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ORIGINAL PAPER

Collecting data on fractures: a review of epidemiological studies on orthopaedic traumatology and the Chinese experience in large volume databases

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Abstract

Purpose This study aimed to review the epidemiological studies on orthopedic traumatology and the Chinese experience in large volume databases of fractures.

Methods Review of international and Chinese literature.

Results Traumatic fractures are associated with high risks of death and disability worldwide, thus increasing financial burden on affected families and society. In the current study, epidemiological surveys on fractures around the world were reviewed to explore distribution and types of fractures in different populations. Different populations exhibit heterogeneity in the type, incidence of traumatic fractures, and the underlying causes and severity of fractures. Fracture epidemiology has strengthened clinical practice and increased understanding of the causes and patterns of fracture occurrence. Fracture and trauma epidemiological studies provide findings for use in public health education and data that can be used to develop targeted prevention intervention strategies by health departments.

Conclusion The current study summarized the worldwide epidemiological studies on orthopedic traumatology. The findings of this study will provide a basis for designing effective methods for fracture prevention and management.

Keywords Fracture · Trauma · Orthopedics · Survey · Epidemiological study · Data collecting

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Introduction

Traumatic injuries are the leading cause of death worldwide [1] and the fifth leading cause of death in China. Traumatic injuries are responsible for higher number of deaths compared with diabetes and infectious diseases [2, 3]. Fractures are caused by forces acting on the bone that exceed the inherent capacity the bone can absorb or bear. A fracture is characterized by severe pain and swelling of the injured part, accompanied by loss of function, which, if not effectively treated, can lead to lifelong disability or death.

Incidence of fractures has increased tremendously owing to advances in transport and construction industries and increase in the aging population [4, 5]. Increased incidence of osteoporosis is associated with increased incidence of osteoporosis-related fractures. The prevalence of osteoporosis in the elderly aged over 60 years in China in the year 2016 was 36% (including 23% in men and 49% in women) [6]. An epidemiological survey reported 2.33 million cases of osteoporotic fractures in China, including 360,000 cases of hip fractures, 10,000 cases of vertebral fractures, and

860,000 cases of other osteoporotic fractures. The number of osteoporotic fractures in China is expected to hit 5.99 million by 2050, resulting in increase in medical expenditure approximated at 174.5 billion yuan [7]. These findings indicate that fractures are major human health concerns resulting in high financial burden to families and society.

Understanding of modern epidemiological data of fracture provides a basis for development of preventive and therapeutic interventions to alleviate the high mortality and morbidity. Studies should explore the distribution and natural history of fractures in the population and explore the causative factors of fractures, thus aiding in the development of effective management strategies. Relevant national policies and health practices should be formulated based on the scientific analysis of causes and health burden caused by fractures. Effectiveness of physicians is limited by the high number of injuries and illnesses encountered in daily practice. However, epidemiological studies have significantly improved clinical practice in several ways. For instance, epidemiological studies guide physicians to have a broader understanding of causes and patterns of fracture occurrence. Understanding of causes and patterns of fractures aids in the development of effective therapeutic approaches and preventive strategies.

In the current study, articles on fractures were retrieved from PubMed, Cochrane library, and EMBASE databases from inception to December 12, 2020. The search was performed using the keywords fracture, epidemiology, survey, and orthopedics. Original clinical trials and systematic reviews or meta-analyses were excluded from the study. A total of 396 articles met the inclusion criteria (Fig. 1). Incidence of fractures in most countries across the world is regularly monitored. Incidence rate of fractures and the proportion of population with fractures differ with countries, regions, and races [8–15]. This can be attributed to differences in the natural environment, regions or cities, and level of social and economic development and differences in transport and construction industries, customs, culture, and living habits in different countries [11, 16].

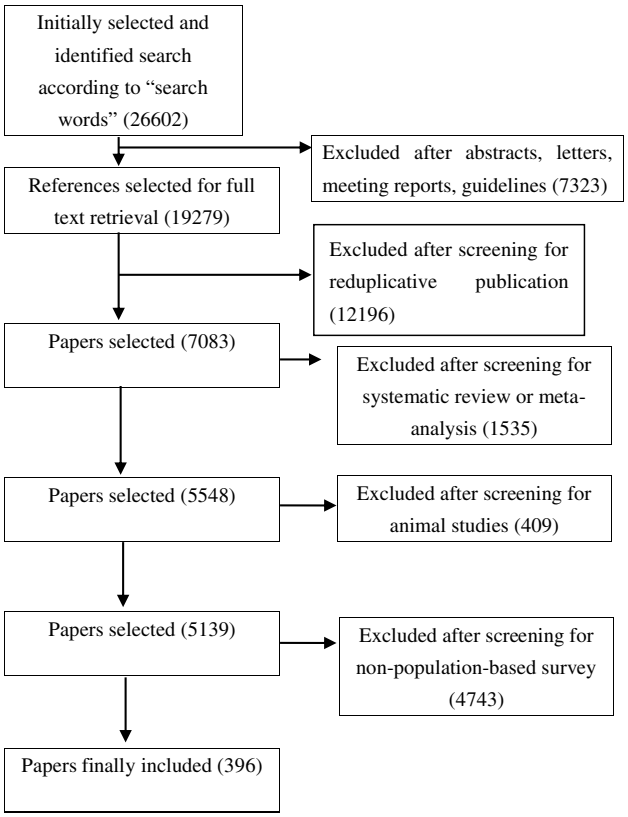

Fig. 1 Flow diagram of literature searching on the incidence or prevalence and risk factors of fractures up to 10 December 2020

Fracture epidemiology in international literature

An epidemiological survey on fractures conducted in the county of Leicestershire in England reported 100 cases of fractures for every 10,000 men and 81 cases of fractures for every 10,000 women [17]. Johansen et al. [18] reported approximately 23.5 fractures for every 1000 males and approximately 18.8 fractures for every 1000 females in England and Wales. In addition, the average age of fracture patients was 49.1 years, and the ratio of male to female patients with fractures was 1:1 [19]. Furthermore, the annual incidence of fractures in males and females was 11.67‰ and 10.65‰, respectively. Moreover, the age and gender curve of the whole population showed a significant increase in the incidence of fractures in women during menopause. The highest incidence of fractures in females was reported in females aged 90–99 years, with a fracture incidence rate of 49.7‰ per year. Analysis of fracture cases in males showed a bimodal curve. Men aged 12–19 years and 90–99 years showed high incidence of fractures with incidence rate at 23.2‰ and 21.9‰ per year, respectively. Fractures of the distal radius, metacarpus, phalange, proximal femur, and ankle accounted for 60% of all fracture cases, and the number of fractures in elderly males was smaller compared with that in females [19]. A nationwide survey on incidence of fractures in the UK comprising 45,293 individuals (10,111 ethnic minorities) revealed that white people had a significantly higher incidence of fractures compared with the incidence in other races (black and other races) [20]. A study by Rouvillain [21] explored the epidemiology of black proximal femur fractures in the Caribbean. In the study, data on proximal femoral fractures treated in French hospitals from 2010 to 2013 were reviewed and analyzed and the findings showed a lower incidence rate of black proximal femur fracture in the Caribbean subjects compared with that of patients from

western countries. In addition, Kannus et al. [22] reviewed data on patients with ankle fractures caused by falls in a Finland hospital between 1970 and 2014 years. The results showed that the incidence rate of ankle fractures caused by falls in Finland increased sharply from the early 1970s to the late 1990s, then a decline was observed. Although the findings showed a decrease in number of fractures towards 2014, the authors projected an increase in the number of elderly ankle fractures owing to increase in the aging of the population. Therefore, further large-scale intervention studies should be conducted to explore methods for fracture prevention. Yoshihara et al. [23] explored the demographic characteristics of 24,059 cases of unstable pelvic fractures in the USA between 2000 and 2009. In the study, demographic variables were stratified and the trend of hospitalization time and related hospital mortality of unstable pelvic fractures was analyzed. The results showed stable in-hospital mortality rate of patients with unstable pelvic fractures at 8.3%. Moreover, Court-Brown et al. [24] explored the trend of adult fracture in Scotland and compared the incidence rate of fractures in Dundee, Scotland, and Oxford from 1954 to 1958 and Scotland Edinburgh from 2010 to 2011. The findings showed a 50% increase in the incidence rate of fractures. In addition, a higher incidence of fragile and non-fragile fractures was observed in the recent years, possibly due to increase in the aging population and social and economic changes.

In summary, population-based studies on the incidence of traumatic fractures have been conducted in some regions, and inconsistent findings have been reported. Studies report that epidemiological differences between populations are important because they mirror different cultures and lifestyles in each region [25]. However, the previous findings do reflect the overall trend in fracture incidence in recent years owing to the small sample sizes (less than 100,000) and relatively outdated data. Some shortcomings of the studies, including poor representation of the population, lack of sampling design, and lack of comprehensive survey content, should be addressed.

Fracture epidemiology in China

The number of epidemiological studies on fractures in China has gradually increased in recent years. Epidemiological surveys on fractures with regional characteristics and large sample sizes were conducted recently (Table 1) [26–41]. Liu et al. conducted a survey comprising 10,930 permanent residents aged over 50 years in Chengdu City and reported that 1,639 participants had fracture occurrence–related factors. The main conclusions for the study were the following: (1) forearm, spine, and femoral neck are the top three fracture prone sites; (2) women have a higher risk of acquiring a fracture compared with men, and urban areas have high incidence of fractures compared with rural areas. Labour intensity, sleep time, and genetic factors affect occurrence of fractures [26]. The "Ninth Five Year Plan" project "Research on the current situation and characteristics of

Table 1 A brief summarization of representative literature about fracture epidemiology in China

No	Age group	Study period	Location (state or city, nation)	Sample size	Fracture	Reference
1	≥50	1992	Chengdu, China	10,930	All	Liu L[26]
2	All	1988–1992	Beijing, China	1,641	Hip fracture	Xu L [27]
3	≥60	2000	Guangzhou, China	1,126	Osteoporotic fracture	Xu D [28]
4	≥50	2001	North China, Southwest China, Mid-south China, Northeast China	8,092	Hip fracture	Li N [29]
5	All	2000–2011	Taiwan, China	49,300	Pelvic fracture	Yang N P [30]
6	≥50	2004	China	243,695	Hip fracture	Peng K [31]
7	All	2008	Honghe, Yunnan, China	25,834	Hip fracture	Zhao H [32]
8	≥65	2001–2009	Hongkong, China	42,717	Hip fracture	Chau PH [33]
9	≤18	2001–2010	Shenyang, China	1,412	Traumatic fractures	Wang HW [34]
10	>20	2000–2012	Taiwan, China	8,384	Stroke rehabilitation with fracture	Huei KH [35]
11	All	2001–2010	Beijing, China	1,392	Extremity fractures with spinal injury	Wang HW [36]
12	All	2014	China	512,187	All	Chen W [37]
13	≥55	2012–2016	China	190,560	Hip fracture	Zhang CG [38]
14	Postmenopausal women	2017	Beijing, China	1,760	Vertebral fracture	Cui L [39]
15	≤18	2018	China	14,141	Pediatric fracture	Song F [40]
16	All	2019	China	2,489	All	Lv H [41]

common senile diseases in China" explored senile osteoporosis in China at the end of the last century. However, the survey only reported the fracture incidence of the elderly rather than the fracture occurrence and characteristics of the entire Chinese population [30]. Small sample size and lack of representation of the entire population imply that these surveys do not present the actual epidemiological statistics on fractures in China. However, there has been increase in fracture epidemiology studies in China, and several studies have been conducted on the high-risk population. Epidemiological studies on fractures in various regions and units can guide physicians in clinical practice, and provide a basis of development of fracture preventive strategies.

China has a vast territory which extends to the tropical temperate zone and comprises several nationalities. The coastal and inland coexist and the level of economic development varies significantly owing to the complex and diverse terrain. In addition, the epidemiological characteristics of fractures in different regions of China are distinct. Therefore, it is challenging to conduct a nationwide epidemiological survey on fractures. To address this, our team conducted a large and comprehensive epidemiological survey on fractures in China [42–65]. The research group selected a representative population in China based on data from the sixth national population census through multistage stratified cluster random sampling and probability proportion scale sampling. On-site flow and strict quality control were conducted and 512,187 valid questionnaires were collected. National authoritative data of fracture incidence rate and factors that cause fracture injuries in different groups were, for the first time, obtained, based on gender, age, nationality, occupation, education level, and causes of injury. Analysis of the data showed that the overall incidence rate of traumatic limb and trunk fractures in China was 3.21‰ in 2014. Analysis based on anatomical location showed that children had the highest incidence of distal radius fractures, young and middle-aged males and females showed the highest incidence of tibiofibular fractures, and elderly women presented with the highest incidence of distal tibiofibular fractures. However, differences in ethnic groups, regions, and residences had no significant effect on the incidence of fractures. On the contrary, participants in different occupations and subjects with different education levels exhibited different fracture rates. For instance, retirees and unemployed subjects presented with higher fracture rates, students and preschool children exhibited relatively lower fracture rates, whereas illiterates presented with the highest fracture rates. Moreover, the study explored factors associated with differences in fracture incidence and reported that lack of sleep (less than 7 hours of sleep per day) was an independent risk factor for fractures. In addition, previous fracture history was a risk factor for fractures in the young and elderly, alcohol consumption was a risk factor for fractures in young and middle-aged and elderly people, and smoking and BMI < 18.5 kg/m^2 were risk factors for fractures in young and middle-aged men (15 ~ 64 years old). The findings showed that fracture protective factors included junior high school education level (compared with illiteracy), office workers, manual workers, farmers, retirees, and other occupations (compared with unemployment). The study reported the overall characteristics of fracture risk factors in different populations; thus, it provides a scientific basis for prevention and treatment of fractures [37, 42–51, 66].

In addition, our team conducted an epidemiological study to explore the types of fracture injury in China. A total of 83 representative hospitals were randomly selected through multi-stage cluster random sampling method based on the fracture types in hospitals at all levels [52–54]. Data for a total of 497 thousands of fracture cases were collected. Injury types and epidemiological characteristics of different parts with fracture were grouped based on AO/OTA classification and other commonly used classification criteria. This classification allowed designing of new instruments and implants, thus providing scientific basis for development of appropriate diagnosis and treatment strategies by orthopaedic doctors. The epidemiological study was different from the national survey on the incidence of traumatic fractures in China, in that fracture injury classification investigation mainly focused on hospitalized patients who require surgical treatment. The findings showed that the ankle, distal radius and ulna, and phalanx were the most common fracture sites in this cohort. Moreover, the top three most common fracture sites in children were the distal humerus, distal radius and ulna, and clavicle. Different fracture sites exhibited different injury characteristics. Analysis of fractures for the distal tibia fracture showed that AO-B1 type fracture was the most prevalent type of injury, and required anatomical reduction of the articular surface during treatment. Notably, garden IV fracture of the femoral neck showed poor reduction and fixation effect and was characterized by high risk of complications including nonunion and avascular necrosis of the femoral head. Clinicians should select the most appropriate surgical method based on the age and physical condition of the patient. Studies report that incidence of the "open book" injury of pelvic ring fracture has been increasing recently; therefore, there is need to explore the vital signs and haemodynamic stability and examine whether patients present with severe combined injuries [52–57].

A multicenter study was conducted to explore fracture-related complications and the findings reported that the risk factors of fracture post-operative complications include fracture of internal fixation and incision infection. Moreover, preventive and treatment strategies were formulated and a series of new internal fixation and micro-invasive instruments were designed to reduce fracture risk. Notably, 24 hospitals were randomly included in a previous study and

data on 19,965 cases of fracture were collected. In the study, information on social demographics, bad living habits, comorbidity of basic diseases, fracture-related information, operation-related information, blood routine examination, and biochemical examination from at least three time nodes (admission, pre-operative, and post-operative first time) were collected. A follow-up of incision infection and other complications and functional recovery was conducted and data were recorded. The risk factors of fracture complications, including fracture of internal fixation and incision infection, were also explored. The scholars developed a new type of implant for reduction of risks of fracture by formulating preventive and treatment strategies [58–62]. Furthermore, analysis of the basic information of patients, fracture information, plate placement, and internal fixation fracture using data for 168 cases of plate fracture collected between January 2005 and January 2015 revealed that the average time from operation to plate fracture was 12.9 ± 12.4 months. Cox proportional hazard regression model analysis of risk factors of plate fracture was performed. The findings provided a basis for development of several novel internal fixators and minimally invasive instruments (with wide adaptability and individualized characteristics, and elastic minimally invasive plate) for reduction of risk of fracture [63].

Importance of epidemiological studies on fractures

Studies on fracture epidemiology and collection of trauma statistics and epidemiological data enable researchers and developers to understand fracture incidence, types, and characteristics across populations and locations. As a result, more targeted fixation devices and related devices for orthopaedics can be developed. Moreover, internal fixation devices and devices specific for the local characteristics can be designed. Our team classified fractures based on the number of fractures in different age groups using different fracture classification systems (including AO/OTA classification and traditional classification systems). The findings showed that a gap existed between the statistical data in China and data reported in other countries. Furthermore, some fracture types were not included in the conventional classification system; thus, the findings provided a guide for further research and development of more effective strategies [64, 65].

In addition, fracture epidemiology studies provide data to conduct public health education and to guide health departments to develop targeted prevention and intervention strategies. These data can reflect the current status of fracture incidence in China or worldwide. Use of inferential statistics allows extrapolation of regional population data for application in other regions with similar populations. Moreover, studies on fracture epidemiology can be used for teaching undergraduate, graduate, and orthopedic surgeons to understand the current status of fracture injuries. This information can help physicians in understanding the incidence, risk factors, and injury characteristics of fracture patients in different countries, populations, and sites. Therefore, understanding of fracture epidemiology and collection of data on trauma statistics and epidemiology provides a basis for reduction of the high incidence and mortality associated with fractures worldwide.

Author contribution YZ designed the study; HL, WC, and MY searched relevant studies; HL and WC analyzed and interpreted the data; HL, WC, and MY wrote the manuscript; HL, WC, MY, and YZ approved the final version of the manuscript.

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Availability of data and materials My manuscript has no associated data.

Declarations

Ethics approval This review was agreed by the institutional review board of the Third Hospital of Hebei Medical University.

Consent to participate Not applicable.

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Competing interests The authors declare no competing interests.

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