The incidence rate of osteoporotic hip fracture in China: a systematic review and meta-analysis

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Introduction. Osteoporotic hip fracture is a common age-related disease, which significantly affect the normal life of patients and may increase their disability and mortality rates. This meta-analysis aims to estimate the incidence rate of osteoporotic hip fractures in China to systematically portray its disease burden.
Methods. The search was conducted in databases including Medline, Embase, Web of Science, the Cochrane Library, and four Chinese databases from inception to March 1st, 2023. We included original studies that either reported incidence of osteoporotic hip fracture in China or provided raw data for calculating, and the methods used for identifying cases must have been provided. Individual studies were summarized using random-effects mode. The pooled incidence rate of osteoporotic hip fracture among the general population and subgroups were obtained. Heterogeneity (I^2 statistic) was assessed with the $\chi 2$ test on Cochrane's Q statistic.
Results. Twelve studies were eligible for the final analysis, and the pooled incidence rate of osteoporotic hip fracture in Chinese adults aged above 50 years was 132.88 (95%CI, 91.46-181.93) per 100,000 person-years. The incidence rate was higher in the female and increased with age. There was an increasing trend of the incidence rate in the past three decades, and the Chinese mainland had the lowest rate, whereas Hong Kong and the Taiwan Region higher.
Conclusion. This first systematic review on osteoporotic hip fractures in China delineated significant disease burdens, especially in the Chinese mainland, calling for attention to promote suitable healthcare 1 policy and clinical guidelines.

INTRODUCTION

Osteoporosis is a common age-related skeletal disorder characterized by low bone mass and microarchitectural deterioration of bone tissue, resulting in fragility and increased fracture risk[1]. The prevalence of osteoporosis was reported to be 20.6% among women aged 40 years or older and 5.0% among men[2].
Osteoporotic fractures, also known as fragility fracture, refers to a fracture that occurs as a result of low-energy trauma (equivalent to falling from a standing height or lower)[3].Osteoporotic fractures are one of the major complications of osteoporosis and can significantly affect the normal life of elderly individuals, even increasing their disability and mortality rates[4]. According to surveys, there were approximately 2.33 million cases of osteoporotic fractures in China in 2010, and it is estimated that the total number of patients will increase to 5.99 million by 2050[5].

Hip fractures are a common site of osteoporotic fractures, with high mortality and disability rates. Relevant studies show that the mortality rate of elderly individuals within one year after hip fracture is 20%, and the mortality rate reaches up to 50% after one year, making it the last fracture in life[6, 7]. In addition to the high mortality rate, the economic cost of treating hip fractures is also very high, accounting for 72% of the total cost of fracture treatment, far exceeding the treatment cost of fractures in other parts of the body[8]. Considering the above characteristics, hip fractures have always been the focus of research on osteoporotic fractures. However, most epidemiological studies on hip fractures in China have not strictly distinguished between osteoporotic and non-osteoporotic hip fractures, which means that these studies do not differentiate between hip fractures caused by low-energy and high- energy trauma. Furthermore, most of the studies were based on hospital or local medical insurance databases[9, 10], lacking nationwide studies on the incidence rate of osteoporotic hip fractures.

Accurate information on the incidence rate of osteoporotic hip fractures is crucial for formulating national medical insurance policies to prevent fractures and reduce the social and economic burden. A systematic review and meta-analysis can provide accurate and effective results.

Therefore, we conducted this systematic review and meta-analysis to investigate the nationwide incidence rate of osteoporotic hip fracture in China. This study has been registered in the PROSPERO (CRD42023409601) and followed the Meta-analysis of Observational Studies in Epidemiology (MOOSE) guidelines.

MATERIALS AND METHODS

Search Strategy

In this systematic review, we searched Medline, Embase, Web of Science, and The Cochrane Library to identify all relevant English studies published up to March 1st, 2023. The search strategies employed are detailed in Table SI1. Further, four Chinese databases, including Wanfang, CBM, CNKI, and VIP, were searched using the correspondent terms in Chinese. We also scrutinized all relevant studies' references to identify potential sources that could supplement our database searches.

Study Selection

Our study only included original studies that reported on the incidence of osteoporotic hip fractures in China or provided raw data that allowed for its calculation. Furthermore, the methods used for identifying cases must have been provided. Given that low bone mineral density (BMD) or a history of low-energy trauma are the only reliable diagnostic criteria for osteoporotic fractures, we only included studies that utilized these criteria to identify target patients or provided corresponding patient numbers. Moreover, we excluded studies focused on specific populations rather than the general population.

Duplicates, reviews, conference proceedings, case reports, and clinical trials were also excluded.

Data Extraction and Quality Appraisal

Two reviewers (Xu and Yang) assessed all the studies independently and extracted the following information in parallel: (1) title, first author, and year of publication. (2) region, calendar period, study design (prospective/retrospective), and case-identifying methods (disease code/ medical record/self- report). (3) the number of incident cases, sample size, incidence rates and corresponding 95% confidence intervals (CI), and data for both gender and ages. As osteoporotic fractures primarily affect the elderly, we only collected data from individuals aged 50 and above. When only the number of hip fracture patients and the proportion of different causes were provided, we calculated the number of patients with

osteoporotic hip fractures through the ratio of low-energy trauma.

Given the lack of validated quality assessment tools for assessing incidence-based epidemiological studies, we utilized the Joanna Briggs Institute (JBI) Critical Appraisal Instrument for Studies Reporting Prevalence Data to evaluate the potential for bias in study design, conduct, and analysis.

Whenever reviewers disagreed on the selection of studies, extracted data, or appraisal scores, a second review was conducted by two other authors (Zhu and Hong). The corresponding author was consulted when there were further discrepancies.

Statistical Analysis

Data were analyzed by R Computing (version 4.2.3) with mate package (version 6.2-1). The annual incidence rate of osteoporotic hip fracture was calculated as the ratio of the number of new cases over the total person-time during the observation period, expressed as per million person-years. When the total person-time was not provided, we estimated it by multiplying the population number and the study duration. The average annual incidence rate was pooled into a random-effects meta-analysis after using the Freeman-Tukey double arcsine transformation to stabilize the variance of the study-specific rate. We assessed the heterogeneity using the I^2 statistics, where I^2 >25%, 50%, and 75% were taken as indicators of low, moderate, and high heterogeneity, respectively. Subgroup analysis of incidence rate was performed in gender, age, region, study period, study design, and case-identifying methods. Age was classified into eight groups: 50-54, 55-59, 60-64, 65-69, 70-74, 75-79, 80-84, and over 85 years. The study region was categorized into three parts, including the Taiwan region, Hong Kong, and the Chinese mainland, while the study period was divided into three categories, including pre-2000, 2000- 2010, and 2010 onwards. In cases where the study period spanned across two groups, the reviewers used the median year to categorize the study period. In addition, study duration, year of publication, and proportion of female patients were added in meta-regression analyses to evaluate its impact on incidence rate in different studies. All P-values for subgroup analysis and meta-regression were based on two-sided tests, and results were deemed statistically significant at P <0.05. Publication bias was evaluated using a funnel plot and Egger regression, with a P-value less than 0.10 on Egger's test considered statistically significant.

RESULTS

Characteristics of Included Studies

The initial search of the database yielded a total of 4,787 records, and no additional articles were found through citation searching. Following the removal of 1,263 duplicates, 3,524 records underwent title and abstract screening, and ultimately, 167 articles were selected for full-text review. After a thorough examination, 12 studies[11–22] were deemed eligible for inclusion in this meta-analysis (Fig.1).

Table 1 summarizes the main characteristics of included studies. Most of these studies were conducted in the Chinese mainland (n=10), one in Hong Kong and another in Taiwan. The earliest study was initialed in 1989, and the most recent was completed in 2017. The median duration of the studies was 2 (1,5) years, ranging from one to fourteen years. Two studies were prospective, while the remaining ten studies were retrospective. Eleven studies reported incident cases and sample size stratified by gender, while only four studies had sufficient data to analyze both age- and gender-specificrates.

The incidence rate of osteoporotic hip fracture in China

The overall pooled incidence rate of osteoporotic hip fracture in Chinese adults above 50 years was 132.88 (95%CI, 91.46-181.93) per 100,000 person-years (Fig. 2). Women had a

higher incidence rate (158.92 per 100,000 person-years, 95%CI, 97.94-234.37) than men (95.98 per 100,000 person-years, 95%CI, 65.00-132.71). The incidence rate increased with age, reaching its peak in the 85 and above age group (956.22 per 100,000 person-years, 95%CI, 170.75-2387.42). This trend was similar in both genders, with males having a slightly higher incidence rate before age 55, while females dominated over 55 years old (Fig 3).

The incidence rate of osteoporotic hip fracture in the Chinese mainland was 122.94 (95%CI, 78.47- 177.26) per 100,000 person-years, which was lower than that in Hong Kong (230.68 per 100,000 person-years, 95%CI, 159.80-322.21) and Taiwan region (158.85 per 100,000 person-years, 95%CI, 157.17-160.55).

There was an increasing trend of incidence rate in more recent study periods. Studies conducted before 2000 found an incidence rate of 97.16 (95%CI, 48.84-161.90) per 100,000 person-years, while studies conducted after 2010 reported a higher rate of 153.32 (95%CI, 94.96-225.42) per 100,000 person-years.

Prospective studies had a higher incidence rate than retrospective studies, with incidence rates of 170.25 (95%CI, 71.10-309.83) and 127.90 (95%CI, 83.44-181.80) per 100,000 person-years,

respectively. Studies using disease codes to identify patients had the highest incidence rate (190.81 per 100,000 person-years, 95%CI, 133.20-258.58), while those using medical records had the lowest (86.02 per 100,000 person-years, 95%CI, 49.18-133.05), and self-reported studies were in between (113.00 per 100,000 person-years, 95%CI, 29.15-248.06). Detailed subgroups rates are provided in Table 2.

Heterogeneity and publication bias

There was high heterogeneity among studies included in our meta-analysis(I^2=100%). Despite Subgroup analysis being conducted, no potential sources of heterogeneity were identified. However, the meta-regression analysis revealed that the proportion of female patients could be a source of heterogeneity (P=0.014, R^2=32.12%; Fig SI1), whereas the study duration and year of publication were not. This finding suggests that the higher incidence rate among women may have contributed to the overall heterogeneity of our results. To assess the possibility of publication bias, we visually inspected the funnel plots (Fig SI2) and conducted Egger's test, which did not show significant evidence of publication bias (P=0.085).

Quality of included studies

The quality of the included studies varies, as demonstrated by the JBI critical appraisal tool scores in Table SI2. While two studies covered multiple provinces across China, the other ten were limited to specific regions, with poor national representativeness. Seven studies focused solely on hospitalized patients, excluding outpatients and non-attendees, which may underestimate the incidence rate. Ten studies had adequate sample sizes of over 100,000 people, while the other two had smaller sample sizes for their prospective designs. Given the high requirements for osteoporotic fracture diagnosis, such as detailed fracture causes or BMD data, only three studies directly focused on osteoporotic fractures, and the other nine studies reported hip fracture incidence rates and proportions of different fracture causes, which may result in particular biases. Most studies provided sufficient raw data for analysis, but only four articles detailed the number of fracture cases and person-years by age and sex. Additionally, a few articles confused cumulative incidence and incidence rate, leading to statistical analysis mistakes.

DISCUSSION

In this systematic review and meta-analysis, we evaluated the nationwide incidence rate of osteoporotic hip fracture and its distributions in Chinese adults aged 50 and above. The incidence rate was relatively high, as 132.88 (95%CI, 91.46-181.93) per 100,000 person-years. This rate indicated that China exhibited an intermediate rate compared to other countries. Previous studies in Asian countries such as Qatar (141.7-162.7 per 100,000 person-years) and Iran (138.26-157.52 per 100,000 person-years) reported incidence rates similar to those observed in China, whereas African countries like Egypt reported lower rates ranging from 55.19 to 123.34 per 100,000 person-years [23–25]. In contrast, Australia reported higher incidence rates ranging from 174 to 370 per 100,000 person-years[26].

In addition, the meta-analysis revealed a consistent rise in the incidence rate of osteoporotic hip fracture over the past three decades. This conclusion differs from previous studies in Hong Kong and Taiwan, which reported a trend towards stabilization in the incidence of osteoporotic hip fractures in recent years, potentially due to the predominance of studies from the Chinese mainland in our research[27, 28]. The discrepancy supports the ongoing annual increase of osteoporotic hip fracture in the Chinese mainland, which calls for attention from healthcare policymakers and clinicians to strengthen osteoporosis early screening among the elderly to conserve medical resources.

In terms of the host distribution, our meta-analysis aligns with previous research findings, revealing a higher incidence rate among the female and the elderly, which correlates with the increased prevalence of age-related osteoporosis and postmenopausal osteoporosis[26, 29]. Concurrently, the rising incidence of sarcopenia in the elderly population contributes to an increased risk of falls, thereby promoting a higher incidence of osteoporotic fractures in the elderly[30].

Strengths and Limitations

To the best of our knowledge, this is the first systematic review that assessed the national incidence rate of osteoporotic hip fracture in China, and no publication bias was found. Despite some heterogeneity observed, this study provided a detailed nationwide profile of osteoporotic hip fractures and investigated its secular and spatial distribution for the first time.

This study also has several limitations. Firstly, the number of included studies meeting the criteria was limited, comprising only 12 articles. Secondly, the majority of included studies were retrospective in nature, which may lead to underestimation of incidence rates due to recall bias. Moreover, only four studies provided age-specific incidence data, which may be insufficient to comprehensively elaborate the distribution across different age groups. Finally, the meta-regression and subgroup analysis indicated that only the proportion of female patients could account for heterogeneity, which was insufficient to fully explain all sources of heterogeneity.

Recommendation for Further Research

The current epidemiological studies on osteoporotic hip fractures often conflated them with hip fractures. The diagnose of osteoporotic hip fractures often requires comprehensive medical history or BMD data. However, most primary epidemiological studies focused on all types of hip fracture and did not provide the above detailed information, leading to limited data available for further analysis of osteoporotic hip fractures. It is crucial to conduct epidemiological assessments for osteoporotic hip fractures, rather than all types of hip fracture, and therefore future researches should prioritize providing more detailed and informative data. Additionally, reports should include age-specific and

gender-specific incidence rates. Offering raw data, such as new case numbers and the at-risk population, enables readers to form a comprehensive understanding and serves as valuable groundwork for future studies. Lastly, researchers should be attentive to the distinction between cumulative incidence and incidence rate to avoid error reporting.

CONCLUSION

This meta-analysis revealed a considering incidence rate of osteoporotic hip fractures among Chinese adults aged 50 years and above, which steady increased over the past three decades. The study highlighted a significant disease burden of osteoporotic fractures in China, particularly in the Chinese mainland. By offering an accurate epidemiological assessment, this study provided comprehensive data support for the formulation of appropriate healthcare policies and clinical guidelines for osteoporotic hip fracture patients in China.

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TABLES

Table 1 Characteristics of the 12 studies included in this study

Study	Region	Studyperiod	Study design	Age group	Case-identifying method	Incident cases	Population atrisk (person-years)
Huang 1994	Chengdu	1989-1989	Retro	≥50years	Record	204	236,106
Yan 1996	Shenyang	1994-1994	Retro	≥50years	Record	358	612,170
Chie 2004	Taiwan	1996-2000	Retro	≥50years	Code	33,789	21,270,598
Bow2012	HongKong	1995-2009	Pro	≥50years	Self-report	34	14,739
Wang 2013	Hangzhou	2000-2010	Retro	≥50years	Record	2,289	3,900,180
Wang 2014	Hefei	2010-2010	Retro	≥50years	Code	1,287	1,262,511
Zhang 2015	Shanghai	2008-2013	Retro	≥50years	Code	2,776	1,417,090
Li 2016	Beijing	2013-2013	Retro	≥60years	Code	4,504	1,643,464
Yuan 2017	Guiyang	2011-2014	Pro	≥50years	Self-report	6	5,697
Zhu 2020	Multiple provinces	2014-2014	Retro	≥50years	Self-report	71	154,099

Gong 2021	Multiple provinces	2013-2016	Retro	≥65years	Code	214,407	85,787,692
Gao 2022	Xi'an	2017-2017	Retro	≥50years	Record	331	210,000

Retro, retrospective; Pro, prospective.

Table 2 Subgroup analysis of osteoporotic hip fracture incidence rate

Group	Number of studies	Incidence rate (95%CI), per 100,000 person-years	I^2, %
Gender			
Male	11	95.98 (65.0,132.71)	100
Female	11	158.92 (97.94,234.37)	100
Age			
50-54	4	25.16 (14.25,39.10)	93
55-59	4	36.71 (23.23,53.23)	94
60-64	4	74.56 (45.73,110.34)	94
65-69	4	128.80 (85.73,180.53)	93
70-74	4	214.36 (147.04,294.23)	93
75-79	4	341.27 (169.38,572.13)	98
80-85	4	603.11 (230.97,1147.68)	99
≥85	4	965.22 (170.75,2387.42)	100
Region			
Chinese mainland	10	122.94 (78.47,177.26)	100
Hong Kong	1	158.85 (157.17,160.55)	NA
Taiwan Region	1	230.68 (159.80,322.21)	NA
Study Period			
Pre-2000	3	97.16 (48.84,161.90)	100
2000-2010	2	127.60 (13.45,353.55)	97
2010 onwards	7	153.32 (94.96,225.42)	100
Study Design			
Retrospective	10	127.90 (83.44,181.80)	100
Prospective	2	170.25 (71.10,309.83)	72
Case-identifying Method			
Disease code	5	190.81 (133.30,258.58)	100
Self-report	3	113.00 (29.15,248.06)	95
Medical record	4	86.02 (49.18,133.05)	99

FIGURES

Fig. 1 Flow diagram of study selection

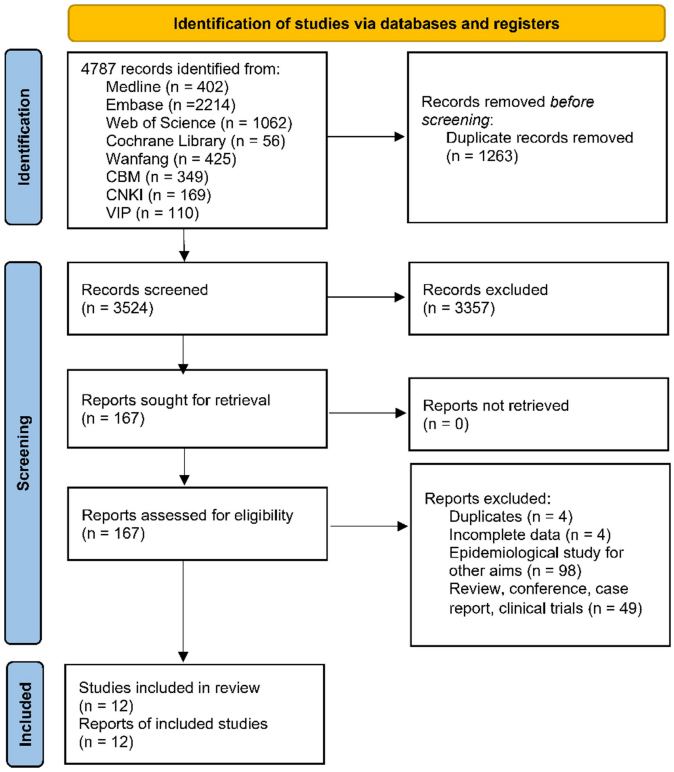
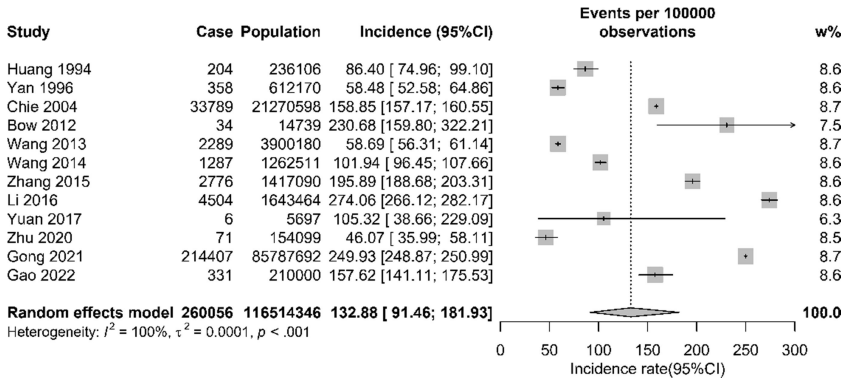
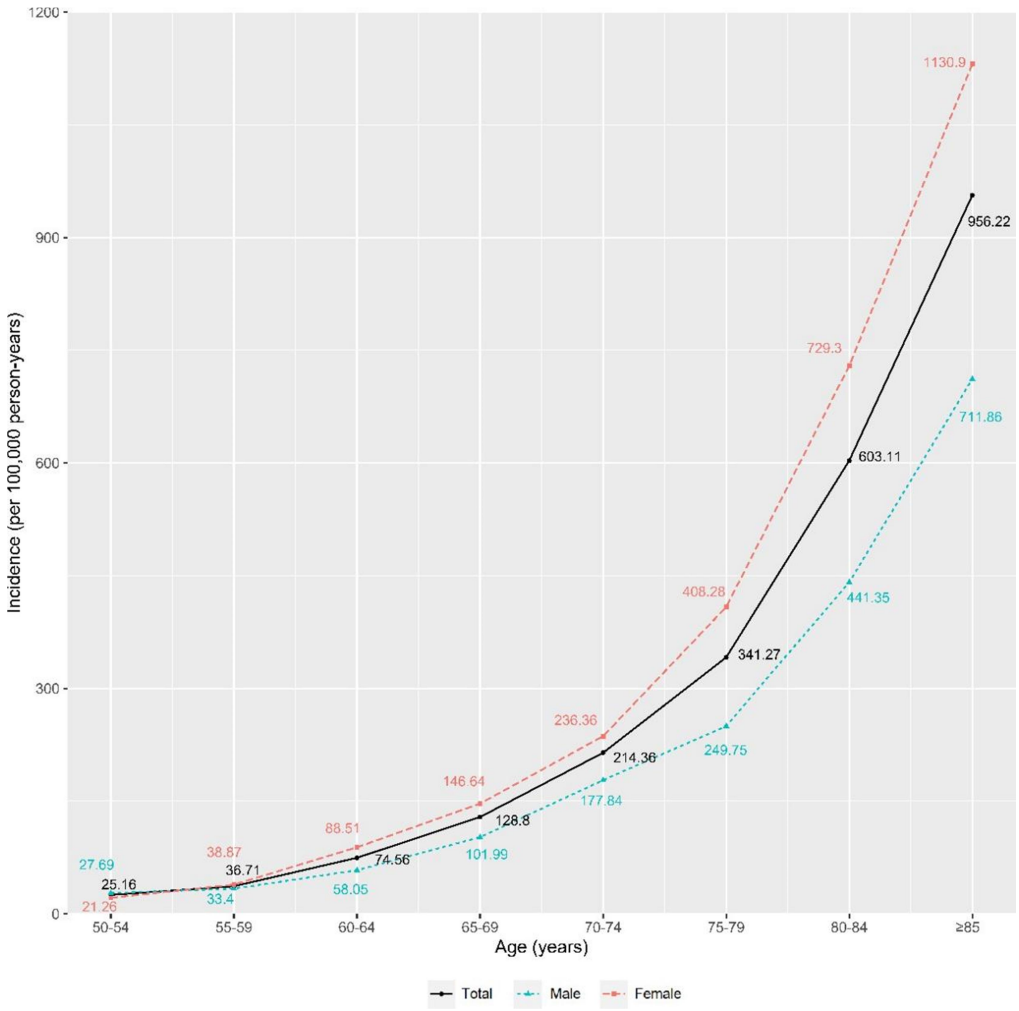


Fig 2 Pooled incidence rate of osteoporotic hip fracture in China



In the forest plot, squares represent the mean values, with the size of the squares reflecting the weightof individual studies on the random effects meta-analysis. The horizontal lines represent the 95% confidence intervals. The diamond at the bottom of the plot indicates the pooled mean value, with theright and left sides corresponding to the lower and upper confidence limits, respectively. w%, relativeweight%.

Fig 3 Incidence rate of osteoporotic hip fracture in China by gender and age



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