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Epidemiology of low-energy wrist, hip, and spine fractures in Chinese populations 50 years or older

A national population-based survey

Yanbin Zhu, MD[a,b], Xin Xing, MD[b], Song Liu, MD[a,b], Wei Chen, PhD[a,b], Xiaolin Zhang, MD[c], Yingze Zhang, MD[a,b,d,*]

Abstract

The aim of the study was to investigate the incidence of low-energy fracture of wrist, hip, and spine and the related risk factors in Chinese populations 50 years or older.

This study was a part of the Chinese National Fracture Survey (CNFS) carried out in 8 Chinese provinces in 2015. Data on 154,099 Chinese men and women 50 years or older were extracted from the CNFS database for calculations and analyses. Low-energy fracture was defined as fracture caused by slip, trip, or falls from standing height.

A total of 247 patients sustained low-energy fractures in 2014, indicating the incidence rate was 160.3/100,000 person-years, with 120.0 [95% confidence interval (CI), 95.5–144.5] and 213.1(95% CI, 180.7–245.6)/100,000 person-years in men and women, respectively. In men, advanced age, alcohol consumption, residence at second floor or above without elevator, sleep duration <7 h/day, and history of past fracture were identified to be significant risk factors for low-energy fractures. In women, advanced age, living in east region, higher latitude zone (40°N –49.9°N), alcohol consumption, more births, sleep duration <7 h/day, and history of past fracture were identified as significant risk factors. Supplementation of calcium or vitamin D or both was identified to be associated with reduced risk of fracture in women (odds ratio, 0.38; 95% CI, 0.20–0.75), but not in men.

These epidemiologic data on low-energy fractures provided updated clinical evidence base for national healthcare planning and preventive efforts in China. Corresponding interventions such as decreasing alcohol consumption and sleep improvement should clearly be implemented. For women, especially those with more births and past history of fracture, routine screening of osteoporosis, and intensive nourishment since menopause should be advocated.

Abbreviation: CNFS = Chinese National Fracture Survey.

Keywords: epidemiology, hip, osteoporosis-related fracture, spine, wrist

1. Introduction

Across the lifetime, bone mass has to experience a double whammy from advancing age and declining estrogen since menopause in women, and from advancing age in men,[1–4] producing a rapid rise in the risk of osteoporosis fractures. In fact, the lifetime osteoporotic fracture risk in Caucasian women was about 40%,[5–8] and in men was about 15%.[9,10] More than 60% of the overall fractures were related to osteoporosis and osteopenia.[11,12] Relative to osteoporosis, fractures are considered to be of greater public concern because they potentially result in personal disability and mortality and impose a substantial burden on family and society.[6,13–16] In 2001, the National Institutes of Health revised the definition of osteoporosis to include qualitative parameters related to low-energy fractures and set fracture prevention as the primary treatment goal for patients with osteoporosis.[17] In China, the aging of the population in recent decades has been well-documented, and the average life expectancy of Chinese has reached to 76.1 years in 2015. Data from National Bureau of Statistics of China showed the number of mid- and old-aged individuals above 50 years was >280 million by the end of 2016 (http://www.stats.gov.cn/tjsj/). Annually, approximately 2.53 million individuals had 1 low-energy fracture,[11] and predictably this figure will increase dramatically in the next decades. Therefore, the challenge from osteoporotic fractures is enormous for Chinese health policy-making institutions. Knowledge of population-based incidence of osteoporotic fractures and the associated risk

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[a] Department of Orthopaedic Surgery, The Third Hospital of Hebei Medical University, [b] Key Laboratory of Biomechanics of Hebei Province, [c] Department of Statistics and Epidemiology, Hebei Medical University, Shijiazhuang, Hebei, [d] Chinese Academy of Engineering, Beijing, P.R. China.

[*] Correspondence: Yingze Zhang, Department of Orthopaedics, The 3rd Hospital, Hebei Medical University, No. 139 Ziqiang Rd, Shijiazhuang 050051, P.R. China (e-mail: drzhang2013@126.com).

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factors is fundamental to develop public health programs aimed at the prevention of this injury.

Known as "typically osteoporotic fracture," low-energy fractures of the vertebrae (spine), proximal femur (hip), and distal forearm (wrist) have always been regarded as the focus of attention and research.[18] Up to now, a large amount of researches have been conducted to assess the epidemiology of osteoporosis-related fractures and provided abundant data on the incidence rates and related risk factors.[19–24] These results, however, might not be applicable to our Chinese populations, due to the great difference in ethnic origins, economic development, cultural practices, and health care systems among countries. Previously, several Chinese studies have reported the incidence of these fractures[25,26] but the results might be compromised by small sample size or restricted geographic areas. Currently, the data from national epidemiological survey for the low-energy fracture remain scarce, either in China or other countries.

Within this cross-sectional study, we focused on low-energy fractures of wrist, hip, and spine and relevant data were extracted from Chinese National Fracture Survey (CNFS) database, and we have 2 aims: to report the national population–based incidence rate of low-energy fracture for overall populations and for different subgroups stratified by age and sex and to explore potential associated risk factors in term of demographics, socioeconomics, geographical locations, and individual lifestyles.

1.1. Subjects and methods

This study was a part of the CNFS, which was a cross-sectional questionnaire survey carried out between January and May in 2015, with aims to investigate the population-based incidence and risk factors for traumatic fractures through 2014. Traumatic fractures referred to the fractures that were caused by high- (traffic injury, fall from height, or others) or low-energy trauma (slip, trip, or falls from standing height). Spontaneous fractures, pathological fracture from chronic bone disease, or metastatic tumor fractures were excluded from the survey. Details of sampling methods and participants inclusion were described elsewhere[11] and the survey is registered with the Chinese Clinical Trial Registry, number ChiCTR-EPR-15005878.

Briefly, stratified multistage cluster randomized sampling method was used to recruit subjects in the CNFS. During the first phase, using stratified random sampling method we selected 8 provinces (municipalities) with 3 in eastern, 2 in central, and 3 in western regions, based on geographic location, climate, population size, and socioeconomic development. During the second phase, within each targeted province (municipalities), sampling was done separately in urban and rural areas, using probability proportional to size method. In each neighborhood or village, the households were calculated and selected. All members of eligible families to be invited to participate in this study must live in their current residence for at least 6 months. Specifically, older adults living in institutions were excluded from the population of the survey.

Standardized questionnaires were administered by our trained research team members for data collection. Written informed consent was obtained from each participant before data collection. The recall period was 1 year, ranging from January 1 and December 31, 2014. The relevant data on demographics, geographical conditions, socioeconomics, and individual lifestyles were documented. Fracture case occurring at 2014 was self-reported initially by participants and further confirmed by their providing clinical or radiographic data. When such medical data were unavailable, the survey team paid to obtain a new radiograph of their reported fracture site at a local hospital. Eight quality control teams (one for each province) were responsible for check of random questionnaires (approximately 10% of all questionnaires) for potential omissions and errors. The CNFS was approved by the Institutional Review Board of the Third Hospital of Hebei Medical University.

1.2. Current study

Low-energy fracture (case group) of wrist, hip, and spine was defined as fractures that were caused by slip, trip, or falls from standing height. Fractured caused by high-energy injuries (traffic trauma, fall from height, crushing injury, sharp trauma, and others) were excluded. A total of 154,099 women and men aged 50 years and older participated in this study and 937 participants had at least 1 fracture of any site caused by either low-or high-energy injury in 2014. A total of 247 participants (case group) reported 254 cases of low-energy fractures of wrist, hip, or spine, with 7 participants having 2 fractures. The remaining 153,162 participants without any fracture were defined as control group.

Variables of interest included age, height, weight, and accordingly calculated body mass index, living areas (rural or urban), regions (eastern, central, or western), latitude zone (20°–29.9°, 30°–39.9°, or 40°–49.9°), ethnic groups (Han or others), occupation, educational level (illiterate, primary school, middle school, high school, and higher level), frequency of drinking intake (tea, carbonate beverages, coffee), smoking status, alcohol consumption, dwelling place (ground floor, above second floor with or without elevator), living house facing the sun or not, average sleep duration per day, history of past fracture, living situation (alone or with others), supplementation of calcium or vitamin D or both (yes or not) for women and men, and age of menopause and number of births additionally for women.

Specifically, the body mass index was grouped based on the reference criteria suited to Chinese populations: underweight, $<18.5\,kg/m^2$; normal, 18.5 to $23.9\,kg/m^2$; overweight, 24 to 27.9 kg/m^2; obesity, $\geq 28\,kg/m^2$.[11,27] Current smoking and alcohol consumption was defined as positive (yes), if participants had smoked ≥10 cigarettes/week or more or drank ≥1 time/week or more for at least 6 months during the 2014 year or the past year before fracture occurrence.[28] Similarly within the time window, the average intake frequency of certain type of drinking (tea, carbonate beverages, coffee) was provided by participants; and supplementation of calcium or vitamin D or both was defined as positive (yes) if participants acknowledged they take these medications for at least 1 month; otherwise, as negative (no).

1.3. Statistical analysis

The incidence rate for the overall 3 fractures or each fracture (wrist, hip, or spine) was calculated either in men or women or both, based on age (5-year interval), and the trends of incidence rate with age were tested in logistic regression model by including these ordered categorical variables as a continuous variable.

Two separate design-based multiple logistic regression models were constructed to explore the potential risk factors associated with low-energy fractures among women and men. Potentially limited by the number of fracture cases for each site (wrist, hip, or spine), we did not perform the subgroup analysis. The above-

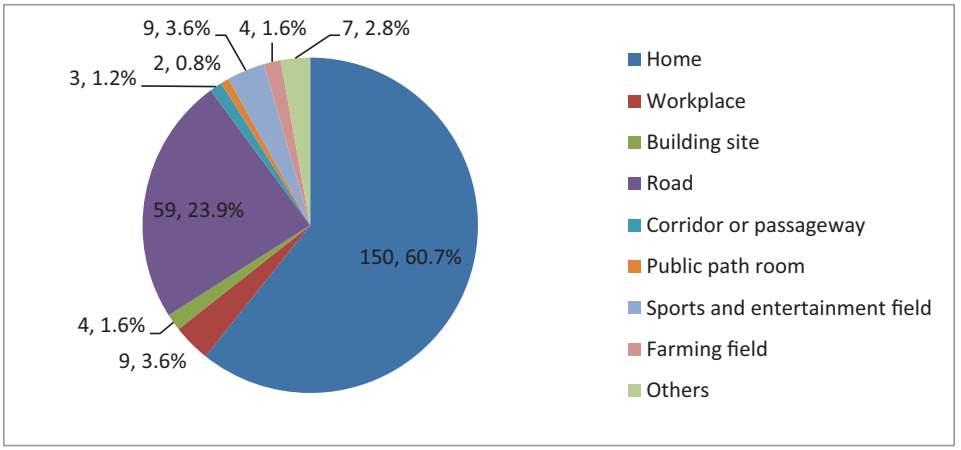

Figure 1. The place of low-energy fracture occurrence in 2014.

mentioned variables that were reported in literature to have positive or negative effect on bone mass density, or be associated with falls or low-energy fracture itself were all entered into the multivariable logistic regression model. A stepwise backward-elimination approach was used to exclude confounding covariates from the final models. Covariates were retained in the final model if the *P* value was ≤.10. Odds ratio (OR) and 95% confidence interval (95% CI) were used to indicate the correlation magnitude between variables and low-energy fracture risk. The Hosmer–Lemeshow test was used to examine the goodness-of-ft of the final model, and a *P* value >.05 indicated an acceptable fitness. All the analyses were performed by SPSS 19.0 (SPSS Inc., Chicago, IL).

2. Results

Of the 247 patients with low-energy fractures, there were 84 men and 163 women; and their average age at which fracture occurred was 65.7±9.6 years (median, 65; range, 50–101). More than six tenths of them reported their fracture occurred at home, followed by the common road (23.9%) and sports or entertainment field (3.6%) (Fig. 1). Totally, there were 254 cases of fractures, which were 118 wrist fractures, 71 hip fractures, and 65 spine fractures.

The overall incidence rate of low-energy fractures was 160.3 (95% CI, 140.3–180.3) per 100,000 person-years in 2014 year, with 120.0 (95.5–144.5) and 213.1 (180.7–245.6) per 100,000 person-years in men and women, respectively (Table 1). The results of trend test showed a significant increasing trend of incidence rate of overall low-energy fracture with age, either in men or women (Table 1).

2.1. Multivariate analysis

After adjustment for confounding variables, advanced age, alcohol consumption, residence at second floor or above without elevator, sleep duration <7 h/day, and history of past fracture were identified to be associated with increased risk of low-energy fractures in men (Table 2). The Hosmer–Lemeshow test demonstrated the adequate fitness (X^2=10.56, *P* = .181).

In women, advanced age, living in east region, higher latitude zone (40°N –49.9°N), alcohol consumption, more births, sleep duration <7 h/day, and history of past fracture were identified to be associated with increased risk of low-energy fractures. Supplementation of calcium or vitamin D or both was identified as a significant protective factor for low-energy fracture and could reduce 62% of the fractures (OR, 0.38; 95% CI, 0.20–0.75). The detailed statistical results are presented in Table 2. The Hosmer–Lemeshow test demonstrated the adequate fitness (X^2 = 6.12, *P* = .602).

3. Discussion

This is currently the most comprehensive, national survey of low-energy fractures of wrist, hip, and spine in mid- and elderly-aged

Table 1

National incidence (cases/100,000 person-year) of low-energy fractures of wrist, hip, and spine in China in 2014.

Age, y	Sample size	Wrist		Hip		Spine		Overall	
		Men	Women	Men	Women	Men	Women	Men	Women
50–54	38,849	25.4 (3.1–47.7)	67.8 (30.9–104.6)	15.3 (0–30.5)	15.6 (0–31.3)	15.3 (0–30.5)	15.6 (0–31.3)	55.9 (22.9–89)	99 (54.5–143.5)
55–59	26,114	63.4 (19.5–107.4)	140.7 (77.5–204)	23.8 (0–47.7)	14.8 (0–29.6)	15.9 (0–31.8)	44.4 (8.9–80)	103.1 (47.1–159.1)	200 (124.6–275.3)
60–64	32,854	43 (11.1–74.8)	114.7 (63.1–166.2)	43 (11.1–74.8)	24.1 (0.5–47.8)	24.6 (0.5–48.6)	78.4 (35.8–121.1)	104.4 (54.8–154)	211.2 (141.3–281.1)
65–69	22,032	18.4 (0–36.8)	179.2 (100.7–257.6)	101.2 (41.4–161)	9.0 (0–18.1)	46 (5.7–86.3)	35.8 (0.7–70.9)	156.4 (82.1–230.7)	224 (136.3–311.7)
70–74	16,713	11.8 (0–23.7)	145.2 (63.1–227.4)	71 (14.2–127.8)	60.5 (7.5–113.5)	23.7 (0–47.4)	121 (46.1–196)	106.5 (37–176)	314.7 (193.9–435.5)
75–79	9275	62.3 (0–124.7)	112.2 (13.9–210.5)	103.8 (12.9–194.7)	89.7 (1.8–177.7)	41.5 (0–83.0)	44.9 (0–89.8)	207.6 (79–336.1)	246.8 (101.1–392.5)
≥80	8262	0	93.7 (1.91–185.4)	75.2 (0–150.4)	327.8 (156.4–499.2)	100.2 (2.1–198.4)	46.8 (0–93.6)	175.4 (45.6–305.2)	468.3 (263.5–673)
Sum	154,099	33.9 (20.9–46.9)	118.8 (94.6–143.1)	49.6 (33.8–65.3)	42.6 (28.1–57.2)	28.7 (16.7–40.7)	51.7 (35.7–67.7)	120.0 (95.5–144.5)	213.1 (180.7–245.6)
P		.433	.184	.001	<.001	.011	.092	.002	<.001

* Note, those estimates refer to the logistic regression modeling with age as a continuous variable.

Table 2

Results of multivariate logistic regression of risk factors for low-energy fractures of wrist, hip, and spine in men and women.

Variables	Odds ratio (OR)	95% CI		P
		Lower limit	Upper limit	
Men				
Age, y				
50–64	Reference			
65–79	1.64	1.03	2.60	.036
≥80	2.33	1.01	5.37	.047
Alcohol consumption	1.85	1.16	2.96	.010
Residence				
Ground floor	Reference			
≥Second floor without elevator	2.18	1.13	4.22	.021
≥Second floor with elevator	0.96	0.60	1.53	.868
Sleep duration <7 h/day	2.45	1.50	4.00	<.001
History of previous fracture	3.17	1.63	6.15	.001
Women				
Age, y				
50–64	Reference			
65–79	1.31	0.90	1.91	.165
≥80	2.30	1.33	3.97	.003
Han (vs others)	0.61	0.35	1.08	.090
Region				
West	Reference			
Middle	0.99	0.64	1.55	.973
East	2.78	1.75	4.35	<.001
Latitude zone				
20–29.9	Reference			
30–39.9	1.09	0.73	1.62	.685
40–49.9	1.79	1.02	3.14	.044
Alcohol consumption	2.05	1.31	3.19	.002
Number of births	1.52	1.20	1.92	.001
Sleep time <7 h/day	2.06	1.46	2.92	<.001
Supplementation of calcium or VD or both	0.38	0.20	0.75	.005
History of previous fracture	2.21	1.24	3.93	.007

CI = confidence interval; OR = odds ratio.

men and women ever done in China. The overall incidence of the 3 typical osteoporotic fractures was 160.3 (95% CI, 140.3–180.3) per 100,000 person-years in 2014, which, by extension, suggested that approximately 448,000 Chinese populations 50 years or older had at least 1 low-energy fracture. Approximately 85% of all the fractures occurred at home and on the common road, which emphasized the importance of the primary preventive measures, especially the family prevention. We observed a significantly increasing trend of incident low-energy fracture with increasing age, both in men and women. In men, advanced age, alcohol consumption, residence at second floor or above without elevator, sleep duration <7 h/day, and history of past fracture were identified as significant factors associated with the increased risk of low-energy fractures. In women, advanced age, living in east region, higher latitude zone (40°N –49.9°N), alcohol consumption, more births, sleep duration <7 h/day, and history of past fracture were identified as significant risk factors for low-energy fractures. Supplementation of calcium or vitamin D or both was identified to be a protective factor that was associated with reduced risk of the fractures (OR, 0.38; 95% CI, 0.20–0.75), but not in men.

Researches on epidemiology of low-energy or osteoporosis-related fractures from population-based questionnaire survey were scarce due to the substantial costs from manpower and financial resources. Péntek et al[29] evaluated the osteoporotic fractures in Hungarian inhabitants older than 50 years from 1999 to 2003 and reported a substantially higher incidence (4771 fractures/100,000 person-years). Even if osteoporotic fractures of other body sites (e.g., proximal humerus, ankle) were added in this study,[29] the overall incidence rate remained very low due to the predominance of wrist, hip, and spine fractures in the osteoporotic fractures. In a prospective cohort study of 1,183,663 women aged 30 to 85 years with follow-up of 7 years in England and Wales, Hippisleycox and Coupland[30] reported the annual incidence rate was 308 for any low-energy fracture and 118/100,000/person-years for hip fracture. Nieves et al[31] using the data from National Hospital Discharge Survey and reported the overall incidence of hip fracture approximately 300/100,000 person-years between 1996 and 2006. Compared to those greatly high incidence rates of osteoporosis-related fractures reported in west developed countries, ours was comparable to the figures reported in some studies conducted in neighboring Asian countries, such as South Korea (hip fracture, 33–144 per 100,000 person-years from 1991 to 2011 in individuals older than 50 years in Gwangju City)[32] and Japan (hip fracture, 30.8–51.1 and 92–181.4 per 100,000 person-years in men and women from 1987 to 2007).[33] These results from literature demonstrated the combined effects of differences of ethnicity origins, geographical location, socioeconomic development, culture practices, manners, customs, and individual lifestyles among countries on the incident fractures.[34,35] Anyhow, on the basis of a huge quantity of >280 million mid-aged and elderly individuals, low-energy fracture undoubtedly constitutes a major public health issue in modern China.

Bone mass declines and the risk of fractures increases as people age, especially as women pass through the menopause.[18] In this study, advanced age was identified as a significant risk factor for low-energy fracture both in men and women. In addition, alcohol consumption, insufficient daily sleep duration (<7 h/day) and history of past fracture were we identified as risk factors for individuals of both sexes. Especially, alcohol consumption[36–38] and inadequate sleep duration[39–41] had been well established and the underlying mechanisms were well-investigated; and most importantly they were modifiable. On the basis of these findings, health policies that focus on decreasing alcohol consumption and encouraging individuals to improve their sleep quality and duration, should particularly be implemented in China to reduce osteoporotic fracture risk.

The results also showed men living at the second floor or above in a building without elevators were more likely to sustain a osteoporotic fracture (OR, 2.24; 95% CI, 1.16–4.47), compared to those living at ground floor. In our opinion, this result should be treated dialectically and might be affected by multiple factors from aspects. Firstly, it is much more likely that living on higher floors in buildings without elevators might be a marker of worse socioeconomic status. Secondly, living on higher floor in buildings without elevators increased the need to walk up and down stairs and, thus, the chance of falling. Xu et al[42] conducted a structured questionnaire study of forearm fracture in Chengdu of China, which demonstrated residence at second floor or above increased the risk of forearm fracture by 71%. Although frequency of falling in the prior year was generally suggested as a significant risk factor of osteoporosis-related fracture,[43] Xu et al[42] also found higher floor is a more important predictor of fracture than falls in their study. Nevertheless, one should understand that place of residence is not an easily modifiable risk

factor, predominantly due to economic conditions. Therefore, primary preventive measures such as daily exercises to keep muscle strength and coordination, hand crutch applied to facilitate balance, and handrails and lighting facility equipped in stairway and so on should be taken to reduce the risk of falls or twisting and related fractures.

Bone mass or osteoporotic fracture risk was significantly influenced by the number of births in this study, which was consistent with findings in literature. Shen et al[44] conducted an epidemiologic study of osteoporosis in perimenopausal women in Beijing, and they found procreative times was negatively correlated with body mineral density (BMD). Shin et al[45] investigated the prevalence of osteoporosis in Korean population, and found the number of live births was an independent risk factor for osteoporosis of the calcaneus (OR, 2.0; 95% CI, 1.20–3.35). Zhang and Shen[46] found the number of births rather than pregnancies was significantly associated with the incident osteoporosis-related fractures in postmenopausal women. Accordingly, women with more births should be a specific target population to care for, and routine screening of osteoporosis every year and intensive nourishment should be immediately implemented, especially since menopause.

Supplementation of antiosteoporosis medications (calcium or vitamin D or both) was identified as an important modifiable factor that was associated with reduced risk of low-energy fracture in women but not in men, which was also demonstrated in most studies but not all. Zhao et al[47] conducted a meta-analysis of 33 randomized trials involving 51,145 community-dwelling participants 50 years or older, but found the nonsignificant association between calcium or vitamin D supplementation and fracture, regardless of medication dose and sex. Currently, US Preventive Services Task Force found inadequate evidence to support the daily supplementation of $\geq$400 IU of vitamin D or $>$1000 mg of calcium, but found adequate evidence that daily supplementation with $\leq$400 IU of vitamin D and $\leq$1000 mg of calcium had no benefit for primary prevention of fractures in community-dwelling, postmenopausal women.[48] On the contrary, US Preventive Services Task Force found adequate evidence that supplementation with vitamin D and calcium increased the incidence of kidney stones.[48] Therefore, how to balance the benefits and harms of supplementation of vitamin D and calcium, alone or combined, for the primary prevention of osteoporosis or related fracture, remains a main topic in the future study. Given the nature of the present study, we do not advocate the supplementation of vitamin D and calcium in all the community-based women, until the adequate evidence arising.

3.1. Strengths and limitations

The main strengths of the current study included the questionnaire survey of community-based population, stratified multistage cluster randomized sampling method for recruiting subjects, and adjustment for numerous important covariates. In addition, "double" confirmation of fracture case by patients' self-reports and their provision of clinical or radiographic data increased the accuracy and precision of diagnosis.

Nevertheless, several limitations should be mentioned. Firstly, recall bias existed in this study, due to the nature of retrospective design. Secondly, there remained some residual confounding, because other factors (impaired vision, antidepressant medication and glucocorticoid use, chronic heart failure, etc) that may have affected BMD or propensity to fall were not able to be adjusted for in the multivariable regression model. Thirdly, the study could not capture information about fracture cases in which the individual died, or about fracture (hip fracture) that resulted in a high mortality within 1 year after fracture. In addition, asymptomatic or subclinical fracture case like low-grade vertebral compression fracture was likely under- or unreported. Therefore, the overall incidence rate of low-energy fracture was underestimated.

4. Conclusion

This study provided detailed epidemiologic information about low-energy fractures of wrist, hip, and spine, including incidence rate, injury mechanism, and the associated risk factors. On the basis of these findings, health policies that focus on decreasing alcohol consumption and encouraging individuals to improve their sleep quality and duration should clearly be implemented in China to reduce fracture risk. Specifically for women, routine screening of osteoporosis every year and intensive nourishment should be immediately implemented since menopause, especially for those with advanced age, more births, and history of past fracture. The role of supplementation of vitamin D and calcium, alone or combined, with what dose in primary prevention of osteoporosis-related fractures remains inconclusive, and more evidences of high level was required.

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Author contributions

Conceptualization: Yingze Zhang.
Data curation: Yanbin Zhu, Song Liu, Xiaolin Zhang.
Formal analysis: Yanbin Zhu, Song Liu, Wei Chen, Xiaolin Zhang.
Investigation: Yanbin Zhu, Song Liu, Wei Chen.
Methodology: Yanbin Zhu, Song Liu, Wei Chen.
Software: Song Liu.
Supervision: Wei Chen, Yingze Zhang.
Validation: Song Liu, Wei Chen, Yingze Zhang.
Writing – original draft: Yanbin Zhu, Xin Xing.
Writing – review & editing: Yanbin Zhu, Xin Xing.

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