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Fall-related mortality trends in older Japanese adults aged ≥65 years: a nationwide observational study

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ABSTRACT

Objectives Fall-related mortality among older adults is a major public health issue, especially for ageing societies. This study aimed to investigate current trends in fall-related mortality in Japan using nationwide population-based data covering 1997–2016.

Design We analysed fall-related deaths among older persons aged ≥65 years using the data provided by the Japanese Ministry of Health, Labour and Welfare.

Results The crude and age-standardised mortality rates were calculated per 100 000 persons by stratifying by age (65–74, 75–84 and ≥85 years) and sex. To identify trend changes, a joinpoint regression model was applied by estimating change points and annual percentage change (APC). The total number of fall-related deaths in Japan increased from 5872 in 1997 to 8030 in 2016, of which 78.8% involved persons aged ≥65 years. The younger population (65–74 years) showed continuous and faster-decreasing trends for both men and women. Average APC among men aged ≥75 years did not decrease. Among middle-aged and older women (75–84 and ≥85 years) decreasing trends were observed. Furthermore, the age-adjusted mortality rate of men was approximately twice that of women, and it showed a faster decrease for women.

Conclusions Although Japanese healthcare has shown improvement in preventing fall-related deaths over the last two decades, the crude mortality for those aged over 85 years remains high, indicating difficulty in reducing fall-related deaths in the super-aged population. Further investigations to uncover causal factors for falls in older populations are required.

Strengthsand limitations of this study

- ► This 20-year retrospective observational study analysed data from 1997 to 2016, taking advantage of the availability of national data.
- ► We calculated crude and age-adjusted fall-related mortality rates per 100 000 persons per year for men and women in the world's foremost ageing society, Japan.
- ► The results may have been influenced by underreporting of fall-related events.
- ► Data validity was uncertain since no clinical information on fall events was available.

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INTRODUCTION

Falls are among the most important aetiologies of unintentional injury among older adults, requiring an urgent intervention worldwide.[1] A 2018 WHO report showed that 28%–35% of people aged ≥65 years worldwide experience a fall every year and that the occurrence of this event increases with age.[2] Nearly half of all fall events cause some injuries,[3] leading to healthcare consultations (24%), functional decline (35%) and impaired social or physical activity (15%).[4] A recent article from the USA reported that nearly one in four US residents aged ≥65 years experienced a fall in 2014, accounting for 29 million falls per year and resulting in ~30 000 deaths in 2016.[5] Considering the burden of fall-related injury and mortality,[6 7] there is a need to investigate and discuss fall-preventive measures in a more multifaceted manner based on adequate epidemiological studies.

Numerous studies have analysed mortality trends worldwide to improve fall-related mortality.[7–13] Global ageing societies are expected to provide significant countermeasures against unintentional falls. Recent studies have reported that the implementation of certain exercises and multifactorial interventions can improve fall-related outcomes in older adults.[14 15] Thus, an understanding of high-risk populations can contribute to policy decisions, effectively introducing a preventive programme. In the 1990s, a study reported that ~20% of Japanese older adults fell more than once per year.[16] Based on the vital statistics of Japan, fall-related mortality was the second most common cause of unintentional deaths with an external cause, followed by drowning and traffic deaths in 2016.[17] However, to the best of our knowledge, no well-established mortality trend analysis of fall-related deaths has been conducted for the super-ageing Japanese society.

In this study, we aimed to evaluate the trends of fall-related deaths in Japan during the last two decades among adults aged ≥65 years by age and sex. We particularly focused on differences and similarities with other countries to address the issues faced by ageing societies worldwide.

METHODS

Data source

This 20-year retrospective observational study analysed data from 1997 to 2016. We obtained data on the number of unintentional fall-related deaths by sex and age from the vital statistics collected by the Japanese Ministry of Health, Labour and Welfare following the international coding rules of the WHO.[18] Data regarding the underlying cause of death were obtained from death certificates using *International Statistical Classification of Diseases and Related Health Problems, Tenth Revision* (ICD-10) codes. Death certificates are completed by a physician within a week after death, and the cause of death is identified and reported to the health ministry through regional health centres. We calculated crude and age-adjusted mortality rates per 100 000 persons per year for men and women. To correct for demographic changes throughout the study period, we adopted age adjustment by the direct-standardisation method and calculated the age-adjusted rates (AARs) of fall-related mortality based on the Japanese population structure in the first year of the study, using 5-year age groups. We identified unintentional falls using the ICD-10 codes W00–W19, which have been used in previous studies.[5 7 9–11] ICD-10 was introduced in 1995 in Japan. In Japan's published mortality data, W18 has been aggregated to W01 and W19 to W17 by the Japanese Ministry of Health, Labour and Welfare. The complete dataset is available in online supplementary table 1.

Statistical analyses and data processing

To estimate trends in AARs, we applied a joinpoint regression model using the Joinpoint Regression Program V.4.5.0.1, June 2017.[19] We entered fall-related mortality rates into the model, which were then used to display the trend inflexion points (years) with changes. We determined annual percentage change (APC) between trend-change points by its CIs. The APC was calculated as APC=100 × (exp (β) - 1), where β is the slope of the regression line. To compare differences in mortality trends among population subgroups, we estimated the average annual percentage change (AAPC) of the entire period and that of the last 5 years. The AAPC was calculated as AAPC=100 × (exp (Σ wj × βj) − 1), where βj are the slopes of each trend, and wj are weights proportional to the length of the time partitions. We performed data processing and aggregation using Microsoft Access V.2013.

Patient and public involvement

The development of the research question and outcome measures were informed by the need to lower fall-related mortality relates, particularly among those aged ≥65 years. However, patients were not directly involved in the study as we utilised a readily available dataset.

Ethics approval

This study used data published by the Japanese Ministry of Health, Labour and Welfare and the Statistics Bureau of the Ministry of Internal Affairs and Communications. Since these data are fully anonymised and open to the public, the ethics committee of the Okayama University Graduate School of Medicine, Dentistry and Pharmaceutical Sciences decided that there was no requirement of a formal ethical review.

RESULTS

Trends in overall crude mortality rates

The total number of fall-related deaths in Japan increased between 1997 (5872 cases; 3761 men and 2111 women) and 2016 (8030 cases; 4488 men and 3542 women). Of these, 110 282 (58 381 men and 51 901 women) involved persons aged ≥65 years, accounting for 78.8% of the total fall-related deaths among all age groups (70.7% of men and 90.6% of women) (online supplementary figure S1). The crude death rates in 2016 were higher among men than women in all age groups aged ≥65 years (online supplementary figure S2).

Table 1 summarises the crude mortality rates of unintentional falls by age (categorised into 5-year groups) and sex in the older population. The overall mortality rates per 100 000 persons increased from 19.5 in 1997 to 20.5 in 2016. Long-term crude mortality rates in men and women are described in online supplementary figure 3. For both men and women aged <90 years, the crude mortality rates decreased in each age category. However, for persons aged ≥90 years, we observed a mortality rate of >100 per 100 000 (>0.1%) in the male population and an increasing trend of mortality rates for both men and women aged ≥95 years.

Trends in crude mortality rates by age

We stratified the crude mortality data into three age categories (65–74, 75–84 and ≥85 years); the trends are presented in figure 1. The higher age category (≥85 years) exhibited greater mortality rates in both sexes. Of the three age categories, the joinpoint analysis demonstrated that the younger age category (65–74 years) showed a faster decline in the mortality rates of both sexes; the AAPCs for the entire period were −2.8% (95% CI −3.9 to −1.7) for men and −2.5% (95% CI −3.3 to −1.7) for women (table 2). In the middle-age category (75–84 years), the mortality of the male population showed decreasing trends in the first 10 years (between 1997 and 2006) and the last 6 years (between 2011 and 2016), resulting in an AAPC for the entire period of a modest decrease at

Table 1 Crude rates of fall-related deaths per 100 000 in older adults aged 65 years or over, 1997–2016

Age (years)	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
≥65																				
Overall	19.5	20.3	20.9	20.2	20.2	19.6	20.9	19.2	20.1	19.1	19.8	20.2	20.5	21.0	21.5	21.7	21.0	20.8	20.8	20.5
Male	25.3	25.3	26.5	24.7	25.0	25.0	26.0	24.0	25.3	24.0	24.4	25.3	25.8	25.9	27.0	27.2	26.3	25.6	25.1	24.7
Female	15.5	16.7	16.9	17.0	16.8	15.7	17.1	15.7	16.3	15.4	16.4	16.5	16.5	17.3	17.5	17.5	16.9	17.1	17.5	17.2
65–69																				
Overall	8.0	7.4	8.4	7.8	7.3	6.7	7.1	6.1	6.3	5.8	6.2	6.1	5.7	5.8	5.1	5.4	5.5	4.9	4.6	4.5
Male	13.8	13.1	14.2	13.5	12.4	11.8	12.3	10.5	10.5	9.9	10.4	10.3	9.5	9.4	8.6	8.9	9.6	8.4	7.4	7.4
Female	2.7	2.3	3.2	2.7	2.7	2.1	2.4	2.2	2.4	2.1	2.3	2.2	2.3	2.4	1.9	2.1	1.7	1.6	1.9	1.7
70–74																				
Overall	9.6	10.0	10.8	10.3	10.0	10.1	11.3	9.6	10.2	9.3	9.6	9.8	9.7	9.2	8.4	8.6	8.1	7.8	7.9	6.5
Male	15.4	16.0	17.0	16.4	16.1	16.6	18.7	16.5	16.9	15.0	15.7	15.7	15.7	14.7	13.5	13.7	13.4	13.0	12.7	11.2
Female	5.1	5.2	5.7	5.2	4.8	4.6	5.2	3.8	4.5	4.3	4.4	4.8	4.5	4.5	4.0	4.1	3.5	3.3	3.6	2.5
75–79																				
Overall	17.2	16.4	15.5	15.4	16.3	16.5	16.4	16.0	15.8	15.6	15.7	15.7	16.6	14.7	15.4	14.9	14.6	14.8	12.6	12.9
Male	27.3	25.2	24.2	22.8	25.0	26.1	24.7	24.6	24.8	25.0	23.9	24.3	26.5	23.2	24.3	24.2	23.6	23.4	20.6	21.0
Female	11.1	11.2	10.1	10.6	10.5	9.7	10.3	9.7	9.1	8.4	9.5	9.0	9.1	8.1	8.5	7.7	7.7	7.9	6.3	6.3
80–84																				
Overall	30.9	32.6	34.4	31.0	30.0	29.1	30.4	26.9	28.7	27.1	26.4	27.8	29.0	29.2	30.3	29.5	27.6	26.5	27.2	24.9
Male	42.4	45.1	48.0	41.0	43.2	45.5	42.1	41.2	40.6	38.2	39.2	42.7	43.9	45.3	47.3	47.1	43.1	40.8	42.7	38.1
Female	24.5	25.8	27.1	25.6	23.0	20.4	24.2	19.3	22.1	20.7	18.6	18.4	19.5	18.9	19.3	18.0	17.5	17.1	16.9	15.9
85–89																				
Overall	58.9	62.5	60.5	60.1	58.0	55.5	55.3	54.6	53.2	49.7	50.8	49.7	48.5	50.5	53.0	51.4	50.8	51.7	52.4	50.5
Male	82.4	81.4	85.2	75.1	73.9	74.1	74.1	69.6	78.1	72.8	70.2	69.7	69.5	73.5	80.0	75.7	74.7	74.3	75.7	72.2
Female	48.2	54.1	49.6	53.3	50.8	47.2	46.9	47.9	42.5	39.9	42.6	41.3	39.4	40.4	40.6	39.7	38.9	40.2	40.6	39.3
≥90 (90–94)*																				
Overall	132.1	140.1	138.0	131.2	132.2	116.4	126.2	107.2	101.5	87.4	99.7	94.3	91.4	98.7	100.0	99.5	93.3	98.6	98.5	100.1
Male	159.3	167.3	172.2	161.6	160.4	131.3	160.4	124.3	129.4	118.5	126.5	127.1	126.5	136.5	141.5	142.9	128.6	135.6	136.2	143.1
Female	122.4	131.0	126.8	121.0	122.9	111.5	115.2	101.7	92.2	77.2	90.8	83.4	80.1	87.0	87.3	86.4	82.7	87.0	86.2	85.5
95–99*																				
Overall	–	–	–	–	–	–	–	–	150.5	151.1	142.5	156.6	149.5	179.5	158.0	176.7	171.7	156.3	185.1	184.3
Male	–	–	–	–	–	–	–	–	214.3	186.7	166.0	194.5	175.0	226.8	194.9	237.7	233.9	207.9	234.4	241.8
Female	–	–	–	–	–	–	–	–	134.7	142.6	137.0	147.6	143.5	168.6	149.6	163.0	158.0	145.0	174.5	172.2
≥100*																				
Overall	–	–	–	–	–	–	–	–	188.0	210.3	174.3	219.5	227.1	250.0	240.4	278.4	270.9	245.0	237.1	260.6
Male	–	–	–	–	–	–	–	–	200.0	300.0	200.0	250.0	257.1	383.3	383.3	400.0	457.1	325.0	237.5	322.2
Female	–	–	–	–	–	–	–	–	177.3	196.0	170.0	214.3	222.0	228.9	219.5	259.1	243.8	232.7	241.5	250.9

*From 2005, from, 90–94, 95–99 and >100 years categories were available.

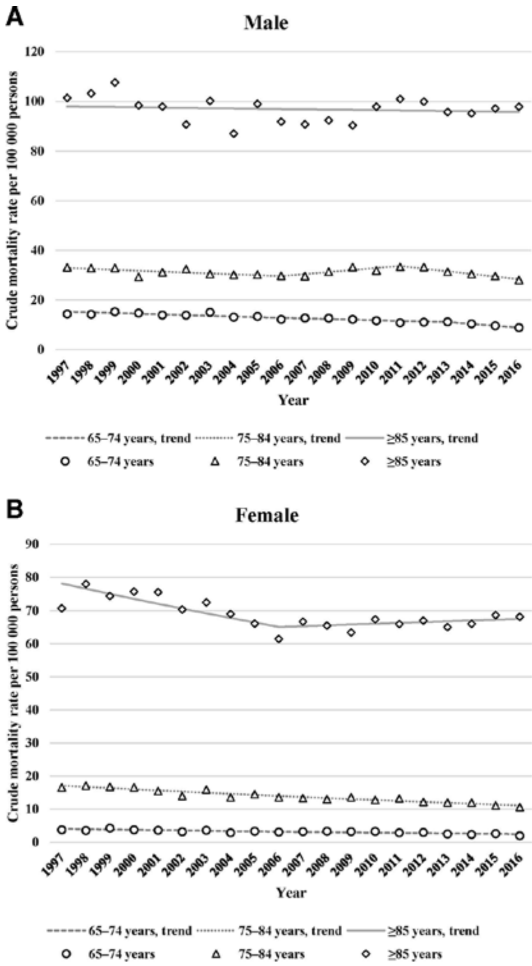

Figure 1 Trends in crude mortality rates from accidental falls by age and sex between 1997 and 2016.

−0.8% (95% CI −1.6 to 0.1). For middle-aged women, on the other hand, the trend in mortality rates has consistently declined in the study period (AAPC, −2.2% (95% CI −2.6 to −1.9)). The higher age category (≥85 years) showed a different trend for men and women. In men, the mortality rates did not show a trend during the study period (AAPC, −0.1% (95% CI −0.5 to 0.3)). However, in women, although the overall mortality trend showed a continuous decline (AAPC, −0.8% (95% CI −1.3 to −0.3)) owing to a decrease in the first decade, it levelled off after 2006 (APC, 0.4%).

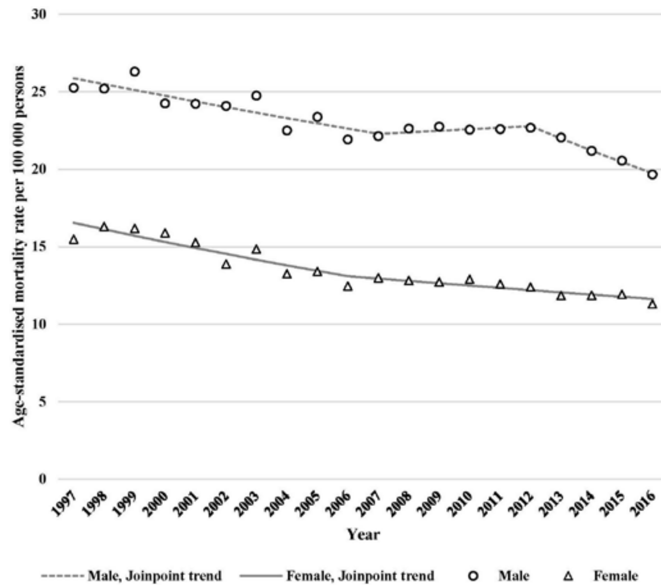

Figure 2 Trends in age-standardised mortality rates from accidental falls in older persons aged ≥65 years by sex between 1997 and 2016.

Trends in age-standardised mortality rates by sex

Figure 2 presents the overall trends in age-standardised mortality rates by sex. Throughout the study period, the age-adjusted mortality rate of the male population remained approximately twice as high as that of the female population. The joinpoint regression analysis corroborated that the overall age-standardised mortality rates demonstrated a continuous decline; the AAPC for the entire period was −1.5% (95% CI −2.2 to −0.9; table 3). In the male population, although the mortality rate did not show a decrease between 2007 and 2012 (APC, 0.4%), a decrease was observed in the most recent 5 years (APC, −3.5%). Consequently, the male population AAPC for the entire period was −1.4% (95% CI −2.1 to −0.7). By contrast, the mortality rate in the female population continuously showed a decrease throughout the research period. Thus, the drop in mortality rates among

Table 2 Trend analysis in crude mortality rates from accidental falls per 100 000 by sex and age, 1997–2016

Age group (years)	Period 1		Period 2		Period 3		Average APC (95% CI)
	Years	APC (95% CI)	Years	APC (%)	Years	APC (%)	Entire study period
Male							
65–74	1997–2013	−2.0 (−2.5 to −1.5)	2013–2016	−7.1 (−13.3 to −0.4)			−2.8 (−3.9 to −1.7)
75–84	1997–2006	−1.1 (−2.1 to −0.2)	2006–2011	2.6 (−0.2 to 5.5)	2011–2016	−3.4 (−5.1 to −1.6)	−0.8 (−1.6 to 0.1)
≥85	1997–2016	−0.1 (−0.5 to 0.3)					−0.1 (−0.5 to 0.3)
Female							
65–74	1997–2016	−2.5 (−3.3 to −1.7)					−2.5 (−3.3 to −1.7)
75–84	1997–2016	−2.2 (−2.6 to −1.9)					−2.2 (−2.6 to −1.9)
≥85	1997–2006	−2.0 (−2.9 to −1.1)	2006–2016	0.4 (−0.3 to 1.0)			−0.8 (−1.3 to −0.3)

APC, annual percentage change.

Table 3 Trend analysis of age-standardised mortality rates per 100 000 persons aged 65 years or over, 1997–2016

	Period 1		Period 2		Period 3		Average APC (95% CI)
	Years	APC (95% CI)	Years	APC (95% CI)	Years	APC (95% CI)	Entire study period
Total	1997–2006	−2.0 (−2.6 to −1.3)	2006–2012	0.0 (−1.6 to 1.5)	2012–2016	−2.7 (−4.7 to −0.7)	−1.5 (−2.2 to −0.9)
Male	1997–2007	−1.5 (−2.1 to −0.9)	2007–2012	0.4 (−1.8 to 2.7)	2012–2016	−3.5 (−5.6 to −1.5)	−1.4 (−2.1 to −0.7)
Female	1997–2006	−2.6 (−3.4 to −1.7)	2006–2016	−1.2 (−1.9 to −0.5)			−1.8 (−2.3 to −1.3)

APC, annual percentage change.

women (AAPC, −1.8% (95% CI −2.3 to −1.3)) occurred faster than that among men.

DISCUSSION

The overall crude mortality rate of Japanese people aged ≥65 years has remained ~20 per 100 000 persons over the last two decades. However, the age-stratified analysis demonstrated that crude mortality among those aged <75 years has decreased in both men and women. Compared with men, we observed decreasing trends even in the older populations (75–84 and ≥85 years) in women. Age-standardised mortality rates have also decreased over the study period for both men and women.

Previous studies have shown increasing trends in fall-related deaths in other developed countries.[9–12 20–22] For instance, in the Netherlands, fall-related deaths among people aged ≥80 years increased between 2000 and 2016.[10] Moreover, a study in Spain found increasing fall-related mortality trends for both men ≥65 years and women ≥75 years using joinpoint analysis.[11] Based on the latest WHO data, the Japanese life expectancy at birth is continuing to rise; in 2016, it reached 80.5 years for men and 86.8 years for women.[23] Our analysis revealed that the fall-related mortality of Japanese people under the life expectancy age roughly showed a decreasing trend. However, the prevention of falls in the super-aged population (ie, those above the life expectancy age) is practically challenging and thus requires individual and innovative approaches. Alternatively, the fact that the oldest people alone showed a levelling-off in the high crude mortality rate suggests that it may be difficult to further reduce the fall-related mortality in any way in this age group.

Although our trend analysis showed declining trends in the overall fall-related mortality, those among persons aged ≥90 years remain over 100 per 100 000 (>0.1%). Multifactorial causes could be associated with the higher fall-related mortality observed in older populations. First, the trend could be related to the presence of reporting bias—namely, a better awareness of falls as a possible cause of death might have contributed to the increasing trend in Japan, as has also been indicated abroad.[24] Second, changes in the living circumstances of older adults might have also affected the trend. In general, as the number of seniors living alone with multimorbidity and polypharmacy increases, so do the rates of fall-related injuries.[25] Additionally, an increase in more active and independent older adults can result in rising numbers of unintentional falls.[5 26] Third, increased frailty among older population could explain a high level of fall-related mortality.[11 27] There might be other factors accounting for the increasing trend of fall-related mortality among the older population; therefore, further multifactorial studies are needed.

We found that fall-related mortality was higher among men than among women throughout the whole study period and in every age category. According to a review article, several studies have suggested that the incidence of falls in Japan tended to be higher among women than among men.[28] Furthermore, the prevalence of frailty in Japan is reported to be higher in women (8.1%) than in men (7.6%).[29 30] These facts conflict with the lower rate of fall-related mortality in women, demanding an explanation. Generally, men tend to have poorer health conditions and multiple underlying diseases.[2] Although it has not been proven, we assume that a plausible reason for the higher mortality in men can be attributed to this difference in comorbidities. Further investigation should be conducted regarding this point.

Several possible factors for the decreasing trend in age-standardised fall-related mortality rates among the older population aged ≥65 years should be discussed. First, the number of incidences of unintentional falls might have affected death rates in Japan. Although the fall incidence rate was reported in a review article published in 2009,[28] the long-term incidence rate, including that during the current decade, has not been revealed in Japan. Although previous studies have reported that the fall-related death rate does not necessarily show a similar trend as does the fall incidence rate,[11 31] a lack of the fall incidence rate in this study limits the evaluation of the results. Second, improvements in the death recording system during the study period might have affected the findings. The vital statistics in Japan incorporated ICD-10 codes in 1995, which preceded the first year of this study. Thus, the disease coding system remained the same during the study period, and progress in the reporting system might not be relevant to the overall decreasing trend of fall-related deaths.

Third, changes in health policy to prevent falls might favourably influence the fall-related death rates. In Japan, the government and related academic societies have tried to reduce the burden of falls. Initially, they emphasised the social cognition of senile frailty.[18] According to a recent systematic review and meta-analysis, the prevalence of frailty increases with age, at 1.9%, 3.8%, 10.0%, 20.4% and 35.1% among those aged 65–69, 70–74, 75–79, 80–84 and ≥85 years, respectively.[30] Given that frailty progresses as people age, better recognition and counterplans for frailty among older adults are warranted to prevent fall-related deaths. As additional policy changes, countermeasures for osteoporosis have been highlighted, in consideration of the fact that the increasing prevalence of osteoporosis in the older population poses a great risk of bone fractures.[32] Additionally, the spread of sarcopenia—the age-related decline or loss of skeletal muscle mass and strength—among the older population is another factor of concern. The prevalence of sarcopenia among community-dwelling Japanese older adults aged 65–89 years is >20% in both men and women, and increases in an age-dependent manner.[33] People with sarcopenia experience falls and fear of falling more frequently than do non-sarcopenic healthy adults.[33] The Japan Geriatrics Society is currently focussing on sarcopenia treatment in order to better address this challenging geriatric problem. These efforts by the government of Japan and academic societies might result in a decreasing trend in fall-related death rates. However, as far as we know, no study has evaluated the effectiveness of these efforts on fall-related deaths. Therefore, further studies to evaluate such social efforts will be required in the future.

The strength of this study was the availability of national data and the novelty of investigating fall-related mortality trends in the world's foremost ageing society, Japan. Moreover, using joinpoint trend analysis for this type of research is a novel approach that has only previously been reported in one recent article from Spain.[11] The present study does, however, have the following limitations. First, underreporting of fall-related events might have influenced the results; for example, falls are the main aetiology of bone fractures in older adults, resulting in frailty and even death. With a femoral neck fracture in older adults, the mortality HRs after 3 months increased to 5.75 (95% CI 4.94 to 6.67) in women and 7.95 (95% CI 6.13 to 10.3) in men.[34] In some cases, deaths might have been registered as a result of a femoral fracture without an actual fall event. Additionally, a recent study comparing aggregate vital records and a representative cohort database in the USA showed an underestimation of fall-related mortality rates in the vital statistics.[35] Second, although ICD-10 codes were utilised in this study, data validity was uncertain since no clinical information on fall events was available. A recent article indicated that coding patterns for fall-related deaths vary by state in the USA, resulting in underestimations of fall events and deaths.[13] Finally, our study lacks an analysis on fall-related incidence rates, which directly influence the fall mortality trends. Despite these limitations, our findings are helpful for evaluating the changes in fall-related deaths, which is important for developing more effective health policies.

CONCLUSIONS

The overall fall-related mortality trend in Japan has been consistently decreasing, especially for women. In this progressively ageing society, we need to develop and implement preventive health programmes that can reduce the social burden caused by unintentional falls. However, the effectiveness and methods of using social resources to improve the fall-related mortality of a super-aged population are unclear. Therefore, further investigation is required to reveal medically and socially associated factors that potentially affect fall-related deaths, including their incidence rate.

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