Study on prevalence and risk factors of falls among community-dwelling elderly adults: results from three consecutive waves of the national health interview survey in Taiwan

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Abstract

Background

An aging society incurs great losses due to fall-related injuries and mortalities. The foreseeable increased burden of injury due to falls among elderly people requires a nationwide study on the fall epidemic in Taiwan.

Methods

The fall epidemic was examined using data from three consecutive waves of the National Health Interview Survey (2005, 2009, and 2013). Common explanatory variables across these surveys included socio-demographic factors (age, sex, and difficulty in performing activities of daily living or instrumental activities of daily living), biological factors (vision, comorbidities, urinary incontinence, and depressive symptoms), and behavioral risk factors (sleeping pill use, and frequency of exercise). After univariate and bivariate analyses were conducted, the prevalence of falls was investigated using multiple linear regression models adjusted for age group, sex, and the year of survey. A multivariate logistic regression model for falls with adjustments for these common explanatory variables was established across three waves of surveys.

Results

For each survey, there were consecutively 2,722; 2,900; and 3,200 respondents, with a mean age of 75.1, 75.6, and 76.4 years, respectively. The multiple linear regression model yielded a negative association between the prevalence of falls and the year of survey. Several sociodemographic and biological factors, including female gender, difficulty in performing one basic ADL, difficulty in performing two or more instrumental ADLs, unclear vision, comorbidities, urinary incontinence, and depressive symptoms, were significantly associated with falls.

Conclusion

Although information regarding the change in fall prevalence over time supports existing fall intervention strategies in Taiwan, the identification of risk factors in the elderly may increase the effectiveness of future fall prevention programs.

Background

As the burden of injury due to falls increased annually by 21.1% between 1990 and 2013, falls among the elderly have become a global health concern. Furthermore, the burden of fall-related injuries reached a new high of 27.5 million disability-adjusted life years in 2013 [1]. Falls have not only created tremendous costs in high-income countries [2–5], but the increased rate of fall-related injuries has gradually eroded the health and ability to perform daily tasks among elderly individuals in low- and middle-income countries.

Analysis of the 1997–2010 National Health Interview Survey (NHIS) in the States revealed that 61.9% of all fall-related injuries among elderly women occurred indoors while 32.8% outdoors. With advanced age, the proportion of indoor fall-related injuries increased, while the proportion of fall-related injuries from "playing/sports/exercising" decreased. Sedentary elderly individuals usually experience fall-related injuries inside, while elderly people with a high level of physical activity experience falls outside[6]. In England, the overall prevalence of falls over the previous two years among people aged 60 and over was 28.4%, with a prevalence of 29.1% among females and 23.5% among males. While the multivariable logistic regression (MLR) models showed that both sexes shared some risk factors for falls, such as chronic health conditions and severe pain, gender-specific risk factors were also identified. These risk factors include incontinence and frailty for females, and depressive symptoms, advanced age, and being unable to maintain full-tandem stance for males [7].

Falls also pose an increasing threat to older adults in low- and middle-income countries. For example, the pooled prevalence (across the countries China, Ghana, India, Mexico, the Russian Federation, and South Africa) of past-year fall-related injuries was 4% among adults aged ≥50 years. Significant independent risk factors for a fall-related injury over the past year, which were identified using the MLR model, included female gender, living in a rural area, depression, severe or extreme problems in sleeping, two or more comorbidities, and poor cognitive function [8]. In Indonesia, the overall prevalence of fall-related injuries over the past two years was 12.8%; the prevalence of fall-related injuries was 14.0% among women and 11.5% among men. The MLR models identified common risk factors for fall-related injuries over the past two years that were present in both genders, such as having two or more comorbidities, urinary problems, and functional disability. However, these models also identified gender-specific risk factors including former tobacco use, cataracts, sleep disturbance, and sleep impairment in men and poorer economic background, depression symptoms, and poor cognitive function in women [9].

In southern Taiwan, falls accounted for 60% of trauma admissions of elderly patients during 2009 and 2013 [10]. As per previous reports, a prevalence rate of 10%–20% among local community-dwelling elderly people was observed; however, these isolated findings cannot be extrapolated to a national scale [11]. Analysis of data from the 1996 and 1999 Taiwan Longitudinal Study on Aging demonstrated that the overall prevalence of falls was 19.5%. Furthermore, the risk of falling was higher among individuals with the following characteristics: female gender, having a disability, reduced activities of daily living (ADL) function, depressive symptoms, using a cane or a walker but still walking well, and not wearing glasses but not seeing clearly [12]. However, there are no multiple-survey research studies on the national falling epidemic, which could provide a solid evidence base for fall prevention strategies. In this study, we attempt to investigate the prevalence and risk factors for falls among elderly people during 2005, 2009, and 2013 to better document fall prevention policies.

Methods

Study subjects and data collection

Data of persons aged 65 and over were collected from three consecutive waves of the NHIS (2005, 2009, and 2013) in Taiwan. The design and sampling strategies used for the 2005 NHIS were described in the previous report [13]. The eligible participants were community-dwelling elderly adults who were at least 65 years of age at the preset start date of the interview according to household registry information. Those who were too weak, sick, frail, or physically/intellectually disabled to participate in the interview were replaced by proxy as stipulated, rather than being excluded from the study. Participants were drawn at a probability proportional to size of the elderly population using a multiple-stage, stratified, systematic sampling design. In summary, we drew consecutively 187, 164, and 168 out of the 358 townships or districts nationwide for each wave of surveys. These townships or districts drawn were further divided into 53 strata according to their geographic location, population distribution, and preceding interview experience. Within each stratum selected, sampling stages varied by the degree of urbanization. Two-stage sampling was conducted for those within high urbanization strata, first with neighborhood unit and then persons. Three-stage sampling was conducted for those within moderate urbanization strata, first with villages followed by neighborhood unit and persons. For those within rural or remote strata, first with townships/districts followed by neighborhood unit and persons. Between April 2005 and August 2005, data werecollected from 2,727 persons (85.5%) among 3,188 eligible subjects ≥ 65 years of age using face-to-face questionnaire interviews for the NHIS. The 2009 and 2013 NHIS were conducted in a similar manner to the 2005 NHIS using a Computer Assisted Personal Interview. These surveys had response rates of 88.2% (2,904/3,294) and 82.8% (3,204/3,868), respectively. After four or five respondents who did not specify their fall experience in each consecutive wave of survey in 2005, 2009, and 2013 were excluded, 2,722, 2,900, and 3,200 respondents were included in the analysis. For quality assurance, any questionnaire containing ambiguous, inappropriate or inconsistent answers, or missing items was returned to the original interviewer for clarification or revisit. The NHIS in Taiwan was approved by the Institutional Review Board of the National Health Research Institute, and written informed consent was obtained from each respondent.

Outcomes and explanatory variables

A fallwas defined as “an event of falling down that occurs while one stands up, sits down, gets into bed, or walks, etc., regardless of its underlying causes or resting on a same or lower level.” Each participant that experienced a fall was required to answer (Yes/No) if he/she had experienced a fall, regardless of frequency, in the past year.

Common explanatory variables that were chosen for correlation analyses with fall data included socio-demographic variables, biological variables, and behavioral risk variables (Additional file 1: Table S1). Sociodemographic variables included age, sex, difficulty in performing ADLs, and difficulty in performing instrumental ADLs (IADLs). The sum of difficulties in performing ADL or IADL was computed and categorized as none, one, or two or more. Biological variables included vision (clear, average, and unclear), comorbidities (using the sum score of seven selected chronic diseases, categorized as none, one, or two or more), urinary incontinence (Yes/No), and depressive symptoms (with a cutoff point of 8 for the sum score of ten questions adopted from the original Centers for Epidemiologic Studies Depression Scale [14]). Behavioral risk variables included use of sleeping pills and the frequency of exercise (no, irregular, regular).

Statistical analyses

The statistical software package used to conduct analyses was SAS Version 9.3. For each wave of survey results, data were weighted to correct for the probability of multi-stage sampling. Univariate analyses were used to examine the frequency distribution of each explanatory variable. The chi-square test was used to compare the risk of falling across each explanatory variable. Multivariate analyses were conducted for two purposes. First, a multiple linear regression model that adjusted for age group, sex, and the year of the survey was used to examine the time-dependent changes in the age- and sex-specific prevalence of falls. The trends of age- and sex-specific prevalence of falls were then compared with those of selected overlapping fall-related measures in terms of the standardized mortality rate (SMR) for accidental falls between 2009 and 2016 [15] and the overall, sex-specific, and age-specific fall-related hospitalization rates between 2003 and 2009 [16]. Second, to investigate the independent association between each explanatory variable and the odds of having fallen in the past year, a common MLR model was established with adjustment for all of the common explanatory variables mentioned above. Statistical significance was set at $\alpha = 0.05$.

Results

The respondents for the 2005, 2009, and 2013 NHIS had mean ages of 75.1, 75.6, and 76.4 years, respectively (Table 1). The weighted prevalence of falls over the previous year gradually dropped from 21.3%, 17.5%, to 16.5%. With regards to sociodemographic variables, adults with an advanced age or females tended to have a higher risk of falls, with the exception of women in the 2013 survey ($p = 0.224$) and those aged ≥85 between 2005 and 2009. There were consecutively 14.5%, 17.8%, and 16.9% of respondents in the 2005, 2009, and 2013 NHIS, respectively, who faced difficulty in performing at least one ADL, whereas the corresponding figures for IADL were 41.9%, 20.7%, and 38.5%, respectively. Surprisingly, a fall-risk gradient was found by the number of IADL difficulty, but not by the number of ADL difficulty.

Table 1 Characteristics of study subjects by number of participants and prevalence of falls during survey years

	2005				2009				2013			
Characteristics	No. of participants		Prevalence of falls and p-value		No. of participants		Prevalence of falls and p-value		No. of participants		Prevalence of falls and p-value	
	N = 2722	%	n	%	N = 2900	%	n	%	N = 3200	%	N	%
Total	2722	100.0	579	21.3	2900	100.0	565	17.5	3200	100.0	528	16.5
Mean age (±SD, year)	75.1	±6.0			75.6	±6.3			76.4	±6.5		
Age				0.002				0.017				0.004
65-69	868	31.9	147	16.9	877	30.2	131	14.0	852	26.6	110	12.1
70-74	743	27.3	161	20.9	726	25.0	141	18.5	866	27.1	135	16.2
75-79	619	22.7	141	23.2	653	22.5	131	16.4	654	20.4	115	17.9
80-84	329	12.1	88	28.1	388	13.4	96	23.0	503	15.7	99	18.7
85+	163	6.0	42	26.1	256	8.8	66	21.3	325	10.2	69	24.3
Sex				<.0001				0.000				0.224
Male	1346	49.4	221	16.5	1252	43.2	198	14.1	1523	47.6	227	15.3
Female	1376	50.6	358	26.2	1648	56.8	367	20.6	1677	52.4	301	17.5
ADL difficulty				<.0001				<.0001				<.0001
None	2324	85.4	419	18.1	2382	82.2	399	15.2	2658	83.1	379	13.8
1 task	74	2.7	33	45.9	109	3.8	33	29.0	112	3.5	38	44.5
≥2 tasks	322	11.8	127	39.4	406	14.0	133	28.4	427	13.4	111	27.2
IADL difficulty				<.0001				<.0001				<.0001
None	1574	58.1	232	15.0	2275	79.4	371	14.8	1943	61.5	244	11.9
1 task	361	13.3	67	19.0	105	3.7	28	25.1	349	11.0	57	16.0
≥2 tasks	775	28.6	278	35.7	486	17.0	161	29.1	868	27.5	216	27.5
Use of sleeping pills				0.005				0.022				0.009

use												
No	2422	89.1	496	20.4	2521	87.4	468	16.7	2715	85.1	422	15.4
Yes	297	10.9	83	28.6	363	12.6	94	22.9	477	14.9	106	22.3
Vision				<.0001				0.002				<.0001
Clear	772	32.1	129	17.4	815	32.0	109	12.8	974	34.2	109	11.1
Average	1020	42.4	184	17.7	1097	43.1	206	17.0	1296	45.5	189	14.3
Unclear	615	25.6	166	28.1	635	24.9	159	22.2	579	20.3	146	27.7
Frequency of exercise				0.018				0.001				<.0001
None	1246	45.8	298	24.2	1370	50.0	311	21.2	1524	50.4	301	20.3
Irregular	167	6.1	34	19.3	138	5.0	17	13.0	107	3.5	20	13.4
Regular	1306	48.0	247	19.1	1233	45.0	196	13.8	1394	46.1	170	12.6
Comorbidities				<.0001				0.051				0.022
0	879	38.5	116	12.2	942	33.5	153	14.2	884	28.6	104	12.4
1	690	30.2	131	19.2	957	34.0	185	17.6	995	32.2	175	16.4
≥2	712	31.2	187	28.5	916	32.5	202	19.6	1207	39.1	218	18.5
Urinary incontinence				<.0001				0.002				<.0001
No	2066	76.1	384	18.8	2603	90.2	485	16.5	2544	79.9	367	14.0
Yes	649	23.9	194	29.6	284	9.8	77	26.0	640	20.1	156	25.5
Depressive symptoms				<.0001				<.0001				<.0001
No	1715	71.4	282	16.3	1999	76.4	297	13.6	2229	79.6	282	12.5
Yes	686	28.6	198	30.0	617	23.6	193	27.7	570	20.4	139	24.9

Note: p-value < 0.05 using the chi-square test indicates a statistically significant fall risk across each explanatory variable. The prevalence of falls was estimated by weighing according to sampling probability proportional to the population size. SD = standard deviation.

For biological variables, the consecutive proportion of respondents who had unclear vision diminished from 25.6%, 24.9%, to 20.3%. As the proportion of each of comorbidities (hypertension, diabetes, hyperlipidemia, etc.) increased over time (Additional file 2: Table S2), the proportion of having two or more comorbidities consecutively increased from 31.2%, 32.5%, to 39.1%. The risk of falls presented a gradient by the number of comorbidities, but was inversely proportional to vision quality. Moreover, the proportion of respondents who reported having urinary incontinence was consecutively 23.9%, 9.8%, and 20.1%. The proportion of respondents with depressive symptoms consecutively decreased from 28.6%, 23.6%, to 20.4%. Those older adults who had urinary incontinence or depressive symptoms were more susceptible to a fall.

Regarding behavioral risk variables, the proportion of elderly adults taking sleeping pills consecutively increased from 10.9%, 12.6%, to 14.9%. Those elderly adults who took sleeping pills were more likely to experience a fall. The consecutive proportions of elderly adults who exercised irregularly were 6.1%, 5.0%, and 3.5%, whereas those who exercised regularly were 48.0%, 45.0%, and 46.1%. Notably, there was a gradient of protective effect from falls by the frequency of exercise. Those older adults who exercised regularly were less likely to experience a fall than those who exercised irregularly, except some discrepancies in the 2009 survey (Additional file 3: Table S3).

The multiple linear regression model revealed that the age- and sex-specific prevalence of falling presented an increase rate of 2.33% per each advancing five-year group and of 6.99% for women relative to men, and a decrease rate of 2.61% per year during 2005–2013 (Table 2). Age, sex, and the year of survey accounted for 76% of the total variation for the age- and sex-specific prevalence of falling (R^2 = 0.76). In contrast to the declining trend of the prevalence rates for falling during 2005–2013, an increasing trend was observed for the SMR for accidental falls during 2009–2016 [15], and for the overall, sex-specific, and age-specific fall-related hospitalization rates between 2003 and 2009 [16]. This trend was especially apparent among elderly women, individuals aged between 75–84 years, and individuals aged 85 and over (Fig 1).

Table 2 Multiple linear regression model for the age- and sex-specific prevalence of falls

Variable	Coefficient	95% CI	p-value
Age group	2.33	(1.48-3.17)	<.0001
Sex	6.99	(4.60-9.39)	<.0001
Year of survey	−2.61	(−4.07-−1.14)	0.001
Intercept	7.48	(2.06-12.91)	0.009
R^2 = 0.76 Adjusted R^2 = 0.73			

n = 30 point estimates of age- and sex-specific prevalence of falls. CI = confidence interval.

[Insert Fig 1 here]

The overall and sex-specific and age-specific fall-related hospitalization rates during 2003–2009 were adopted from Bai [16]. Bai's fall-related data were retrieved from the inpatient expenditures by admissions (DD) of the longitudinal national health insurance research database (LHID) 2005. This database contained information on patients who were at ≥ 65 years of age and hospitalized due to fall injuries with E880-E888 of the International Classification of Disease-Clinical Modification, ninth revision (ICD–9-CM), either for external cause codes or for major diagnosis and secondary diagnosis.

Table 3 reveals that independent risk factors of falls identified in the MLR models varied with attenuation of adjusted odds ratios (OR) across these surveys. Those risk factors identified from the 2005 model included female gender (OR:1.64 95% CI: 1.26–2.15), difficulty in performing one ADL (OR: 2.39 95% CI: 1.25–4.58), difficulty in performing two or more IADLs (OR: 1.45 95% CI: 1.00–2.11), having one (OR: 1.61 95% CI: 1.16–2.24) or two or more comorbidities (OR:2.41 95% CI: 1.74–3.35), and depressive symptoms (OR:1.51 95% CI: 1.12–2.03). However, only female gender (OR: 1.38 95% CI: 1.09–1.76) and depressive symptoms (OR: 1.77 95% CI: 1.35–2.31) were identified in the 2009 model. In the 2013 model, we identified difficulty in performing one ADL (OR: 2.74 95% CI: 1.55–4.86), unclear vision (OR: 1.92 95% CI: 1.36–2.72), urinary incontinence (OR: 1.42 95% CI: 1.04–1.94), and depressive symptoms (OR: 1.45 95% CI: 1.06–1.98). In contrast, advanced age, use of sleeping pills, and exercise were not independently correlated to falling in the three waves of survey.

Table 3 Multivariate logistic regression analyses for falls by the year of survey

Covariate (reference)	2005		2009		2013	
Age (65-69)						
70-74	1.16	(0.83-1.62)	1.26	(0.93-1.69)	1.13	(0.81-1.58)
75-79	1.24	(0.87-1.76)	0.87	(0.62-1.22)	1.17	(0.81-1.70)
80+	1.34	(0.88-2.03)	1.35	(0.97-1.89)	1.19	(0.82-1.73)
Sex (male)						
Female	1.64	(1.26-2.15)	1.38	(1.09-1.76)	0.93	(0.72-1.20)
ADL difficulty (none)						
1 task	2.39	(1.25-4.58)	0.44	(0.10-1.87)	2.74	(1.55-4.86)
≥2 tasks	1.41	(0.80-2.47)	0.42	(0.09-2.04)	1.14	(0.66-1.95)
IADL difficulty (none)						
1 task	0.76	(0.51-1.14)	1.41	(0.74-2.72)	1.13	(0.77-1.66)
≥2 tasks	1.45	(1.00-2.11)	4.56	(0.98-21.23)	1.27	(0.85-1.90)
Use of sleeping pills (no)						
Yes	1.09	(0.75-1.60)	1.06	(0.75-1.49)	1.21	(0.88-1.67)
Vision (clear)						
Average	0.93	(0.69-1.27)	1.25	(0.94-1.65)	1.10	(0.82-1.48)
Unclear	1.09	(0.77-1.55)	1.23	(0.88-1.71)	1.92	(1.36-2.72)
Comorbidities (0)						
1	1.61	(1.16-2.24)	1.16	(0.87-1.54)	1.18	(0.85-1.64)
≥2	2.41	(1.74-3.35)	1.19	(0.89-1.61)	1.12	(0.81-1.54)
Urinary incontinence (no)						
Yes	1.09	(0.80-1.49)	1.29	(0.90-1.84)	1.42	(1.04-1.94)
Depressive symptoms (no)						
Yes	1.51	(1.12-2.03)	1.77	(1.35-2.31)	1.45	(1.06-1.98)
Frequency of exercise (none)						
Irregular	1.20	(0.70-2.04)	0.77	(0.46-1.29)	0.87	(0.45-1.69)

Regular	1.12	(0.85-1.49)	0.81	(0.63-1.04)	0.80	(0.62-1.03)

Note: Adjusted odds ratios and 95% confidence interval (OR and 95%CI) are presented for each dummy variable. Variables controlled across three waves of survey in the MLR model included age, sex, developing difficulty in performing ADLs or IADLs, use of sleeping pills, vision, comorbidities, urinary incontinence, depressive symptoms, and frequency of exercise.

Discussion

Our study not only demonstrates the decreased prevalence of falls across the three waves of the NHIS, but it also identifies several significant independent risk factors for falls during the previous year. These risk factors including the following: female gender, difficulty in performing one basic ADL, difficulty in performing two or more instrumental ADLs, unclear vision, comorbidities, urinary incontinence, and depressive symptoms. However, there was no significant risk of falling associated with advanced age, use of sleeping pills, and getting exercise on either a regular or irregularly basis. Several insights were gained from our study regarding the paradox between the prevalence of falls, the SMR of accidental falls, and the fall-related hospitalization rates. Furthermore, these risk factors may help dictate the future direction of fall prevention policies.

Although a multifactorial fall risk awareness program was launched in 2004, we cannot attribute the declining trend in the prevalence of falls to it for several reasons. During 2005–2013, there were other overlapping health promotion programs that were initiated at different times and locations in Taiwan. These programs included the Community Health Building (since 1996), Safe Communities (since 2002), Healthy Cities (since 1995), and Health Promotion Programs for the Elderly (with which the multifactorial fall risk awareness program has been integrated since 2009) [17]. Second, these aforementioned programs were spreading, either community by community or county/city by county/city, in a disjointed and fragmented fashion without sufficient participation among the informal and formal caregivers for elderly adults. Successful fall prevention strategies are supposed to encompass the full array of contributing variables or causes over a broad target audience with user design strategies [18], and accomplish a significant risk reduction in falls and fall-related hospitalizations and deaths. Accordingly, we can assume that the previous fall prevention strategies in Taiwan indicate a lot of ground for improvement, judging from two folds. First, there were some discrepancies between the decreasing trend of prevalence of falls and the increasing trend of SMR due to accidental falls from 2009–2016 [15] and for the overall, sex-specific, and age-specific fall-related hospitalization rates from 2003–2009 [16]. It implies that falls and fall-related injuries, even sharing some risk factors for falling, cannot be prevented with one-size-fits-all strategies [19,20]. Second, as the population is rapidly aging, the functional disability status among older Taiwanese accelerates over time, especially among women and the old–old (≥75 years old) population. Women in the older age groups suffer from disproportionately greater levels of disability [21] and are more susceptible to falls and fall-related injuries than their male counterparts. This disparity in fall risk is also apparent in the old–old compared with the young–old (65 years old). Elderly women and the old–old tended to have a higher fall-related hospitalization rate during 2003–2009. These higher rates may be because of a higher risk of frailty, restricted mobility, and being less likely to participate in community-based fall prevention activities (Fig 1).

Regarding the socio-demographic risk factors for falling that were identified using the MLR models, women had a higher risk of falls, which was probably owing to osteoporosis and reduced knee muscle strength [22]. The association between difficulties in performing two or more IADLs and an increased risk of falling is compatible with the findings of preceding reports [11,23]. However, there was no corresponding finding among those older adults with difficulty in performing ADLs. A possible explanation is that they were subject to selective survival [24] and became too small a number to obtain a stable OR across the three waves of survey.

Regarding biological factors, our finding that elderly adults with unclear vision had an OR that was twice as high as elderly adults with clear vision aligns with that in a previous report by Lord [25]. Consistent with the findings of Qin & Baccaglini [26], we observed that having one or two or more comorbidities was also identified as a significant risk predictor of falls because physical functions may be compromised by comorbidities. For example, diabetic patients are more liable to falls because they tend to have a high prevalence of frailty [27] and declined compensation for the pathophysiological and psychological factors associated with chronic pain including reflex inhibition, joint instability, fear of falling, and reduced attention [28]. Stroke survivors are usually more susceptible to falls, probably due to unilateral weakness, hemisensory or visual neglect, impaired coordination, visual field defects, perceptual difficulties, cognitive issues [29], and deficits in gait and balance [30]. The 40% higher risk of falling among respondents with urinary incontinence in 2013 was compatible with the conclusions drawn from a previous systematic review [31]. The fact that depressive symptoms were proven to be a significant risk factor of falls might be explained by an intricate bidirectional and self-perpetuating interaction between depression and falls [32].

It is also noteworthy that taking sleeping pills and getting physical exercise either irregularly or regularly were not independently correlated with falls in the three waves of surveys, and these findings contradict those of two large published studies [33,34] and the updated review of exercise as a single intervention for preventing falls [35]. Further studies are needed to clarify this discrepancy.

Our study has two main strengths. First, it has a comparable fall-related questionnaire administered to a large sample size of elderly adults on a national scale. These factors allow this study to analyze the time-dependent trend in the prevalence of falls and to identify risk factors across three waves of surveys. Second, data quality was assured through the pre-job training of interviewers, standardization of the questionnaire administration process, and auditing. However, several aspects of this study may be improved. First, a cross-sectional survey cannot infer a causal relationship between the outcome and explanatory variables. Second, data regarding the instances of falls and explanatory variables might be subject to recall bias for not verified using medical records. Further studies might make use of data linkage with the longitudinal national health insurance research database to examine the medical records of respondents who had experienced falls. Third, the observation period and interval of data collection of our study are not comparable with those of other fall-related hospitalization [16]. The aforementioned discrepancies awaits further study because the evaluation of health promotion for elderly people was beyond the scope of our study [36]. Finally, extrapolation of our study findings to other cultures or nations should be performed with caution because the definitions of falls and coverage of comorbidities vary across surveys.

The present study suggests that a combination of low-risk and high-risk strategies [37] should be adopted to tailor fall prevention programs to people with several different risk factors for falling. Even though the declining prevalence of falls implies that previous community-based health promotion programs, including multifactorial fall risk awareness, were successful, elderly adults with multiple risk factors are often overlooked. It is recommended to deliver an approach that accounts for adults who have multimorbidity and are prescribed multiple medicines because they are likely to be at a higher risk for adverse events and drug interactions [38]. In the face of the projected 2.7-fold growth in the number of hip fractures between 2010–2035 [39], it is recommended that the fall epidemic must be surveyed regularly, as the identification of risk factors in the elderly may help with developing individualized fall risk assessments [19] among high-risk seniors. Furthermore, this approach could enhance fall prevention programs to be more efficient and effective to reduce fall-related hospitalizations [10] in the future.

Conclusions

This study, which examined the national epidemic of falls among community-dwelling Taiwanese elderly people between 2005 and 2013, identified multiple risk factors and a declining trend in the prevalence of falls across three consecutive waves of the NHIS. However, the rate of hospitalization due to fall-related injuries increased from 2003–2009, and the SMR for accidental falls also increased from 2009–2016. Tailoring fall prevention strategies to different segments of the target population is necessary to mitigate the forthcoming burden of fall-related injuries.

List Of Abbreviations

ADLActivities of daily living

IADLInstrumental activities of daily living

MLRMultivariable logistic regression

NHISNational Health Interview Survey

SMRStandardized mortality rate

Declarations

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Authors' contributions: YJT and PYY had full access to all of the NHIS data and take responsibility for the integrity of the data and the accuracy of the data analysis. YJT was responsible for conceptualization and design of the study. PYY was responsible for the data curation and formal analysis. TYJ drafted the manuscript and was responsible for interpretation of the data. YCY and MRL helped with the study methodology and participated in interpretation of the data and revision of the manuscript. YWW helped with funding acquisition, resources allocation, supervision, and writing review and editing of the manuscript. All authors contributed to the critical revision of the manuscript for important intellectual content, and all approved the article submitted for publication.

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Availability of data and materials: The NHIS datasets used and/or analyzed during the current study were available from the Health and Welfare Data Science Center, Ministry of Health and Welfare, Taiwan, upon regular application.

Ethics approval and consent to participate: The NHIS was approved by the Institutional Review Board of the National Health Research Institute (HPA09808001092; EC1020502), which was not required in 2005. Written form consent was obtained from respondents for participation in the NHIS.

Consent for publication: Not applicable.

Competing interests: The authors declare that they have no competing interests.

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Supplementary Files Legend

Additional file 1: Table S1. Measures of explanatory variables

Additional file 2: Table S2. Distribution of falls across selected chronic conditions during the year of survey

Additional file 3: Table S3. Univariate logistic regression analyses for explanatory variables of falls

Figures

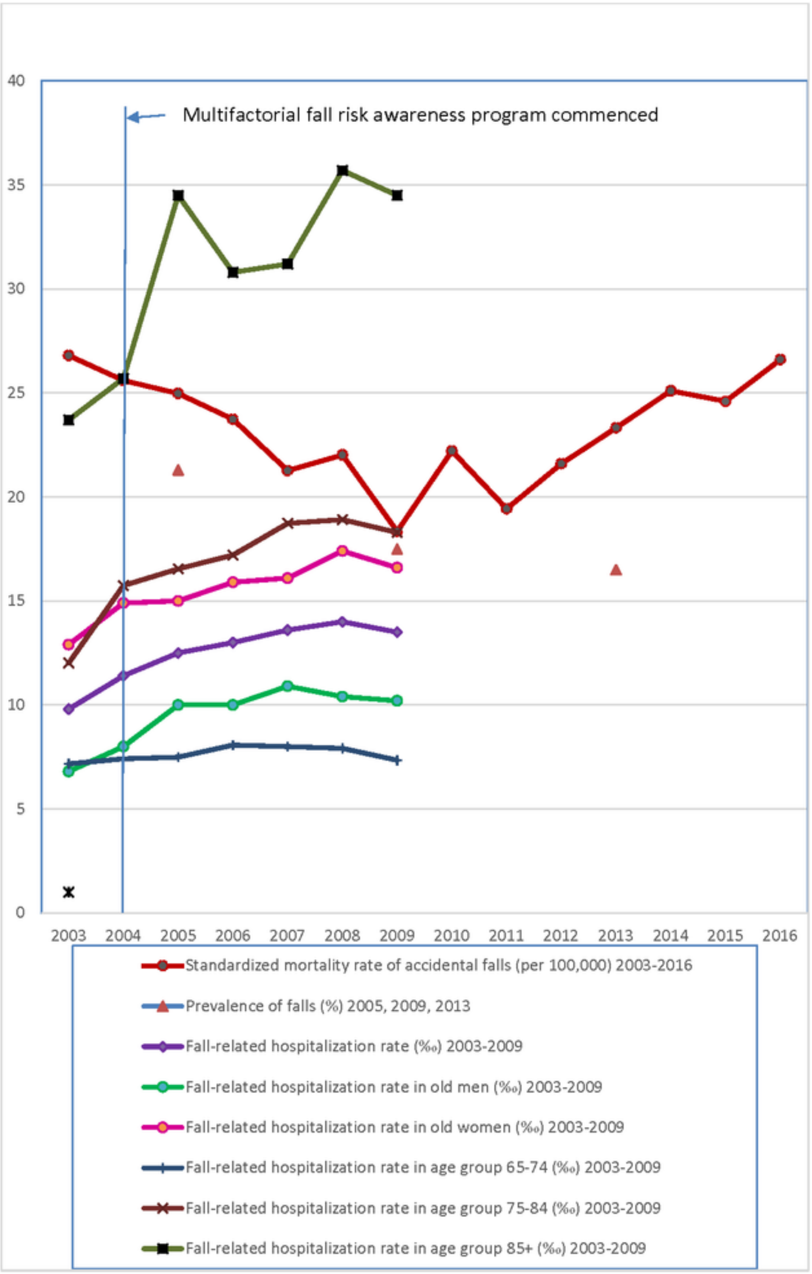

Figure 1

Trends of prevalence of falls, fall-related hospitalization rates and standardized mortality rate of accidental falls

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- TableS3Univariatelogisticregressionanalyses.docx
- TableS1Measuresofexplanatoryvariables.docx
- TableS2Distributionoffallsbychronicconditions.docx