

# BMJ Open Population ageing and injurious falls among one million elderly people who used emergency medical services from 2010 to 2017 in Beijing, China: a longitudinal observational study

Siyu Zhao,<sup>1</sup> Yu Cao,<sup>2</sup> Yanni Lei,<sup>3</sup> Fangchao Liu,<sup>1</sup> Shiyu Shao,<sup>3</sup> Jue Liu,<sup>1</sup> Dongni Nie,<sup>3</sup> Nannan Yang,<sup>3</sup> Min Liu<sup>1</sup>

**To cite:** Zhao S, Cao Y, Lei Y, *et al.* Population ageing and injurious falls among one million elderly people who used emergency medical services from 2010 to 2017 in Beijing, China: a longitudinal observational study. *BMJ Open* 2019;**9**:e028292. doi:10.1136/bmjopen-2018-028292

► Pre-publication history and additional material is published online only. To view please visit the journal online (<http://dx.doi.org/10.1136/bmjopen-2018-028292>).

SZ and YC contributed equally.

Received 30 November 2018

Revised 8 June 2019

Accepted 10 June 2019



© Author(s) (or their employer(s)) 2019. Re-use permitted under CC BY-NC. No commercial re-use. See rights and permissions. Published by BMJ.

<sup>1</sup>Department of Epidemiology & Biostatistics, Peking University, School of Public Health, Beijing, China

<sup>2</sup>Emergency office, Beijing Municipal Commission of Health and Family Planning, Beijing, China

<sup>3</sup>120 Command and Dispatch Center, Beijing Emergency Medical Center, Beijing, China

## Correspondence to

Min Liu; [liumin@bjmu.edu.cn](mailto:liumin@bjmu.edu.cn)

## ABSTRACT

**Objectives** To access the epidemiological characteristics of elderly people using emergency medical services (EMS) in Beijing, as a consequence of injurious falls, and the association between an ageing population and injurious falls.

**Design** A longitudinal observational study based on Beijing EMS data.

**Setting** All citizens aged 60 years or above who used EMS from 2010 to 2017 in Beijing, China.

**Participants** During 2010 to 2017, 2516 128 people used EMS in Beijing. Of these, 1528 938 people aged under 60 years were excluded and the remaining 987 190 people were included in our study.

**Methods** Data were from the emergency dispatch database of Beijing's Emergency Medical Centre. We described the proportion of elderly people using EMS in Beijing due to injurious falls with regard to region, time, sex, age and proportion of the elderly population.

**Results** Among the 987 190 participants who used EMS, 82 694 (8.38%) had had a fall. The proportion of falls rose from 7.12% in 2010 to 9.45% in 2017, and was higher in urban (8.62%) than in suburban (7.80%) regions. Elderly people were more likely to use EMS due to injurious falls during September to November (8.99%) than during December to February (7.68%) (adjusted OR (aOR)=1.19), and during 08:00 to 09:59 (10.02%) than during 00:00 to 01:59 (4.11%) (aOR=2.52). Elderly people in districts with high (8.92%, aOR=1.15) and medium (8.23%, aOR=1.09) proportions of an elderly population were more likely to use EMS due to injurious falls than those in districts with a low proportion of elderly population (7.81%).

**Conclusions** In Beijing, the proportion of elderly people using EMS due to injurious falls increased with age, and was positively correlated with the proportion of the elderly population. Taking care of elderly people and preventing injurious falls should be one of the key issues to be handled in a society with an ageing population.

## INTRODUCTION

Falls among elderly adults are a major public health concern, especially in countries with

## Strengths and limitations of this study

- This was a long-term study of injurious falls among elderly people using emergency medical services (EMS) in a metropolis with the largest sample size to date.
- Our study was the first to study the correlation between the proportion of elderly population and injurious falls among elderly people, which was of great value to enhancing care for older adults in metropolises.
- Some people use taxis or private cars instead of calling for an emergency ambulance in an emergency, so that could not be calculated in our study.
- Our study was not able to identify and specifically describe those who used EMS more than once during the study period.

a huge amount of an ageing population. Approximately 28%–35% of people aged 65 years or above fall each year.<sup>1</sup> The proportion of emergency department visit and hospital admission due to falls for people aged 60 years or above range from 5.5 to 8.9 per 10 000 population and 1.6 to 3.0 per 10 000 population, respectively.<sup>1</sup> Falls are a cause of 19% of all emergency department visits<sup>2</sup> and more than 50% of injury-related hospitalisations among elderly people.<sup>3 4</sup> From 1990 to 2010 in USA, the disability-adjusted life years (DALYs) rank for falls had declined from 24 to 15, which had become the third in injuries, next only to road injury and self-harm.<sup>5</sup>

In China, falls are one of the leading contributors to disease burden among elderly people, leading to three million DALYs in 2012.<sup>6</sup> Among elderly people who reported unintentional injuries in the previous year in China, about 60% were related to falls.<sup>7</sup> In China's largest cities, more

than a third of community-living persons aged 60 years or older had fallen each year, and about 30% of these falls needed medical treatment.<sup>8</sup>

Over the past half century, China has witnessed a steady increase in life expectancy.<sup>6</sup> The average life expectancy at birth has risen from 44.6 years in 1950 to 75.3 years in 2015, and is expected to be around 80 years by 2050.<sup>6</sup> Beijing is one of the largest cities in China and in the world. By 2016, the registered population of Beijing had reached 13 629 000.<sup>9</sup> The number of people over 60 years old had risen from 2.35 million in 2010 to 3.29 million in 2016, with the proportion rising rapidly from 19% in 2010 to 24% in 2016.<sup>9 10</sup> The huge population size and rapid pace of population ageing poses great challenges to the health of elderly people in Beijing.

Previous studies found that older adults use emergency medical services (EMS) at higher rates than younger populations.<sup>11</sup> As a result, the ageing population will place a greater demand on EMS systems. Emergency calls related to falls account for a large proportion of EMS. As the number of older adults is increasing rapidly in China, the number of falls and fall-related injuries will also increase. However, because of the lack of a large data sample on elderly people's fall-related injuries and on their use of EMS due to injurious falls, the improvement of EMS for injurious falls among elderly people still lacks evidence. Moreover, previous studies indicated that prevalence of falls among elderly people changed over time and the living environment,<sup>12 13</sup> and the degree of population ageing and infrastructure construction such as roads in urban and suburban regions of Beijing are quite different from each other. Therefore, it is necessary to look into the current situation, trends and differences among different times and regions about the use of EMS due to injurious falls among elderly people, so as to enhance the capability of EMS in Beijing.

Using the emergency dispatch database of Beijing Emergency Medical Center from 2010 to 2017, this study aimed to explore the epidemiological characteristics of elderly people using EMS due to injurious falls in the past 8 years in terms of month, time of the day, sex, age, region, and to analyse if prevalence of injurious falls in

older adults was correlated with the proportion of the elderly population. The results of this study would fill the blank in literature on injurious falls among elderly people in Chinese EMS, draw attention towards injurious falls among elderly people in an ageing society, and provide the basis for prevention and timely treatment of injurious falls among elderly people, enhancing the level of EMS, and enhancing care for older adults.

## METHOD

### Study design and sample

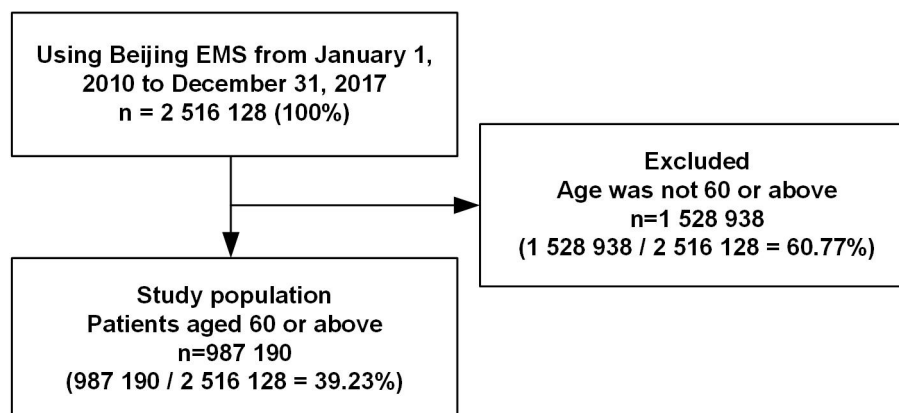
This study is a long-term longitudinal observational study based on EMS in Beijing. EMS in Beijing is undertaken by the Beijing Emergency Medical Center. The study data covered all 16 administrative districts in the city, including 6 urban districts (Fengtai, Shijingshan, Chaoyang, Xicheng, Dongcheng, Mentougou) and 10 suburban districts (Tongzhou, Pinggu, Shunyi, Fangshan, Yanqing, Huairou, Miyun, Changping, Haidian, Daxing).

The study population included all elderly people (a total of 2516 128 people aged 60 years or above) who used EMS in Beijing from 1 January 2010 to 31 December 2017. After excluding 1528 938 people aged under 60 years, 987 190 people were included in our study. The participant selection flow diagram is shown in figure 1.

### Data collection

Data were from the emergency dispatch database of Beijing Emergency Medical Center. Trained and qualified dispatchers asked and recorded data on sex, age and call reasons of the patients at the time a call was received. Data on year, month, time of day and district of the call were automatically recorded by the dispatching system.

In our study, the overall proportion of the elderly population in Beijing and in urban and suburban regions was calculated by the number of registered people aged 60 years or above (elderly population) and the number of registered people in Beijing. Data on elderly population every year were collected from the *Report on the Information and Development Status of older people Population in Beijing* written by the Beijing Working Committee Office



**Figure 1** Participant selection flow diagram. EMS, emergency medical services.

on Ageing. Data on registered population every year were collected from the *Beijing Statistical Yearbook* written by the Beijing Municipal Bureau of Statistics and Survey Office of the National Bureau of Statistics in Beijing. The data on registered population in 2017 were not available until our study. The proportion of elderly population in each district every year was directly collected from the *Report on the Information and Development Status of older people Population in Beijing*.

## Measures

### Injurious falls

Patients were determined as using EMS due to injurious falls if falls were mentioned in the reasons for the call. We excluded re-examinations for a fall-related injury, fall histories and falls related to suicide.

### Sociodemographic factors

According to the administrative divisions, 16 districts were divided into two groups as follows: urban regions and suburban regions. According to the division of four seasons in China, 12 months were divided into four groups as follows: March to May, June to August, September to November and December to February. According to the 24-hour system, accurate times of the calls were divided into 12 groups of 2 hours each. The ages of the participants were divided into three groups as follows: 60–79 years old, 80–100 years old and age not indicated (age of these people was informed as over 60 years at the time of calling, but the specific age was not given). The proportion of elderly population in each district every year was categorised as three groups according to the maximum (29.2%) and the minimum (15.8%): low proportion of elderly population (15.0%–19.9%), medium proportion of elderly population (20.0%–24.9%) and high proportion of elderly population (25.0%–30.0%). The group interval was equal to a third of the difference between the upper limit (30.0%) and the lower limit (15.0%). Data on the registered population in 2017 were not available until our study.

### Statistical analyses

Proportions were used to describe data distribution related to region, month, time of day, sex, age and proportion of elderly population of all the participants and those called due to injurious falls. The proportion of using EMS due to injurious falls among elderly people using EMS (proportion of falls) was calculated using percentage and 95% CI. The differences in the proportion of falls between urban and suburban regions among different sex and age groups were analysed using the  $\chi^2$  test. The analyses of trends of the proportion of falls from 2010 to 2017 were evaluated both overall and for participants in urban and suburban regions separately using percentage, 95% CI and linear trend  $\chi^2$  test. Percentages with 95% CI were unadjusted and were calculated by the normal distribution method. Univariable and multivariable logistic regression models were used to analyse determinants

related to the proportion of falls. Month, time of day, sex, age, region and proportion of elderly population were all included in the multivariable logistic regression model as independent variables. Crude ORs (cORs) and adjusted ORs (aORs) with 95% CIs were used to quantify effect size. IBM SPSS Statistics V.22 was used for  $\chi^2$  test and linear trend  $\chi^2$  test, and Stata MP V.14 was used for other data management and analyses.

### Ethical considerations

The study used information that is available in the emergency dispatch database of the Beijing Emergency Medical Center, and all identifiable information was removed.

### Patient and public involvement

Patients and the public were not involved in the design and conduct of the study. But the study findings will be disseminated through multiple channels including publication, meetings, conferences and social media.

## RESULTS

The analyses included 987 190 participants. Time distribution of the participants are as follows: 514 320 (52.10%) were from September to February; 553 641 (56.08%) were at 08:00 to 17:59. Demographic characteristics of the participants are as follows: 559 073 (56.63%) were between 60 years to 79 years of age; 489 388 (50.43%) were male; 698 988 (71.09%) were in urban regions, and 797 818 (81.14%) were in districts with medium and high proportions of elderly population (table 1).

Among the 987 190 participants who used EMS, 82 694 had had a fall, a proportion of 8.38% (95% CI 8.32% to 8.43%). The proportion of elderly population rose from 18.7% in 2010 to 24.2% in 2016, while the proportion of falls rose from 7.12% (95% CI 6.95% to 7.29%) in 2010 to 9.45% (95% CI 9.31% to 9.58%) in 2017. In urban regions, the proportion of elderly population rose from 20.0% in 2010 to 25.5% in 2017, while the proportion of falls rose from 7.38% (95% CI 7.20% to 7.57%) in 2010 to 9.76% (95% CI 9.59% to 9.94%) in 2017. In suburban regions, the proportion of elderly population rose from 16.6% in 2010 to 21.9% in 2017, while the proportion of falls rose from 5.61% (95% CI 5.23% to 6.01%) in 2010 to 8.93% (95% CI 8.72% to 9.15%) in 2017. The same trend was seen in all the 16 districts of Beijing (table 2, figure 2, online supplementary table 1).

Among male participants, proportion of falls was higher in urban regions (7.30%, 95% CI 7.22% to 7.39%) than in suburban regions (6.77%, 95% CI 6.65% to 6.91%) ( $p<0.0001$ ). Among female participants, proportion of falls was higher in urban regions (9.92%, 95% CI 9.82% to 10.02%) than in suburban regions (8.89%, 95% CI 8.74% to 9.05%) ( $p<0.0001$ ). An upward trend in the proportion of falls was seen in urban and suburban regions in both, the male and female groups ( $p<0.0001$ ) (figure 3, online supplementary table 3).

**Table 1** Characteristics of elderly people using emergency medical services (EMS) in Beijing from 2010 to 2017

Characteristics	Number of participants	
	N	%
Overall	987 190	100.00
Month of the call		
March–May	245 292	24.85
June–August	227 578	23.05
September–November	250 852	25.41
December–February	263 468	26.69
Time of the call during a day		
00:00–01:59	48 736	4.94
02:00–03:59	42 573	4.31
04:00–05:59	46 115	4.67
06:00–07:59	72 382	7.33
08:00–09:59	151 010	15.30
10:00–11:59	104 199	10.56
12:00–13:59	111 506	11.30
14:00–15:59	100 812	10.21
16:00–17:59	86 114	8.72
18:00–19:59	79 393	8.04
20:00–21:59	80 701	8.17
22:00–23:59	63 649	6.45
Sex		
Male	489 388	50.43
Female	480 974	49.57
Age, years		
60–79	559 073	56.63
80–100	391 079	39.62
Not indicated	37 038	3.75
Region		
Urban	698 988	71.09
Suburban	284 215	28.91
Proportion of elderly population		
Low	185 385	18.86
Medium	469 367	47.74
High	328 451	33.41

Participants with missing sex data (16 828) or missing district data (3987) were respectively excluded in the corresponding analysis.

Among participants aged 60–79 years, the proportion of falls was higher in urban regions (7.37%, 95% CI 7.29% to 7.46%) than in suburban regions (6.87%, 95% CI 6.75% to 6.99%) ( $p < 0.0001$ ). There was no difference in proportion of falls between urban regions (9.41%, 95% CI 9.31% to 9.52%) and suburban regions (9.60%, 95% CI 9.41% to 9.79%) among participants aged 80–100 years ( $p = 0.100$ ). An upward trend in proportion of falls was seen in urban and suburban regions,

both in the 60–79 years and the 80–100 years age groups ( $p < 0.0001$ ) (figure 3, online supplementary table 3).

The proportion of falls in different months, time of day, sex, age, region and proportion of elderly population groups is shown in table 3. Through multivariate logistic regression analysis, factors associated with proportion of falls are as follows: month, time of day, sex, age, region and proportion of elderly population. Elderly people in Beijing were more likely to use EMS due to injurious falls from September to November (autumn) than from December to February (winter) (aOR=1.19, 95% CI 1.16 to 1.21). Elderly people in Beijing were more likely to use EMS due to injurious falls during 08:00 to 09:59 than during 00:00 to 01:59 (aOR=2.52, 95% CI 2.40 to 2.64). Female elderly people were more likely to use EMS due to injurious falls than male elderly people (aOR=1.38, 95% CI 1.36 to 1.40). Elderly people in Beijing with unindicated age (aOR=2.18, 95% CI 2.11 to 2.25) and those aged 80–100 years (aOR=1.29, 95% CI 1.27 to 1.31) were more likely to use EMS due to injurious falls than those aged 60–79 years. Elderly people in urban regions were more likely to use EMS due to injurious falls than those in suburban regions (aOR=1.07, 95% CI 1.05 to 1.09). Elderly people in districts with high (aOR=1.15, 95% CI 1.12 to 1.17) and medium (aOR=1.09, 95% CI 1.06 to 1.11) proportions of elderly population were more likely to use EMS due to injurious falls than those in districts with low proportion of elderly population (table 3).

## DISCUSSION

Our study found that the overall proportion of falls among elderly people in Beijing was 8.38%, and the proportion of falls increased with time in 8 years. A previous study among people aged 70 years or more who presented to the emergency department in Vancouver General Hospital in 2008 found that among all the elderly patients' visits, 19% were fall-related.<sup>2</sup> The proportion of falls in our study is lower than in the results of the study in Vancouver, maybe due to differences in family structures and or because of the differences in the prevalence of other diseases between the two countries. A previous study in 2013 based on a community questionnaire in China indicated that the overall prevalence of falls among people aged 60 years or above in the previous 6 months was 8.0%.<sup>14</sup> And the prevalence of falls among community-dwelling elderly people in Beijing and Shanghai had been increasing with years.<sup>8</sup> In our study, we found the same rising trend. The EMS in China's megacities like Beijing is the most widespread and affordable EMS for residents, and plays a very important role in the timely treatment and care of elderly people. Sometimes it is even the only available health resource. Thus, it is a good indicator of elderly people's injuries which require medical assistance. However, to our knowledge, there has been no research on the proportion of falls among Chinese people using EMS.

**Table 2** Proportion of elderly population and elderly people using emergency medical services (EMS) due to injurious falls in urban and suburban regions of Beijing from 2010 to 2017

Year	Proportion of elderly population (%)			Using EMS					
	Overall	Urban	Suburban	Overall		Urban		Suburban	
				Number, N	Proportion of falls, % (95% CI)	Number, N	Proportion of falls, % (95% CI)	Number, N	Proportion of falls, % (95% CI)
Overall	-	-	-	987 190	8.38 (8.32 to 8.43)	698 988	8.62 (8.55 to 8.68)	284 215	7.80 (7.70 to 7.90)
2010	18.7	20.0	16.6	88 894	7.12 (6.95 to 7.29)	75 534	7.38 (7.20 to 7.57)	13 358	5.61 (5.23 to 6.01)
2011	19.4	20.7	17.3	95 960	7.51 (7.34 to 7.68)	75 051	7.81 (7.62 to 8.01)	20 764	6.42 (6.10 to 6.77)
2012	20.3	21.5	18.2	104 937	7.87 (7.71 to 8.03)	84 073	8.08 (7.90 to 8.26)	20 342	7.04 (6.70 to 7.40)
2013	21.2	22.5	19.1	111 746	8.17 (8.01 to 8.33)	85 918	8.69 (8.50 to 8.88)	25 397	6.43 (6.13 to 6.73)
2014	22.3	23.5	20.1	119 348	8.20 (8.05 to 8.36)	86 112	8.60 (8.42 to 8.79)	32 729	7.16 (6.89 to 7.45)
2015	23.3	24.6	21.2	133 893	8.67 (8.52 to 8.82)	86 304	8.95 (8.76 to 9.14)	45 498	8.18 (7.93 to 8.44)
2016	24.2	25.5	21.9	153 886	8.78 (8.64 to 8.92)	95 197	9.03 (8.85 to 9.22)	58 401	8.38 (8.16 to 8.61)
2017	-	-	-	178 526	9.45 (9.31 to 9.58)	110 799	9.76 (9.59 to 9.94)	67 726	8.93 (8.72 to 9.15)
$\chi^2$					616.897		432.603		372.839
P values					<0.0001		<0.0001		<0.0001

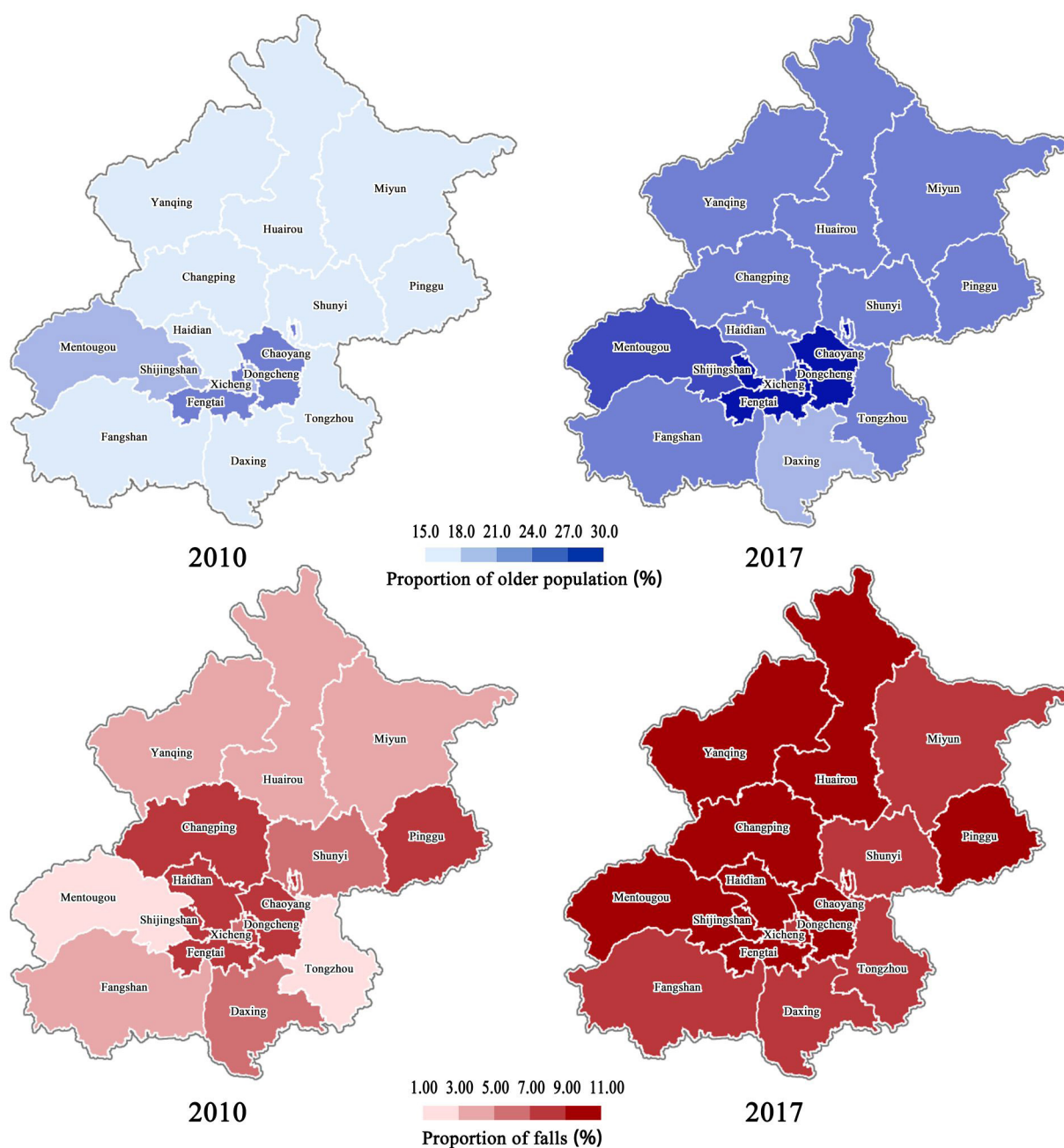
Participants with missing district data (3987) were excluded in the analysis of urban and suburban regions. Percentages with 95% CI were unadjusted and calculated by the normal distribution method.

According to WHO, China has become an ageing society, while Beijing, as the capital of China, has become an aged city.<sup>15</sup> From 2010 to 2017, the proportion of elderly population has increased from 18.7% to 24.2%. Ageing in China means the increase in the number of elderly people, and the decline of family size and changes in family structure. More and more elderly people no longer live with young adults. In 2005, 56.7% of elderly people in China were living with their children, noticeably down from 73.1% in 1982.<sup>16</sup> In Beijing, the proportion of the elderly population living in pure older family had increased to 16.1% in 2016, which was 14.7% in urban regions and 18.8% in suburban regions.<sup>9</sup> As a result, more elderly people are not getting enough care from their relatives.

In the 8years, the proportion of falls increased with time in both urban and suburban regions, while the proportion of elderly population in both urban and suburban regions increased as well. The proportion of falls was higher in urban regions over the years, but the growth was more drastic in suburban than in urban regions. Previous studies have found that elderly people in rural areas are more likely to fall<sup>7 17</sup> or to be hospitalised due to fall-related injuries<sup>18</sup> than those in urban areas because of differences in environmental and socioeconomic factors such as roads, indoor floors and income.<sup>1</sup>

However, our study found a higher overall proportion of falls in urban regions (8.62%) than in suburban regions (7.80%), which was inconsistent with previous studies. This might be because the differences in the living environment between urban and suburban regions of Beijing are not as distinct as the differences between urban and rural areas in other cities. Besides, differences between the indicators of our study and previous studies might also be an important reason, as higher awareness of the serious consequences of falls among elderly people in urban regions than in suburban regions might lead to a higher proportion of people using EMS due to falls.

Adequate and accessible aged care services play a critical role in reducing the risk of falls. Previous studies have reported that fall risk was higher among elderly people living alone than those cohabitating.<sup>19</sup> Elderly people are care-dependent because of loss of functioning resulting from chronic diseases and age-associated impairments, such as mobility impairment, cognitive impairment, vision impairment, hearing impairment and urinary incontinence.<sup>6</sup> Social care needs of elderly people are driven by their inability to self-care and live independently, most often assessed by needing help to undertake one or more basic activities of daily living such as bathing, dressing or toileting.<sup>20</sup> These function impairments are all risk factors for

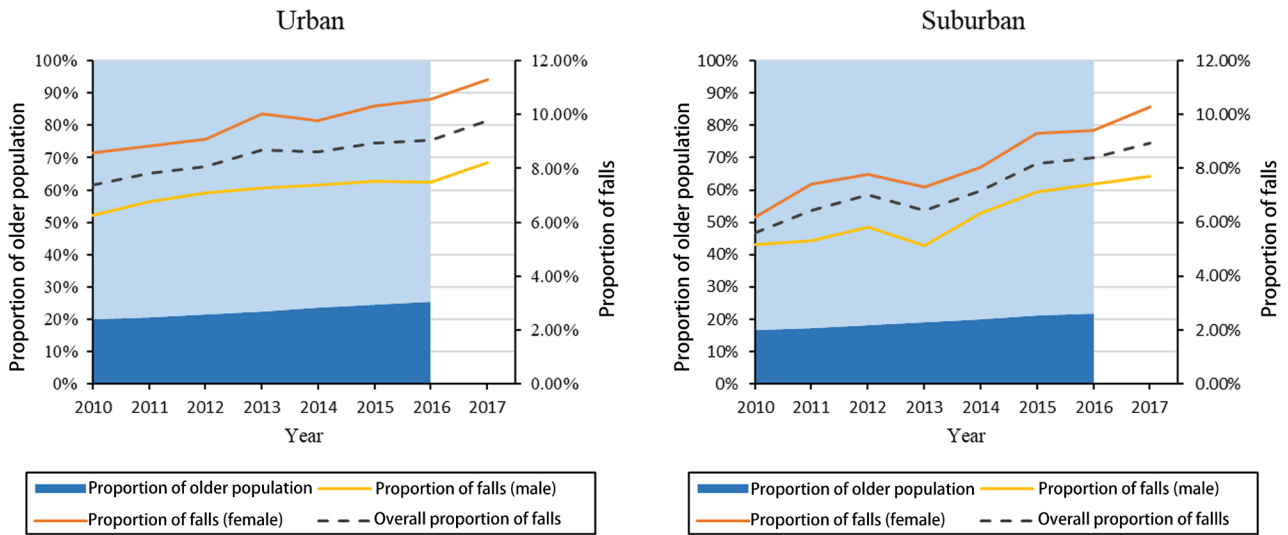


**Figure 2** Proportion of elderly population and proportion of falls in 2010 and 2017 for each district of Beijing.

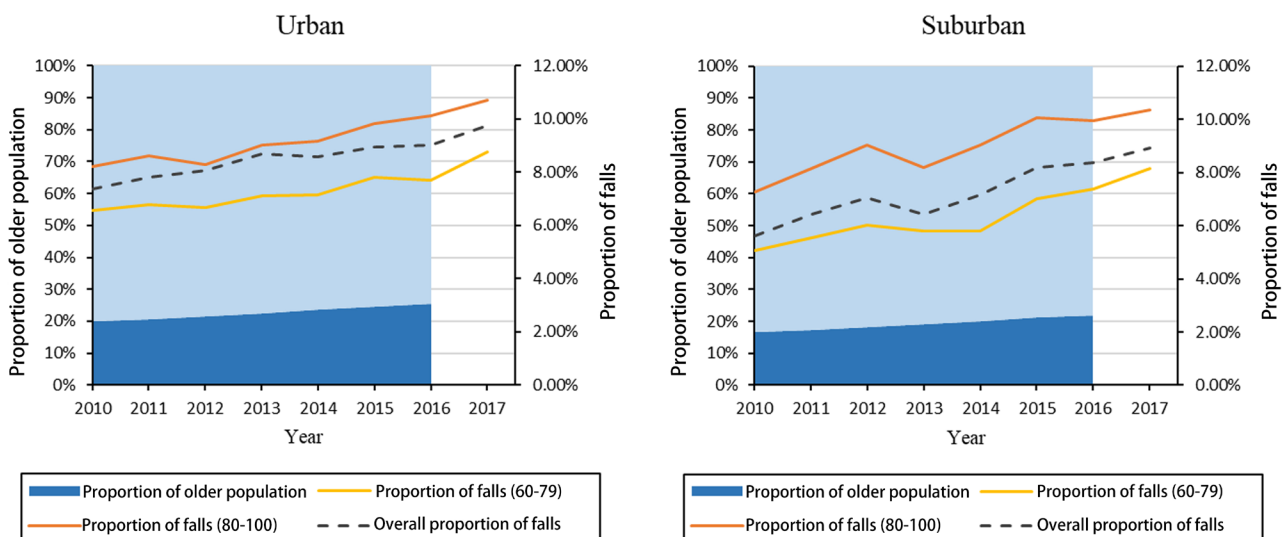
falls in elderly people.<sup>13 21–24</sup> Now, many communities in Beijing are trying to improve safety by providing multiple services to elderly people based on communities and institutions, including providing meals for elderly people, installing emergency medical rescue callers for pure older families in urban regions, and opening spiritual care hot lines for elderly people.<sup>9</sup> These kinds of services are playing a role in preventing elderly people from falling and helping them get emergency medical assistance in time after falling. However, studies have found that, because of a heavier burden of the elderly population, aged care services in the urban regions of Beijing were inadequate compared with the suburban regions,<sup>25</sup> which might be the main reason for

the higher proportion of falls in the urban regions of Beijing. Compared with urban regions, suburban regions have witnessed great changes in the economic structure in the past decade. The share of agriculture in the GDP has been decreasing and young adults have tended not to live in a big family with their old parents any more. However, young people moving out of the big family may need economic support from their parents, which make elderly people continue to work despite functional disability.<sup>6</sup> These might lead to a faster increase of the proportion of falls in suburban regions. Besides, rapid development of road construction and traffic have also complicated the impact on residents' health and safety in both urban and suburban regions, and may lead

[A] Trends in proportion of older population and proportion of falls in urban and suburban regions among different sex groups



[B] Trends in proportion of older population and proportion of falls in urban and suburban regions among different age groups



**Figure 3** Trends in proportion of elderly population and proportion of falls in urban and suburban regions from 2010 to 2017.

to changes in prevalence of falls among elderly people.<sup>26</sup> This should be studied in future research.

The growing tendency of proportion of falls in urban and suburban regions was also seen among different age and sex groups. The proportion of falls was higher in urban regions than in suburban regions in every age and sex group except in the 80–100 years age group. That highlighted a harsh condition of injurious falls among the very elderly age group in suburban regions. It seems that most elderly people in suburban regions are facing more serious problems of injurious falls than those in urban regions.

Previous studies have demonstrated that older age and female gender is related to higher risk of falls among

elderly people because of a decline in physical function.<sup>7 19</sup> Our study found that elderly people in Beijing aged 80–100 years were 1.29 times more likely to use EMS due to injurious falls than those aged 60–79 years, and female elderly people were 1.38 times more likely to use EMS due to injurious falls than male elderly people, which were consistent with previous studies. This emphasised the importance of paying close attention to injurious falls among women and people with advanced age. Moreover, the age group of ‘non-available’ showed a notable higher proportion of injurious falls than other age groups. This shows that elderly people in this group were those not able to state their age clearly because of poor cognitive performance or lack of caregivers. As a

**Table 3** Proportion of falls and risk factors for using emergency medical services (EMS) due to injurious falls among elderly people in Beijing from 2010 to 2017

Characteristics	Participants using EMS due to injurious falls, N (%)	Proportion of falls, % (95% CI)	cOR (95% CI)	aOR* (95% CI)
Overall	82 694 (100.00)	8.38 (8.32 to 8.43)	-	-
Month of the call				
March–May	19 808 (23.95)	8.08 (7.97 to 8.18)	1.06 (1.03 to 1.08)	1.05 (1.03 to 1.07)
June–August	20 108 (24.32)	8.84 (8.72 to 8.95)	1.17 (1.14 to 1.19)	1.16 (1.14 to 1.18)
September–November	22 545 (27.26)	8.99 (8.88 to 9.10)	1.19 (1.16 to 1.21)	1.19 (1.16 to 1.21)
December–February	20 233 (24.47)	7.68 (7.58 to 7.78)	1.00	1.00
Time of day during the call				
00:00–01:59	2001 (2.42)	4.11 (3.93 to 4.29)	1.00	1.00
02:00–03:59	1934 (2.34)	4.54 (4.35 to 4.74)	1.11 (1.04 to 1.18)	1.11 (1.04 to 1.19)
04:00–05:59	2810 (3.40)	6.09 (5.88 to 6.32)	1.52 (1.43 to 1.61)	1.50 (1.42 to 1.59)
06:00–07:59	7027 (8.50)	9.71 (9.49 to 9.93)	2.51 (2.39 to 2.64)	2.46 (2.34 to 2.59)
08:00–09:59	15 125 (18.29)	10.02 (9.87 to 10.17)	2.60 (2.48 to 2.73)	2.52 (2.40 to 2.64)
10:00–11:59	10 261 (12.41)	9.85 (9.67 to 10.03)	2.55 (2.43 to 2.68)	2.49 (2.36 to 2.61)
12:00–13:59	9847 (11.91)	8.83 (8.67 to 9.00)	2.26 (2.15 to 2.38)	2.20 (2.09 to 2.31)
14:00–15:59	9302 (11.25)	9.23 (9.05 to 9.41)	2.37 (2.26 to 2.49)	2.31 (2.20 to 2.43)
16:00–17:59	8570 (10.36)	9.95 (9.75 to 10.15)	2.58 (2.46 to 2.71)	2.51 (2.39 to 2.64)
18:00–19:59	6562 (7.94)	8.27 (8.08 to 8.46)	2.10 (2.00 to 2.22)	2.06 (1.96 to 2.17)
20:00–21:59	5932 (7.17)	7.35 (7.17 to 7.53)	1.85 (1.76 to 1.95)	1.82 (1.72 to 1.91)
22:00–23:59	3323 (4.02)	5.22 (5.05 to 5.40)	1.29 (1.22 to 1.36)	1.27 (1.20 to 1.35)
Sex				
Male	34 971 (43.01)	7.15 (7.07 to 7.22)	1.00	1.00
Female	46 339 (56.99)	9.63 (9.55 to 9.72)	1.39 (1.37 to 1.41)	1.38 (1.36 to 1.40)
Age, years				
60–79	40 280 (48.71)	7.20 (7.14 to 7.27)	1.00	1.00
80–100	36 978 (44.72)	9.46 (9.36 to 9.55)	1.34 (1.33 to 1.36)	1.29 (1.27 to 1.31)
Not indicated	5436 (6.57)	14.68 (14.32 to 15.04)	2.22 (2.15 to 2.28)	2.18 (2.11 to 2.25)
Region				
Urban	60 243 (73.11)	8.62 (8.55 to 8.68)	1.12 (1.10 to 1.13)	1.07 (1.05 to 1.09)
Suburban	22 160 (26.89)	7.80 (7.70 to 7.90)	1.00	1.00
Proportion of elderly population				
Low	14 481 (17.57)	7.81 (7.69 to 7.93)	1.00	1.00
Medium	38 622 (46.87)	8.23 (8.15 to 8.31)	1.06 (1.04 to 1.08)	1.09 (1.06 to 1.11)
High	29 300 (35.56)	8.92 (8.82 to 9.02)	1.16 (1.13 to 1.18)	1.15 (1.12 to 1.17)

Participants with missing sex data (16 828) or missing district data (3987) were respectively excluded in corresponding analysis of proportion of falls and crude OR (cOR). Participants with missing sex or district data (20 723) were excluded in analysis of adjusted OR (aOR).

Percentages with 95% CI were unadjusted and calculated by the normal distribution method.

\*Adjusted using the multivariable logistic regression model that included all six characteristics in this table.

result, they were faced with a higher risk of injurious falls.

A previous report has indicated that autumn was the peak time of falls among elderly people, with a proportion of 27.69%.<sup>27</sup> Our study came to a similar conclusion that elderly people were more likely to use EMS due to injurious falls in autumn. Because of the relatively pleasant climate during autumn in Beijing, elderly people may increase

their activities at this time. In our study, the proportion of falls was higher in summer than in winter, however, the number of people using EMS due to injurious falls was lower in summer than in winter. This may be because of relatively more distinct increase of diseases other than falls in winter, such as cardiovascular diseases. Previous studies showed that most falls among elderly people occurred in the morning (34.6%–42.1%),<sup>13 28</sup> but few



studies reported a specific estimate of time for falls or fall-related injuries. Our study found that 08:00–09:59 and 16:00–17:59 were two peaks of using EMS due to injurious falls among elderly people. Previous studies indicated that bedroom and community were the most common locations of falls indoors and outdoors for elderly people,<sup>28</sup> and using the toilet and walking were two main activities elderly people were doing when a fall occurred.<sup>29</sup> In Chinese cities, 08:00–09:59 is always the time for many elderly people to get up from bed, use the toilet and go out for a walk or shopping, and 16:00–17:59 is the time for some elderly people to go out to shop or to pick up their grandchildren. These periods of time are exactly the peaks of using EMS due to injurious falls in our results. As is mentioned above, elderly people today in China are getting less care from their adult children. Moreover, a pretty big number of elderly people start to play an important role in shopping and housework in a family. Plenty of activities and lack of intensive care lead to a huge potential of injurious falls. Therefore, the government and social forces are supposed to play a more important role in the care of elderly people, in accordance with healthy and active ageing.<sup>30</sup> The provision of affordable and accessible social care services to elderly people and the improvement of the geriatric healthcare system entail vigorous support from the government at all levels and the active participation of all in society.<sup>31 32</sup>

Our research has the following strengths. First, it was a long-term study of injurious falls among elderly people using EMS in a metropolis with the largest sample size till now. Second, different from most previous research based on questionnaire surveys in the community, the data of our study were the dispatch data from the Beijing Emergency Medical Center, which focused on actual falls requiring medical care and avoided recall bias to some extent. Occurrence of injurious falls in our study was better in authenticity and timeliness. Third, our study was the first to study the correlation between the proportion of older population and injurious falls among elderly people, which was of great value to enhancing care for older adults in metropolises. Our study also has several limitations. First, some people use taxis or private cars instead of calling for an emergency ambulance in an emergency, so that could not be calculated in our study. Second, we used the number of dispatches as the statistical unit in this study. However, some elderly people might use EMS more than once during the study period. This group of people might be at higher health risk than others. Limited by the data, our study was not able to identify and specifically describe these people. Third, not all of our participants called for EMS immediately after falling. People falling at night might not call for EMS until daytime came, which might lead to underestimation of the proportion of falls at night.

## CONCLUSION

In this large sample study of elderly people using EMS in Beijing, China, the proportion using EMS due to injurious falls increased with the years from 2010 to 2017, while the proportion of the elderly population increased as well. The proportion of falls was higher in urban than in suburban regions. Using EMS due to injurious falls was more likely to happen in autumn and daytime. Higher age, female gender and living in urban regions were associated with an increased proportion of falls. The proportion of falls was positively correlated with the proportion of older population.

The effects of a fall on an older person can be devastating, possibly resulting in chronic pain, loss of independence and diminished quality of life.<sup>33</sup> Beijing has become an aged society with the population ageing at a high pace. Injurious falls among elderly people has become an important public issue, which is severely affecting the health of the older population. Recently, the government of Beijing has issued a series of policies to continuously integrate and improve the prehospital emergency medical system and the dispatch command system, in order to provide better services to residents of Beijing. However, there are things that remain to be done by the relevant departments of the government to allocate limited health resources and improve EMS more reasonably and specifically. Moreover, care and prevention of falls in elderly people were crucial to achieve healthy and active ageing for all ageing societies. Close care should be paid to women and those older, while some specific time and activities should be paid special attention to. More studies focused on geriatric emergency medical assistance and injury prevention should be conducted, especially for those developing countries which were becoming or have already turned into aged societies.

**Contributors** SZ searched the literature, analysed the data, interpreted the results and drafted the manuscript. YC supervised the study and revised the manuscript. YL, DN and NY collected the data and revised the manuscript. FL and JL analysed the data and revised the manuscript. SS interpreted the results and revised the manuscript. ML conceived and designed the study, supervised the study, interpreted the results, and revised the manuscript. All authors have approved the final version of the manuscript. ML is the guarantor.

**Funding** The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

**Map disclaimer** The depiction of boundaries on the map(s) in this article do not imply the expression of any opinion whatsoever on the part of BMJ (or any member of its group) concerning the legal status of any country, territory, jurisdiction or area or of its authorities. The map(s) are provided without any warranty of any kind, either express or implied.

**Competing interests** None declared.

**Patient consent for publication** Not required.

**Ethics approval** Beijing Municipal Commission of Health and Family Planning.

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Data sharing statement** No additional data are available.

**Open access** This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given,

any changes made indicated, and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>.

## REFERENCES

- World Health Organization. *WHO Global Report on Falls Prevention in Older Age, France, 2007*.
- Woolcott JC, Khan KM, Mitrovic S, et al. The cost of fall related presentations to the ED: a prospective, in-person, patient-tracking analysis of health resource utilization. *Osteoporos Int* 2012;23:1513–9.
- Scott V, Pearce M, Pengelly C. Technical report: Hospitalizations due to falls among Canadians age 65 and over an analysis of data from the Discharge Abstract Database as presented in: Report on Seniors' falls in Canada (section 2.2). *British Columbia* 2005.
- Weir E, Culmer L. Fall prevention in the elderly population. *CMAJ* 2004;171:724.
- US Burden of Disease Collaborators. The State of US Health: Burden of Diseases, Injuries and Risk Factors 1990 to 2010. *Jama* 2013;310:591–608.
- World Health Organization. *China country assessment report on ageing and health. Geneva* 2015.
- Stewart Williams J, Kowal P, Hestekin H, et al. Prevalence, risk factors and disability associated with fall-related injury in older adults in low- and middle-income countries: results from the WHO Study on global AGEing and adult health (SAGE). *BMC Med* 2015;13:1–12.
- Yuxin T, Xiaomu G, Zhijiao Q, et al. Analysis on prevalence and risk factors for falls among the elderly in communities of Beijing and Shanghai. *Chin J Dis Control Prev* 2017;21:72–6.
- The Office of the Beijing Municipal Committee on Aging, China Philanthropy Research Institute. *Report on the development of elderly services in Beijing*. Beijing, 2017.
- The Office of the Beijing Municipal Committee on Aging. Report on the development of elderly services in Beijing. *Beijing* 2011.
- Goldstein J, Jensen JL, Carter AJ, et al. The epidemiology of prehospital emergency responses for older adults in a provincial EMS system. *CJEM* 2015;17:491–6.
- Liao Y, Wang Y, Liu H, et al. Characteristics of unintentional fall-related injuries and the related factors among the elderly in Guangzhou from 2014 to 2016. *Chin J Dis Control Prev* 2018;22:117–21.
- Almegebel FY, Alotaibi IM, Alhusain FA, et al. Period prevalence, risk factors and consequent injuries of falling among the Saudi elderly living in Riyadh, Saudi Arabia: a cross-sectional study. *BMJ Open* 2018;8:e019063–9.
- Qi SG, Wang ZH, Wang LM, et al. [Current status of falls and related injuries among Chinese elderly in 2013]. *Zhonghua Liu Xing Bing Xue Za Zhi* 2018;39:439–42.
- Lin YY, Huang CS. Aging in Taiwan: Building a Society for Active Aging and Aging in Place. *Gerontologist* 2016;56:176–83.
- Herd R, Hu Y, Koen V. Providing Greater Old Age Security in China", OECD Economics Department Working Papers, No. 750. *Paris* 2010.
- Wu H, Ouyang P. Fall prevalence, time trend and its related risk factors among elderly people in China. *Arch Gerontol Geriatr* 2017;73:294–9.
- Jin A, Brussoni M, George MA, et al. Risk of Hospitalization Due to Unintentional Fall Injury in British Columbia, Canada, 1999–2008: Ecological Associations with Socioeconomic Status, Geographic Place, and Aboriginal Ethnicity. *J Racial Ethn Health Disparities* 2017;4:558–70.
- Hammarlund CS, Hagell P, Westergren A. Fall Risk and Its Associated Factors among Older Adults without Home-Help Services in a Swedish Municipality. *J Community Health Nurs* 2016;33:181–9.
- Kingston A, Comas-Herrera A, Jagger C. MODEM project. Forecasting the care needs of the older population in England over the next 20 years: estimates from the Population Ageing and Care Simulation (PACSim) modelling study. *Lancet Public Health* 2018;3:e447–55.
- Allali G, Launay CP, Blumen HM, et al. Falls, Cognitive Impairment, and Gait Performance: Results From the GOOD Initiative. *J Am Med Dir Assoc* 2017;18:335–40.
- Crews JE, Chou C-F, Stevens JA, et al. Falls Among Persons Aged ≥65 Years With and Without Severe Vision Impairment — United States, 2014. *MMWR Morb Mortal Wkly Rep* 2016;65(17):433–7.
- Agmon M, Lavie L, Doumas M. The Association between Hearing Loss, Postural Control, and Mobility in Older Adults: A Systematic Review. *J Am Acad Audiol* 2017;28:575–88.
- Hung CH, Wang CJ, Tang TC, et al. Recurrent falls and its risk factors among older men living in the veterans retirement communities: A cross-sectional study. *Arch Gerontol Geriatr* 2017;70:214–8.
- Dai W, Hasegawa N, Suzuki H. Distribution and occupancy rate of aged careservice in Beijing: on rational allocation of aged careservice. *Aged Care Serv Plan* 2011;35:60–7.
- Jiang B, Liang S, Peng ZR, et al. Transport and public health in China: the road to a healthy future. *Lancet* 2017;390:1781–91.
- Liao Y, Wang YL, Liu HZ, et al. Characteristics of unintentional fall-related injuries and the related factors among the elderly in Guangzhou from 2014 to 2016. *Chinese J Dis Control Prev* 2018;22:117–21.
- Hy P, Mm H, Zhang J, et al. Circumstances of falls and fall-related injuries among frail elderly under home care in China. *Int J Nurs Sci* 2015;2:237–42.
- Rice L, Kalron A, Berkowitz SH, et al. Fall prevalence in people with multiple sclerosis who use wheelchairs and scooters. *Medicine* 2017;96:e7860.
- World Health Organization. *World report on ageing and health. Luxembourg* 2015.
- Wong YC, Leung J. Long-term care in China: issues and prospects. *J Gerontol Soc Work* 2012;55:570–86.
- Chen Z, Yu J, Song Y, et al. Aging Beijing: challenges and strategies of health care for the elderly. *Ageing Res Rev* 2010;9(Suppl 1):S2–S5.
- Kalula SZ, Scott V, Dowd A, et al. Falls and fall prevention programmes in developing countries: environmental scan for the adaptation of the Canadian Falls prevention curriculum for developing countries. *J Safety Res* 2011;42:461–72.