The mortality trends of falls among the elderly adults in the mainland of China, 2013—2020: A population-based study through the National Disease Surveillance Points system

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Summary

Background Fall in elderly is a major public health problem. Characterizing trends in fall mortality in different subpopulations could help identifying the needs and developing preventive program for target groups. Here we evaluated the trends of fall-related deaths in Chinese mainland among adults aged ≥60 years specific in sex, age, and provinces, to measure the change in this mortality rate between 2013 and 2020, and to explore the underlying factors influencing this change.

Methods Mortality data were retrieved from the National Disease Surveillance Points system(DSPs) of China, a national-level and provincial-level representative data source, to estimate the impact of elderly falls on mortality in the mainland of China and the specific provinces from 2013 to 2020. The joinpoint regression model was used to estimate the temporal trend of mortality in elderly fallen by calculating the annual percentage change (APC).

Findings The age-standardized falls mortality was 10·438 per 100 000 in 2020. The age-standardized mortality of elderly falls in total and female showed a steady increasing trend (APC=1·96%, p = 0·023 total; APC=3·42%, p = 0·003 female), with it was stable in males (APC=1.26%, p>0·05). Fall mortality among the elderly was more common in people over 70 years of age and increased sharply. The death rates and APCs were highest among the oldest age groups(aged≥85 years). The higher fall mortality was mainly focused in the southeast and central regions, and lower rates were in the northeast provinces and Tibet.

Interpretation Since 2013, the overall fall-related mortality trend among individuals aged ≥60 years has been consistently increasing in China, making it most critical public health challenge. Adherence interventions and increased social support for those at most risk should be considered.

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Keywords: Elder people; Falls; Mortality; Trend

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Introduction

Falls in the elderly are considered as a major problem.[1] Deaths from unintentional injuries are the seventh leading cause of death among older adults,[2] while falls account for the second leading cause of those deaths.[3] The mortality rate from falls is the highest among older adults.[4] Falls and fall-related injuries constitute a critical and raising public health problem, as evidenced from the Centers for Disease Control and Prevention national initiative,

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Research in context

Evidence before this study

With the accelerating rate of population aging in China and the increase in average life expectancy of the population, the number of elderly people and their proportion in the overall elderly population were also increasing. As they age and their body functions deteriorate, older adults were vulnerable to injury. Fall is a common unintentional injury among older adults, affecting their health and reducing their quality of life. This paper aimed to evaluate the trends of fall-related deaths in Chinese mainland among adults aged ≥60 years specific in sex, age, and provinces, to measure the change in this mortality rate between 2013 and 2020, and to explore the underlying factors influencing this change.

Added value of this study

We described fall mortality in older adults and its trends based on a national-level and provincial-level representative data source in China. Throught trend analysis, we have found that during 2013 to 2020, the fall mortality rate among older people in China showed an increasing trend. We also found regional differences in fall mortality rates in China, with higher fall mortality rates concentrated in the southeast and central regions and lower rates in the northeastern provinces and Tibet. This differs from majority of previous studies on falls in older adults that have focused on specific segments of the populations and/or limited geographic areas with small sample sizes, but more detailed data are lacking.

Implications of all the available evidence

Adherence interventions and increased social support for those at most risk should be considered. The local public health agencies should develop technical guidelines and standards for fall injury interventions according to the characteristics of each province in order to curb the increasing trend of fall deaths among older adults and reduce the burden on society in the future.

Stopping Elderly Accidents, Deaths and Injuries (STEADI).[5] Falls are the most common cause of fatal and non-fatal injuries among older adults.[6] Studies have shown that,[7,8] one in three community-dwelling adults aged 65 years or older, and one in two aged 80 years or older, experience a fall each year. The number of disability-adjusted life years due to falls increased by 14% per 100,000 population between 2006 and 2016.[9] In China, unintentional falls are the leading cause of fatal and non-fatal injuries for people aged ≥65 years.[10] Load the high burden of falls on older people, a significant economic burden of falls and fall-related injuries could be reasonably expected, implying that greater attention should be given to this looming health crisis, especially to achieve the sustainable development goal of healthy aging.[11,12]

Although unintentional falls in elderly adults have been the subject of extensive research in recent decades, they were a raising major health concern,[13] and a relatively limited number of studies have analyzed trends in mortality among older adults from specific fall causes.[14–16] In China, most studies of falls in older adults had focused on specific segments of the populations and/or limited geographic areas with small sample sizes,[17,18] but more detailed data are lacking (e.g., Global Burden of Disease (GBD) estimates; the National Cause-of-Death Surveillance Dataset).[19] Effective public health interventions have been found to prevent the occurrence of falls and their complications.[16,20] Therefore, characterizing trends in fall mortality in different subpopulations could help identifying the special needs of these groups and developing appropriate prevention program for specific target groups.

In this study, we used the National Disease Surveillance Points system (DSPs) to estimate the impact of elderly falls on mortality in the mainland of China and its provinces from 2013 to 2020. By including these subnational data, the primary aims of our study were to evaluate the trends of fall-related deaths in Chinese mainland among adults aged ≥60 years by sex, age, and provinces, to measure the change in this mortality rate between 2013 and 2020, and to explore the underlying factors influencing this change. This information can be used to priorities action to prevention and control of falls in elderly people in Chinese mainland and its provinces.

Method

Data source

This is a population-based longitudinal analysis in China between January 1, 2013, and December 31, 2020. Mortality data were obtained from the 605 Disease Surveillance Points system (DSPs), which is managed by the Chinese Center for Disease Control and Prevention (CDC). The DSPs system covers more than 324 million people in China, which accounts for 24·3% of the country's population,[21] and provides the government and policy makers with timely and reliable cause of death data. For each surveillance point, deaths that occurred in hospitals, homes, nursing homes are reported, and the causes of death are determined according to a standard protocol by trained staff located in local hospitals or CDC branches. This analysis was approved by the ethics committee of Shantou University Medical College, Shantou, China (NO. SUMC-2018−41). Data were de-identified for analyses.

Quality control

DSPs implement rigorous quality control procedures to assess the completeness, accuracy of disease codes and logic checks of each relevant item reported on the medical death certificates. The procedures include annual

Year	Mortality					
	60–64	65–69	70–74	75–79	80–84	≥85
2013	11·499	15·518	21·788	45·375	106·346	352·557
2014	12·936	17·847	26·138	52·263	118·683	397·033
2015	11·706	16·761	24·738	48·395	116·853	405·105
2016	13·420	16·819	24·775	46·980	116·695	415·106
2017	13·725	18·841	27·016	50·006	124·577	464·339
2018	14·690	18·947	27·653	45·987	120·540	472·727
2019	11·702	17·662	30·120	60·247	132·639	572·045
2020	12·454	17·924	30·259	62·084	151·007	505·133
APC(%)[†]	0·91	1·73	4·17	3·41	3·84	6·03
95%CI	−2·53–4·47	−0·38–3·87	2·29–6·08	−0·23–7·18	1·81–5·91	3·67–8·45
p	0·547	0·092	**0·002**	0·062	**0·003**	**0·001**

***Table 1*: Mortality rate (per 100 000) of fall deaths by age and period, 2013–2020.**
[†] The annual percentage change was equated to the average annual percentage change for the years 2013–2020, due to the relatively small time span of trend analysis.

training of standard work flow, random checking of the accuracy of disease classification and duplication. These quality checks are required to be done at the county, province, and national levels. Retrospective surveys on underreporting would be implemented every three years, including 2012–2014, 2015–2017. The crude mortality rate obtained was adjusted according to the obtained under-reporting rate to obtain the true mortality level for the corresponding year. Estimated mortality rate = reported mortality rate / (1 - underreporting rate), and the underreporting rate for 2018–2020 was replaced by the approximate years. For uncertain cause of death, reviewing the detailed medical records or by redoing the verbal autopsy would be used to improving the quality of cause of death data.[22]

Classification of falls

The underlying cause of death are coded in accordance with the International Classification of Diseases-10th revision (ICD-10).[23] We classified fall of deaths W00–W19·9. The geographic unit of analysis includes 31 provinces and autonomous regions in the mainland China region. In the remainder of this paper, all locations would be referred to as provinces.

Statistical analysis

The standardized mortality rate for falls in the elderly was calculated based on the standardized population of China in 2010, with age-specific population data from the National Bureau of Statistics of China. Joinpoint analysis of the data was performed using Join-point regression Program 4.8.1 developed by the National Cancer Institute. It was used to identify time points (joinpoints) where linear trends changed during the time period examined. The software fits the simplest linear model with no joinpoints (a straight line) and tests whether 1 or more joinpoints (changes in linear trend) are statistically significant and should be added to the model. The dependent variables selected for the construction of the study were the fall mortality rate and the age-standardized mortality rate among the elderly, respectively. The independent variable is the year. The data file includes by-variables such as age group (Table 1), provinces (Figure 1), and gender (Figure 2). The temporal trend of elderly falls was assessed by calculating via the annual percentage change (APC) and average annual percent change (AAPC) for each indicator[24] and testing for statistical significance of the overall trend and the change in trend for each segment. The APC is used to calculate the internal trend for each independent interval of the segmentation function, or the global trend with zero connected points. The AAPC is used to synthetically evaluate the global average change trend involving multiple regions.[25] Due to the short study period, the maximum number of one linkage was set for each analysis, that is, the APC is equal to the AAPC. The significance level was set at 0·05. The spatial distribution of fall mortality in older adults in 2013 and 2020 was mapped using ArcGIS software.

Role of the funding source

This study received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Results

In 2020, the crude and age-standardized mortality rates for falls in older adults were 13·770 per 100,000 population and 10·438 per 100,000 population, respectively. There was a substantial geographical variation in fall mortality among older adults in Chinese mainland. Before adjustment, the higher fall mortality rate among

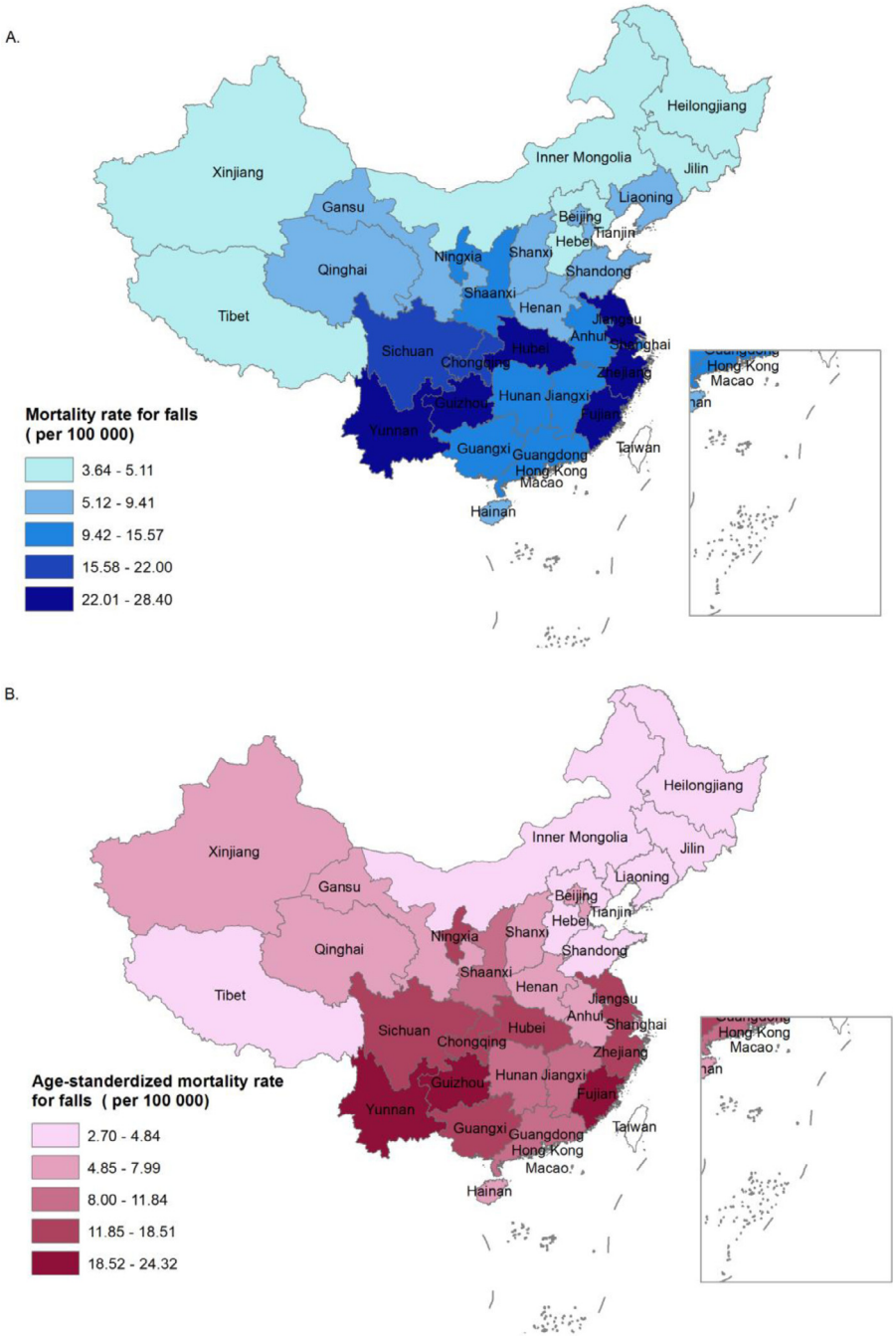

Figure 1. Fall mortality rates for elderly adults aged ≥60 years in provinces of China in 2020 in crude mortality (A) and age-standardized mortality (B).

the elderly was mainly concentrated in Zhejiang, Fujian, Yunnan, Guizhou, Hubei, Jiangsu, Sichuan, and Chongqing, with lower rates in Jilin, Tibet, Hebei, and Heilongjiang. After standardization by age, the fall mortality rate decreased, and the higher mortality rates were mainly concentrated in Yunnan, Guizhou, Fujian, Hubei, Zhejiang, and Jiangsu, while the lower rates in Jilin, Heilongjiang, Hebei, Tibet, Inner Mongolia, Liaoning, and Shandong (Figure 1). That is, the higher mortality rates among the elderly due to falls were mainly concentrated in the southeast and central regions, with lower rates in the northeast provinces and

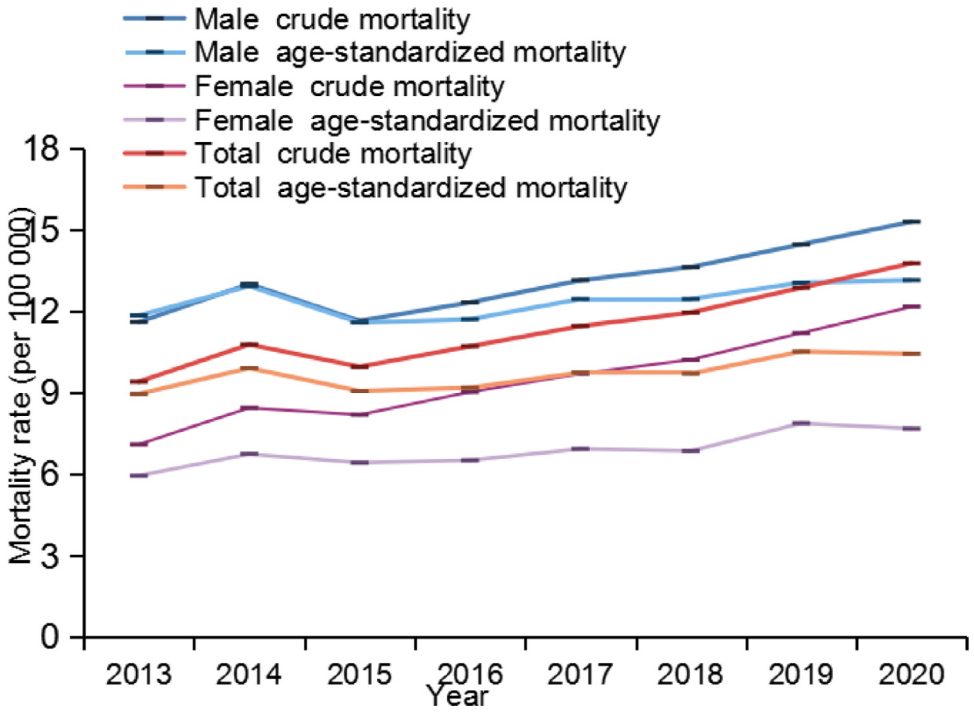

Figure 2. Mortality rate of falls among people aged 60 and above in the mainland of China, 2013–2020.

Tibet. In 2020, the age-standardized fall mortality rates among older adults ranged from 2·699 (1 per 100,000) in Jilin in the Northeast region to 24·319 (1 per 100,000) in Yunnan in the South-central region, approximately nice-fold.

Long-term crude mortality rates and standardized mortality in men and women from 2013 to 2020 were reported in Figure 2 and Supplementary Table 1. During the study period, the crude rates of fall-related deaths in the mainland of China increased from 9·412/100,000 in 2013 to 13·770/100,000 in 2020 (APC=5·08%, $p<0·05$) (For men:11·611/100,000 in 2013, 15·304/100,000 in 2020; for women: 7·103/100,000 in 2013, 12·174/100,000 in 2020). The age-standardized mortality of elderly falls in total and female showed a steady increasing trend (APC=1·96%, $p = 0·023$ total; APC=3·42%, $p = 0·003$ female). In contrast, among males, the mortality rate consistently showed a stable trend between 2013 and 2020 (APC=1·26%, $p>0·05$). After standardization based on demographic information, the fall mortality rates in 2020 for the male and female elderly were 13·147/100,000 and 7·683/100,000, respectively, with a higher standardized mortality in males than in females from 2013 to 2020.

Among all of the age groups, fall mortality among the elderly people was less common in people under 70 years old and more common in people over 70 years old, and had since increased sharply. The death rates and APCs were highest among the oldest age groups (aged≥85 years). The mortality of injuries in the 70–74, 80–84, and ≥85 age groups showed an increasing trend over the 8 years of this study, with a statistically significant of the annual percentage change ($p<0·05$), whereas there was no significant trend in the 65–69 and 75–79 age groups, and their annual percentage change decrease were not statistically significant ($p>0·05$), as detailed in Table 1.

The APCs for crude mortality from falls and standardized mortality in people aged 60 years and above from 2013 to 2020 were presented in Figure 3 and Supplementary Table 2. The largest APC in age-standardized mortality rates from falls (10·92% per year) occurred in Tianjin, followed by Ningxia (9·18%) and Shanxi (8·68%)($p<0·05$). A significant increase in the standardized rate from 2013 to 2020 occurred in 17 provinces (Fujian, Guangdong, Guizhou, Hainan, Hebei, Henan, Hubei, Hunan, Inner Mongolia, Jiangsu, Jiangxi, Liaoning, Ningxia, Shanxi, Sichuan, Tianjin, Yunnan) (APC>0 with $p<0·05$). No significant change in the standardized fall mortality rates occurred in 14 provinces (Anhui, Beijing, Chongqing, Gansu, Guangxi, Heilongjiang, Jilin, Qinghai, Shaanxi, Shandong, Shanghai, Tibet, Xinjiang, Zhejiang). That was, most provinces in the mainland of China showed an upward trend in fall mortality among the elderly.

Discussion

Using large, national-level and provincial-level representative data source on fall death, this study found that the

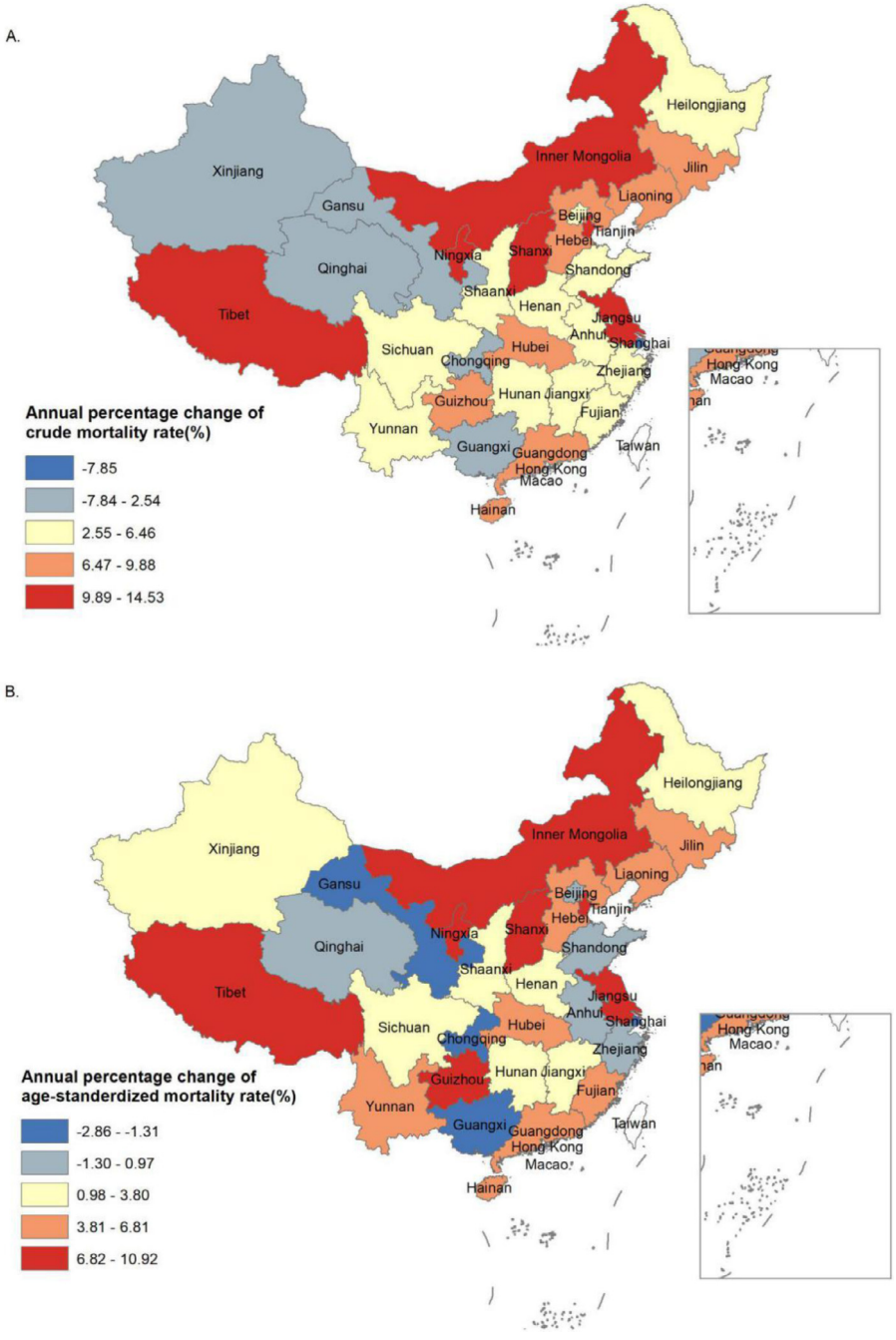

Figure 3. Percentage change in crude mortality rate (A) and percentage change in age-standardized mortality rate (B) for elderly falls from 2013 to 2020.

overall trend of increasing fall mortality among the elderly aged ≥60 years in China's mainland during the past 8 years could reflect the importance of focusing on fall prevention and control among the elderly in the context of the increasing aging phenomenon in China.

Previous studies showed an increasing trend of fall-related deaths in developed countries. For example, Drew and Xu[26] reported an increase in the falls death rate among people aged 65 years and over from 2004 to 2007 in the United States. In the Netherlands, the number of fall-related deaths among people ≥80 years old have increased since the period 2000 to 2016.[15] Our analysis revealed an increasing trend in fall mortality among older adults in the mainland of China from 2013

to 2020, and the increasing trend was statistically different among females. The population of older adults had changed in ways that increase the risk of death from falls. In fact, many older adults are now living longer, which in themselves increases the risk of fall injury. Furthermore, our result was similar to those[24,26,27] indicated that fall-related mortality rates were higher in men than in women throughout the study period. Several studies had attempted to explain the high falls mortality in male. Firstly, the higher mortality rate among older men following injuries from falls might be related to their increased incidence of falls outdoors and the relatively rapid decay of their leg muscles, combined with higher overall activity levels,[28] resulting in more serious types of injuries that are more likely to result in death.[26] For example, an analysis of data between 1996 and 2012 found that man was more likely to have sustained traumatic brain injury in car crashes in which they were the driver.[29] Studies examining sex differences in the types of fall-related injuries, found that after a fall injury, men had more head, face, and chest injuries than women, whereas women were more likely to have extremity injuries than men.[28,30] Secondly, the adverse severity effects that were detrimental to men were primarily driven by a small number of smoking-related conditions, including hypertension, stroke, pulmonary heart disease and other cardiovascular-related diseases.[31] And these, as important risk factors for elderly falls, had an interactive relationship with the presence of falls. When elderly men were prone to fall events during acute episodes of disease or accidental falls coupled with the elderly man's own comorbidities, it could easily lead to a life-threatening fall. Thirdly, a survey of Western populations showed that in terms of fear of falling and lower fall efficacy among female than male,[32] and fundamental differences between men and women, such as perceived and actual physical susceptibility, might have emerged.[33]

There is evidence from numerous studies that age was associated with a higher likelihood of fall mortality. Our findings in the current study were consistent with that. This phenomenon might be attributed to the decline in bodily functions, such as gait or balance, the decreased performance of activities of daily life and visual impairment, along with increasing age. As they age, older adults might therefore be becoming increasingly frail, more likely to fall, and less likely to survive the resultant injuries.[34] Fall mortality in the elderly showed an increasing trend in the 70–74 group as well as in the 80+ group, suggesting that we need to pay special attention to the health of the oldest-old individuals. Randomized trials have almost invariably showed, and meta-analyses and systematic reviews confirmed, that strength and balance training for older adults could reduce the risk of both non-fatal and fatal falls.[35–36] Cadore *et al.* [37] had reported that certain exercises performed a high velocity of movement (i.e., bilateral knee extensions, semi-tandem foot stance, alignment, proprioceptive exercises on unstable surfaces) could be used to help improve muscle strength characteristics in a very elderly population. A randomized controlled trial of senior community-dwelling adults over the age of 70 showed that Tai Chi training was effective and useful measurement to reducing the number of falls, the risk of falls and improving functional balance and physical performance in physically inactive.[38]

We observed significant geographical disparities in the fall mortality among Chinese older adults. Older adults living in southeast part as well as the central provinces had higher mortality rates than those residing in northeast and Tibet. There were some plausible explanations for these regional differences. First, environmental and sociodemographic factors might contribute to the high mortality rates in south-eastern and the central China. Most of the population is concentrated in the southeastern side of China.[39] The population density is higher in the eastern coastal region, while the northeastern region is vast with relatively low population density. In addition, coastal regions in eastern and southern China might be vulnerable to severe weather such as typhoons, rainfall, and storm surges,[40] these environmental and geographical factors may, at least partially, explain these regional differences in mortality. Second, the higher rate of elderly falls in the south-eastern and the central region might also be related to the warmer weather, which might increase in the activity frequency of the elderly to a certain extent. Previous studies found that physical activity levels in older adults decrease in colder temperatures.[41] Therefore, it is recommended to strengthen the importance of fall prevention and control according to the fall situation of each provinces, improve the awareness of fall prevention among the elderly population, and formulate scientific and effective strategic measures for fall prevention and control in key areas and populations, considering into account the actual situation in the region.[42]

This study has several strength and limitations. The strengths of this study are the availability of nationally representative vital statistics, reporting the wide province-to-province variations in fall mortality rates in Chinese mainland and the need of investigating trends in fall-related deaths in China, a progressively aging country. The research does, however, have the several limitations. First, our study lacks other important parameters or clinical outcomes related to falls (such as the analysis of not-fatal falls), which may directly affect trends in fall-related deaths. Since, as with almost all public health surveillance systems, the DSPs data do not collect detailed information on the associated factors for falls. Second, misclassification or incomplete recoding of deaths is another concern that might lead to overestimation or underestimation of deaths from falls.[14] The mortality rates in Tibet and Hainan Province in this paper may be underestimated. Therefore, we will improve the motivation and responsibility of primary staff, enhance the

coverage of cause of death registration and the quality of data reporting, and gradually perfect the cause-of-death surveillance information for the whole Chinese population to obtain comprehensive population-wide mortality information. Finally, age-standardized populations may not fully adjust for populations in higher age groups (e.g., ≥85 years) and may explain differences between subgroups. Despite these limitations, our findings were beneficial in assessment of changes in fall-related mortality, which was important for the development of more effective health policies.

In general, the results of this study are of great significance to public health in China. This study, which examined the mortality of falls in more detail in terms of province, gender and age-specific patterns, revealed that since 2013–2020, the overall fall-related mortality trend among individuals aged 60 years and above have been consistently increasing in the mainland of China, making it most critical public health challenge. Therefore, adherence interventions and increased social support for those at most risk should be considered.[14] The local public health agencies should be conducted to improve, promote and implement effective interventions and develop technical guidelines and standards for fall injury interventions according to the characteristics of each province in order to curb the increasing trend of fall deaths among older adults and reduce the burden on society in the future.

Contributors

For research articles with several authors, LL and LW designed and conceived of the study and were primarily responsible for supervised data analysis and writing. JQ and KZ completed software analysis. KZ drafted the manuscript. JQ, PZ, PY, YL and JL collected and checked data. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

Declaration of interests

The authors declare no competing interests.

Data sharing Statement

Data used in this study can be accessed by contacting the Division of Vital Registration and Cause of Death Surveillance, National Center for Chronic and Noncommunicable Disease Control and Prevention, Chinese Center for Disease Control and Prevention (email crvsdata@chinacdc.cn).

Editor note

The Lancet Group takes a neutral position with respect to territorial claims in published maps and institutional affiliations.

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Supplementary materials

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