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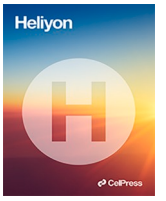

Research article

Bibliometric analysis of systematic review and meta-analysis on diabetic foot ulcer

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ABSTRACT

Many clinical management strategies have been proposed to deal with diabetic foot ulcers. However, the occurrence and recurrence of foot ulcers remain the major problems for diabetics. This study aims to identify, visualize, and characterize the meta-analyses on diabetic foot ulcer research. Articles published online were retrieved from the Web of Science core collection database using a search query incorporating MeSH terms and topics related to diabetic foot ulcers and meta-analysis. The publications were then analyzed for basic characteristics, including publication year, countries, topics covered, references, and keywords discussed in the articles. Data visualization was performed using CiteSpace. 334 meta-analyses and systematic reviews on diabetic foot ulcers were identified. The number of publications has experienced rapid growth in recent years (nearly 6-fold since 2016). The United States, China, Netherlands, England, and Australia had a strong collaboration in the contribution of publication. 7 primary topics were summarized from the top 100 highly cited publications: #1 Interventions (proportion: 59%), #2 Risk factors and Prevention (22%), #3 Epidemiology analysis (6%), #4 Cost-effectiveness of interventions (5%), #5 Long-term prognosis (3%), #6 Quality of life analysis (3%), and #7 Economic burden analysis (2%). Footwear and offloading interventions, multidisciplinary care, hyperbaric oxygen, platelet-rich plasma, and negative pressure wound therapies are highly regarded in terms of intervention. Diabetic foot osteomyelitis, peripheral diabetic neuropathy, chronic limb-threatening ischemia, and infections are the main comorbidities. In recent years, offloading interventions, debridement, telemedicine, long-term prognosis, and economic burden analyses have gradually received attention. Individualized treatment, multidisciplinary collaboration, quality of life considerations, and economic burden analyses are the long-term concerns.

1. Introduction

Diabetic foot ulcer, a prevalent complication in diabetic patients, is the most common lower extremity condition encountered [1]. According to Zhang et al.'s meta-analysis, the global prevalence of diabetic foot ulcers is 6.3% higher in men compared to women [2]. These ulcers have a severe impact on patients, as individuals with diabetic foot ulcers face a 2.5 times greater risk of death within five years than those without such ulcers [1,3]. Moreover, roughly 20% of moderate or severe diabetic foot infections lead to amputations [4,5]. The five-year mortality rate after diabetes-related amputation surpasses 70%, with an increased risk in the presence of co-morbidities like renal disease and peripheral neuropathy [1]. Consequently, this results in continuous and expensive medical care

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accompanied by relentless physical and psychological suffering. Treating diabetic foot complications incurs more direct costs than many common cancers [6], with annual expenses for managing diabetic lower extremity issues amounting to $60 billion in the United States alone [7]. Undoubtedly, diabetic foot disease imposes an immense burden on society, healthcare systems, and the economy.

Given the difficulty of managing diabetic foot ulcers, many diagnostic and therapeutic studies have been conducted [8–11]. The treatment strategies are varied and mechanism-specific and have resulted in a high number of high-quality clinical trials and meta-analyses [12–14]. Unfortunately, even with so many treatment strategies being pushed, the incidence and recurrence rates of diabetic foot ulcers remain high, requiring reflection. The incidence of recurrence of diabetic foot ulcers is estimated to be as high as 42 percent at 1 year and 65 percent at 5 years after healing [1]. This is accompanied by heavy medical costs as well as psychological burdens. Therefore, further analysis of management strategy orientations for diabetic foot ulcers will help to target research priorities and accelerate the research process and translation.

Bibliometric analysis utilizes mathematical and statistical methods to examine the distribution structure, quantitative relationships, and research themes of published data. It serves as a valuable tool for researchers to assess publishing trends and identify current hot topics in specific fields [15,16]. In addition, bibliometric research can identify the majority of historically significant studies and trace their developmental trends, thereby elucidating cutting-edge research [16]. Surprisingly, no previous bibliometric studies have been conducted specifically on meta-analyses related to diabetic foot ulceration. Therefore, the primary objective of this study was to explore the research topics covered in each article, including treatment approaches, analysis of risk factors, and economic evaluations. The secondary objectives were basic publication information such as authors, countries, and citation frequency.

2. Methods

2.1. Articles search and selection

On the 15th of June 2023, we conducted a search using the Web of Science Core Collection database to gather a collection of published studies concerning diabetic foot ulcers. Since the Web of Science lacks a subject term database, we utilized Medical Subject Headings (MeSH) from the American National Library of Medicine to formulate our search terms. Our search query was designed as follows: ((Title/Abstract=(diabetic foot ulcer*) AND Title/Abstract=(meta OR systematic review)). We specifically selected “Article” as the file type and limited the language to “English,” resulting in a total of 408 publications retrieved from the database. This approach enabled us to compile a comprehensive list of systematic reviews focusing on diabetic foot ulcers for approximately two decades. It’s worth mentioning that this search strategy was updated on the 17th of July 2023. For more details, please refer to Table 1 for the search history.

Two reviewers (Yanyan Wang and Cong Wang) conducted the article search, identification, and analysis separately and independently. The third senior reviewer, Lei Zheng, reevaluated any ambiguous articles and engaged in thorough discussions until a consensus was reached. To be included, the publications had to meet the criteria of being a meta-analysis or systematic review specifically focused on diabetic foot ulcers. Any publications that were not relevant to our research interests were excluded from the analysis.

2.2. Bibliometric analysis

The primary variables of this study include research topics, including treatment approaches, risk factor analysis, and economic evaluations covered in systematic reviews. The secondary variables include publication information such as authors, countries, and citation frequency. The Web of Science was utilized to extract essential details regarding the publications, allowing for an in-depth analysis of their basic characteristics. Each article underwent a comprehensive review to collect information such as the publication year, authors, countries, publication journal, Journal Citation Reports (JCR) data, and the keywords discussed in the article. Furthermore, this study also examined the distinctive features of the top 100 most cited publications related to diabetic foot ulcers (DFUs). These highly cited articles are considered pivotal within the field, as they possess substantial influence and impact [17]. By examining these influential works, valuable insights into research trends and significant scientific advancements within the given field can be gained [18].

Table 1
Search strategy in Web of Science.

Step	Query	Results
#1	TS = diabetic foot ulcer* OR DFU	10,490
#2	TS = meta OR systematic review	577,588
#3	#1 AND #2	608
#4	Document types: Review Article AND	414
#5	Language: English	408
#6	Two doctors independently checked the title and abstract and excluded irrelevant studies (such as general reviews, comments, conferences, etc.	334
#6	Number of included studies	334

initial data: June 15, 2023; updated: July 17, 2023; TS: Topic = Title, Abstract, and Keywords.

2.3. Data visualization and knowledge-map analysis

Microsoft Office Excel and GraphPad Prism (version 8.3.0) were employed to store data and visualize annual publications, citations, and research categories, respectively. For the visualization of co-citation and co-occurrence analysis, CiteSpace (Advanced version 6.2.R2) was utilized. Developed by Chaomei Chen, CiteSpace is a widely used visual analysis software in bibliometric studies. It enables researchers to explore and visualize research hotspots and trends within a specific field by analyzing specific clusters of literature from multiple perspectives [19]. Co-authorship analysis was conducted to assess collaboration among countries, while co-cited references refer to two or more references cited simultaneously by one or more articles [15,20]. Clustering analysis of the co-citation results can indicate the research categories and directions of each study cluster. To identify emerging references during a specific period and track research progress, reference burst analysis in CiteSpace was performed. Additionally, co-occurrence analysis (also known as keyword analysis) was utilized to cluster keywords from different studies, providing insights into representing and predicting research hotspots within the field [20].

2.4. Statistical analysis of the top 100 cited articles

We utilized IBM SPSS Statistics (version 26.0, Armonk, NY, USA) to describe the distribution of data and analyze the correlation between the Journal Impact Factor (JIF) and the Citations/Impact Factor (CIF) ratio. To assess the normality of continuous data, the Kolmogorov-Smirnov test was employed. Continuous variables that passed the normality test were presented as means and standard deviations (SD), while those that did not exhibit normal distribution were presented as medians with interquartile ranges (IQR). A statistical significance level of $P < 0.05$ was considered as the threshold for determining significance.

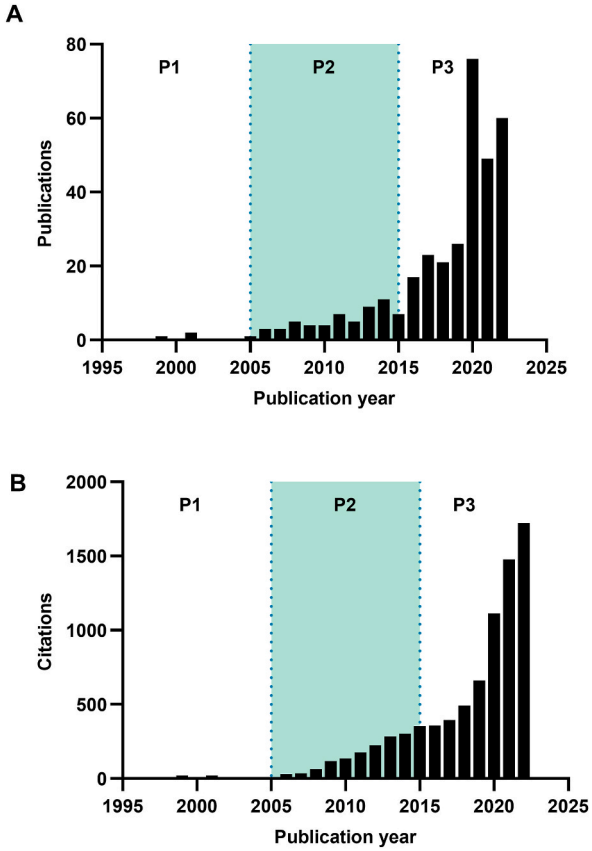

Fig. 1. The number of publications over the years and the annual total citations. According to the trends in publications (Fig. 1A) and total citations (Fig. 1B), the research is divided into three periods: resting period (P1, 1999–2005), slow growth period (P2, 2006–2015), and accelerating growth period (P3, 2016–2022).

3. Results

3.1. Characteristics of publications

A total of 334 meta-analyses and systematic reviews on diabetic foot ulcers were determined for further analysis. The number of publications over the years and the annual total citations are shown in Fig. 1. Three periods were divided based on the increasing tendency of publications and corresponding citations: resting period (P1, 1999–2005), slow growth period (P2, 2006–2015), and accelerating growth period (P3, 2016–2022). The number of published meta-analyses increased relatively rapidly after 2016 with more than 75 articles per year in 2020, which is nearly 6-fold more than in 2016. The number of publications will continue to climb (Fig. 1A).

4, 58, and 272 (81.4%) studies were published in periods 1, 2, and 3, respectively (Fig. 1B). The number of citations of the meta-analyses on DFUs ranged from 0 to 651 (median: 46), spiking in period 3. All of these reviews received an overall 8918 global citations with 386 citations in period 1, 3819 citations in period 2, and 4713 citations in period 3. The top 20 most cited meta-analyses on DFUs and relative citation frequency were summarized in Table 2. The table also shows the article title, publication year, first author, and

Table 2
The top 20 publications and their characteristics in terms of citations received.

Rank	Article	Year	Author	P1	P2	P3	AC	Journal Abbr.	JIF	CIF
1	Global epidemiology of diabetic foot ulceration: a systematic review and meta-analysis	2017	Zhang PZ	0	0	568	93	Ann Med	4.4	148
2	Cost-Effectiveness of Interventions to Prevent and Control Diabetes Mellitus: A Systematic Review	2010	Li R	0	128	180	22.14	Diabetes Care	16.2	19
3	The humanistic and economic burden of chronic wounds: A systematic review	2019	Olsson M	0	0	229	54.8	Wound Repair Regen	2.9	94
4	Diabetic foot osteomyetitis: a progress report on diagnosis and a systematic review of treatment	2008	Berendt AR	0	110	86	12.69	Diabetes-Metab Res	8.0	25
5	A systematic review on the impact of leg ulceration on patients' quality of life	2007	Herber OR	0	85	104	11.35	Health Qual Life Out	3.6	54
6	The effectiveness of footwear and offloading interventions to prevent and heal foot ulcers and reduce plantar pressure in diabetes: a systematic review	2008	Bus SA	0	93	66	10.19	Diabetes-Metab Res	8.0	20
7	Hyaluronic acid derivatives and their healing effect on burns, epithelial surgical wounds, and chronic wounds: A systematic review and meta-analysis of randomized controlled trials	2012	Voigt J	0	46	104	13.25	Wound Repair Regen	2.9	55
8	Diagnostic accuracy of the physical examination and imaging tests for osteomyelitis underlying diabetic foot ulcers: Meta-analysis	2008	Dinh MT	0	67	90	9.88	Clin Infect Dis	11.8	13
9	A systematic review of the effectiveness of interventions to enhance the healing of chronic ulcers of the foot in diabetes	2008	Hinchliffe JR	0	118	34	9.63	Diabetes-Metab Res	8.0	19
10	Systematic review of antimicrobial agents used for chronic wounds	2001	O'Meara	19	76	27	5.39	Brit J Surg	9.6	13
11	The impact of foot ulceration and amputation on mortality in diabetic patients. I: From ulceration to death, a systematic review	2016	Jupiter DC	0	0	107	15.38	Int Wound J	3.1	40
12	Predicting foot ulcers in patients with diabetes: a systematic review and meta-analysis	2007	Crawford F	0	69	51	7.12	Qjm-Int J Med	13.3	10
13	Biomechanical characteristics of peripheral diabetic neuropathy: A systematic review and meta-analysis of findings from the gait cycle, muscle activity and dynamic barefoot plantar pressure	2013	Fernando M	0	15	93	10.55	Clin Biomech	1.8	64
14	Negative Pressure Wound Therapy: a Systematic Review on Effectiveness and Safety	2008	Vikatmaa P	0	58	52	7	Eur J Vasc Endovasc	5.7	20
15	Systematic review of hyperbaric oxygen in the management of chronic wounds	2005	Roeckl W	3	84	22	5.84	Brit J Surg	9.6	12
16	Hyperbaric Oxygen Therapy for Wound Healing and Limb Salvage: A Systematic Review	2009	Goldman RJ	0	54	48	7	*Pm&r*	2.1	50
17	Hyperbaric Oxygen for the Treatment of Diabetic Foot Ulcers: A Systematic Review	2014	Stoeken B	0	14	80	10	Eur J Vasc Endovasc	5.7	18
18	Systematic review of economic evaluations of human cell-derived wound care products for the treatment of venous leg and diabetic foot ulcers	2009	Langer A	0	59	35	6.4	Bmc Health Serv Res	2.8	34
19	Accuracy of Monofilament Testing to Diagnose Peripheral Neuropathy: A Systematic Review	2009	Dros J	0	35	56	6.33	Ann Fam Med	4.4	22
20	Evidence on the use of platelet-rich plasma for diabetic ulcer: A systematic review	2010	Villela DL	0	40	47	6.29	Growth Factors	1.8	49

P1, 1999–2005; P2, 2006–2015; P3, 2016–2022; AC, average citations; JIF, Journal impact factor; CIF, total citations/impact factor ratio.

journal information of relevant articles. The CIF (total citations/impact factor ratio) of the top 20 publications ranged from 10 to 148 (median: 43.5). The meta-analysis with the highest total citations and average citations was published in the Annals of Medicine in 2017 by Zhang et al. [2]. This article provides a systematic review of the global epidemiological characteristics of diabetic foot ulcers and describes the prevalence of diabetic foot ulcers across gender, age, and comorbidities.

The publications covered 60 countries or regions. The majority of the meta-analyses were contributed by the United States (n = 75, 22.5%), followed by China (n = 71, 21.3%), England (n = 53, 15.9%), and the Netherlands (n = 39, 11.7%) (Fig. 2A). Collaboration network analysis of countries visualized in Fig. 3 showed that the United States, China, Netherlands, England, and Australia had a relatively higher volume of outputs and close cooperation networks with each other. All the studies involved 47 research categories, of which the top 5 in terms of publications were Surgery (n = 97, 29%), Dermatology (n = 86, 25.7%), Endocrinology Metabolism (n = 72, 21.6%), Medicine General Internal (n = 40, 12.0%), and Orthopedics (n = 27, 8.1%) (Fig. 2B). The top 10 institutions in terms of publications are summarized in Fig. 2C.

3.2. Main topics covered in the meta-analysis

The main topics covered in the top 100 highly cited meta-analyses and the subgroup analysis based on citations and publications were summarized in Table 3. 7 key research categories were concluded through a case-by-case review of the title and abstract of publications: #1 Interventions (proportion: 59%), #2 Risk factors and Prevention (22%), #3 Epidemiology analysis (6%), #4 Cost-effectiveness of interventions (5%), #5 Long-term prognosis (3%), #6 Quality of life analysis (3%), and #7 Economic burden analysis (2%). Furthermore, detailed delineation and subgroup analyses were performed. There are numerous intervention options, of which footwear and offloading interventions, multidisciplinary management, hyperbaric oxygen, platelet-rich plasma, and negative pressure wound therapies are highly regarded. Dressings are also in the spotlight as additional therapy. Risk factor analysis, prediction, and early prevention of DFUs have been the center of research. Diabetic foot osteomyelitis, peripheral diabetic neuropathy, chronic limb-threatening ischemia, and infections are the main comorbidities, and early diagnosis and intervention in these conditions can help to decelerate the progression of the DFUs. In recent years, debridement, footwear and offloading interventions, telemedicine,

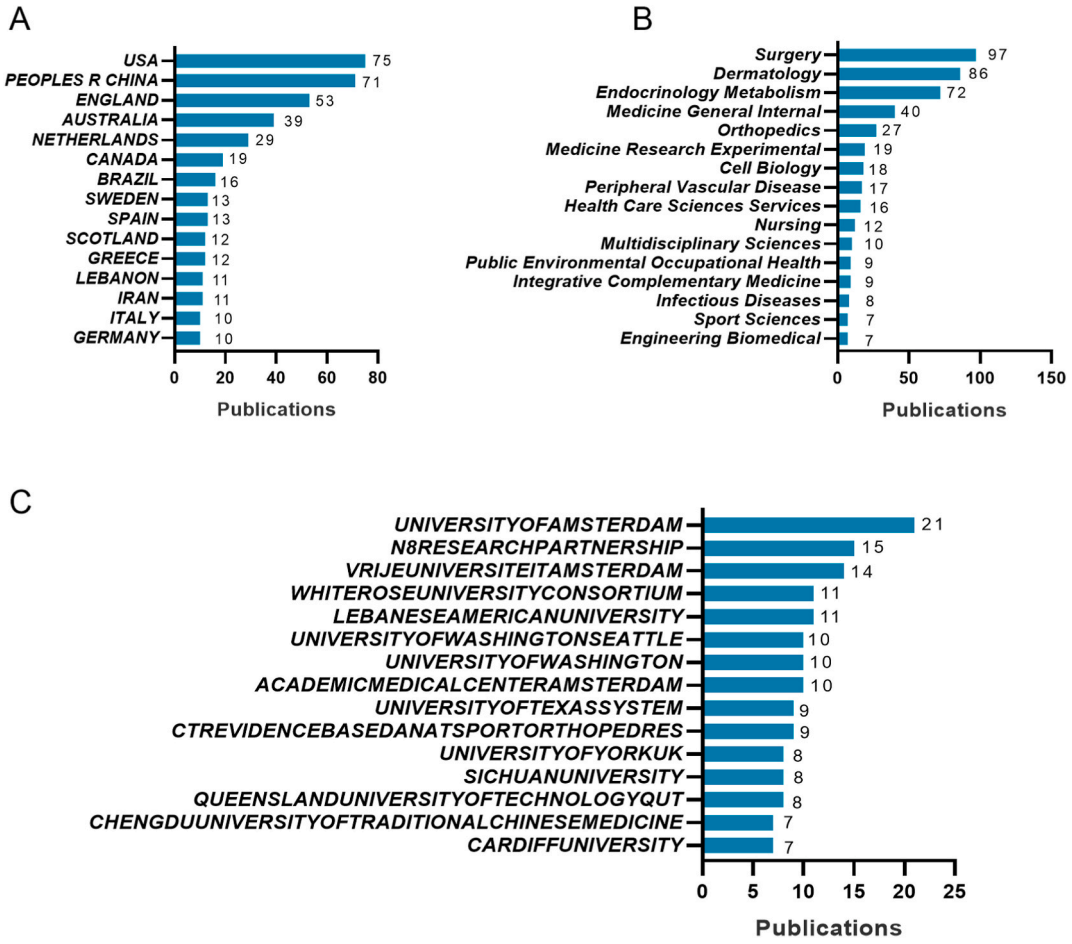

Fig. 2. The top 15 countries (Fig. 2A), research categories (Fig. 2B), and institutions (Fig. 2C) in terms of publications.

Fig. 3. Collaboration network analysis of countries. The size of the circles in the graph represents the level of collaboration between countries or regions. The larger the circle, the higher the intensity of collaboration between countries or regions. Additionally, circles with a purple ring indicate the current focus of research concentration.

Table 3
Main topics covered in the top 100 highly cited meta-analyses.

Topic	Number of analysis				
	Total	Citations		Publication years	
		≤ 46	>46	1995–2015	2015–2022
#1 Interventions	**59**	**30**	**29**	**26**	**33**
Footwear and offloading interventions	9	6	3	2	7
Comprehensive and multidisciplinary	7	3	4	4	3
Hyperbaric oxygen	6	1	5	4	2
Platelet-rich plasma	4	1	3	1	3
Negative pressure wound therapy	4	0	4	3	1
Telehealth and telemedicine	3	3	0	1	2
Antimicrobial agents	2	0	2	2	0
Bioelectricity and electrical stimulation	2	2	0	0	2
Dressings (honey, hydrogel, hyaluronic acid, phenytoin, essential oils)	7	4	3	3	4
Surgeries (Enzymatic debridement with collagenase, maggot debridement, free tissue transfer, skin substitutes, tendon lengthening and fascia release)	7	4	3	4	3
Others (glycemic control, Low-frequency ultrasound, bisphosphonates, autologous stem cells, Vitamin D)	8	7	1	2	6
#2 Risk factors and Prevention	**22**	**11**	**11**	**12**	**10**
Independent factors/Predicting foot ulcers	10	6	4	5	5
Comorbidities (Diabetic foot osteomyelitis, Peripheral diabetic neuropathy, chronic limb-threatening ischemia)	6	2	4	4	2
Diagnosis and identification of infection	2	1	1	2	0
Prediction of wound healing	2	0	2	0	2
Evaluation tools (hyperspectral imaging, transcutaneous oximetry)	2	2	0	1	1
#3 Epidemiology analysis	**6**	**4**	**2**	**3**	**3**
Prevalence of diabetic retinopathy, microvascular complications, infections	3	2	1	2	1
Prevalence of DFU in different genders and ages	2	1	1	0	2
Genetic variants	1	1	0	1	0
#4 Cost-effectiveness of interventions	**5**	**2**	**3**	**3**	**2**
Cost-Effectiveness of Interventions, complications, and comorbidities	5	2	3	3	2
#5 Long-term prognosis	**3**	**1**	**2**	**0**	**3**
Amputation and mortality	2	0	2	0	2
Physical activity and exercise	1	1	0	0	1
#6 Quality of life analysis	**3**	**0**	**3**	**2**	**1**
#7 Economic burden analysis	**2**	**1**	**1**	**1**	**1**
	100	**49**	**51**	**47**	**53**

long-term prognosis, glycemic control and economic burden analyses have gradually received attention. Multidisciplinary collaboration and quality of life considerations are the long-term management options.

3.3. Co-cited feature analysis

The top 5 most frequently co-cited references involved Armstrong DG (2017) [1], Zhang PZ (2017) [2], Schaper NC (2020) [21], Bus SA (2020) [22], Nussbaum SR (2018) [23] and Shamseer (2015) [24] (Table 4). These high-quality articles cover the epidemiology of diabetic foot ulcers, prevention recommendations, and economic evaluations. Fig. 4 provides a comprehensive overview of the clustering analysis, which categorizes research directions and offers detailed characterizations of co-cited references. The five categories identified include interdisciplinary management, prediction of prevention/risk factors, complications, pre-clinical studies, and biological dressings. Furthermore, Fig. 5 showcases the top 25 references with the most significant citation bursts, denoted by their burst intensity. These references represent key works that have garnered notable attention and citations in the field.

3.4. Keywords analysis

A total of 1075 keywords were extracted. Based on their frequency of occurrence, we have listed the top 10 keywords in Table 5: diabetic foot ulceration, interventions, prevention and prediction, systematic review, lower limb amputation, wound healing, clinical outcomes, multidisciplinary team, prevalence, and clinical trials. The main treatment areas revolve around risk factors, wound healing, limb preservation, and long-term clinical outcomes.

4. Discussion

Here, we first used bibliometric analysis to characterize the meta-analyses and systematic reviews on diabetic foot ulcers. Results and topics of published highly evidence-based meta-analyses have an important impact on future treatment. Meta-analysis synthesizes aspects of controversial diagnostic strategies, treatments, and epidemiological evidence that are commonly used in clinical practice to support decision-making with data of a higher level of evidence [25]. Given the difficulties in the management of diabetic foot ulcers, clinical studies of diverse therapeutic measures have flourished [9,26–28]. Gaining insights into the publication trends and characteristics of these studies holds great importance for clinicians and the general public. Clinicians can utilize this information to guide diabetic patients with foot ulcers, helping them make informed choices regarding suitable interventions and effectively managing distressing symptoms. Additionally, the general public can benefit from our study by acquiring specific information such as common topics and interventions. This knowledge will aid individuals in seeking appropriate medical attention and adhering to informed clinical and preventive treatments in their daily lives.

The number of meta-analyses related to the clinical practices of diabetic foot ulcers has experienced rapid growth in recent years (nearly 6-fold since 2016). This also indicates the high incidence of diabetic foot ulcers as well as their difficult management characteristics. Patients with diabetic foot ulcers are up to 40 percent more likely than normal diabetics to develop a physical disability and mortality in the long term [3]. This critical situation calls for effective clinical management programs. An analysis of highly cited publications in this study revealed that current clinical practices mainly incorporate footwear and offloading, hyperbaric oxygen, platelet-rich plasma, negative pressure wound therapy, telemedicine support, antimicrobial agents, bioelectrical stimulation, dressings, surgeries, and other interventions such as glycemic control. These practices call for multidisciplinary collaboration, which is the future of management. These primary care practices have high recommendation grades [4,29,30].

Diabetic foot ulcers are usually the result of repetitive stresses in areas subjected to high vertical or shear stresses in patients with peripheral neuropathy [31,32]. Footwear and offloading interventions have been proposed and successive randomized control trials and clinical studies have demonstrated their effectiveness. It has now been shown to have both preventive and curative effects. Rizzo et al. conducted a clinical trial to evaluate the efficacy of custom-made shoes in the prevention of neuropathic ulcers in high-risk diabetic foot patients [8]. They divided the patients into standard treatment and structured program groups. The results showed

Table 4
Characteristics of the top 5 co-cited references.

Rank	References	Type	Journal	Topic
1	Armstrong (2017) [1]	Review	N Engl J Med	diabetic foot ulcers and their recurrence
2	Zhang (2020) [2]	Meta	Ann Med	global epidemiology of diabetic foot ulceration
3	Schaper (2020) [21]	Guideline	Diabetes Metab Res Rev	guidelines on the prevention of foot ulcers in persons with diabetes
4	Bus (2020) [22]	Guideline	Diabetes Metab Res Rev	guidelines on the prevention of foot ulcers in persons with diabetes
5	Shamseer (2015) [24]	Guideline	BMJ	elaboration and explanation of Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P)
6	Nussbaum (2018) [23]	Article	Value Health	economic evaluation of the impact, cost, and medicare policy implications of chronic nonhealing wounds including DFUs

Articles 5 and 6 received the same citations.

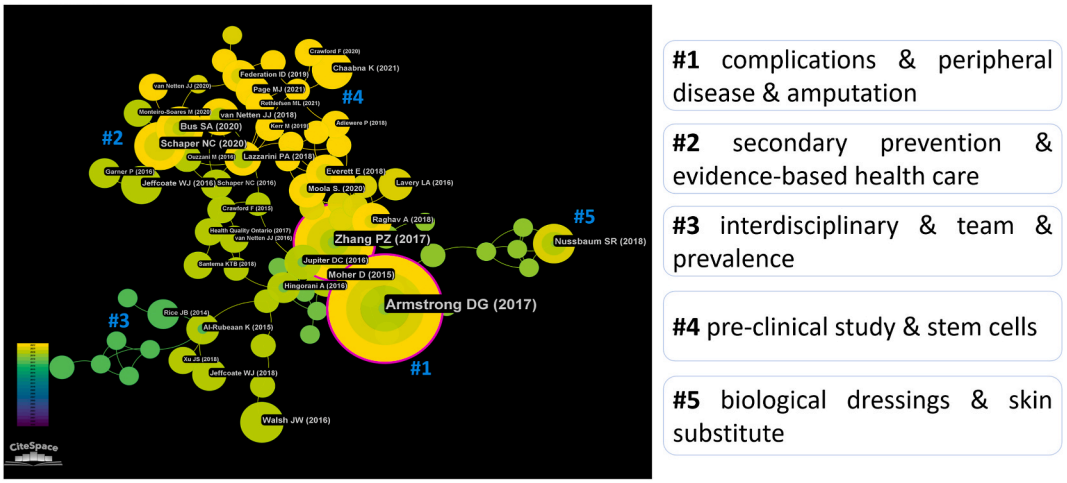

Fig. 4. Visualization of co-cited references analysis associated with diabetic foot ulcer studies and corresponding clusters based on research direction. The size of the circles in the graph represents the level of collaboration between countries or regions. The larger the circle, the higher the intensity of collaboration between countries or regions. The labels on the right side indicate the clustering results, which provide insights into the current focus areas in the field.

Top 25 References with the Strongest Citation Bursts

References	Year	Strength	Begin	End	1999 - 2022
Hinchliffe RJ, 2008, DIABETES-METAB RES, V24, PS119, DOI 10.1002/dmrr.825, DOI	2008	2.6	2012	2013	
Bus SA, 2008, DIABETES-METAB RES, V24, PS162, DOI 10.1002/dmrr.850, DOI	2008	2.01	2013	2013	
Bakker K, 2012, DIABETES-METAB RES, V28, P225, DOI 10.1002/dmrr.2253, DOI	2012	2.48	2014	2016	
[Anonymous], 2012, DIABETES CARE, V35, PS11, DOI 10.2337/dc12-s004, DOI	2012	2.01	2014	2014	
Moher D, 2010, INT J SURG, V8, P658, DOI 10.1016/j.ijsu.2010.07.299, DOI	2010	2.01	2014	2014	
Murad MH, 2011, J VASC SURG, V53, P1375, DOI 10.1016/j.jvs.2011.01.036, DOI	2011	2.67	2016	2016	
Sterne JAC, 2011, BMJ-BRIT MED J, V343, P0, DOI 10.1136/bmj.d4002, DOI	2011	1.99	2016	2016	
Rice JB, 2014, DIABETES CARE, V37, P651, DOI 10.2337/dc13-2176, DOI	2014	3.26	2017	2017	
Moher D, 2015, SYST REV-LONDON, V4, P0, DOI 10.1136/bmj.g7647, DOI	2015	3.8	2018	2020	
Jupiter DC, 2016, INT WOUND J, V13, P892, DOI 10.1111/iwj.12404, DOI	2016	2.64	2018	2020	
Hingorani A, 2016, J VASC SURG, V63, P3S, DOI 10.1016/j.jvs.2015.10.003, DOI	2016	2.26	2018	2020	
Nussbaum SR, 2018, VALUE HEALTH, V21, P27, DOI 10.1016/j.jval.2017.07.007, DOI	2018	2.61	2019	2022	
Walsh JW, 2016, DIABETIC MED, V33, P1493, DOI 10.1111/dme.13054, DOI	2016	4.28	2020	2020	
Jeffcoate WJ, 2016, LANCET DIABETES ENDO, V4, P781, DOI 10.1016/S2213-8587(16)30012-2, DOI	2016	3.8	2020	2020	
Jeffcoate WJ, 2018, DIABETES CARE, V41, P645, DOI 10.2337/dc17-1836, DOI	2018	2.84	2020	2020	
Schaper NC, 2016, DIABETES-METAB RES, V32, P7, DOI 10.1002/dmrr.2695, DOI	2016	2.36	2020	2020	
Garner P, 2016, BMJ-BRIT MED J, V354, P0, DOI 10.1136/bmj.i3507, DOI	2016	2.36	2020	2020	
Schaper NC, 2020, DIABETES-METAB RES, V36, P0, DOI 10.1002/dmrr.3266, DOI	2020	4.62	2021	2022	
Lavery LA, 2016, WOUND REPAIR REGEN, V24, P112, DOI 10.1111/wrr.12391, DOI	2016	3.3	2021	2022	
Zhang PZ, 2017, ANN MED, V49, P106, DOI 10.1080/07853890.2016.1231932, DOI	2017	2.9	2021	2022	
Everett E, 2018, ANN NY ACAD SCI, V1411, P153, DOI 10.1111/nyas.13569, DOI	2018	2.81	2021	2022	
Raghav A, 2018, THER ADV ENDOCRINOL, V9, P29, DOI 10.1177/2042018817744513, DOI	2018	2.81	2021	2022	
Armstrong DG, 2017, NEW ENGL J MED, V376, P2367, DOI 10.1056/NEJMra1615439, DOI	2017	2.55	2021	2022	
Moola S., 2020, JOANNA BRIGGS I REVI, V0, P0	2020	2.45	2021	2022	
Federation ID, 2019, IDF DIABETES ATLAS, V0, P0	2019	2.1	2021	2022	

Fig. 5. The top 25 references on diabetic foot ulcers with the strongest citation bursts. The graph displays the time span and citation intensity of influential citations, representing the focus points during specific time periods. Listing highly emergent citations over the past 20 years indirectly reveals the changing research trends in the field.

that the implementation of custom-made footwear can result in fewer ulcers in diabetic patients. Recently, two high-quality meta--analyses found significantly higher healing rates of plantar ulcers in patients receiving non-surgical offloading interventions [33,34]. Similarly, other standard therapies play a therapeutic role in unique ways. Debridement drastically reduces the risk of infection and amputation [35,36], dressings ensure that the wound is moist and exudation well controlled [37,38], platelet-derived products facilitate wound healing [39,40], glycaemic control delays microangiopathy [14,41], and telemedicine provides continuous, expert management guidance [10,42]. This study further emphasizes the significance of multidisciplinary care [43,44].

There has been an increase in surgical treatments for diabetic foot, including surgical offloading techniques [45,46], skin grafting [47], free tissue transfer [48], and amputation surgery. Surgical offloading techniques involve achilles tendon lengthening and metatarsal head resection. Lazzarini et al. [49] found that surgical offloading interventions combined with non-removable offloading devices had a non-significant difference in healing time compared to using devices alone, but combining the metatarsal head resection

Table 5
The top 10 keywords based on frequency are covered in all systematic reviews.

Clusters or classes	Frequency	Proportion
Diabetic foot ulceration	341	31.72%
Interventions	165	15.35%
Prevention and prediction	77	7.16%
Systematic review	57	5.30%
Lower limb amputation	32	2.98%
Wound healing	31	2.88%
Clinical outcomes	26	2.42%
Multidisciplinary team	24	2.23%
Prevalence	16	1.49%
Clinical trials	16	1.49%

technique showed better healing rates. Huang et al. [47] compared the healing rate between patients underwent conventional wound therapy and grafting surgery and found that autologous wound edge dotted full-thickness skin grafting has a higher healing rate than traditional wound care. However, there is insufficient data on long-term survival rates and limb preservation. Recently, Bhat et al. conducted a systematic review to investigate the clinical outcomes associated with free tissue transfer in DFUs. The pooled analysis showed that this technique may be suitable in selected patients [flap survival, major amputation, and ambulation rates were 88% (85–92%, 49 studies), 10% (7–14%, 50 studies), and 87% (80–92%, 36 studies), respectively)]. In conclusion, Currently reported results in the literature are mostly encouraging, but in reality, diabetic foot ulcers (DFUs) still have a high recurrence rate. Limb preservation remains a long-term consideration. We believe that while standardized treatments for DFUs have been established, individualized treatment may be the key to significantly improving clinical outcomes.

Studies addressing risk factors and predictive models for DFU should not be neglected. Early diagnosis and treatment focus on prevention rather than cure. It has been shown that patients with DFU have a 2.5 times higher risk of long-term mortality events than diabetic patients without ulcers [3]. This is accompanied by a further increase in the healthcare burden [50], a further decrease in the quality of life [51,52], a further poor psychosocial adjustment [52], and even a further decrease in the productivity of society. This strongly suggests the need for early diagnosis. This study found that the main topics concerning risk factors and prevention were early diagnosis and identification of comorbidities such as diabetic foot osteomyelitis and peripheral diabetic neuropathy, infections, and precise evaluation of wound healing with the help of hyperspectral imaging. Thus, recognition and management of concomitant lesions should also be another important component of diabetic foot ulcer treatment.

4.1. Areas of uncertainty and future research

The priorities and difficulties in managing diabetic foot ulcers include prevention of ulcer occurrence as well as recurrence after healing. The incidence of recurrence of diabetic foot ulcers is estimated to be as high as 42 percent at 1 year and 65 percent at 5 years after healing [1]. This is accompanied by heavy medical costs as well as psychological burdens. The development of more effective preventive measures is often more important than the treatment itself. Much work has been done by international research teams [12,13], but further precision is needed. The cost-effectiveness of innovative approaches also needs to be taken into consideration, as well as the impact of technical support and patient feedback on improving self-management and treatment adherence. Continuous and effective management and feedback also rely on telemedicine interventions.

We believe systematic reviews reflect current clinical focus and controversies. Diabetic foot ulcers have diverse and complex systematic reviews, involving various treatment efficacies. Incidence and recurrence rates remain high, requiring reflection. Therapy indications are unclear, lacking individualization despite treatment standardization. Bibliometric analysis integrates literature to clarify popular treatments and explore future research directions, surpassing traditional and systematic reviews. The biggest limitation is database bias. Only the Web of Science database was included and the publications searched may differ from other databases such as PubMed, Scopus, and Embase. In addition, country and keyword plural forms and abbreviated forms may need to be combined during the analysis, which makes the analysis process cumbersome. Finally, Intelligence analyses provide an overview of the research situation and hotspot tendencies but fail to delineate specific details that may make the research less in-depth.

5. Conclusion

The treatment of diabetic foot ulcers is comprehensive and encompasses multiple components, including the risk factors analysis, severity assessment, interventions, and evaluation of long-term effectiveness. Multidisciplinary care with a focus on offloading interventions, platelet-derived products, surgical debridement, telemedicine, and glycemic control is currently the main intervention for diabetic foot ulcers. Risk factors and prevention, quality of life considerations, long-term prognosis, and economic burden analyses are also the directions of long-term concern. Clinically, it is crucial to select appropriate patients for different treatment regimens in order to develop multidisciplinary management plans aimed at minimizing the rates of recurrence and amputation.

Data availability statement

Data yielded in our study will be made available by the authors to any qualified researchers.
Institutional Review Board Statement.
Not applicable, because this article does not contain any studies with human or animal subjects.

Informed consent statement

Not applicable.

CRediT authorship contribution statement

Yanyan Wang: Writing – original draft, Methodology, Formal analysis, Data curation. **Cong Wang:** Writing – review & editing, Validation, Methodology. **Lei Zheng:** Writing – review & editing, Supervision, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors and their immediate family have no relevant financial or non-financial interests to disclose.

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