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Bibliometric and visualization analysis of literature relating to diabetic erectile dysfunction

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Introduction: Diabetic erectile dysfunction (DMED) refers to erectile dysfunction secondary to diabetes. Erectile dysfunction is characterized by a persistent inability to achieve and maintain an erection sufficient to permit satisfactory sexual activity.

Methods: Based on the Web of Science core collection database, we firstly analyzed the quantity and quality of publications in the field of DMED, secondly profiled the publishing groups in terms of country, institution, author's publication and cooperation network, and finally sorted out and summarized the hot topics of research.

Results: From 2001 to 2022, a total of 1,403 articles relating to this topic were published in 359 journals. They represent the global research status, potential hotspots, and future research directions. The number of DMED-related publications and citations has steadily increased over the few past decades. Academic institutions from Europe and the United States have played a leading role in DMED research. The country, institution, journal, and author with the most publications were the United States (294), INHA University (39), the Journal of Sexual Medicine (156), and Ryu, Ji-Kan (29), respectively. The most common keywords were erectile dysfunction (796), men (256), diabetes (254), diabetes mellitus (239), prevalence (180), corpus cavernosum (171), dysfunction (155), mellitus (154), nitric-oxide synthase (153), and expression (140). The main keyword-based research topics and hotspots in the DMED field were oral sildenafil, smooth muscle relaxation, nitric oxide synthase, gene therapy, metabolic syndrome, cavernous nerve injury, stem cell, and penile prosthesis.

Discussion: The terms oral sildenafil, smooth muscle relaxation, nitric oxide synthase, gene therapy, metabolic syndrome, cavernous nerve injury, stem cell, and penile prosthesis will be at the forefront of DMED-related research.

KEYWORDS

diabetic erectile dysfunction, bibliometric analysis, CiteSpace, VOSviewer, visualization

Introduction

Diabetes is a chronic, non-infectious disease caused by both genetic and environmental factors. Over the past three decades, the number of people with diabetes worldwide has more than doubled, making it one of the most important global public health challenges (1). Erectile dysfunction is defined as the persistent inability to achieve and maintain sufficient erectile capacity to permit satisfactory sexual behavior (2). Diabetic erectile dysfunction (DMED) refers to erectile dysfunction secondary to diabetes mellitus (3). The incidence of erectile dysfunction ranges from 0.1% to 18% in the normal population but is nearly three-fold higher in patients with diabetes, and affected people tend to be younger (4).

There is evidence for a link between diabetes and the development of erectile dysfunction in both animal models and humans (5). The central nervous system and pericardial nerve damage caused by a high-glucose environment is an important cause of DMED (6). In addition, age, duration of diabetes, blood glucose control, smoking, hypertension, atherosclerosis, adverse drug reactions, and psychological factors are all closely related to the occurrence of DMED. Current treatment methods for DMED can be summarized as primary disease treatment, psychological treatment, and symptomatic treatment.

The term bibliometrics was coined by Alan Pritchard in 1969 (7). Bibliometric analysis is a powerful tool that uses literature measures or indicators to quantify research performance in a given field (8, 9). CiteSpace and VOSviewer are commonly used processing tools for visualizing research impact based on co-word, co-citation, and literature-coupling analysis (10).

Based on the advantages of clustering technology and map presentation, the research trend of any given field can be analyzed and displayed as a multivariate, comprehensive, visual knowledge map (11, 12). Using such bibliometric software, literature related to DMED in recent decades can be visually displayed and analyzed. Accordingly, with Scopus as the data source, we utilized CiteSpace, VOSviewer, and Microsoft Excel to show the knowledge base, development trends, and emerging hotspots in the DMED field.

Materials and methods

Ethics statement

No approval was required from the Institutional Review Board as data were retrieved from the Web of Science (WOS) database (<https://www.webofscience.com/wos/woscc/basic-search>) and no human subjects were involved.

Sources and collection

The WOS is the most commonly used database in scientific and bibliometric research. It contains nearly 9,000 of the world's most prestigious high-impact journals and more than 12,000 academic conferences, thus providing a comprehensive overview of the global research results in science, technology, medicine, and other fields (13, 14).

Publication information in the DMED area was searched within one day to ensure that no data were updated. The period was January 1, 2001, through September 30, 2022, and the retrieval date was October 1, 2022. The WOS Core Collection was selected, the subject words were “Diabetic erectile dysfunction”, and the article types were “article” and “review”. The retrieved results were exported in “Plain text file” format, and “Full Record and Cited References” was selected for “Record content”.

The search query string was described as follows: Results for “diabetic erectile dysfunction” (Topic) and Article or Review Article (Document Type) and Book Chapters (Exclude - Document Type).

Bibliometric analysis and software

CiteSpace software (Drexel University, Philadelphia, PA, USA), designed by Dr. Chen Chaomei in 2004 (11), is a freely available Java application widely used for the visualization and analysis of trends and patterns in scientific literature (15). CiteSpace (<https://citespace.podia.com/download>, R6.1.3) to scientometrics, data and information visualization technology as the foundation, through the analysis of the potential

knowledge of literature, regularity and distribution, present knowledge structure. In this study, CiteSpace was used for keyword clustering and salient word analysis.

VOSviewer 1.6.18 (<https://www.vosviewer.com/>) is a software tool for constructing and visualizing bibliometric networks (16). In this study, VOSviewer was used to visualize countries/regions, authors, institutional collaborations, citations, and keyword co-occurrence, as well as to construct density maps.

The aim was to describe all the literature characteristics, including country/institution, journals, highly cited articles, cluster network of co-cited references, and most frequently cited keywords. In particular, in addition to noun phrases extracted from article titles and abstracts, burst detection was applied to the keywords of publications in the article collection assigned to the citation extension.

Results

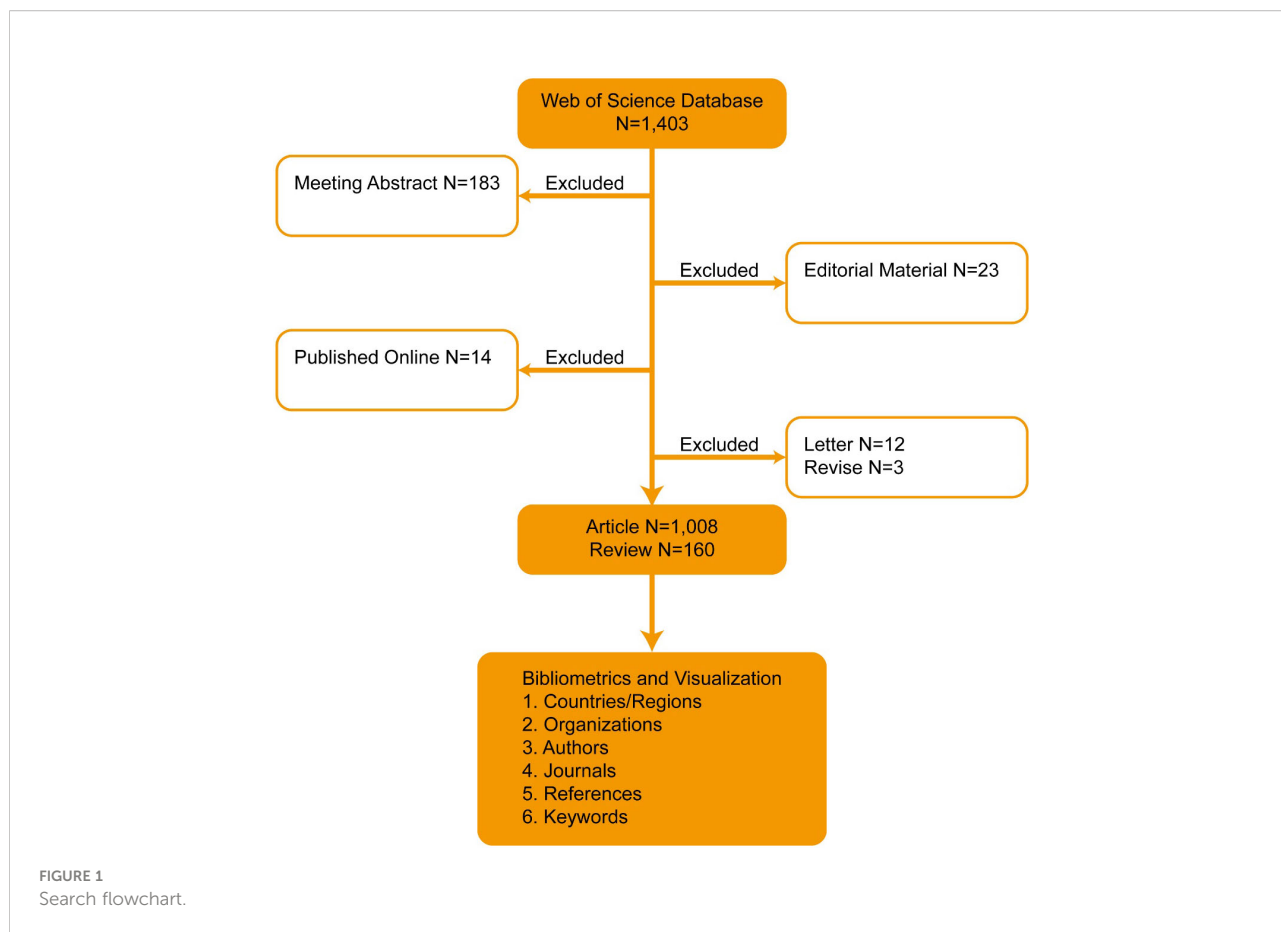
Time trends in publications and citations

The number of annual publications is an important parameter for evaluating the development of scientific research

and can reflect the growth of knowledge in this field to a certain extent. As of September 30, 2022, a total of 1,403 publications related to DMED were published (Figure 1). The number of articles published per year is shown in Figure 2. Although the trend was upward overall, it fluctuated slightly in some years. Notably, the number of publications per year can be easily divided into two phases. In the first phase, from 2001 to 2008, the average number of publications per year was around 30; in the second phase, from 2009 to 2022, the average number of publications per year stabilized at more than 50. Overall, the amount of knowledge in the DMED research field showed a linear growth trend ($R^2 = 0.6709$), reflecting the increasing research interest in this field.

Analysis of the most productive countries/regions

A total of 75 countries/regions have published articles in this field. The 10 countries that made the most significant contributions to DMED-related publications were the USA (294), China (244), Italy (111), South Korea (85), England (79), Turkey (73), Egypt (45), Japan (44), Spain (40), and Germany (38) (Figure 3; Table 1).



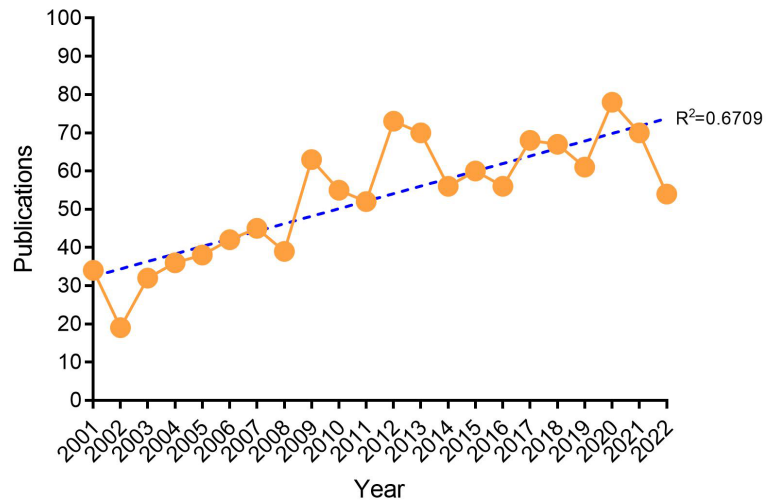


FIGURE 2 Annual trends of global publications.

The size of the nodes is determined by the number of publications (the larger the number, the larger the node). The same colors represent the same clusters. The lines between nodes represent the alignment between countries/regions (the stronger the partnership, the wider the boundaries). The total link strength reflects the combined strength between countries/regions. As shown in

Table 2, the USA had the largest number of publications, the highest number of citations (15,620), and the greatest link strength (164). The USA (15,620), Italy (6,917), England (6,645), China (4,495), and Germany (2,381) were the top five countries in terms of citations. The above results indicated that these countries exerted the greatest influence on DMED-related research.

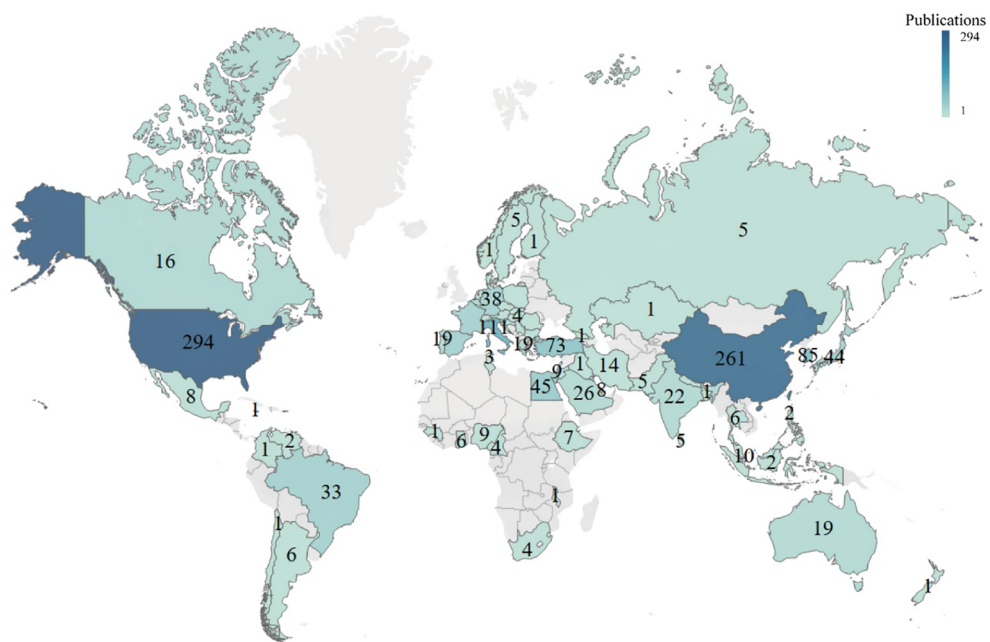


FIGURE 3 Analysis of the global research trends based on the origins of the publications.

TABLE 1 The 10 countries that contributed the most to DMED-related publications.

| Rank | Country | Documents | Citations | Total link strength | H-index |
|------|-------------|-----------|-----------|---------------------|---------|
| 1 | USA | 294 | 15620 | 164 | 51 |
| 2 | China | 244 | 4495 | 78 | 35 |
| 3 | Italy | 111 | 6917 | 66 | 40 |
| 4 | South Korea | 85 | 1510 | 32 | 24 |
| 5 | England | 79 | 6645 | 82 | 30 |
| 6 | Turkey | 73 | 844 | 31 | 15 |
| 7 | Egypt | 45 | 777 | 21 | 15 |
| 8 | Japan | 44 | 894 | 13 | 16 |
| 9 | Spain | 40 | 1280 | 35 | 17 |
| 10 | Germany | 38 | 2381 | 38 | 11 |

VOSviewer was used to analyze cooperation across countries, with lines between nodes indicating co-authorship between countries (the thicker the line the stronger the cooperation). China, the USA, Italy, South Korea, and England cooperated the most with other countries (Figure 4).

Contributions of the top organizations

A total of 1,465 institutions participated in the publication of papers related to DMED technology. The 10 institutions that contributed the most to DMED publications were INHA University (39), Huazhong University of Science & Technology (32), Tulane University (29), University of California San Francisco (25), Peking University (23), Seoul National University (20), Cairo University (20), University of Florence (19), Nanjing University (19), and Southern Medical University (18) (Table 3). These results demonstrated that INHA University had the greatest number of publications with the highest number of citations (663) and the greatest link strength (20). Each node represents a different institution. The size of the node is determined by the number of publications (the larger the number, the larger the node). The same colors represent the

same clusters. Boundaries between nodes represent a collaboration between organizations (the stronger the partnership, the wider the boundaries). The total link strength reflects the aggregate strength between institutions. As can be seen from the map, 146 institutions actively cooperated both within and between clusters. The three institutions with the highest total link strength were Peking University (34), the University of Florence (24), and the University of California San Francisco (23). The five institutions with the greatest number of citations were Eastern Virginia Medical School (4,067), Harvard University (3,845), The University of Pavia (2,092), the University of Manchester (1,684), and the University of Rome Tor Vergata (1,558) (Table 4). Tulane University, University of Florence, University of California San Francisco, INHA University, and Huazhong University of Science & Technology were at the center of such collaborations. However, most institutions were fragmented and displayed little cooperation (Figure 5).

Analysis of authors and co-cited authors

Author co-occurrence analysis can identify the core authors in a field and the strength of collaboration among authors. Co-citation

TABLE 2 The number of citations of publications on DMED in the top 10 countries.

| Rank | Country | Documents | Citations | Total link strength |
|------|-------------|-----------|-----------|---------------------|
| 1 | USA | 294 | 15620 | 3542 |
| 2 | Italy | 111 | 6917 | 1150 |
| 3 | England | 79 | 6645 | 1219 |
| 4 | China | 244 | 4495 | 2638 |
| 5 | Germany | 38 | 2381 | 241 |
| 6 | France | 34 | 2358 | 436 |
| 7 | Australia | 19 | 2057 | 192 |
| 8 | Canada | 16 | 2053 | 322 |
| 9 | South Korea | 85 | 1510 | 1048 |
| 10 | Spain | 40 | 1280 | 532 |

TABLE 4 The number of citations for publications on DMED by the top 10 institutions.

| Rank | Organization | Documents | Citations | Total link strength |
|------|----------------------------------|-----------|-----------|---------------------|
| 1 | Eastern Virginia Medical School | 5 | 4067 | 59 |
| 2 | Harvard University | 6 | 3845 | 63 |
| 3 | University of Pavia | 12 | 2092 | 207 |
| 4 | University of Manchester | 8 | 1684 | 100 |
| 5 | University of Rome Tor Vergata | 5 | 1558 | 55 |
| 6 | University of Michigan | 8 | 1543 | 67 |
| 7 | University of Florence | 19 | 1532 | 307 |
| 8 | Mayo Clinic | 5 | 1486 | 33 |
| 9 | University of Dusseldorf | 8 | 1403 | 58 |
| 10 | John Hopkins University Hospital | 14 | 1145 | 375 |

Impotence Research (2,058), Diabetes Care (1,676), and Urology (997) (Table 8).

Analysis of highly cited and co-cited literature

A total of 1,168 references and 29,269 co-cited references were obtained. Some papers were cited over 300 times, including those by Tesfaye (2010), Boulton (2005), Vinik (2003a), Gallagher (2007), Jurenka (2008), Jones (2011), and Kapoor (2007b) (Table 9). In addition, a total of 19 references were obtained to highlight the analysis results. The three references

with the highest intensities were Kouidrat Y, 2017 (doi: 10.1111/dme.13403), citation burst strength: 26.95; Malavige LS, 2009 (doi: 10.1111/j.1743-6109.2008.01168.x), citation burst strength: 21.88; and Rendell MS, 1999 (doi: 10.1001/jama.281.5.421), citation burst strength: 19.24 (Figure 8).

Keyword analysis

Changing trends in research topics over time can be identified through keyword co-occurrence and salience analysis to better grasp the development of research hotspots. A total of 3,969 keywords were obtained, the top 10 of which

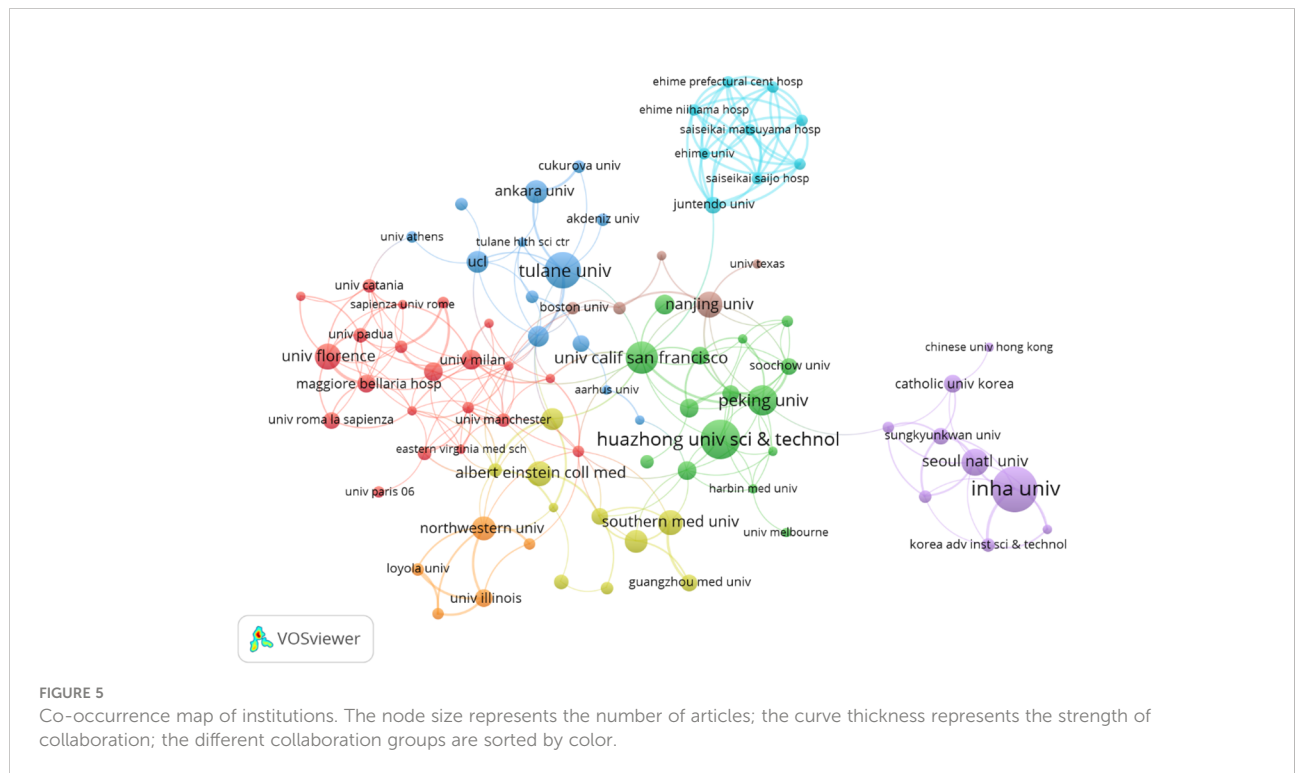


TABLE 5 The number of articles published by the top 10 authors.

| Rank | Author | Documents | Citations | Total link strength |
|------|--------------------|-----------|-----------|---------------------|
| 1 | Ryu, Ji-Kan | 29 | 483 | 189 |
| 2 | Suh, Jun-Kyu | 29 | 483 | 189 |
| 3 | Wang, Tao | 26 | 294 | 100 |
| 4 | Yin, Guo Nan | 25 | 334 | 174 |
| 5 | Liu, Jihong | 20 | 213 | 90 |
| 6 | Song, Kang-Moon | 17 | 274 | 142 |
| 7 | Gur, Serap | 17 | 154 | 19 |
| 8 | Podlasek, Carol A | 15 | 286 | 46 |
| 9 | Hellstrom, Wayne J | 15 | 309 | 13 |
| 10 | Kwon, Mi-Hye | 14 | 257 | 119 |

were erectile dysfunction (796), men (256), diabetes (254), diabetes mellitus (239), prevalence (180), corpus cavernosum (171), dysfunction (155), mellitus (154), nitric oxide synthase (153), and expression (140) (Table 10; Figure 9).

After clustering using CiteSpace software, a total of 18 categories of keywords were obtained. From 2001 to 2011, keyword-based research hotspots in the DMED field mainly included impotence, oral sildenafil, smooth muscle relaxation, nitric oxide synthase, epidemiology, relaxation, gene therapy, *in vivo*, type 2 diabetes, metabolic syndrome, and sexual function. From 2014 to 2022, meanwhile, the research hotspots (by keyword) included cavernous nerve injury, diabetic rat, pathway, radical prostatectomy, stem cell, apoptosis, model, pathophysiology, and penile prosthesis, among others (Figure 10).

Discussion

Comprehensively and systematically summarizing the research topics, research trends, and global research status relating to DMED allows a rapid preliminary understanding of the research status of this condition. With the advent of big data, researchers need to fully understand the developments in their research field. Different from systematic review or meta-analysis, bibliometric analysis uses visualization software, such as VOSviewer and CiteSpace, to comprehensively analyze the existing literature and obtain an intuitive understanding of the research trends, as well as to predict research hotspots (16). This study is the first to summarize the research status relating to DMED in the past 20 years through bibliometric analysis.

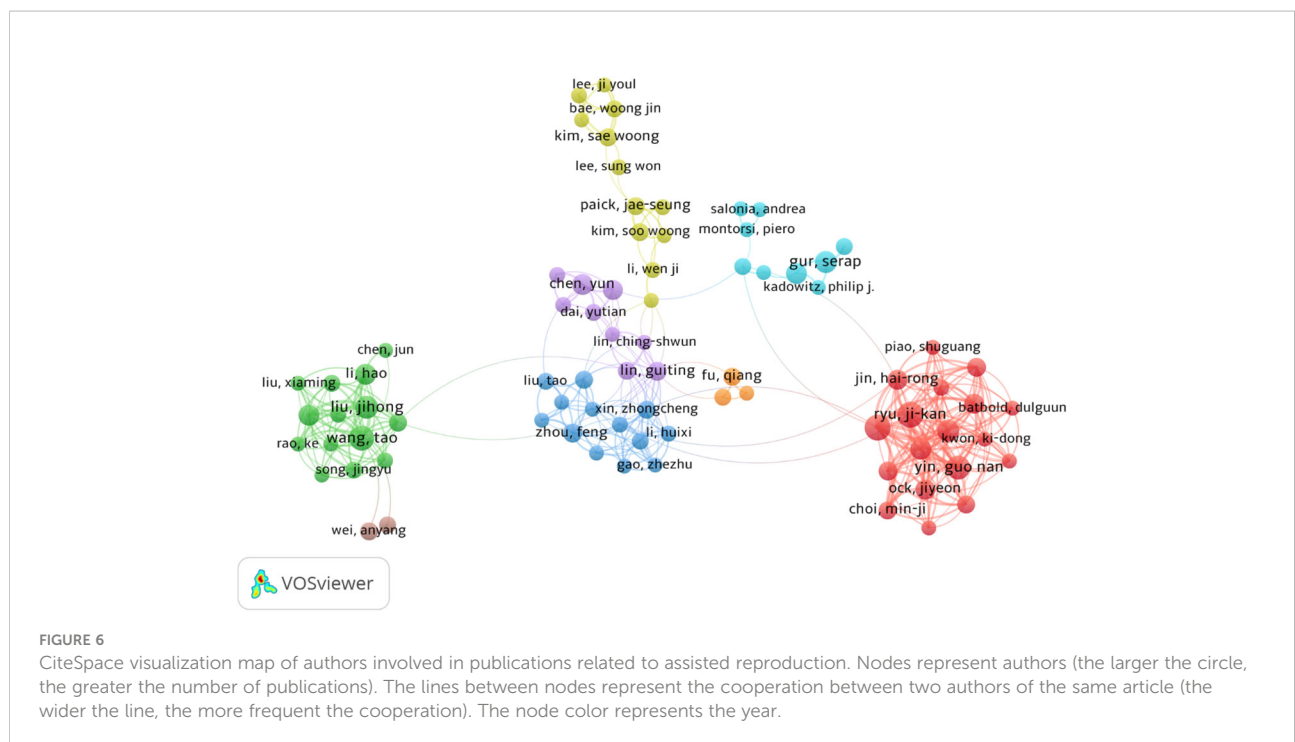


TABLE 6 The number of co-citations of the top 10 authors.

| Rank | Author | Citations | Total link strength |
|------|----------------|-----------|---------------------|
| 1 | Bivalacqua, TJ | 430 | 6879 |
| 2 | Corona, G | 340 | 3315 |
| 3 | Feldman, HA | 259 | 2611 |
| 4 | Rosen, RC | 258 | 2373 |
| 5 | Burnett, AL | 213 | 3175 |
| 6 | Musicki, B | 202 | 2633 |
| 7 | Cellek, S | 167 | 2646 |
| 8 | Angulo, J | 165 | 2022 |
| 9 | Goldstein, I | 163 | 2161 |
| 10 | Andersson, KE | 163 | 2127 |

General information about the literature on diabetic erectile dysfunction

Over the past 20 years, the number of DMED-related articles published in journals showed a linear upward trend ($R^2 = 0.6709$).

From the perspective of countries/regions and institutions, the number of publications originating from the United States as well as the number of associated citations far exceeded that of other countries. Although the number of articles published in China ranked second, the number of citations was low, ranking only fourth. This indicates that, although the number of papers from Chinese institutions is increasing yearly, there is still a lack of high-quality articles. This may be partly explained by a lack of cooperation with internationally renowned researchers as well as language barriers. Among the 10 institutions with the most published papers, only Huazhong University of Science & Technology, Peking University, and Nanjing University were from China—with the remainder being mainly from Europe and the USA—and these institutions had low levels of research cooperation. These observations highlight the need to strengthen communication and cooperation with global

research teams, especially those from countries and institutions in the Asian region.

Regarding authors and references, Ryu, Ji-Kan and Suh, Jun-Kyu had the greatest production efficiency, while Bivalacqua, TJ had the most co-citations. Corona, G; Feldman, HA; Rosen, RC; and Burnett, AL also made important contributions to DMED research. The research undertaken by Ryu, Ji-Kan and Suh, Jun-Kyu is mostly mechanism-related. The former has mainly focused on identifying potential target genes associated with DMED in mouse cavernous pericytes (17). Meanwhile, Suh, Jun-Kyu found that pericellular-derived extracellular vesicles mimicking nanovesicles can promote neurovascular regeneration and erectile function recovery under diabetic conditions through a lipid chain enzyme 2 (LCn2)-dependent mechanism (18). Both authors reported that the preservation of damaged cavernous neurovasculature through the inhibition of the proNGF/p75NTR pathway may represent a novel therapeutic strategy for radical prostatectomy-induced erectile dysfunction (19).

The Journal of Sexual Medicine published the most DMED-related papers and the 10 most cited and co-cited journals were

TABLE 7 The 10 most productive journals.

| Rank | Source | Documents | Citations | IF/JCR (2022) | Total link strength |
|------|---|-----------|-----------|---------------|---------------------|
| 1 | Journal of Sexual Medicine | 156 | 5048 | 3.937/Q3 | 1051 |
| 2 | International Journal of Impotence Research | 77 | 1893 | 2.408/Q3 | 549 |
| 3 | Andrologia | 36 | 356 | 2.532/Q3 | 178 |
| 4 | Asian Journal of Andrology | 35 | 624 | 3.054/Q1 | 323 |
| 5 | Andrology | 35 | 410 | 4.674/Q1 | 288 |
| 6 | BJU International | 30 | 1000 | 5.969/Q1 | 179 |
| 7 | Journal of Urology | 29 | 1277 | 7.600/Q1 | 274 |
| 8 | Diabetes Care | 21 | 5982 | 17.152/Q1 | 215 |
| 9 | Urology | 20 | 351 | 2.633/Q3 | 89 |
| 10 | PLoS One | 19 | 494 | 3.752/Q2 | 173 |

IF, impact factor; JCR, journal citation report.

TABLE 9 The number of citations for the top 10 references.

| Rank | Document | Citations | Links |
|------|-------------------|-----------|-------|
| 1 | Tesfaye (2010) | 1389 | 7 |
| 2 | Boulton (2005) | 1207 | 7 |
| 3 | Vinik (2003a) | 1157 | 7 |
| 4 | Gallagher (2007) | 510 | 3 |
| 5 | Jurenka (2008) | 395 | 0 |
| 6 | Jones (2011) | 387 | 2 |
| 7 | Kapoor (2007b) | 342 | 5 |
| 8 | Bivalacqua (2004) | 266 | 21 |
| 9 | Malavige (2009) | 256 | 21 |
| 10 | Gandaglia (2014) | 250 | 3 |

corpus cavernosa, and improve erection. Treating DMED with a PDE5 inhibitor can improve the International Index of Erectile Function-5 (IIEF-5) score and sexual success in a significant number of patients (26, 27).

Nevertheless, PDE5 inhibitors are ineffective in patients with severe erectile dysfunction (28) and are occasionally associated with side effects such as headaches, flushing, indigestion, nasal congestion, vision abnormalities, and diarrhea. The prerequisite

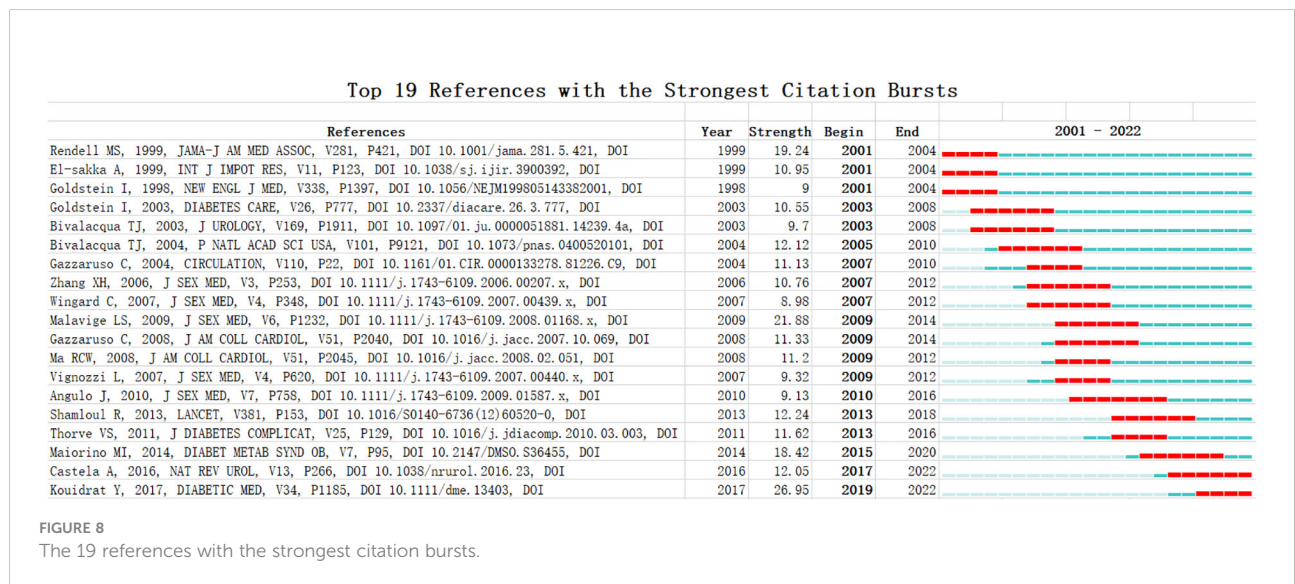


TABLE 10 Top 10 keywords related to the field of assisted reproduction.

| Rank | Keyword | Occurrences | Total link strength |
|------|-----------------------|-------------|---------------------|
| 1 | Erectile dysfunction | 796 | 4150 |
| 2 | Men | 256 | 1471 |
| 3 | Diabetes | 254 | 1503 |
| 4 | Diabetes mellitus | 239 | 1392 |
| 5 | Prevalence | 180 | 1004 |
| 6 | Corpus cavernosum | 171 | 1136 |
| 7 | Dysfunction | 155 | 930 |
| 8 | Mellitus | 154 | 961 |
| 9 | Nitric oxide synthase | 153 | 951 |
| 10 | Expression | 140 | 892 |

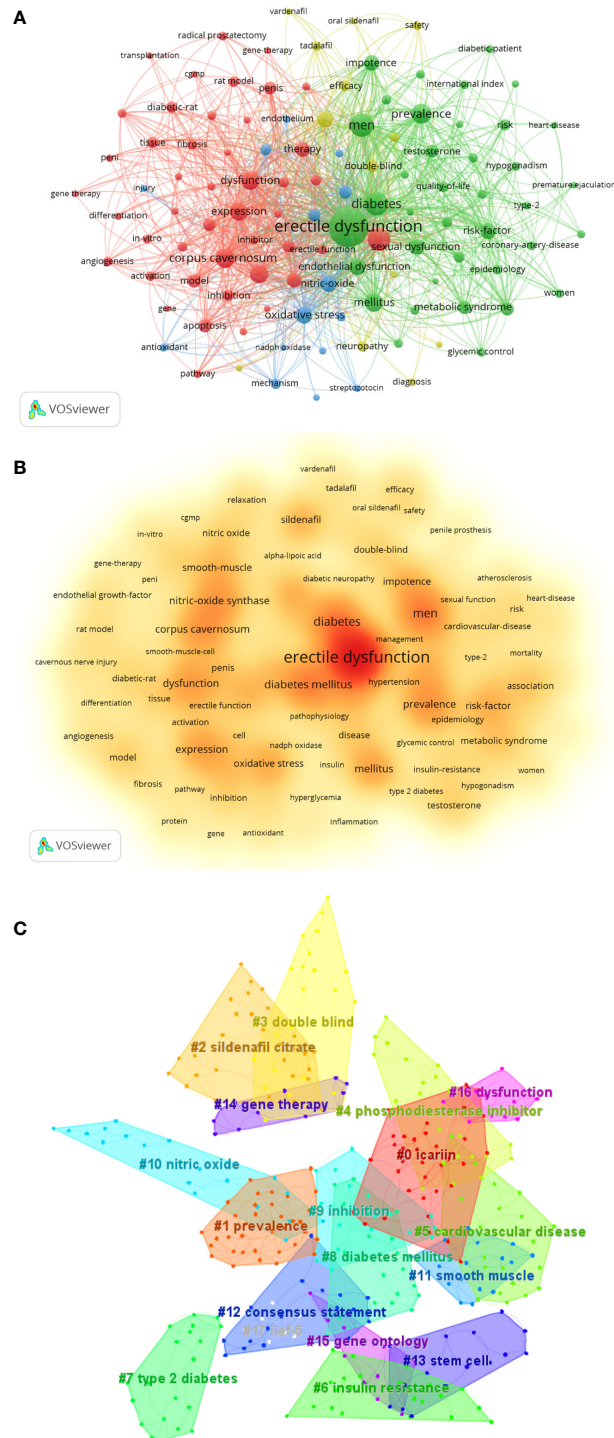


FIGURE 9 Keyword analysis. **(A)** Map of the keyword co-occurrence analysis obtained using VOSviewer. The size of the nodes represents the number of occurrences; the thickness of the curve represents the strength of collaboration; the different colors represent the different clusters. **(B)** Keyword density visualization analysis. The redder the node color, the higher the frequency of the keyword. **(C)** Keyword clustering map analysis using CiteSpace. A total of 16 categories of keywords were obtained; the different color blocks represent different keyword clusters.

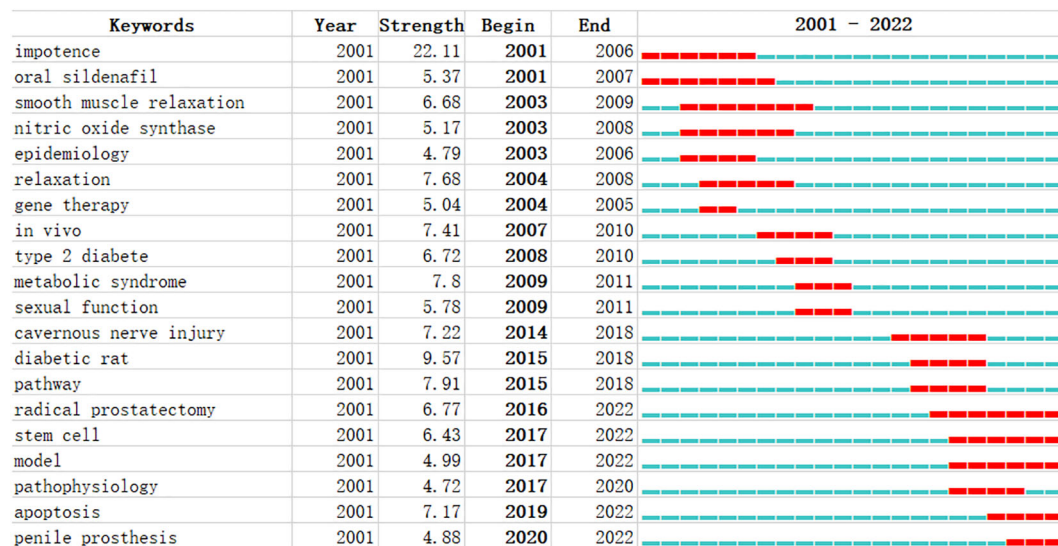


FIGURE 10
Keyword burst analysis using CiteSpace.

for PDE5 inhibitor to function is that ED patients must have intact molecular and neurological pathways and some degree of sexual stimulation. Therefore, PDE5-Is has poor efficacy in patients lacking upstream nitric oxide (NO) pathway (29) in some disease states, such as diabetes with peripheral neuropathy (30) and prostate cancer (31). In addition to drugs, other alternative strategies are available, such as vacuum contractile devices and penile prosthesis implantation. The three-piece inflatable penile prosthesis (IPP) is the most common implant used in penile surgery (32). The satisfaction rate of patients is 90% ~ 100%, which varies with different prosthesis devices (33, 34). However, IPP may only be offered to patients who fail due to the high cost of conservative treatment, its invasive nature, and myriad potential complications. Thus, novel therapeutic approaches are urgently required to overcome these disadvantages in DMED treatment.

Stem cell therapy has attracted increasing attention owing to its ability to promote functional recovery and tissue structural repair in patients with diabetes. Stem cell mainly include bone marrow mesenchymal stem cells (BMSCs) (35), adipose-derived stem cells (ADSCs) (36), neural derived stem cells (37), mesenchymal stem cells (MSCs) (38), umbilical cord derived stem cells (39) and urine-derived stem cells (USCs) (40). Mesenchymal stem cells (MSCs) are adult stem cells derived from mesoderm with a high potential for proliferation, self-renewal, and multidirectional differentiation (41). The culture of bone marrow-derived MSCs is relatively simple; accordingly, they are widely used in animal studies and clinical trials (42). Given their abundant autologous availability, MSCs are one of the most promising candidates for the treatment of DMED (43).

Importantly, allogeneic MSCs can also be successfully transplanted owing to the low immunogenicity (44, 45). In animals, bone marrow-derived MSC transplantation can significantly improve the recovery of erectile function by inhibiting apoptosis (46). For DMED, MSC-based treatment has also attained encouraging therapeutic effects (47). The restoration of erectile function is mainly attributed to the increased endothelial cell and smooth muscle content in the corpus cavernosum (48, 49). Various strategies have recently emerged to improve the therapeutic effect of MSCs on DMED (50, 51). In a single-blind study, 6 out of 7 ED patients developed morning erections 3 months after treatment with umbilical cord derived stem cells (39). Chen S et al. found that adipose mesenchymal stem cells were more effective in treating diabetes-related erectile dysfunction than bone marrow mesenchymal stem cells (52).

Erectile dysfunction has been associated with the upregulation of Toll-like receptor 4 (TLR4) expression. It has been reported that TLR4 expression is significantly increased in the corpus cavernosum of diabetic rats compared with that of controls (53). The overexpression of inducible nitric oxide synthase (iNOS) may also be associated with penile microvascular dysfunction in diabetes mellitus, while endotoxemia has been linked with iNOS upregulation (54). Studies on conducting vessels have shown that iNOS overexpression in endotoxemia contributes to endothelial dysfunction by reducing the activity of endothelial nitric oxide synthase (eNOS) (55). iNOS inhibitors can alleviate DMED-related injury by moderating eNOS phosphorylation and chronic iNOS overexpression as well as improving microvascular fibrosis (56).

Trabecular smooth muscle relaxation during sexual stimulation and dilatation of penile resistance arteries in the cavernous body are essential for penile erection (57). Nitric oxide (NO) is a key factor in both processes. NO can be released from nerve endings or endothelial cells to stimulate cGMP production in penile smooth muscle cells, relaxing them and increasing blood flow to the corpus cavernosum (58, 59). Defects in the NO/cGMP pathway at any level will lead to inadequate penile smooth muscle relaxation, which affects erectile function (60).

In vitro low-intensity shockwave therapy (LI-SWT) is a potential treatment option for ED. The micro-damage of Li-SWT to the spongy tissue may stimulate neovascularization and up-regulate some factors related to tissue healing and remodeling (61). A prospective, randomized, sham controlled study reported a clinically significant improvement in erectile function in 40.5% of the treatment group based on the minimum clinically significant difference (MCID) criteria (62). Another randomized clinical trial evaluated changes in penile hemodynamics and IIEF-EF scores in patients with vascular ED. In the IIEF-EF score, 56.7% of the treatment group achieved MCID at 1 month and 75% achieved MCID at 12 months (63).

Through keyword co-occurrence and salience analysis, we also found that there is a regional imbalance in the development of DMED research and influential authors and institutions are mainly concentrated in Europe and Asia, which may be due to greater research interest. Additionally, despite the numerous studies undertaken on DMED, the underlying mechanism remains incompletely understood and represents a key future research direction.

Limitations and prospects

To the best of our knowledge, this is the first bibliometric analysis of DMED-related studies undertaken in the last 20 years. However, our study still had some limitations. First, high-quality articles published in recent years may not have yet reached the ideal citation threshold, which may have introduced research bias. Second, there may be a delay in exploring the frontiers of research. Finally, we only included literature written in English from the WOS, which may have resulted in the omission of important documents in other languages.

Conclusions

Overall, our bibliometric analysis provides comprehensive information on DMED-related publications. Our findings

suggested that the field of DMED is thriving and has stimulated great interest in the research community worldwide. Although DMED is a relatively common disease, much remains unknown about both the underlying mechanisms and how to treat it. Likely, the terms oral sildenafil, smooth muscle relaxation, nitric oxide synthase, gene therapy, metabolic syndrome, cavernous nerve injury, stem cell, and penile prosthesis will be at the forefront of DMED-related research.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding authors.

Author contributions

FM and HL (10th author) designed the study. XL, HC, LW, MZ, HL (7th author), GG and DL conducted the literature search. FM, XL and LW analyzed the data and wrote the paper. FM and JW approved the final manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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