%)	445 (14.1%)

Abbreviations: IQR, interquartile range; T-POMA, Tinetti Performance-Oriented Mobility Assessment; MMSE, Mini-Mental State Examination

older adults [6, 21], likely due to a combination of advanced age, multimorbidity, cognitive decline, and mobility impairments, highlighting the need for comprehensive risk assessment and tailored intervention programs.

The stratification of fall incidence based on the T-POMA score supports its predictive validity, with residents in the high-risk category ( $\leq 18$ ) exhibiting a significantly greater likelihood of falling compared to those in the moderate (19–24) and low-risk ( $\geq 25$ ) groups. Poor balance and gait



**Fig. 2** Crude incidence rates of first falls per 100 person-years by age classes, according to sex, physical restraint use, and T-POMA score. Abbreviations: T-POMA, Tinetti Performance-Oriented Mobility Assessment

disorders were strongly associated with increased falls, a finding consistent with previous studies emphasizing balance disorder as a major risk factor in institutionalized older adults [9, 10]. Additionally, moderate-to-severe functional dependence was highly prevalent among fallers, indicating that mobility limitations substantially contribute to fall susceptibility. Comprehensive functional and mobility assessments in NHs are essential for identifying individuals at heightened risk and implementing early preventive measures. Notably, in our study, the level of independence in performing basic ADLs assessed by the Barthel Index was not associated with an increased fall risk. These findings emphasize the need for further research to refine evaluation methods and guide the development of tailored rehabilitation programs aimed at improving balance and mobility among NH residents [22].

In most older populations, falls are typically more common among older adult females, though males often experience more severe outcomes [23, 24]. Similarly to other studies conducted in NH settings, we found that male residents have a higher incidence of falls compared to their female counterparts. The increased risk of falls in male NH residents may firstly be attributed to a higher prevalence of health issues that predispose them to falls, including neurological disorders, balance impairments, or cardiovascular conditions [7]. Therefore, the higher fall incidence observed

among males in this research may reflect these nuanced dynamics within the NH environment, highlighting that the relationship between sex and fall incidence can vary based on specific population characteristics and settings.

In addition to the well-established role of impaired mobility, in our multivariable analysis several other clinical factors emerged as a significant predictor of falls in NH residents. Moderate to severe hearing impairment emerged as a significant predictor, which reflects the impact of sensory deficits on balance, environmental awareness, and timely response to hazards, all of which are critical for fall prevention [25]. Similarly, cognitive impairment was associated with a 30% increased fall risk, aligning with evidence indicating that deficits in attention, executive function, and judgment can compromise safety and increase vulnerability to falls in institutionalized older adults, among whom the prevalence of conditions associated with cognitive decline is high [26, 27]. The presence of moderate to severe mood and behavioural disorders was also linked to higher fall risk. Symptoms such as agitation, impulsivity, or depressive withdrawal may influence fall either directly—by altering behaviour—or indirectly—through reduced engagement in preventive care or structured activities [28]. Finally, the use of therapies known to influence fall risk (Table S1) was associated with a 29% increase in fall risk. In long-term care settings, polypharmacy is common and often involves

**Table 2** Unadjusted and adjusted hazard ratios (HR) with 95% confidence intervals (CI) for first falls

Residents' characteristics	Unadjusted HR [95% CI]	Adjusted HR [95% CI]
<b>Age class</b>		
65–74	Reference	Reference
75–84	1.06 [0.77–1.46]	1.20 [0.87–1.66]
85+	1.09 [0.80–1.48]	<b>1.39 [1.02–1.90]</b>
<b>Sex</b>		
Females	Reference	Reference
Males	1.44 [1.24–1.66]	<b>1.47 [1.27–1.71]</b>
<b>Length of stay</b>		
0–2 years	Reference	Reference
> 2 years	0.96 [0.78–1.17]	1.09 [0.88–1.34]
<b>T-POMA score *</b>		
25+	Reference	Reference
19–24	1.78 [1.49–2.13]	<b>1.63 [1.30–2.05]</b>
≤18	2.24 [1.90–2.66]	<b>2.13 [1.61–2.81]</b>
<b>Physical restraint</b>		
No / Sporadic	Reference	Reference
Frequent / Daily	0.52 [0.45–0.61]	<b>0.70 [0.58–0.86]</b>
<b>General health conditions</b>		
Good / Discrete	Reference	Reference
Poor	0.51 [0.43–0.61]	<b>0.63 [0.52–0.77]</b>
<b>Visual impairment</b>		
No / Mild	Reference	Reference
Moderate / Severe	0.74 [0.56–0.96]	0.81 [0.61–1.07]
<b>Hearing impairment</b>		
No / Mild	Reference	Reference
Moderate / Severe	1.09 [0.88–1.35]	<b>1.26 [1.01–1.58]</b>
<b>Cognitive impairment (MMSE)</b>		
18+ (No / Mild)	Reference	Reference
<18 (Moderate / Severe)	0.93 [0.81–1.07]	<b>1.30 [1.10–1.53]</b>
<b>Functional assessment (Barthel index)</b>		
75+ (Autonomous / Mild Dependence)	Reference	Reference
<75 (Moderate / Severe Dependence)	0.58 [0.47–0.70]	1.05 [0.82–1.34]
<b>Mood and behaviour disorders</b>		
No / Mild	Reference	Reference
Moderate / Severe	1.23 [1.05–1.43]	<b>1.29 [1.09–1.54]</b>
<b>Comorbidities influencing the risk of falls</b>		
No / Not Relevant	Reference	Reference
Relevant	0.86 [0.73–1.01]	1.16 [0.96–1.40]
<b>Therapies influencing the risk of falls</b>		
No / Mild Risk	Reference	Reference
Moderate / Severe Risk	1.11 [0.96–1.28]	<b>1.29 [1.09–1.52]</b>
<b>Previous falls within the last 180 days</b>		
No	Reference	Reference
1+	1.07 [0.87–1.31]	1.18 [0.96–1.44]

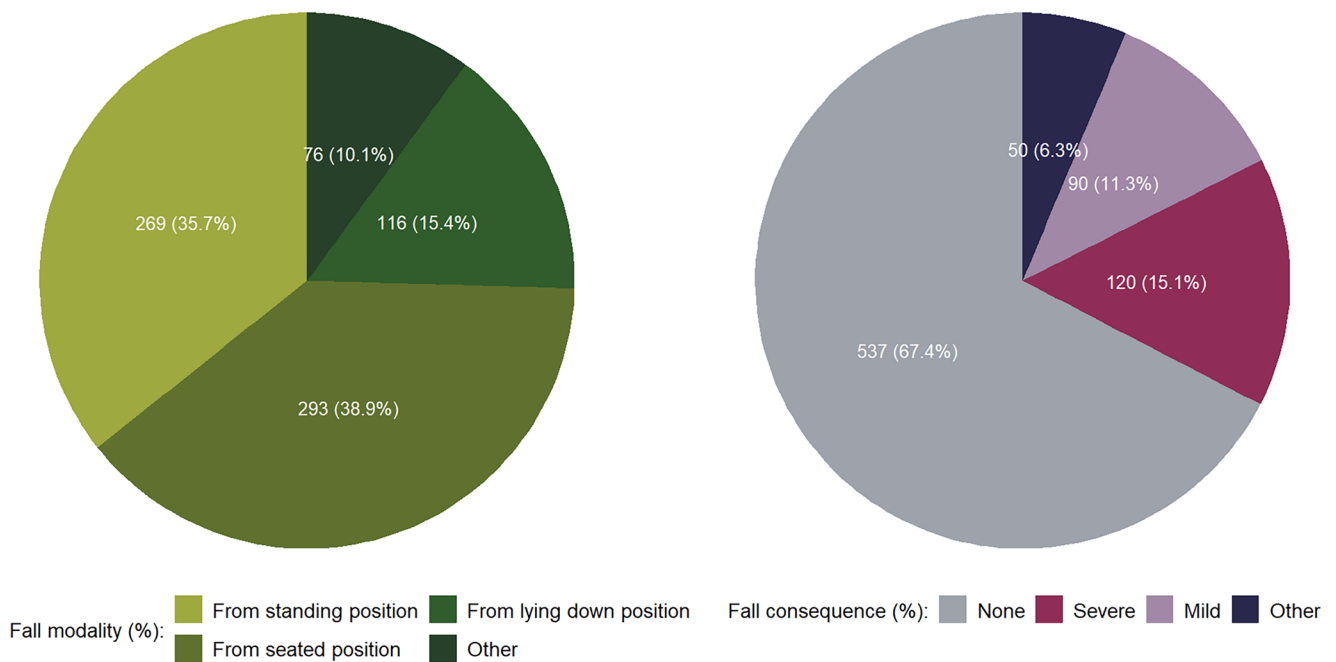
Abbreviations: T-POMA, Tinetti Performance-Oriented Mobility Assessment; MMSE, Mini-Mental State Examination

medications with sedative or hypotensive effects, underscoring the importance of carefully evaluating fall-related risks—an aspect that is often overlooked at the time of prescription due to pressing clinical needs [29, 30]. Together, these findings support a multifactorial approach to fall prevention that incorporates not only physical and functional assessments but also systematic evaluation of sensory, cognitive, psychological, and pharmacological risk factors. Tailoring interventions to address this complex interplay is critical to effectively reduce fall risk and improve resident safety.

Notably, residents with poor general health conditions showed a reduced fall risk. This counterintuitive finding underscores the complex relationship between frailty, mobility, and fall risk. It may be explained by the fact that residents with severe illnesses or extreme mobility limitations engage in fewer high-risk activities, spend more time in bed or seated, and receive closer supervision from caregivers. It also highlights that evaluating general health status alone is not sufficient for planning interventions, which should instead be tailored based on both functional and clinical profiles.

While results, in line with some reports, suggested that physical restraint may reduce immediate fall occurrence, the ethical and clinical implications of restraint use remain controversial [8, 31]. Prolonged restraint use has been linked to increased frailty, reduced muscle strength, and other adverse outcomes, necessitating a careful balance between fall prevention and residents' functional autonomy [31–33]. Our findings suggest that the use of physical restraints may also be associated with more severe consequences when falls occur. Several possible explanations support this association, including reduced protective reflexes and mobility due to deconditioning, an increased risk of high-trauma falls—often abrupt or involving head-first impact—and heightened agitation, which may lead to more forceful or uncontrolled falls [32].

Several key clinical implications emerge from our findings. Routine mobility and functional assessments should be incorporated into NH care protocols to identify high-risk residents early, and personalized fall prevention strategies should consider sex-specific differences in fall patterns, activity levels, and clinical risk factors. Multifactorial interventions, including strength and balance training, medication reviews, environmental modifications, and tailored rehabilitation programs, should be prioritized over restrictive measures. In this sense, the integration of EHRs in NHs offers an opportunity to develop real-time fall risk prediction models based on longitudinal data. Also, technology-driven solutions, such as sensor-based monitoring and AI-assisted fall risk prediction models, could enhance early detection and intervention efforts [34].



**Fig. 3** Frequencies of fall modalities and consequences. More than one consequence of a single fall can be recorded per patient

Beyond their clinical implications, falls are recognized as a key quality indicator in NHs, reflecting the effectiveness of clinical risk management and safety protocols [31, 35]. A high incidence of falls can signal gaps in care pathways, insufficient staffing, or inadequate environmental adaptations, all of which impact the overall quality of care in NHs. Moreover, falls—particularly in NHs—carry substantial economic consequences. The costs associated with fall-related hospitalizations, fracture treatment, rehabilitation, and long-term disability care place a significant burden on healthcare systems. Implementing effective fall prevention strategies in NHs could not only reduce morbidity and mortality but also lower healthcare expenditures, making fall prevention a critical public health priority [36, 37].

A major strength of this study is its large sample size and the use of comprehensive EHR data from multiple nursing homes across Italy, enhancing the generalizability of our findings on fall risk factors in institutionalized older adults to similar long-term care settings. It is worth noting that, according to the most recent data from the Italian National Institute of Statistics (ISTAT), there are 12,363 active long-term residential care facilities in the country (regardless of facility type or number of beds per facility), accommodating approximately 362,850 residents as of December 31, 2022. More than 75% of these residents are aged 65 or older, and this number is once again increasing in line with the trend observed in the years preceding the COVID-19 pandemic [38].

Additionally, the inclusion of objective assessments (T-POMA) and detailed clinical characteristics enhances the

robustness of our study. However, some limitations should be acknowledged. First, a standardized evaluation of functional status was not conducted uniformly across all residents at the same time prior to the fall. Instead, the analysis relied on the most recently recorded T-POMA scores, which were collected at varying time intervals prior to the fall event for each resident. Second, unmeasured confounders—such as environmental factors (e.g., flooring conditions, lighting), staff–resident ratio, and residents’ engagement in fall prevention programs—may have influenced fall risk but were not available for inclusion in the analysis. Although our dataset includes residents from 32 facilities, the absence of these covariates prevented us from conducting a facility-level adjusted analysis. Future studies should incorporate such structural characteristics to enable multilevel modeling and more accurately assess the impact of facility-level factors on fall risk. Third, the classification of health status reported in the database was based on the subjective clinical judgment of the attending physician, which may limit the reliability and interpretability of this variable in the analysis. Fourth, the database did not specify whether the date of cohort exit was due to death or discharge. As a result, it was not possible to apply a survival analysis framework that accounts for competing risks, preventing us from estimating marginal probabilities of events in the presence of competing outcomes. Fifth, the database did not include information on the fall-related outcome experienced by each individual resident, limiting the assessment of the health consequences of falls or their impact on healthcare resource utilization. An additional consideration is that the

study period overlapped with a time when healthcare facilities were still coping with the challenges imposed by the COVID-19 pandemic [39]. As such, the results may have been influenced by pandemic-related disruptions in staffing, care routines, and resident activity levels—even though our findings are broadly consistent with those reported in non-Italian settings during other time periods.

In conclusion, this study provides valuable epidemiological data on fall incidence and risk factors among NH residents in Italy, highlighting the significant role of mobility impairments, age, sex, and clinical factors in determining fall risk. Our findings underscore the importance of routine functional assessments, structured fall prevention programs, and cautious evaluation of physical restraint use in NH settings. Future research should explore personalized, technology-assisted interventions to enhance fall risk detection and prevention in long-term care facilities. By implementing evidence-based fall prevention strategies, NHs can improve residents' safety, mobility, and overall quality of life, ultimately reducing the healthcare burden associated with falls in older adults.

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**Author contributions** P.F., C.C.M., D.R. and G.M. designed the study and drafted the manuscript. D.R. planned and performed the statistical analysis. C.F. participated in the data analysis and interpretation. All authors provided input on study design, participated in interpreting the results, contributed to the final version of the manuscript, and had final responsibility for the decision to submit the manuscript for publication.

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**Data availability** No datasets were generated or analysed during the current study.

## Declarations

**Ethical approval** This study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the University of Milan-Bicocca, under protocol no. 928/2025. All data were analysed anonymously.

**Consent to participate** Not applicable.

**Consent to publish** Not applicable.

**Competing interests** The authors declare no competing interests.

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