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Incidence of pressure injuries in fracture patients: A systematic review and meta-analysis

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ABSTRACT

Objective: To systematically evaluate the incidence of pressure injuries (PIs) in hospitalized fracture patients and to provide evidence for the prevention and treatment of PIs.

Methods: A systematic review and meta-analysis was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines. Electronic databases including PubMed, Embase, the Cochrane Library, Web of Science, CINAHL, China Knowledge Resource Integrated Database (CNKI), Wan-Fang Database, Weipu Database (VIP), and Chinese Biomedical Database (CBM) were searched to collect cross-sectional studies and cohort studies related to PIs among hospitalized fracture patients. All electronic literature sources were searched from inception to March 2022, and a hand-search through references was also conducted to find relevant articles. Studies were evaluated independently by two researchers and audited by a third researcher. The data were extracted and presented in tables. The risk of bias was assessed using the Joanna Briggs Institute (JBI) Critical Appraisal Checklist. All data analysis used Stata14.0. The I^2 statistic and random-effects model were used to determine the heterogeneity.

Results: A total of 7906 articles were screened, and 18 studies with 8956 patients were ultimately involved in this review. The pooled incidence of PIs in the fracture patients was 20.4% (95%*CI*: 14.9 to 25.8), and the incidence of PIs only in spinal and hip fracture patients was 23.9% (95%*CI*: 19.6 to 28.2). The incidence of PIs in 65 years old or over was significantly high (23.3% [95%*CI*: 15.3 to 31.2]). The most affected body sites were sacro-coccygeal regions (56.7%) and heels (19.9%). The most common stages were stage 2 (62.2%) and stage 1 (17.4%).

Conclusion: The overall incidence of PIs in fracture patients was as high as 20.4%, significantly higher than the average incidence of adults. We found that the potential for PIs in fracture patients increases with age. Hence, our discoveries recommended that healthcare givers should consider reducing the occurrence of PIs. Additionally, more research may be conducted to improve the understanding of characteristics of PIs among fracture patients and to identify PIs risk factors to prevent and treat them effectively.

1. Background

Pressure injuries (PIs) now are defined as "localized damages to the skin and/or underlying soft tissue usually over a bony prominence or related to medical or other devices, caused by sustained pressure (containing pressure associated shear). The injury can present as intact skin or an open ulcer and may be painful" [1]. PIs are one of the most common complications in hospitalized patients and older people worldwide, and the incidences of PIs are also gradually increased in recent years [2]. A systematic review and meta-analysis found that the incidence of PIs in hospitalized adult patients ranged from 1.1% to 35.7%, and between 0.2% and 26.3% for hospital-acquired pressure

Abbreviations: Pressure injuries, PIs.

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injuries (HAPIs) [3]. PIs can not only cause patients in poor outcomes such as pain and disability but also reduce the patient's quality of life and prolong the hospital length of stay by an average of 5–8 days [4,5]. In addition, significant challenges and heavy financial burden for the healthcare system are also due to the difficulty and cost of treatment of PIs. Meanwhile, it also causes increasing medical expenditure on patients [6]. A systematic review reported that the cost of PIs prevention per patient per day varied between €2.7 to €87.6, while the cost of treating PIs ranged from €1.7 to €.470.5 [7].

Fracture patients are at high risk of PIs, especially hospitalized patients. There are some significant problems like surgical treatment, plaster splint, and traction fixation after a fracture of the lower extremity or pelvis or lumbar thrust occurs, which all would result in resisting skin damage from external stimuli difficultly for patients. Research showed that orthopedic surgery was one of the most critical risk factors for PIs among hospitalized patients, and the incidence of intraoperatively acquired pressure injuries (IAPIs) was higher than those patients with extensive surgery [8]. The incidence of PIs development in intraoperative patients for orthopedic surgery was 16.7%, and 22.0% for hip fracture surgery [9]. During the operation, a fixed surgical position must be maintained, and patients cannot change their position voluntarily after the operation, which will restrict their physical activity. After a period, the local soft tissue compression may cause impaired blood circulation. And because of hypoxia, ischemia, and malnutrition following trauma to the bone, patients are more prone to PIs occurring [10,11]. In addition, patients with lower limb fractures, knee ligament injuries, or epiphyseal injuries often require external fixation to maintain the stability of the fractured end of the socket. Due to limb immobilization and gravity, the injured limbs are in a passive position for a long time, and the pressures are concentrated on the heels. The local tissues of the heel are under constant pressure, causing ischemia and peripheral vasodilation, which all will cause the occurrence of PIs [12]. The main manifestations of PIs among fracture patients include changes in skin color, increased skin temperature, pain, and changes in hardness [13]. Moreover, fracture patients with PIs will suffer more damage, such as increased infection, delayed recovery, multi-organ failure, and reduced survival rate [14].

Presently, many scholars pay more attention to exploring the incidence of PIs among fracture patients, and a few relevant kinds of literature are also published simultaneously. However, those studies cannot accurately provide reliable evidence for preventing PIs among fracture patients because of the wide variation of the results. Hence, this study aims to conduct a comprehensive search of PIs in fracture patients and use meta-analysis to evaluate the incidence of PIs in fracture patients, aiming to provide a reference for the prevention and treatment of PIs.

2. Methods

2.1. Inclusion and exclusion criteria

Studies were eligible for inclusion in the review if they reported an incidence of PIs among fracture patients. The inclusion criteria were as follows: (a) Patients diagnosed with fractures, and there are no restrictions on their age, gender, race, and region. (b) Observational studies (cross-section, cohort). (c) Literature data is detailed and complete. Studies presenting the effectiveness of nursing interventions and management strategies of PIs, studies reporting incidence of PIs among other populations, studies with repeating or reviews, case studies, conference papers, animal experiments, incomplete data, or other types of research were excluded. In addition, articles in which subjects had developed PIs before admission were also excluded.

2.2. Search strategies

A comprehensive electronic literature search of PubMed, Embase, the Cochrane Library, Web of Science, CINAHL, China Knowledge Resource Integrated Database (CNKI), WanFang Database, Weipu Database (VIP), and Chinese Biomedical Database (CBM) was conducted. All electronic sources of information were searched from inception to March 2022 without language restriction. Retrieve cross-sectional and cohort studies on the occurrence of PIs in fracture patients. We did not restrict the date of publication in our literature search. The detailed search strategy is presented in Appendix A. Reference lists of identified studies and bibliographies of reviews were hand-searched for additional studies.

2.3. Studies selection process

Two researchers independently screened the literature, extracted data, and cross-checked it according to the inclusion and exclusion criteria. If there was doubt or disagreement, resolve it through discussion or negotiation with third parties. After removing duplicate studies, the titles and abstracts of all studies were screened to identify studies that met the inclusion criteria. Full-text articles of the remaining studies were obtained and screened against the inclusion criteria. The Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) [15] flow diagram was used to illustrate the study selection (refer to Fig. 1).

2.4. Data extraction

We used Endnote X9 to manage literature and create an Excel database according to the designed tables. Data extracted comprised of: (a) The methodological information of the studies, first author, year of publication, scale, age range, language, study area, research method, sampling frame, sampling method, inclusion/exclusion criteria, sample size, diagnostic criteria/classification criteria, and data collection methods (see Table 1). (b) Reported study outcomes, the incidence of PIs, the most affected body sites, and typical stages (see Fig. 4 and Table 2).

2.5. Quality assessment

Two investigators independently assessed the risk bias of included studies through the Joanna Briggs Institute (JBI) Critical Appraisal Checklist and answered with "yes", "no", and "unclear", respectively. A validated tool for assessing the risk of bias in prevalence studies with 9-items [16]. A sample representative, data collection method, disease definition, reliability and validity of study tools, test period, and response rate were assessed. A third researcher resolved the disagreements.

2.6. Statistical analysis

The single rate meta-analysis was performed using Stata 14.0, and the combined incidence rate and the corresponding 95% *CI* were calculated. The heterogeneity among the included studies was evaluated by I^2 statistic and Q tests; if $P > 0.1$ and $I^2 < 50\%$, indicating good homogeneity between the studies, the fixed-effects model was used for combined analysis. Otherwise, a random-effects model was used. Try to find out the source of heterogeneity through subgroup analysis. In addition, the stability of meta-analysis results is evaluated by sensitivity analysis. The Begg's rank correlation test and Egger regression analysis were used to detecting publication bias. Differences between groups were compared with χ^2 statistic, and $P < 0.05$ was considered statistically significant.

3. Results

3.1. Characteristics of included studies

A total of 7906 articles were searched from nine electronic

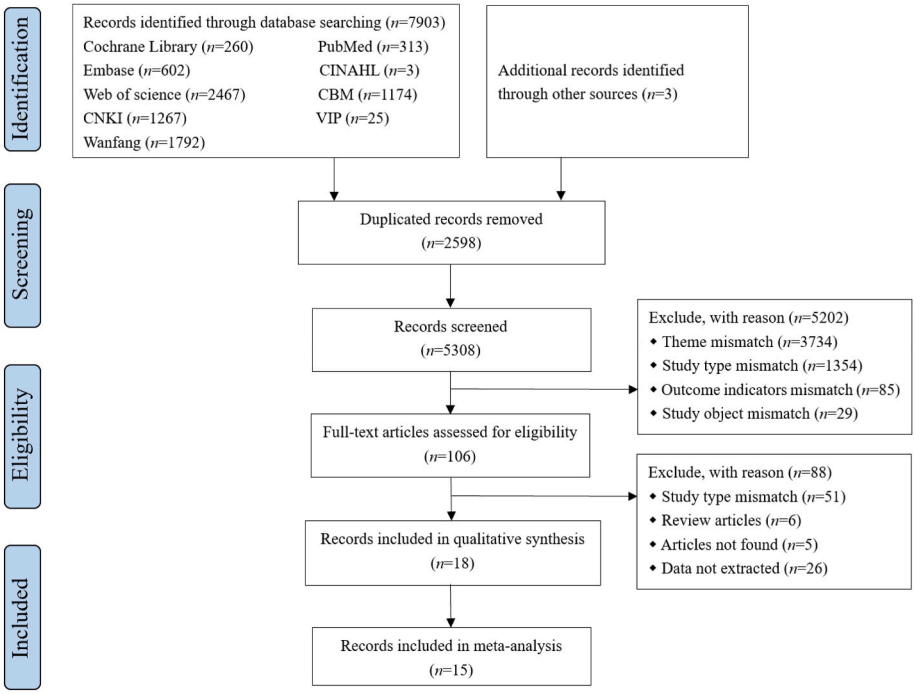

Fig. 1. PRISMA flow diagram showing study selection.

databases. After eliminating duplicates, 5308 articles were screened for titles and abstracts, and a further 5202 articles were excluded because they did not meet the inclusion criteria. The full-text screening was conducted for the remaining 106 articles, where an additional 88 studies were excluded because they did not meet the eligibility criteria. At last, eighteen studies [17–34] were eligible for inclusion in a systematic review, of which two studies [17,18] were excluded due to publication for a long time. And Gunningberg et al. 's study [19] was also not included in the meta-analysis after sensitive analysis with a large bias. Thus, fifteen studies [20–34] were included in the meta-analysis (see Fig. 1).

The included studies comprised data on 8956 patients across seven countries, including the UK, Sweden, Denmark, USA, Canada, Italy, and China. All included 18 studies were hospital-based researches, and the study design including 14 cohort studies [17,19–23,25,27,29–34] and 4 cross-sectional studies [18,24,26,28]. In addition, seventeen (94.44%) of the included studies described the incidence of PIs in spinal and hip fracture patients [17–33], and ten (55.56%) were described for those aged 65 and over [19,22,25,27–32,34]. The basic characteristics of the included studies for incidence of PIs in fracture patients were concluded in Table 1.

3.2. Quality assessment of included studies

A summary of the included studies' quality assessment (risk of bias) was presented in Fig. 2. There was a low risk of selection for all included studies. As a result, 93.33% of included studies reported that the sample frame was appropriate to address the target population, and all studies provided an adequate sample size. Similarly, there was a low risk of measurement bias because 80.00% of the included studies used diagnostic criteria of PIs, and 60.00% of the studies reported the data were collected in a standard, reliable way from all participants. However, only 40.00% of studies used random sampling or everyone in the sampling frame, and 40.00% of studies reported a high response rate, suggesting an increased risk of bias in these domains.

3.3. The pooled incidence of PIs in fracture patients

Eighteen articles [17–34] reported the incidence of PIs in fracture patients, and fifteen studies [20–34] were included in the Meta-analysis. The pooled incidence of PIs in fracture patients was 20.4% (95%*CI*: 14.9 to 25.8). The included studies had a considerable amount of heterogeneity [$I^2 = 98.1\%$, $P < 0.001$] (see Fig. 3a). Nine studies [22,25,27–32,34] were described for those aged 65 and over, and the incidence of PIs was 23.3% (95%*CI*: 15.3 to 31.2) with a high heterogeneity [$I^2 = 98.7\%$, $P < 0.001$] (see Fig. 3b). Fourteen studies [20–33] were conducted among spinal and hip fracture patients, and the incidence of PIs in spinal and hip fracture patients was 23.9% (95%*CI*: 19.6 to 28.2) also with a high heterogeneity [$I^2 = 93.6\%$, $P < 0.001$] (see Fig. 3c).

3.4. Anatomic locations and stages

Nine studies [20,22–24,27–29,31,34] reported information about affected anatomic locations and stages in fracture patients, and 935 patients developed 1085 PIs. The number (percentage) of overall PIs at the most affected body locations in Fig. 4 and the most frequently reported PIs stage in these studies are summarized in Table 2. Across all studies, PIs occurred most frequent body sites like sacrococcygeal regions (56.7%), heels (19.9%), ischial tuberosities (4.0%), scapula (3.9%), hips (2.1%), legs (1.9%), elbows (1.6%) and back (1.1%). In addition, the most common stages of PIs were stage 2 (62.2%) and stage 1 (17.4%), respectively.

3.5. Sensitivity analysis and publication bias detection

A sensitivity analysis of the 18 included studies showed that the estimates obtained by Gunningberg et al.'s study were significantly different from the overall estimates (20.36% [95% CI:14.90 to 25.81]) VS (21.95% [95%CI:16.50 to 27.39]). After eliminating this study one by one, the results obtained were not significantly different from the total combined estimated value. It showed that the sensitivity was low, and the combined results of this meta-analysis were robust and reliable. Begg's rank correlation test ($Z = 0.40$, $P = 0.692$) and Egger regression analysis ($t = 0.59$, $P = 0.567$) suggested that there no publication bias. (see Appendix B).

Table 1
Basic characteristics of included articles ($n = 18$).

First Author Published Year Country	Sample Size	Cumulative Incidence% (n)	Average Age (years)	Sample Source	Investigation Time	Study Design	Assessment Tool	DiagnosticCriteria /Classification Criteria
Versluysen et al. [17] (1985) London	283	31.8(90)	NP	St Bartholomews Hospital, London	May 31, 1981 to May 31, 1982	Retrospective cohort study	the Norton scale	NP
Jensen et al. [18] (1987) Denmark	156	30.1(47)	80	Department of Orthopedics Skanderborg Hospital, Skanderborg, Denmark	January 1, 1983 to December 31, 1984	Cross-sectional study	NP	NP
Gunningberg et al. [19] (2000) Sweden	45	55.6(25)	82	Orthopaedics at the University Hospital in Uppsala	between March and July 1997	prospective, comparative and descriptive	The Modified Norton Scale	EPUAP
Söderqvist et al. [20] (2007) Sweden	356	16.3(58)	NP	Karolinska Institutet, Department of Orthopaedics at Stockholm So der Hospital, Stockholm, Sweden	1998–2000	Retrospective cohort study	NP	EPUAP
Lindholm et al. [21] (2008) Sweden	609	21.5(131)	80	Sweden, Finland, UK (North), Spain, Italy, Portugal (South)	NP	Prospective cohort study	The Braden QD Scale	EPUAP
Baumgarten et al. [22] (2009) USA	658	36.1(208)	83.2 ± 6.6	In nine hospitals that participate in the Baltimore Hip Studies network15and in the 105 post-acute facilities to which patients from these hospitals were discharged	2004–2007	Prospective cohort study	Standard wound assessment practice	NPUAP
Campbell et al. [23] (2010) Canada	150	13.3(20)	70.6	London Health Sciences Centre, University Hospital [UH]	June 2006 to January 2007	prospective cohort study	the Braden QD Scale	NPUAP
Zhong et al. [24] (2010) China	188	5.85(11)	56.8 ± 5.2	Orthopedic Surgery, Affiliated Hainan Hospital of Nantong University	January 2005 to June 2008	Cross-sectional study	the Braden QD and Waterlow Scale	NP
Kopp et al. [25] (2011) NP	269	34.2(92)	81	In the Trauma center	January 2003 and June 2005	Retrospective cohort study	NP	NP
Xie [26] (2011) China	206	20.9(43)	45.8	Affiliated Hospital of Shaoyang Medical College	NP	Cross-sectional study	NP	NP
Baumgarten et al. [27] (2012) USA	658	14.6(96)	83.2 ± 6.6	In nine hospitals that participate in the Baltimore Hip Studies network 15 and in the 105 post-acute facilities to which patients from these hospitals were discharged	2004–2007	Prospective cohort study	standard wound assessment practice	NPUAP
Li et al. [28] (2016) China	147	37.4(55)	77.1 ± 9.6	The 421st Hospital of the Chinese People's Liberation Army	January 2010 to December 2014	Cross-sectional study	NP	NPUAP
Chiari et al. [29] (2017) Italy	1083	22.7(246)	84.1	In orthopedic wards in three Italian public hospitals	October 1, 2013 to January 31, 2015	Prognostic Cohort Study	the Braden QD Scale	NPUAP
Forni et al. [30] (2018) Italy	467	27.2(127)	83.3	An orthopedic hospital in Italy	October 1, 2013 to September 30, 2014	Prospective prognostic cohort study	the Braden QD Scale	NPUAP
Gazineo et al. [31] (2019) Italy	761	12.0(91)	83.68	Emergency department of two public hospitals in Italy	October 2013 to October 2014	Prospective cohort study	the Braden QD Scale	NPUAP
Gong et al. [32] (2019) China	465	27.1(126)	NP	Orthopedics, Dalian Central Hospital	October 1, 2015 to September 30, 2017	Prospective cohort study	the Braden QD Scale	NP
Wang [33] (2020) China	362	18.8(68)	49.97 ± 2.21	Spine Surgery, Affiliated Hospital of Qingdao University	April 2018 to May 2019	Retrospective cohort study	NP	NP
Guo et al. [34] (2021) China	2093	4.7(98)	NP	Department of Bone Diseases, Affiliated Hospital of Shaanxi University	October 2015 to October 2019	Retrospective cohort study	the Braden QD Scale	NPUAP

Note: NP = not provided relevant data, NPUAP=National Pressure Ulcer Advisory Panel, EPUAP = European Pressure Ulcer Advisory Panel.

4. Discussion

4.1. Main findings

The main aim of this study was to systematically evaluate the incidence of PIs in fracture patients and provide a basis for prevention and treatment decisions. The study can provide the latest information on the trend of PIs incidence in fracture patients. We included 18 studies in the current research with over 8956 fracture patients worldwide. Those articles all reported the incidence of PIs, which reflected researchers paid more attention to the new cases of PIs for fracture patients. Incidence could provide a more accurate understanding of the risk of developing new PIs and the quality of care for fracture patients [3]. From the risk of bias assessment of the included studies, the strength of this evidence is reliable, and it also could provide strong evidence to account for the incidence of fracture patients. The most significant

Table 2
Stages of PIs (most frequently reported).

Study	Stage 1	Stage 2	Stage 3	Stage 4	Unstageable PIs	Deep tissue PIs	Total
Söderqvist et al. [20] (2007)	27	31	–	–	–	–	58
Baumgarten et al. [22] (2009)	–	288	2	–	28	–	318
Campbell et al. [23] (2010)	14	2	–	–	–	–	16
Zhong et al. [24] (2010)	6	5	–	–	–	–	11
Baumgarten et al. [27] (2012)	–	107	2	–	13	–	122
Li et al. [28] (2016)	50	4	1	–	–	–	55
Chiari et al. [29] (2017)#	–						123
Gazineo et al. [31] (2019)	–	102	6	–	3	–	111
Guo et al. [34] (2021)	59	30	8	2	–	2	101
Total (%)	156(17.4)	569(62.2)	19(2.1)	2(0.2)	44(4.8)	2(0.2)	915

Note: # = The PIs of stage 2 or higher was 123 cases.

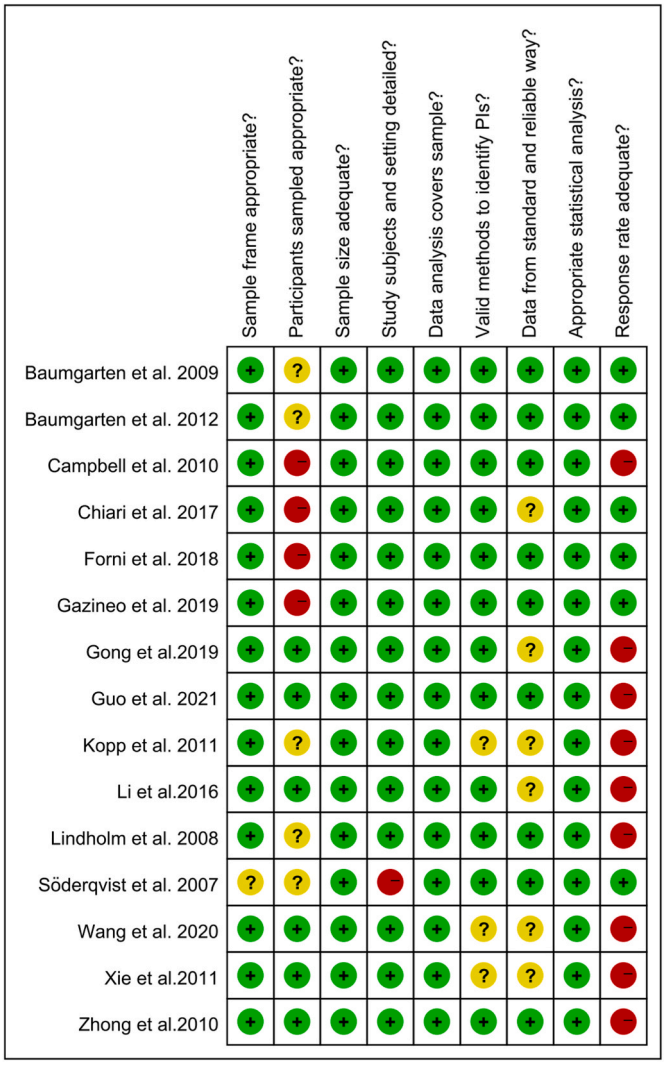

Fig. 2. Risk of bias for included studies.

reason for the high risk of bias was that the study participants were recruited inappropriately as convenience sampling, which cannot be considered to provide a representative sample of the base population [16]. This was one of the factors affecting the quality of most of the literature included in this study.

The pooled incidence of PIs in fracture patients was 20.4%, which was consistent with Chiari et al.'s report [29] with an incidence of PIs in fracture patients of 22.7%. However, our results were significantly higher than Zhong et al.'s report [24], which reported the incidence was only 5.85%. Previously, PIs have been poorly researched in fracture patients, which might lead to a lack of focused attention on the prevalence of PIs. In recent decades, clinical scholars gradually improved their awareness of the prevention of PIs and paid more attention to the epidemiology of PIs in fracture patients. Those may explain why our result was higher than Zhong et al.'s report. Our findings suggest that PIs remain a considerable burden for healthcare systems worldwide and highlight the necessity of additional efforts in patient safety initiatives. Meanwhile, the incidence of PIs only in spinal and hip fracture patients was 23.9%. Studies showed that the incidence of PIs in spinal and hip fracture patients was 44% and 55%, respectively [19,35]. At last, the incidence of PIs in 65 years old or over was 23.3%.

The incidence of fractures has significantly increased in recent years. Studies showed that pressures are the most important factor for skin PIs. When the average pressure of capillaries is lower than that of local tissue, the blood supply to the skin and subcutaneous tissue is blocked or reduced—the local tissues lacking blood supply experience functional abnormalities or necrosis due to ischemic hypoxia [36]. Reperfusion injury, which occurs because of the return of blood supply after a period of ischemia, has been posited as an additional source of tissue damage leading to pressure ulcers [37]. In addition, lack of activity and appetite suppression lead to malnutrition or anemia, which reduces the body's immunity and increases the incidence of PIs [38,39]. Finally, when patients are on prolonged bed rest, excess moisture from either perspiration or incontinence can macerate the skin, making it more susceptible to breakdown with friction and repositioning [40,41].

Our study results showed that the incidence of PIs in fracture patients aged 65 years or older was significantly higher than pooled incidence. It means that the elderly were more likely to develop PIs after fractures. Due to the muscle strength and joint flexibility of the lower limbs of the elderly gradually declining, it is often accompanied by low back and leg pain and cardiovascular and cerebrovascular diseases. With the increase of age, the bone mass of the elderly gradually decreases, and the bone microstructure is destroyed, resulting in an increase in bone fragility and more prone to fractures [29]. For elderly patients with fractures, due to their poor skin elasticity, were affected by factors such as reduced subcutaneous fat, decreased immunity, and weak mobility, which can easily cause pressure on the patient's bony process and increase the probability of PIs [42,43]. With the acceleration of the aging process, fractures in the elderly have become one of the leading health problems of global concern [31]. Studies showed that about half of adults in rural areas had decreased bone density, and about one-fifth suffered from osteoporosis [44]. However, most people did not have the idea of prevention or treatment in advance, which increased the possibility of fractures, and PIs and other complications may occur in severe cases. Therefore, healthcare should pay more attention to preventing and managing fractures associated with PIs in the elderly. Caregivers should raise the awareness of responsibility and strengthen the assessment of the risk of PIs, which is the first step to preventing PIs in the elderly. In addition to routine care mode, special care should be taken to avoid falls because it's different in bone health in older and young people. Essential parts of the joints of the elderly become stiff and inflexible due to bone

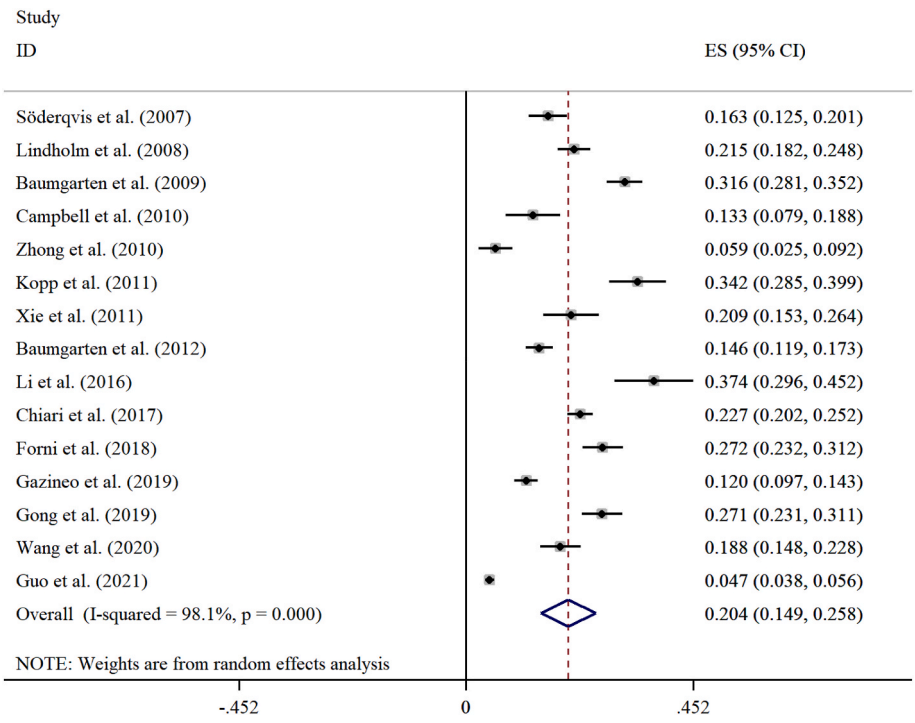

Fig. 3a. Forest plot showing the incidence of PIs in fracture patients.

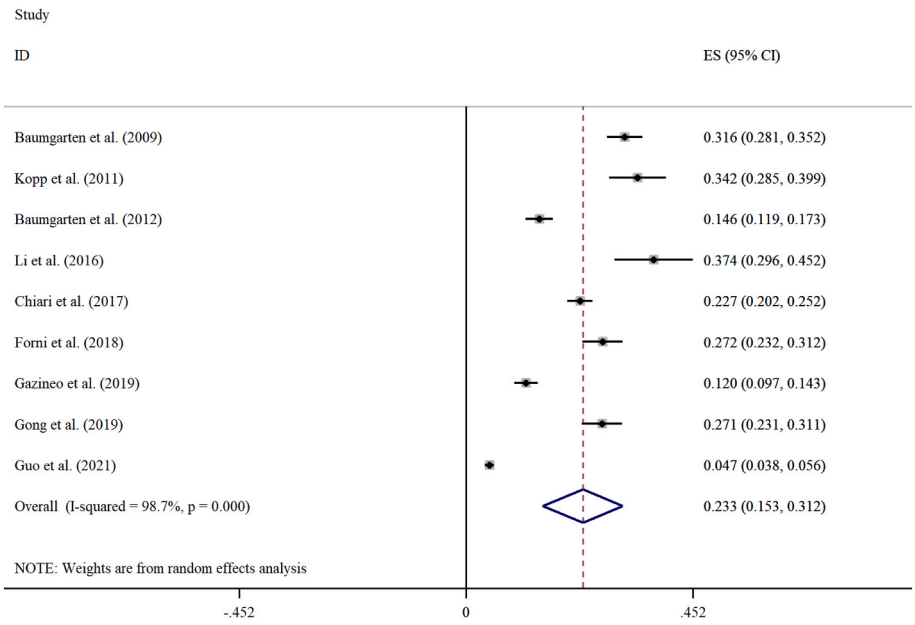

Fig. 3b. Forest plot showing the incidence of PIs in aged ≥65 years.

hyperplasia, joint deformation, and long-term wear and tear of soft tissue around the joints. So, when the elderly were unstable, had mobility problems, or were hobbled, they more easily fractured due to careless falling. In addition, psychological care should be carried out in a planned manner according to the psychological characteristics of elderly orthopedic patients, which can establish confidence to overcome the disease and actively cooperate with treatment [45].

According to the results of the systematic review, the most common areas of PIs in fracture patients were the sacrococcygeal regions (56.7%) and heels (19.9%), which was similar to figures from a global systematic review of hospitalized patients [3]. The main physiological structure of the sacrococcygeal regions was the direct cause of PIs. Due to no muscle attachment, lack of fat protection, prolonged bed rest, long-term vertical force, friction and shear force, and blood circulation disorders, the sacrococcygeal regions were particularly prone to PIs [46]. On the other hand, the sacrococcygeal parts were not easy to observe from the field of view. Suppose the caregiver did not perform a thorough turn-over cleaning while performing skin care. Then the sacrococcygeal regions will not be adequately decompressed, and sweat and other dirt will quickly gather here, which is more likely to lead to PIs [47]. Heels PIs were mainly caused by traction or plaster fixation. The heels belonged to the far end of the limb and were the internal cause of PIs due to poor blood circulation and low muscle fat attachment [48]. However, traction or plaster fixation was the external cause of PIs. When the fracture

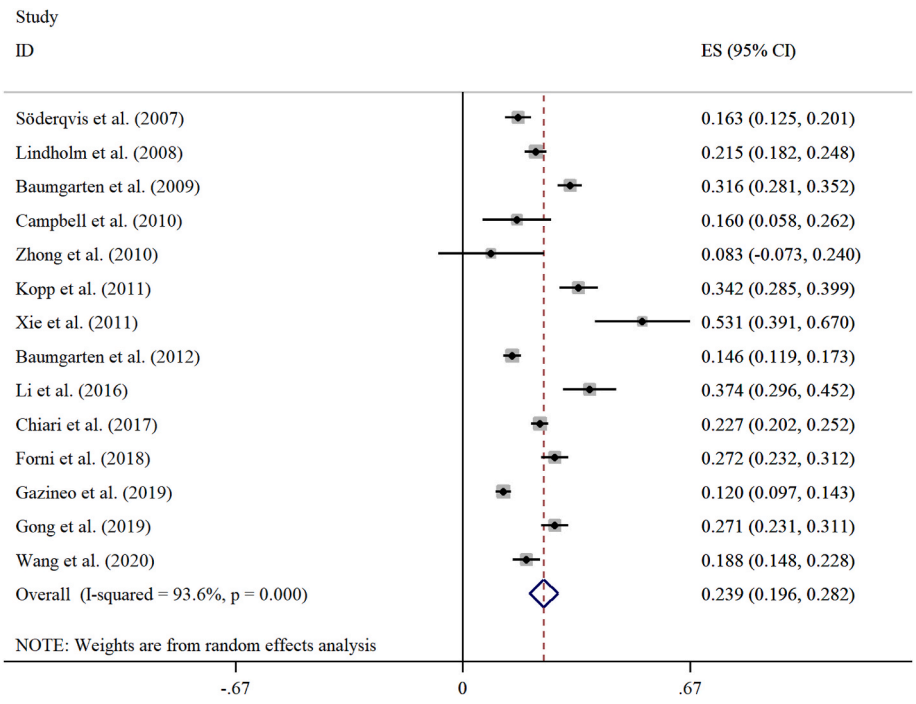

Fig. 3c. Forest plot showing the incidence of PIs in spinal and hip fracture patients.

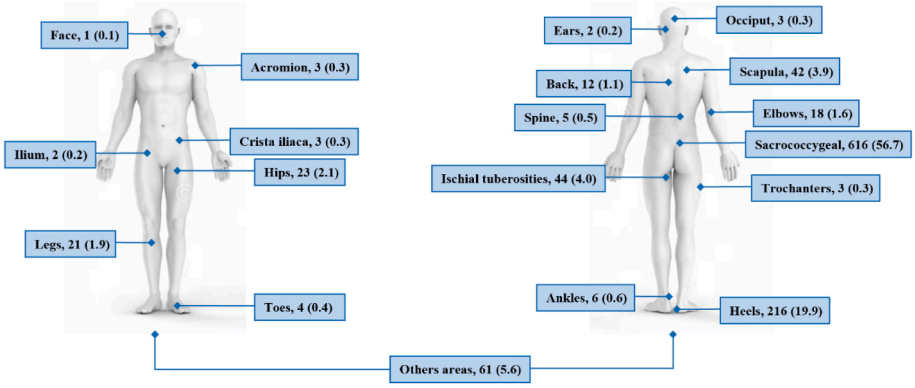

Fig. 4. Anatomical locations of PIs (most affected body sites).

patients perform skin traction, the holes strapped to the calf are easily slipped by the pull hammer, so traction gravity concentrates on the heels, resulting in the heels straight to accept pressure. Patients with bone traction will have a foot that is involuntarily spiraled and droopy foot, and the affected foot's gravity will be trapped on the canvas pad [49]. Moreover, patients with lower limb gypsum fixation were more prone to PIs because the gypsum can directly wrap the heels and affected limb, causing blood flow back disorders [36].

In addition, we found the most common stages of PIs were stage 2 (62.2%) and stage 1 (17.4%), respectively. The results were consistent with the findings of related studies [22,23,27,31,34]. It is worth noting that stage 2 was significantly higher than stage 1. Studies have shown that stage 1 PIs are generally considered reversible if promptly identified and appropriately managed [50], so this stage is often excluded from scientific reports [51]. Furthermore, stage 1 was the most sensitive of the PIs stages to intervention. The desired effect can generally be achieved by promptly removing the causative agent and preventing further injury development [52]. Those all can explain why the incidence of stage 2 PIs was higher than that of stage 1. Therefore, it is vital to strengthen the training of clinical staff on the relevant knowledge of stage 1 PIs and to equip them with the correct nursing methods.

4.2. Clinical recommendations and implications

The findings of this review support the need to develop and implement effective strategies and policies for PIs risk assessment and prevention for fracture patients. First, the healthcare givers should screen the fracture patients at high risk of PIs effectively, mainly focusing on stage 1 and stage 2 of PIs for fracture patients. In addition, the most common areas of PIs in fracture patients were the sacrococcygeal regions and heels. Clinical nurses should focus on these areas in patients' fractures and take adequate measures to prevent them from occurring. The high incidence of PIs for fracture patients we detected in our review suggested some PIs preventing initiatives and policies maybe not be enough or ineffective. Our results supported the need for continuous focus on prompting PIs prevention in healthcare systems, such as providing PIs assessment and prevention education for front-line nursing staff, introducing guideline-based practice protocols and improving the implementation of preventive strategies, and organizing fracture patients PIs care training. In addition, according to the results,

we should conduct effective measures to prevent the occurrence of PIs in fracture patients in daily nursing. Firstly, the regular turnaround was the simplest and most effective way to prevent PIs. We should closely observe the patient's skin, wipe the body with warm water every day and change clothes in time after sweating. Secondly, minimize bedtime and encourage patient activity when illness and treatment permit. It is also very meaningful to do a good job in the nursing work of rehabilitation and exercise to promote the rehabilitation of diseases, shorten bedtime, extend life expectancy, and improve the quality of life [53]. What's more, encouraging patients to eat is the third most important measure to prevent PIs.

4.3. Strengthens and limitations

One of the essential advantages of this study is that we have adopted a comprehensive methodology. Firstly, we retrieved nine electronic databases in English and Chinese to increase the study's authenticity and reliability and used hand searches. Secondly, to improve the high heterogeneity of the literature, we carried out a sensitivity analysis to ensure the reliability of the incidence of PIs in fracture patients. We also performed analyses based on patient age and fracture type to identify the high risk of PIs among these groups. Most importantly, the results of this study can alert and urge health care providers to pay attention to the assessment, prevention, and treatment of PIs for fracture patients, because of the high incidence of PIs in this population.

However, the following limitations remain in this study: (a) The types of studies included in the literature are not uniform. There are cohort studies and cross-sectional studies. The biases of these different types of studies are relatively large, and the biases in the implementation, measurement and response of cross-sectional studies are inevitable. (b) Most of the included studies used convenience sampling to choose the study objects, which would influence the representative of samples. (c) No subgroup analyses were performed. We included studies that did not report baseline variables such as the participants' sociodemographic characteristics (including gender, age groups underlying diseases), and length of stay in the hospital, which prevented the subgroup analyses from estimating the incidence of PIs using each variable.

5. Conclusion

PIs are one of the essential indicators of patient safety and nursing quality in medical institutions. This study showed that the incidence of PIs in fracture patients is higher, and the incidence of PIs in patients 65 years and older is significantly higher than average. To reduce the occurrence of PIs in fracture patients, improve their quality of life and reduce medical costs. The clinical workers should take targeted prevention and treatment strategies. In addition, it is essential to investigate the situation of elderly fracture patients with PIs and analyze related risk factors, providing a reliable basis for implementing effective rehabilitation and care for this population.

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Declaration of competing interest

There is no conflict of interest to be declared.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jtv.2022.08.006.

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