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Prevalence and Incidence of Osteoporosis Fracture in Population-based Studies in Chinese Mainland: A Meta-analysis and Systematic Review

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Abstract: *We conducted a systematic review and meta-analysis to acquire a reliable estimation of the prevalence and incidence of osteoporosis fracture in Chinese mainland and to characterize its epidemiology. We identified eligible studies with information on the prevalence or incidence of osteoporosis fracture in population-based observational studies and extracted data from published reports. We did random-effects meta-analysis to generate estimates. This study was preregistered in the INPLASY data-base (INPLASY202240112). Out of 3535 records identified, 33 studies with 1,970,135 participants were eligible for this study. The prevalence of osteoporosis fractures shows an interesting Kuznets curve (also known as inverted U curve) over time; In terms of incidence rate, the incidence of osteoporosis fracture obviously decreased over the past few decades. The prevalence and incidence of osteoporosis fracture was higher in females than in male and increased with age. Osteoporosis fracture prevalence was higher in urban than in rural areas and higher in southern than in northern areas. Osteoporosis fracture incidence was higher in rural than in urban areas and higher in southern than in northern areas.at present, the prevalence and incidence of osteoporosis fracture among the Chinese mainland was very high. Our study provides the prevalence (17.98% [95% CI, 13.12-23.41%]) and incidence (988 per 10,000 person-years [95% CI, 4.98%-16.22%]) of osteoporosis fracture in Chinese mainland. These findings can be used to better assess the China health burden of osteoporosis fracture.*

Keywords: *Osteoporosis fracture, Prevalence, Incidence, Meta-analysis, Chinese mainland*

1. Introduction

Osteoporosis (OP) can be defined as a degenerative bone disease characterized by decreased bone mass, raised skeletal fragility and the structure deterioration of bone tissue[1]. Subsequently it is susceptibility of fracture that is increased[2]. The most frequently sites of fracture are the spine, hip and wrist, and these have an enormous health and economic destruction[3,4]. Nowadays, osteoporosis fractures are a considerable burden to public health services and have very high morbidity and mortality, and are also an independent risk factor for future osteoporosis fractures [4-6]. So, typically osteoporosis 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 study[4].

In developed countries, according to the report, approximately 8 million female and 2 million male who are age more than 50 years in the United States have been diagnosed with osteoporosis, and 34 million people are estimated with osteopenia[7]. About 5.5 million males and 22milliom females in Europe were affected by osteoporosis in 2010[8]. A worldwide epidemic of hip fractures is to be expected according to some epidemiologic projections published, and it is estimated that the incidence of hip fracture will increase 6.26 million by 2050[9,10]. In developing countries, the life expectancy of the total population and the elderly will more than triple in the next 25 years, so osteoporosis hip fractures alone will play a greater role in health care[11]. The number and the incidence of hip fractures will continue to increase with the aging of population, city development and the change of people's life style. Although

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vertebral fractures are often accompanied by back pain, height loss and kyphosis, a large number of vertebral fractures are asymptomatic, and the causes of these physical symptoms are difficult to distinguish, which means that only 30% - 40% of vertebral fractures receive medical treatment[12]. Li, Y. et al[13] examined the prevalence of Spinal Vertebra Compression Fracture on chest radiographs of hospitalized female patients aged 50 years and older and 66.8% of patients with vertebral fractures found in this study were undiagnosed in the original radiology reports. The incidence rate of distal forearm osteoporotic fractures increased linearly from 40 to 65 years[14]. At present, there is little research on the incidence and prevalence of distal forearm fractures in Chinese mainland.

In the People's Republic of China, however, the mean prevalence of OP in older adults is estimated at 15.7%, and it is considered to be increasing gradually with the increasing age of the total population, which is associated with the improvement of the average life expectancy[15]. The seventh national population census data from National Bureau of Statistics of China showed the population aged 15-59 is 894,376,020, accounting for 63.35%; There are 264,018,766 people aged 60 and above, accounting for 18.70%, of which 190,635,280 people aged 65 and above, accounting for 13.50% by the end of 2020 (http://www.stats.gov.cn/tjsj/). Compared with the sixth national census in 2010, the proportion of people aged 15-59 decreased by 6.79%, the proportion of people aged 60 and over increased by 5.44%, and the proportion of people aged 65 and over increased by 4.63%. Annually, approximately 2.53 million people had 1 low-energy fracture[16] .The overall major osteoporosis fracture in Chinese population was estimated to be 2.69 million cases in 2015, illustrating a tremendous disease cost of osteoporotic fractures in China[17], and the number will increase significantly in the coming decades. However, our knowledge of the epidemiology for osteoporosis fracture in China still remains poor[18]. Knowledge of population-based prevalence and incidence of osteoporotic fractures is fundamental to develop public health programs aimed at the prevention of this damage[17].

2. Methods

2.1 Search strategy and selection criteria

An ethical statement is not needed for this study because this is a meta-analysis and systematic review based to published studies. We used this systematic review and meta-analysis in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) reporting guideline, the Meta-analysis of Observational Studies in Epidemiology (MOOSE) reporting guideline, and Guidelines for Accurate and Transparent Health Estimates Reporting: The GATHER Statement[19-22]. The protocol of this study was preregistered in the INPLASY data-base (INPLASY202240112).

We conducted electronic searches of the PubMed, Web of Science, Embase, Cochrane Library, CNKI (China National Knowledge Infrastructure), VIP (Chinese), Wanfang (Chinese) and CBM(SinoMed) databases to identify population-based studies that measured the prevalence and incidence of osteoporosis fracture from inception until October 2021.These searches used medical subject heading terms and free text and combined osteoporosis fracture-related keywords.

Language of publication was restricted to English and Chinese. We also retrieved the reference lists of included articles and previous reviews to identify potential studies as comprehensively as possible. Studies were restricted to those evaluating the Chinese mainland population. We identify the searching terms as 'osteoporosis 'fracture', 'prevalence', 'epidemiolog*', 'morbidity', 'incidence', 'Chin*'.

The criteria for study inclusion are as follows: (1) Study population: Participants were aged≥15 years and included a representative sample of Chinese mainland population; (2) The time period of the study was not restricted; (3) an original study reporting the prevalence or incidence of osteoporosis fracture; (4) Study type: The data are from population-based cross-sectional studies or baseline investigations from cohort study; (5) Information: Studies including metrics for sample size and directly and/or indirectly providing prevalence and incidence of osteoporosis fracture with or without age-specific estimates were included.

The criteria for study exclusion are as follows: Studies conducted in a population with specific other diseases or occupations were excluded (connective tissue disease, gastrointestinal and nutritional diseases, endocrine and metabolic diseases, hematological system diseases, and a population working in an environment with lead, cadmium and aluminum). Reviews, commentaries, and case reports were also excluded. A hospital-based study.

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2.2 Data extraction

Two investigators (WMF, ZRS) extracted data using a standardized data collection sheet from published reports. Where several studies used data from the same research cohort, we only analyzed one study that presented the most comprehensive and representative and latest data. If there are differences, we will discuss with team members to determine a mutually agreed result. The prevalence of osteoporosis fracture is defined as a proportion, namely, the number of cases of osteoporosis fracture divided by the sample sizes. The incidence equals the number of cases of incident osteoporosis fracture divided by the person-years at risk.

The following information was collected from each study: year of publication; year in which the study was conducted; first author; province; the sample size; number of osteoporosis fracture cases; minimum age of participants; number of Age group; number of osteoporosis fracture patients in age group; number of female sample size; number of female osteoporosis fracture patients; number of female osteoporosis fracture patients in age group; number of male sample size; number of male osteoporosis fracture patients; number of male osteoporosis fracture patients in age group; area(northern or southern) ; region(urban or rural) ; sampling method; type of Article; type of article; response rate of the survey; source of sample; study quality score; reference type. The outcome of interest was the prevalence and incidence of osteoporosis fracture in different settings. If necessary, we contacted the first author of the article.

2.3 Quality assessment

The quality included cross-sectional study was assessed using the quality assessment criteria for observational studies recommended by the Agency of Healthcare Research and Quality (AHRQ)[23]. A score≤3 points was considered as low quality; A score 4-7 points was considered as medium quality; A score≥8 points was considered as high quality. The quality included cohort study was assessed using the quality assessment criteria by The Newcastle-Ottawa Scale (NOS). Two raters (WMF, ZRS) independently assessed each item and any discrepancy was resolved by consensus[24].

2.4 Statistical analysis

We estimated the prevalence and incidence rates of osteoporosis fracture with 95 % confidence intervals (CIs) overall and by subgroup. The point prevalence and incidence rates were first transformed into arcsine square root transformed proportions. The transformed data were fitted for a random effects model using DerSimonian-Laird weights [25]. Heterogeneity across studies was examined using Cochran chi-square ($\chi 2$) tests. The classification of heterogeneity depended on the I2 statistic: < 25 % indicated a low level, 25–50 % indicated a moderate level, and >50% indicated a high level of heterogeneity[26]. We adopted a random effects model to estimate the prevalence of osteoporosis fracture and performed subgroup analyses by year of publication (before 2009, 2010–2015, and 2016–2021), area (urban and rural),region (South and North China), age at onset (<50, 50–, 60–, 70- and 80- years), gender (female and male) and age group (<60, 60-, 70-, 80- years) overall and separately for males and females ,which adopted a random effects model to estimate the incidence of osteoporosis fracture and performed subgroup analyses by year of publication (before 2009, 2010–2015, and 2016–2021), area (urban and rural),region (South and North China), age at onset (<50, 50–, 60–, 70- and 80- years) and gender (female and male). The categorization of year of data collection was based on the distribution of the number of studies; age at onset was categorized based on the categorization and lack of specific ages within the included studies. Publication bias was evaluated by inspecting Begg's funnel plots with log prevalence, incidence and standard errors. Egger's Test were used for qualitative judgements of bias. $P < 0.05$ was considered statistically significant. We used R software (version 4.1.2) to conduct the meta-analysis.

3. Results

3.1 Study selection and characteristics

In total, 3536 citations were retrieved. First, the title and abstract were screened, then the repeated articles were excluded, and finally through the full-text screening. 3457 were ineligible for inclusion criteria and 46 were duplicated articles, of 33 remaining articles were included for this meta-analysis. The process of selecting studies was showed in Fig. 1.

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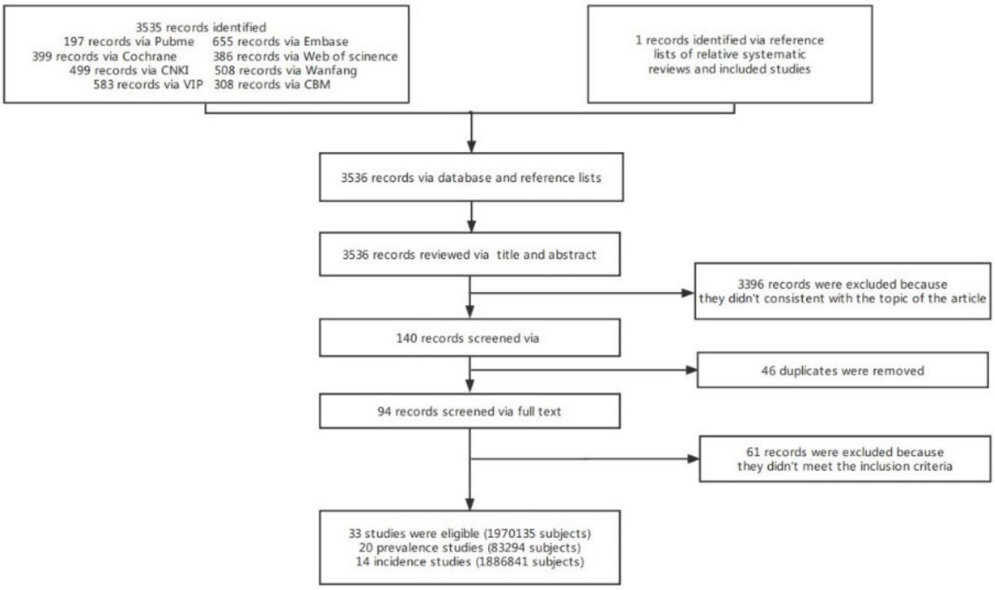

Figure 1: Flow diagram of included/excluded studies.

We finally conducted the present meta-analysis based on 33 articles with 1,970,135 participants, which 20 prevalence studies were showed in Table 1, 14 incidence studies were showed in Table 2(An article contains both prevalence data and incidence rate data; The two prevalence studies used the same database). Of the 33 studies, 24 had been conducted in urban areas (15 articles contain prevalence data; 10 articles contain incidence data) and 9 had been conducted in rural areas(4 articles contain prevalence data; 5 articles contain incidence data); 21 studies were conducted in South China (11 articles contain prevalence data; 10 articles contain incidence data)and 8 were conducted in North China(6 articles contain prevalence data; 2 articles contain incidence data); and 20 and 30 studies focused on males(12 articles contain prevalence data; 8 articles contain incidence data) and females(18 articles contain prevalence data; 12 articles contain incidence data), respectively. The sample size of prevalence per study ranged from 251 to 12,000, and the total population of prevalence included in this meta-analysis was 83,294 participants, including 25,457 males and 54,531 females. The sample size of incidence per study ranged from 300 to1,643,464, and the total population of incidence included in this meta-analysis was 1,886,841 participants, including 895,431 males and 836,185 females. The total number of included participants was not equal to the total of numbers of males and females because some studies only give total numbers and numbers of men and women were not given. Except one cohort study, 32 studies had a cross-sectional design. 30 cross-sectional studies were identified as medium quality studies, 2 cross-sectional studies were identified as high-quality studies, and 1 cohort study was assessed as acceptable. The overall quality of the included studies was acceptable.

Table 1: The summary characteristics of included prevalence studies.

NO.	First author	Publication Year	Province	Study design	Regiom	Area	Minimum age	Sex (M)	Case (n)	Sample size
1	Zhen A et al	2002	Chengdu	Cross-sectional	Southern	Mixed	50	0.52	175	1081
2	Ling X et al	1995	Beijing	Cross-sectional	Northern	Urban	50	1.00	60	402
3	Bo C et al	2019	Shanxi	Cross-sectional	Northern	Urban	50	1.00	47	260
4	Xin C et al	2017	Shanghai	Cross-sectional	Southern	Urban	60	0.53	323	510
5	Zhengye J et al	2018	Heilongjiang	Cross-sectional	Southern	Urban	60	0.67	204	4453
6	Zhengjiang L et al	2015	Chengdu	Cross-sectional	Southern	No	60	0.53	468	1600
7	Jinfu M et al.	2004	Chengdu	Cross-sectional	Southern	Mixed	50	0.52	175	1081
8	Yongsheng Y et al	2013	Guizhou	Cross-sectional	Southern	No	50	0.57	148	822
9	Chenxia Z et al	2020	Shanxi	Cross-sectional	Northern	No	38	1.00	42	1054
10	Hanmin Z et al	2003	Shanghai	Cross-sectional	Southern	Mixed	60	0.60	1910	12000
11	Cui L et al	2017	Beijing	Cross-sectional	Northern	Urban	50	1.00	420	1760
12	Gao C et al	2021	Shanghai	Cross-sectional	Southern	Urban	< 50	0.90	1735	11984
13	Gao C et al	2019	Shanghai	Cross-sectional	Southern	Urban	60	0.55	2414	14075
14	Liu, J. M. et al	2012	Shanghai	Cross-sectional	Southern	Urban	< 50	0.62	1301	9352
15	Shang, W. et al	2005	Beijing	Cross-sectional	Northern	No	60	No	71	251
16	Wang, L. et al	2019	12 regions in China	cohort study	No	No	< 50	0.63	551	3273
17	Wang, L. et al	2021	Random sampling area	Cross-sectional	Mixed	Mixed	50	0.57	932	8423

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18	Xu, L. et al	2000	Beijing	Cross-sectional	Northern	Urban	50	1.00	59	400
19	Xia, W. et al	2019	No	Cross-sectional	No	Urban	50	1.00	635	2634
20	Lu Y et al	2017	Guizhou	Cross-sectional	Southern	Urban	< 50	0.73	1262	8960

Table 1: (Continued)

NO.	First author	Screening Year	Sample selection method	Reference type	Type of Article	Study quality score
1	Zhen A et al	no	Clustered randomized sampling	journal article	full text	medium
2	Ling X et al	June 1993 to May 1994	Clustered randomized sampling	journal article	full text	medium
3	Bo C et al	No	Clustered randomized sampling	thesis	full text	medium
4	Xin C et al	2016	Whole sample	journal article	full text	medium
5	Zhengye J et al	Aug. 2012 to Jun. 2013	Clustered randomized sampling	thesis	full text	medium
6	Zhengjiang L et al	Jun. 2008 to Apr. 2011	Clustered randomized sampling	journal article	full text	medium
7	Jinfu M et al.	No	Clustered randomized sampling	journal article	full text	medium
8	Yongsheng Y et al	No	Clustered randomized sampling	journal article	full text	medium
9	Chenxia Z et al	Jun. 2017 to Jun. 2019	Clustered randomized sampling	journal article	full text	medium
10	Hanmin Z et al	Aug. 1997 to May 1998	Clustered randomized sampling	journal article	full text	medium
11	Cui L et al	No	Clustered randomized sampling	journal article	full text	medium
12	Gao C et al	Mar. 2019 to Jul. 2019	Whole sample	journal article	full text	medium
13	Gao C et al	2014 to 2016	Whole sample	journal article	full text	medium
14	Liu, J. M. et al	Mar. to Aug. 2010	Whole sample	journal article	full text	medium
15	Shang, W. et al	No	Whole sample	journal article	full text	medium
16	Wang, L. et al	Mar. 2013 to Aug. 2017	Whole sample	journal article	abstract	yes
17	Wang, L. et al	Dec. 2017 to Aug. 2018	Clustered randomized sampling	journal article	full text	high
18	Xu, L. et al	No	Clustered randomized sampling	journal article	full text	medium
19	Xia, W. et al	No	Clustered randomized sampling	journal article	abstract	medium
20	Lu Y et al	May 2011 to Oct. 2011	Clustered randomized sampling	journal article	full text	high

Table 2: The summary characteristics of included incidence studies.

NO.	First author	Publication Year	Province	Study design	Regiom	Area	Minimum age	Sex (M)	Case (n)	Sample size
1	Wenyuan C et al	2010	Hainan	Cross-sectional	southern	No	60	0.58	51	531
2	Wei H et al	2018	Shanghai	Cross-sectional	southern	Mixed	60	1.00	1053	4428
3	Lijin Y et al	2018	Guangzhou	Cross-sectional	southern	Urban	40	0.78	221	1529
4	Zhu, Y. et al	2019	Random sampling area	Cross-sectional	No	Mixed	40	1.00	309	70357
5	Yanbin, Z. et al	2020	Random sampling area	Cross-sectional	No	No	50	No	247	154099
6	Lu Y et al	2017	Guizhou	Cross-sectional	southern	Urban	40	0.73	277	5697
7	Shaoguang Li et al.	2016	Beijing	Cross-sectional	northern	no	60	0.46	4504	1643464
8	Ling S et al	2001	Hubei	Cross-sectional	southern	Urban	60	0.45	129	1764
9	Feng C et al	2013	Guangzhou	Cross-sectional	southern	Mixed	50	0.52	160	597
10	Dongliang X et al	2000	Guangzhou	Cross-sectional	southern	Mixed	60	No	137	1126
11	Guoying Z et al	2004	Shanghai	Cross-sectional	southern	Urban	50	1.00	173	723
12	Jianxin Z et al	2007	Fujian	Cross-sectional	southern	Rural	60	0.60	147	500
13	Aiguo W et al	2014	Shenzhen	Cross-sectional	southern	Urban	60	0.60	34	300
14	jieying W et al	2012	Beijing	Cross-sectional	northern	Urban	50	1.00	143	1726

Table 2: (Continued)

NO.	First author	Screening Year	Sample selection method	Reference type	Type of Article	Study quality score
1	Wenyuan C et al	No	Clustered randomized sampling	journal article	full text	medium
2	Wei H et al	No	Clustered randomized sampling	journal article	full text	medium
3	Lijin Y et al	No	Whole sample	journal article	full text	medium
4	Zhu, Y. et al	Jan. and May 2015	Clustered randomized sampling	journal article	full text	medium
5	Yanbin, Z. et al	2001 to 2011	Clustered randomized sampling	journal article	full text	medium

6	Lu Y et al	Jul. 2014	Clustered randomized sampling	journal article	full text	high
7	Shaoguang Li et al.	2013	Health insurance database	journal article	full text	medium
8	Ling S et al	Apr. 1999 to Jun. 2001	Clustered randomized sampling	journal article	full text	medium
9	Feng C et al	No	Clustered randomized sampling	journal article	full text	medium
10	Dongliang X et al	No	Clustered randomized sampling	journal article	full text	medium
11	Guoying Z et al	No	Whole sample	journal article	full text	medium
12	Jianxin Z et al	No	Clustered randomized sampling	journal article	full text	medium
13	Aiguo W et al	Mar. 2012 to Aug. 2012	Clustered randomized sampling	journal article	full text	medium
14	jieying W et al	Aug. 2008 to Aug. 2011	Clustered randomized sampling	journal article	full text	medium

3.2 Pooled prevalence and incidence of osteoporosis fracture

3.2.1 Overall

The meta-analysis of the total prevalence estimates of studies evaluating 83,294 participants showed that the prevalence rate of osteoporosis fracture was 17.98 % (95 % CI: 13.12–23.41 %, fig.2 and Table 3). The prevalence rates of osteoporosis fracture at onset age of study of <50 (n = 5, N = 34,623), 50-60(n=9, N=15,782) and 60-(n=6, N=32,889) years were 12.22 % (95 % CI: 7.70-17.60 %),17.47 % (95 % CI: 14.30–20.89 %) and 24.41 % (95 % CI:10.37–42.04 %), respectively.

The meta-analysis of the total incidence estimates of studies evaluating 1,886,841 participants showed that the incidence rate of Osteoporosis fracture 988 per 10,000 person-years (95 % CI: 4.98–16.22 %, fig.3 and Table 4). The incidence rates of osteoporosis fracture at onset age of study of <50(=3, N=77,583) 50-60(n=4, N=157,145) and 60-(n=7, N=1,652,113) years were 501 per 10,000 (95 % CI: 0.17-15.83 %), 1150 per 10,000 (95 % CI: 1.33–29.60 %) and 1148 per 10,000 (95 % CI:4.74–20.64 %), respectively.

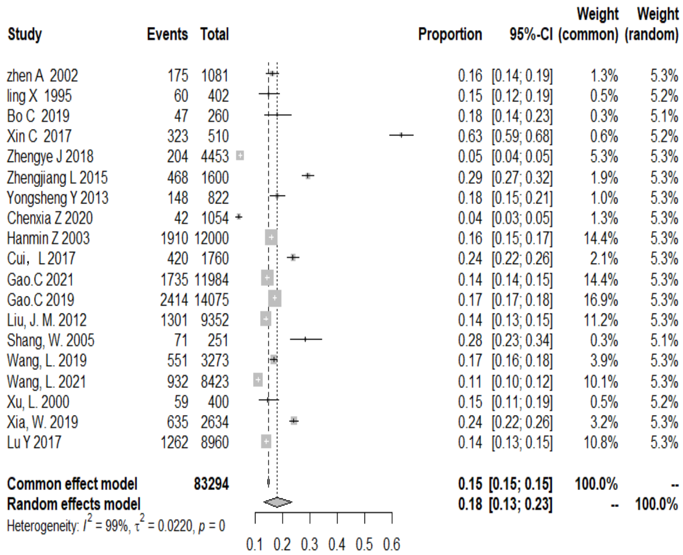

Figure 2: Forest plot of prevalence of osteoporosis fracture for total people.

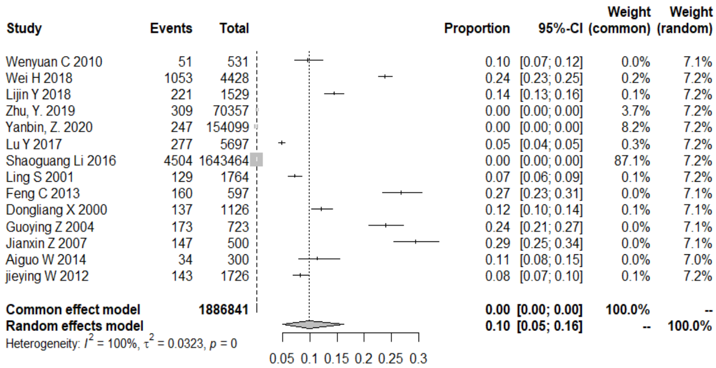

Figure 3: Forest plot of incidence of osteoporosis fracture for total people.

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Table 3: Prevalence of osteoporosis fracture according to different items.

Category	subgroup	No. of studies	Prevalence (95 % CI) (%) (Random effects model)	N	I^2(%)
Total		20	17.98[13.12-23.41]	83294	99.1
Study year	Before 2009	6	17.23[14.01-20.71]	15215	78.7
	2010-2015	3	20.00[11.96-29.51]	11774	99.0
	2016-2021	11	17.57[9.91-26.86]	57386	99.4
Sex	Female	18	18.17[12.83-24.19]	54531	98.8
	Male	12	16.06[8.86-24.89]	25457	98.7
Onset age of Study(y)	<50	5	12.22[7.70-17.60]	34,623	97.5
	50-	9	17.47[14.30-20.89]	15782	98.0
	60-	6	24.41[10.37-42.04]	32889	99.6
Age-specific group(y)	<50	2	2.81[0.00-14.07]	2720	91.1
	50-	9	7.00[3.63-11.32]	7426	98.1
	60-	13	17.42[10.43-25.74]	20631	97.7
	70-	13	23.50[17.13-30.52]	16949	97.0
	80-	12	34.87[24.88-45.57]	6244	96.3
Female(age)	<60	6	5.78[1.95-11.33]	8335	98.2
	60-	10	17.56[9.67-27.18]	13352	98.0
	70-	10	23.92[16.46-32.27]	9849	95.7
	80-	9	37.33[24.05-51.64]	3617	95.3
Male(age)	<60	2	4.64[1.26-10.71]	1059	83.2
	60-	6	19.59[5.43-39.61]	6677	96.9
	70-	6	21.47[9.99-35.81]	6678	97.2
	80-	6	26.66[13.07-42.95]	2499	95.7
Area	Urban	15	17.80[11.90-24.59]	67481	99.3
	Rural	4	12.52[7.38-18.78]	8813	95.8
Region	Southern	11	19.29[11.19-28.97]	64837	99.4
	Northern	6	16.33[9.59-24.42]	4127	98.2

Table 4: Incidence of osteoporosis fracture according to different items.

Category	subgroup	No. of studies	Incidence (95 % CI) (/10000) (Random effects model)	N	I^2(%)
Total		14	988[4.98-16.22]	1886841	99.8
Study year	Before 2009	4	1720[8.31-28.47]	4113	98.5
	2010-2015	4	1332[6.57-21.95]	3154	97.4
	2016-2021	6	477[0.29-13.20]	1879574	99.9
Sex	Female	12	1383[6.81-22.80]	836185	99.9
	Male	8	834[3.27-15.39]	895431	99.2
Onset age of Study(y)	<50	3	501[0.17-15.83]	77583	99.8
	50	4	1150[1.33-29.60]	157145	99.8
	60	7	1148[4.74-20.64]	1652113	99.9
Age-specific group(y)	<60	3	864[0.25-26.31]	38093	99.3
	60-	8	832[2.43-17.17]	968222	99.4
	70-	6	1403[4.56-27.45]	541460	99.3
	80-	6	1854[3.86-40.27]	170461	98.9
Area	Urban	10	1080[5.66-17.32]	41322	99.7
	Rural	5	1767[5.90-33.94]	45425	99.8
Region	Southern	10	1542[10.34-21.29]	17195	99.2
	Northern	2	292[0.00-15.68]	1645190	99.7

3.2.2 Study year

The meta-analysis results showed a general decline trend. The prevalence rates among studies with data collected before 2009, from 2010 to 2015, and from 2016 to 2021 were 17.23 % (95 % CI: 14.01–20.71 %), 20.00 % (11.96–29.51%) and 17.57 % (9.91–26.86 %), respectively (Table 3). These data indicated that osteoporosis facture prevalence evidently increased from before 2009 to 2010–2015; however, the prevalence from 2016 to 2021 were obviously lower than during off from 2010–2015 periods.

The incidence rates among studies with data collected before 2009, from 2010 to 2015, and from 2016 to 2021 were 1,720 per 10,000 person-years (95 % CI: 8.31–28.47 %), 1,332 per 10,000 person-years (6.57–21.95 %) and 477 per 10,000 person-years (0.29–13.20 %), respectively (Table 4).

3.2.3 Sex- and age-specific groups

The prevalence rate of osteoporosis fracture was significantly higher among females (18.17 %, 95 % CI: 12.83-24.19 %, Fig. 4) than males (16.06 %, 8.86–24.89 %, Fig. 5) (Table 3). In all age groups, the prevalence rates of osteoporosis fracture increased with age. Specifically, the rate was the lowest (2.81 %)

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in the group younger than 50 years old and the highest (34.87 %) in the 80 years and older age group in combined populations (7.00 % for 50- years, 17.41 % for 60- years and 23.50 % for 70- years). The prevalence rates among women (5.78 % for<60 years, 17.56 % for 60- years, 23.92 % for 70- years and 37.33 % for 80- years) and men (4.64 % for<60 years, 19.59 % for 60- years, 21.47 % for 70- years and 26.66 % for 80- years) were consistent with this overall tendency. Interestingly, the overall prevalence in females was higher than the prevalence in males in lower than 60 age group,70- age group and 80- age group, except for the 70- age group.

The incidence rate of osteoporosis fracture was significantly higher among females (1383 per 10,000, 95 % CI: 6.81-22.80 %, Fig. 6) than males (834 per 10,000, 3.27–15.39 %, Fig. 7) (Table 4). Specifically, the incidence rates among in lower than 60 age group, 60- age group, 70- age group and 80- age group were 864 per 10,000 person-years (95 % CI: 0.25–26.31 %), 832 per 10,000 person-years (2.43–17.17 %), 1,403 per 10,000 person-years (4.56–27.45 %) and 1,854 per 10,000 person-years (3.86–40.27 %) respectively.

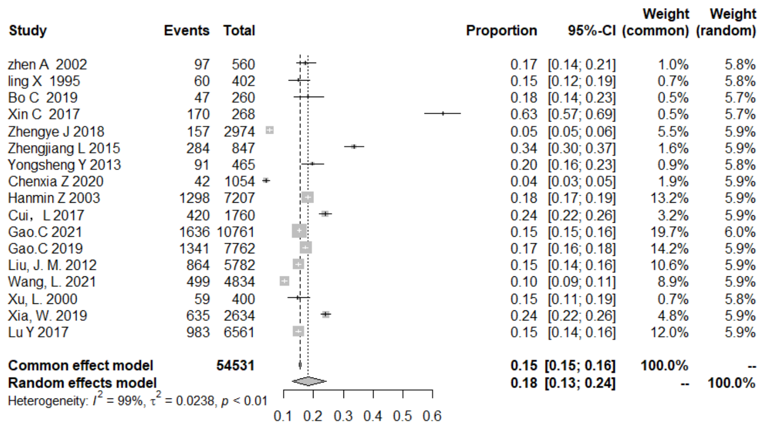

Figure 4: Forest plot of prevalence of osteoporosis fracture for female.

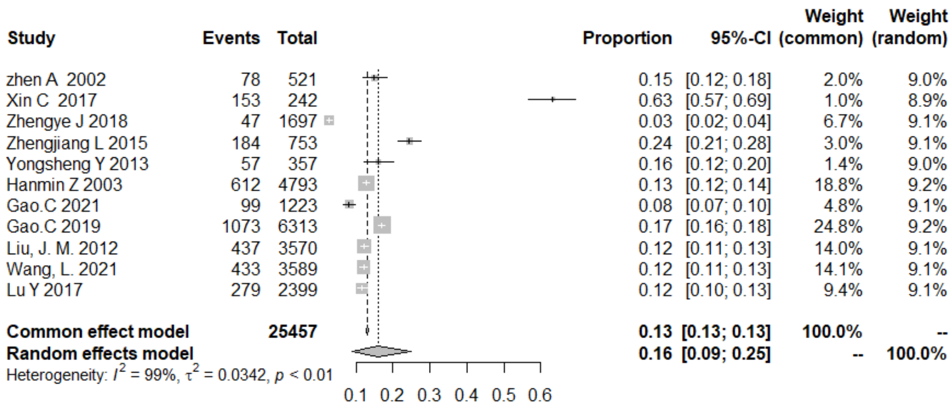

Figure 5: Forest plot of prevalence of osteoporosis fracture for male.

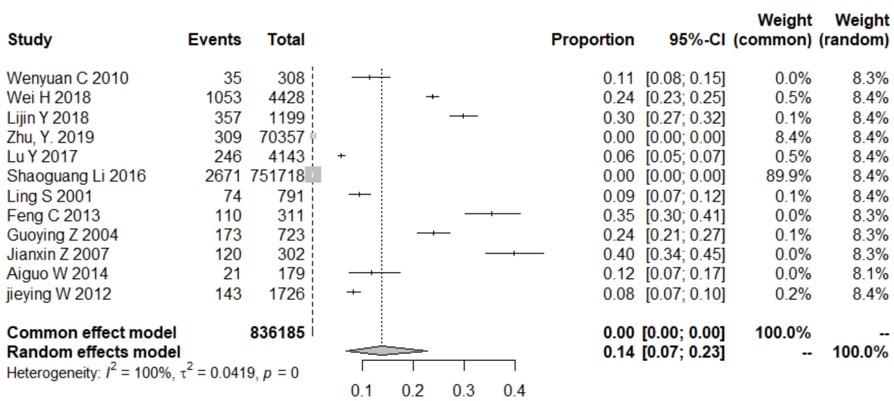

Figure 6: Forest plot of incidence of osteoporosis fracture for female.

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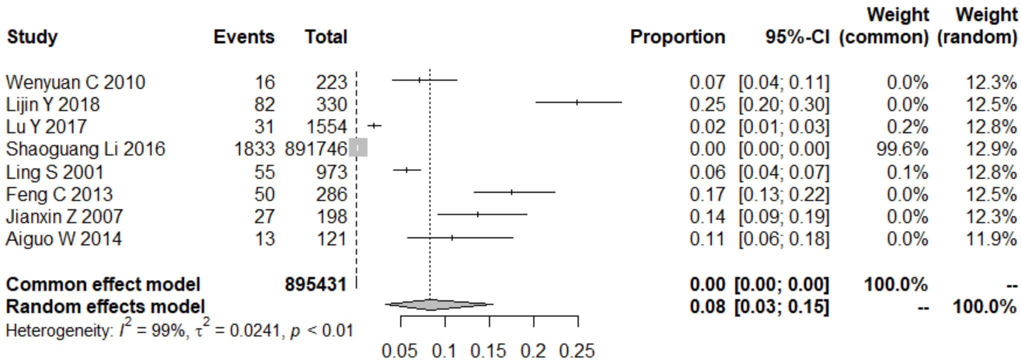

Figure 7: Forest plot of incidence of osteoporosis fracture for male.

3.2.4 Region and area

The prevalence rate of osteoporosis fracture was slightly higher in urban (17.80 %, 95 % CI: 11.90-24.59 %) than in rural areas (12.52 %, 95 % CI: 7.38–18.78 %). Similarly, the prevalence rate was slightly higher in South China (19.29 %, 95 % CI: 11.19–28.97 %) than in North China (16.33 %, 9.59–24.42 %) (Table 3).

The incidence rate of osteoporosis fracture was slightly lower in urban (1080 per 10,000, 95 % CI: 11.90-24.59 %) than in rural areas (1767 per 10,000, 95 % CI: 7.38–18.78 %). The incidence rate was memorably higher in South China (1542 per 10,000, 95 % CI: 11.19–28.97 %) than in North China (292 per 10,000, 9.59–24.42 %) (Table 4).

3.3 Heterogeneity and publication bias

We observed that the heterogeneity across studies is particularly high when studies were evaluated overall. Sensitivity analysis showed that there was no significant change in the estimates of prevalence and incidence after omitting any one of the included studies. The funnel plots showed visually asymmetrical distribution of published studies on prevalence and incidence of osteoporosis fracture. But Egger tests indicated that there was no statistically significant publication bias on prevalence (Egger test: bias=5.2758; p = 0.2544). However, Egger tests indicated that there was statistically significant publication bias on incidence (Egger test: bias=22.7723; p = 0.0002).

4. Discussion

This systematic review and meta-analysis were conducted to estimate the prevalence and incidence rates of osteoporosis fracture among Chinese mainland population, feature the epidemiology of osteoporosis fracture in Chinese mainland, and compare osteoporosis fracture prevalence and incidence rates between the Chinese mainland population and other populations.

As far as we know, the present systematic review and meta-analysis is the first study collecting the latest data and the largest sample sizes to estimate the epidemiologic features of osteoporosis fracture in the Chinese mainland at the beginning of the 21st century. Some characteristics of osteoporosis fracture in Chinese mainland population were confirmed. First, the prevalence of osteoporosis fractures shows an interesting Kuznets curve (also known as inverted U curve) over time (from a prevalence of 17.23 % before 2009 to 20.00 % in the period spanning 2010–2015, and dropped to 17.57% in 5 years); In terms of incidence rate, a strange phenomenon is shown in the incidence rate, the incidence of osteoporosis fracture obviously decreased over the past few decades (from an incidence of 1720 per 10,000 before 2009 to 477 per 10,000 in the period spanning 2016–2021). There were 4,113 participants before 2009 and 3154 participants from 2010 to 2015, which there were from 2016 to 2021 that 1,879,574 participants were studied. The sample size of incidence rate before 2015 was too small, which had little reference value. The latest research from 2016 to 2021 is more representative. Second, both the prevalence and incidence rate increase with age. Third, the prevalence rate was higher in females than in males of the same age groups. Fourth, the prevalence was higher in urban areas than in rural areas and higher in South China than in North China, but the incidence was higher in rural areas than in urban areas and higher in South China than in North China. Fifth, at present, the prevalence of osteoporosis fracture among the Chinese elderly population identified in this study was very high.

On a world-wide scale, osteoporosis fractures accounted for 0.83% of the global burden of non-communicable disease. In Europe, osteoporosis fractures accounted for more Disability Adjusted Life

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Years (DALYs) lost than common cancers with the exception of lung cancer. OP causes more than 8.9 million fractures annually worldwide approximately 1,000 cases per hour[27]. In the People's Republic of China, the risk of osteoporosis fractures in women is higher than the sum of the incidence of breast cancer, endometrial cancer, and ovarian cancer, while in men, it is higher than the risk of prostate cancer[15]. The prevalence and incidence varied with the characteristics of studies (e.g., age, sex, region, area etc.). One of the main risk factors for osteoporosis fracture in both males and females is ageing, which is an unalterable factor. Bone mass density declines and the risk of osteoporosis fracture increases as people age, especially as postmenopausal women[4]. A systematic review and meta-analysis showed that the prevalence rates of osteoporosis increased with age and the rate was the lowest (2.40 %) in the 15 to 30-year age group and the highest (56.10 %) in the 80 years and older age group in combined populations[28]. After that, a slight impact can lead to osteoporosis fractures.

Sex is another non-modifiable factor. A possible reason for the gender difference is that the menopause or oophorectomy have a bearing on estrogen decrease may bring about a speedy BMD reduction in women, however, a decrease in testosterone levels may have a similar but a little pronounced effect in men by comparison[29]. An animal study showed that androgen receptor-mediated action was pivotal to bone maintenance in male mice, and estrogens and androgens may regulate bone growth[30]. That could explain why postmenopausal women may be more prone to osteoporosis, and the prevalence of brittle fracture is higher in postmenopausal women[31]. In this meta-analysis, we did not distinguish participants into premenopausal and postmenopausal subgroups. However, we still saw an important increase in the prevalence of osteoporosis fracture in females (from 5.78 to 37.33 %). Among the national population, the male population is 723,339,956, accounting for 51.24%; The female population is 688,438,768, accounting for 48.76%. The sex ratio of the total population (100 for women, male to female ratio) was 105.07.

Another non-modifiable factor is Region.We divided the studies into those divided into South China and North China. The prevalence was higher in South China (19.29%) than North China (16.33%), and that regional difference was may be attributed to differences in vitamin D levels. As has been reported, vitamin D3 synthesis may not be sufficient to account for BMD reduction due to the lack of ultraviolet rays in high-latitude regions[32]. In addition to this factor, eating habits and climate may account for some of the differences in osteoporosis fracture prevalence in China. People in North China mainly eat cooked wheaten food, while people in South China live on eat more rice and aquatic products. Moreover, the climate is dry in North China and moist in South China, the more slippery road is more likely to cause falling injury, which also may account for the different results. However, the specific mechanism behind this difference is still unclear. Diet and lifestyle have been found to be associated with increased BMD[33]. Additionally, the prevalence of osteoporosis fracture was slightly higher in urban than rural areas, this may be related to the complex urban road conditions and more steps. However, the incidence of osteoporosis fracture was slightly higher in rural than urban areas, this difference was probably due to disparities in health and medical resources, which still few relevant studies in rural areas[34]. Osteoporosis is also a genetic disease. Those with a family history have a higher risk of osteoporosis; however, the heritability of BMD reduction has been found to vary widely from 25 to 80 %, and osteoporosis has been found to be associated with more than 30 genes[35].The research show that different areas of the skeleton have different degrees of heritability, and that the diversity depends on gender[36]. The aggravation of osteoporosis must affect the occurrence of brittle fracture.

In the study, we found that the incidence rate of osteoporosis fracture was decreasing with time, and the prevalence rate was Kuznets curve, and the overall prevalence rate was also declining. According to the data, although osteoporosis and brittle fracture are affected by age, they can be controlled. This phenomenon first appeared in Britain, North America and countries in northwest Europe at the end of last century and the beginning of this century[37]. In a study in Taiwan, China, the incidence of hip fracture in Taiwan remained unchanged from 2001 to 2005, and decreased significantly after 2006[38]. In addition to the western countries that lagged behind, the improvement trend in Taiwan was very similar to that in 2006[38]. This phenomenon has also occurred in Hong Kong, China[39]. This study shows that this phenomenon has also appeared in Chinese mainland. It indicates that the continuous improvement of public health system and protection of risk factors are necessary and fruitful. Published factors include urbanization, birth cohort effects, changes in bone mineral density and body mass index (BMI), osteoporosis drug use and / or lifestyle interventions, such as quitting smoking, improving nutritional status and preventing falls[37,39,40]. We believe that most of the above factors are related to the trend of osteoporosis and brittle fracture in China.

China will always face three major challenges. First, China is the most populous country in the world, which means that the incidence rate of osteoporosis fractures will remain at the present level, and the number of osteoporosis fractures is still increasing. Second, China's aging population needs to establish a fully functional social security system for the elderly population. It is well known that people aged 50 and over have an increased risk of osteoporosis fractures. According to the data of the seventh national

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census of the Bureau of statistics, there are 264,018,766 people aged 60 and above, accounting for 18.70%, including 190,635,280 people aged 65 and above, accounting for 13.50% by the end of 2020. Although China has opened up the two-child policy so far, the current population structure will increase the proportion of people over the age of 50. Third, China is still the most populous developing country, and its medical and health system still needs to be continuously improved[41]. In this data collection, we found that there are few relevant epidemiological studies in Northwest China. The population in this area is 382,852,295, accounting for 27.12% of the national population. However, the development level of this area is relatively backward, and the prevalence and incidence of osteoporosis fractures may be higher, and many patients are not treated accordingly.

This study has some limitations. First, more females than males were included in the prevalence studies, which may have resulted in an overestimate of the prevalence of osteoporosis fracture, as it occurs more frequently among females. Second, the onset ages in the included studies were categorized differently, which we believe could affect the results in some subgroups since the point prevalence and incidence of osteoporosis fracture was found to increase with increased age. Third, heterogeneity was relatively high in all analyses. Although we identified one factor affecting these results, the degree of explain ability was very limited. Fourth, there is a high publication bias in the incidence rate study. When comparing the difference between China and the north and south, the difference in data comparison is very strange due to the lack of relevant research in the north. Fifth, since many studies have only counted spinal fractures or hip fractures, and there are few studies on distal forearm fractures, we have collected them without any subdivision, which may lead to inaccurate estimation of prevalence and incidence rate. Nevertheless, the main strengths of this study were that most of the included studies had large sample sizes. Two investigators independently extracted data and reviewed the articles to obtain data accurately. The number of Chinese populations in this article comes from the seventh national census bulletin issued by the National Bureau of Statistics. We report the results in accordance with the PRISMA statement.

5. Conclusions

The prevalence and incidence rate of osteoporosis fractures in China are relatively high. The study found that the prevalence and incidence rate of osteoporosis fractures increased with age, and the prevalence and incidence rate of female prevalence were higher than that of men. Prevention and control measures become more important as China's population aging is becoming more and more serious and the incidence rate of osteoporotic fractures is higher.

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