

ORIGINAL RESEARCH

Global Trends of Diabetic Erectile Dysfunction Research from 2012 to 2022: A Bibliometric and Visualized Study



Yohanes Andy Rias^{1,2}, Ratsiri Thato^{2,3*}, Hsiu Ting Tsai^{4,5}, Noor Rohmah Mayasari⁶, Zulfa Avidiansyah⁷, Iswanti Purwaningsih⁸, Suhartini Ismail⁹

¹Faculty of Health and Medicine, Institut Ilmu Kesehatan Bhakti Wiyata Kediri, Indonesia

²Faculty of Nursing, Chulalongkorn University, Thailand

³Center of Excellence for Enhancing Well-being in Vulnerable and Chronic Illness Population, Faculty of Nursing, Chulalongkorn University, Thailand

⁴Post-Baccalaureate Program in Nursing, College of Nursing, Taipei Medical University, Taiwan

⁵School of Nursing, College of Nursing, Taipei Medical University, Taiwan

⁶Department of Nutrition, Faculty of Sports and Health Sciences, Universitas Negeri Surabaya, Indonesia

⁷Law Library, Faculty of Law, Universitas Gadjah Mada, Yogyakarta, Indonesia

⁸Department of Nursing, Faculty of Medicine, Politeknik Kesehatan Karya Husada Yogyakarta, Indonesia

⁹Department of Nursing, Faculty of Medicine, Universitas Diponegoro, Indonesia

Article Info

Article History:

Received: 31 January 2024

Revised: 26 April 2024

Accepted: 23 June 2024

Online: 30 April 2025

Keywords:

Bibliometric analysis; diabetes; erectile dysfunction; oxidative stress; physical activity

Corresponding Author:

Ratsiri Thato

Faculty of Nursing, Chulalongkorn University, Thailand,

E-mail: ratsiri.T@chula.ac.th

Abstract

Background: Several studies have been conducted to investigate the trends of erectile dysfunction (ED) among individuals with diabetes. Nonetheless, a comprehensive analysis of the literature concerning ED among individuals with diabetes is required, especially in the nursing field, which yet remains elusive.

Purpose: This study uses bibliometric and visualized analysis to analyze the global scientific trends and research keywords of previous studies on ED in diabetes published from 2012 to 2022.

Methods: The literature, specifically related to ED in diabetes, was obtained from the Web of Science Core Collection database. VOS viewer, Cite Space, and Excel 2019 were used to examine the journal title, research frontiers, authors, institutions, countries, and citation reports.

Results: A total of 2,367 articles on ED and diabetes between 2012 and 2022 were identified as of September 30, 2022. The global trend was comparatively declining in the last two years (2021 and 2022). International Journal of Impotence Research (568 papers) owned the highest number of publications. A.L. Burnett (41 papers) was the top most productive author, and T. F. Lue had the largest number of citations (842 citations) during the past decades. USA was the leading contributor in this field, with 668 articles. Active cooperation between countries and between institutions was observed. The main keywords and exciting topics related to ED were frontiers of physical activity included in therapy, quality of life, and oxidative stress.

Conclusion: Global trend of research on ED in people with diabetes increased up to 2020 and decreased in 2021 and 2022. Nurses and healthcare should explore the links between oxidative stress, physical activity, and quality of life among diabetes with ED.

How to cite: Rias, Y. A., Thato, R., Tsai, H. T., Mayasari, N. R., Avidiansyah, Z., Purwaningsih, I., & Ismail, S. (2024). Global trends of diabetic erectile dysfunction research from 2012 to 2022: A bibliometric and visualized study. *Nurse Media Journal of Nursing*, 14(3), 329-343. <https://doi.org/10.14710/nmjn.v14i3.61941>

Copyright © 2025 by the Authors, Published by Department of Nursing, Faculty of Medicine, Universitas Diponegoro. This is an open-access article under the CC BY-SA License (<http://creativecommons.org/licenses/by-sa/4.0/>).

1. Introduction

Erectile dysfunction (ED) is a common complication among individuals with diabetes (Defeudis et al., 2022). ED generates an inability to achieve and control erections, complicated sexual dysfunction, and reduced libido (Corona et al., 2020; Nisahan et al., 2019). In fact, high blood glucose enhanced oxidative stress and visceral adiposity, which caused declined nitric oxide and impaired vasodilatation in the corpora cavernosa, potentially resulting in ED (Maiorino et al., 2018). The prevalence of ED in individuals with diabetes was approximately 52.5%, with precisely 37.5% in type 1 diabetes and 66.3% in type 2 diabetes (Kouidrat et al., 2017). Due to the significant prevalence and threats of ED in people with diabetes, a meta-analysis revealed that the number

of studies conducted in this field throughout the past four decades (1980–2016) increased dramatically (Kouidrat et al., 2017). Furthermore, the incidence of ED was two to three times more prevalent among individuals with diabetes than in individuals without diabetes (Malavige & Levy, 2009). Previous studies also showed that the individuals with diabetes who have ED were significantly related to increased oxidative stress (Belba et al., 2016), low level of quality of life (Shiferaw et al., 2020; Ventura et al., 2018) and risk of mortality (Zhao et al., 2019). Thus, it is essential to explore global trends of ED among individuals with diabetes.

Remarkably, one way to effectively evaluate the trend and impact of ED in diabetes research publications is through a bibliometric and visualized study. Unlike general systematic reviews, bibliometric and visualized study lies in its comprehensive, multi-tool bibliometric analysis over a decade, identification of research hotspots, trend analysis, and call for more research in specific areas (Wang, 2018). Bibliometric analysis, a series of both geometrical methodologies and statistical analysis for establishing and quantifying publication data, was involved to identify the most influential researchers, institutions, and countries (Gutiérrez-Salcedo et al., 2018). In fact, bibliometrics was indicated to identify emerging global research trends, networks, and research hotspots, such as analysis of keywords, publication numbers, and citations (Wang, 2018). The results of the bibliometric studies could assist researchers in identifying trends in global research and guiding future research. Consequently, in recent decades, several bibliometric articles have been published in leading medical journals, especially in urology or sexual journals (Bao et al., 2022; Hui et al., 2020; Paniagua Cruz et al., 2020; Rezaee et al., 2019).

Moreover, the benefit of comprehensive bibliometric and visualized assessments is crucial for achieving coherence among academic disciplines in the social and behavioral sciences. The utilization of bibliometric and visualized techniques is driven by the necessity to evaluate scientific productivity and facilitate the dissemination of discoveries to policymakers, scientists, and other relevant parties. Nevertheless, it is worth considering if a genuine demand for such analyses drives the growing number of publications and if the research effectively achieves its intended objectives. This study encompasses a decade of research (2012–2022), offering a thorough overview of the area for 10 years. Clearly, better understanding of the mechanisms between ED and diabetes is needed, including how they affect each other and what important topics to focus on. It is expected that by examining the growth and distribution of bibliometric and visualized analyses published over time, as well as their citation, it will be possible to identify patterns and obtain the necessary answers related to ED among diabetes between 2012 and 2022. For these reasons, in the present study, a bibliometric analysis of research papers on ED among individuals with diabetes was conducted to examine emerging global trends, research keywords, and obtain additional information to guide future research directions published between 2002 and 2022.

2. Methods

2.1. Research design

This study used a bibliometric and visualized study approach to carefully evaluate the global research concerning ED in diabetes. The integration of bibliometric and visualized study facilitates a thorough comprehension of the field's prospective future trajectories. This analytical technique is especially effective for identifying gaps in the literature and guiding strategic decisions for future research and policy formulation (Waltman, 2016).

2.2. Literature search

The articles were collected from the Web of Science Core Collection (WoSCC) Data Based on September 30th, 2022. Remarkably, the WoSCC links to citation indexes, patent databases, and specialized citation indexes, such as more than 33,000 journals, book series, and conference proceedings. The databases were relevant for the scientific article on global trends and research hotspots. Consequently, the characteristics of this database have been examined in considerable detail (Waltman, 2016). MeSH was utilized to collect the following search terms: “Diabetes” OR “Diabetic” OR “Diabetes Mellitus” AND “Erectile Dysfunction” OR “Dysfunction, Erectile” OR “Male Impotence” OR “Impotence, Male” OR “Male Sexual Impotence” OR “Impotence, Male Sexual” OR “Sexual Impotence, Male” OR “Impotence” AND LANGUAGE “English”. YAR, NRM, and ZA searched the literature.

2.3. Inclusion and exclusion criteria

In this study, the publication types were restricted to “article” OR “review”. The other inclusion criteria included publications published within the timeframe of 30 September 2012 to 30 September 2022, written in English, and indexed in the WoSCC database. Editorial materials, letters, book chapters and studies irrelevant to ED in diabetes were excluded. NRM, ZA and IP screened the data. Three authors (NRM, ZA and IP) conducted independent reviews of the cited articles, and any inconsistencies were reconciled through consensus. The authors (YAR and RT) then reviewed each paper to confirm its relevance to ED in diabetes. The screening and selection process can be seen in Figure 1.

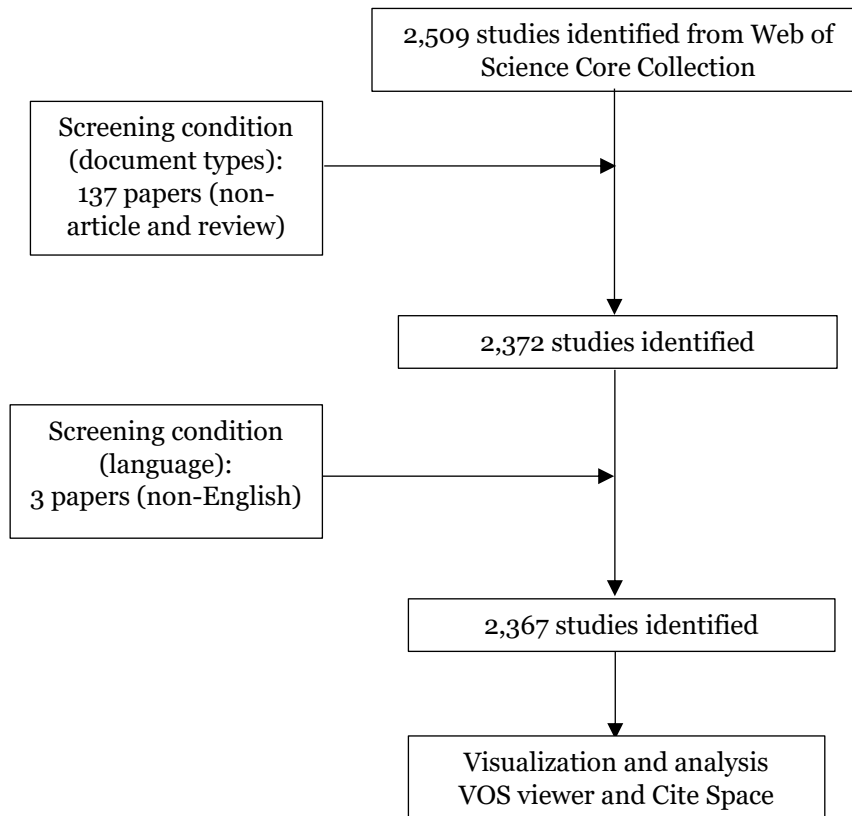


Figure 1. Flowchart of the data screening process

2.4. Data extraction

The data of all eligible papers, including title, publication year, authors' names, countries, affiliation, name of publishing journal, keywords, and number of citations were retrieved and meticulously collected. Two independent authors (YAR and ZA) retrieved and extracted the data from WoSCC. Furthermore, the data were analysed with VOS viewer Version 1.6.17, Cite Space V.2 Version and Excel 2019.

2.5. Data analysis

Visualization software generated node-link maps that enable easy viewing of publishing outputs and hotspots of a study topic, including VOS viewer (Waltman, 2016) and Cite Space (Wang & Lu, 2020). VOS viewer software was used to produce infographics and identify the collaboration networks of authors and institutions; to investigate other countries collaborating on ED and diabetes research during the specified time frame; to analyze the bibliographic including authors, institutions, and journals; to investigate the authors and sources citation; and to evaluate co-occurrence keywords on the subject. In addition, data were recorded into a Microsoft Excel spreadsheet for effective data management. Furthermore, Cite Space was utilized to identify terms with substantial citation bursts that can be regarded as predictors of research frontiers. NRM and ZA analyzed the data.

2.6. Validity and reliability

To minimize potential sources of bias and error in this bibliometric and visualized investigation, several precautionary measures were implemented. The primary data source chosen was the WoSCC, characterized by its comprehensive and standardized indexing, which guarantees consistent data extraction. The search strategy was meticulously developed using well-defined keywords pertinent to diabetes and erectile dysfunction. It was subsequently refined through iterative testing. To ensure quality and relevance, only articles and reviews published in English between 2012 and 2022 were employed. However, this might introduce language and publication-type bias, which was acknowledged as a limitation. Authors independently conducted screening and selection, with discrepancies resolved by a third party to enhance objectivity. To reduce the likelihood of manual error, data were extracted through standardized methods and analyzed using validated bibliometric tools (e.g., CiteSpace, VOSviewer). To prevent interpretation bias, visualizations were interpreted within the context of existing literature, and findings were cross-verified across multiple indicators.

2.7. Ethical considerations

This bibliometric study utilized secondary data, which did not require approval from the Ethics Committee for research involving human subjects. Nevertheless, we adhered to the ethical guidelines suggested for this analysis by demonstrating respect for ideas and citations and correctly referencing authors and their publications.

3. Results

3.1. Trends of global publications

Figure 2 demonstrated that 2,367 articles satisfied the inclusion criteria. During the search period, the number of publications increased from 233 (9.84%) articles in 2012 to 302 (12.76%) articles in 2020, with an average of 213 articles per year. Unfortunately, it declined in the last two years (2021-2022). On September 30th, 2022, 151 (6.38%) articles were published.

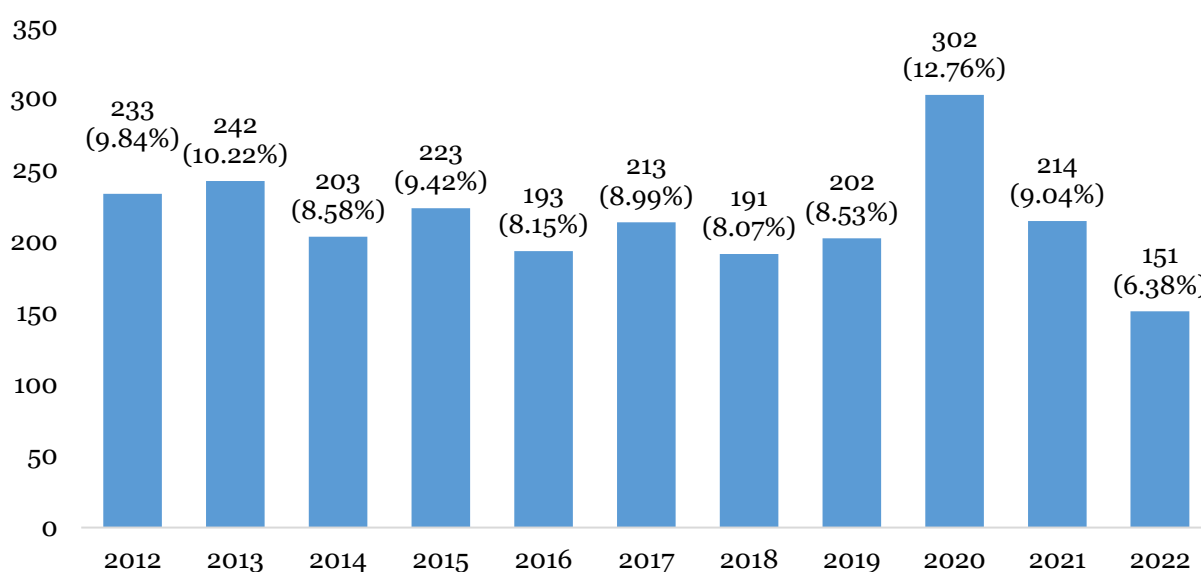


Figure 2. Publication outputs: the annual number of publications in “erectile dysfunction” and “diabetes” research from 2012 to 2022.

3.2. Journal distribution

Regarding ED and diabetes-related articles, there were 729 academic journals published in this field which can be seen in Table 1 listing the top 15 journals. International Journal of Impotence Research (IF=2.408) had the most articles published (568; 24.0%), followed by Journal of Sexual Medicine (IF=3.937; 219 publications; 9.3%), Andrologia (IF=2.532; 63 publications; 2.7%), Andrology (IF=4.456; 51 publications; 2.2%), and PLOS ONE (IF= 3.752; 37 publications; 1.6%).

Table 1. The top 15 journals publishing articles in “diabetes” and “erectile dysfunction” research

Rank	Journal titles	Country	f	%	IF
1	International Journal of Impotence Research	UK	568	24.0	2.408
2	Journal of Sexual Medicine	USA	219	9.3	3.937
3	Andrologia	Germany	63	2.7	2.532
4	Andrology	USA	51	2.2	4.456
5	PLOS ONE	USA	37	1.6	3.752
6	Urology	USA	35	1.5	2.633
7	Aging Male	UK	34	1.4	2.398
8	Journal of Urology	USA	32	1.4	7.600
9	Asian Journal of Andrology	India	31	1.3	3.054
10	Sexual Medicine	UK	30	1.3	2.523
11	BJU International	UK	24	1.0	5.969
12	Journal of Ethnopharmacology	Ireland	22	0.9	5.195
13	Translational Andrology and Urology	China	18	0.8	2.479
14	World Journal of Men's Health	Korea	17	0.7	6.494
15	International Brazilian Journal of Urology	Brazil	16	0.7	3.050

3.3. Distribution of published countries and institutes

As many as 97 countries across the world documented a total of 2,367 articles in ED on diabetes research. Table 2 revealed that the United States led the top 15 countries involved in ED among diabetes research with 668 publications (28.2%), followed by the People's Republic of China (338 publications; 14.3%), Italy (220 publications; 9.3%), Turkey (200 publications; 8.5%), and England (132 publications; 5.6%). Among these countries, there were several collaborative teams (Figure 3a). The countries were represented by nodes of different sizes and colors, indicating their centrality and connections within the network. Larger nodes like the USA, Italy, China, and Turkey suggested that these countries had more connections. Smaller nodes like Ethiopia, Denmark, Mexico, and Thailand indicated fewer connections.

Table 2. The top 15 publication countries in “diabetes” and “erectile dysfunction” research

Rank	Countries	f	%
1	USA	668	28.2
2	People's Republic of China	338	14.3
3	Italy	220	9.3
4	Turkey	200	8.5
5	England	132	5.6
6	South Korea	125	5.3
7	Brazil	90	3.8
8	Taiwan	86	3.6
9	Germany	82	3.5
10	Spain	74	3.1
11	Egypt	73	3.1
12	Australia	71	3.0
13	Canada	66	2.8
14	India	54	2.3
15	Japan	51	2.2

Moreover, 2,861 institutions were identified as proactively involved in ED and diabetes research with a network spanning collaboration (Figure 3b). The figure reveals key insights into academic collaborations and institutional linkages. Larger nodes, such as Seoul National University and Johns Hopkins University, indicated institutions with strong connections across multiple research networks. Smaller nodes represented universities with fewer collaborative ties. The different colored clusters suggested groupings. The connections between nodes highlighted how universities interacted, exchanged knowledge, and contributed to global research partnerships. In addition, Table 3 revealed that the University of California Schools (243 publication) topped the list, followed by Johns Hopkins University (121 publications), University

of Florence (43 publications), Harvard University (41 publications), and University of London (40 publications).

Table 3. The top 15 publication institutes in “diabetes” and “erectile dysfunction” research

Rank	Institutions	f	%
1	University of California Schools	243	10.3
2	Johns Hopkins University	114	4.8
3	University of Florence	43	1.8
4	Harvard University	41	1.7
5	University of London	40	1.7
6	Sapienza University Rome	37	1.6
6	Vita Salute San Raffaele University	37	1.6
7	University of Texas System	36	1.5
8	Sun Yat-sen University	34	1.4
9	University College London	32	1.4
10	Huazhong University of Science and Technology	31	1.3
11	Baylor College of Medicine	30	1.3
12	INHA University	29	1.2
12	Mayo Clinic	29	1.2
13	Cairo University	28	1.2

3a

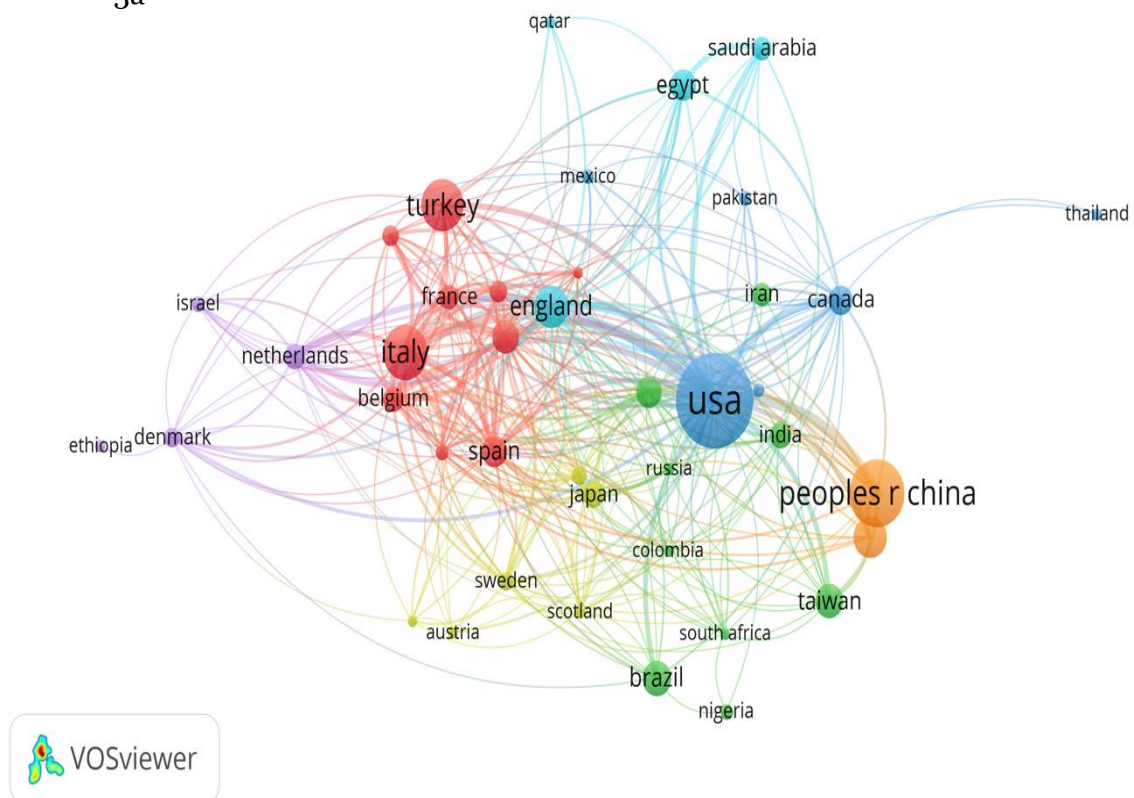
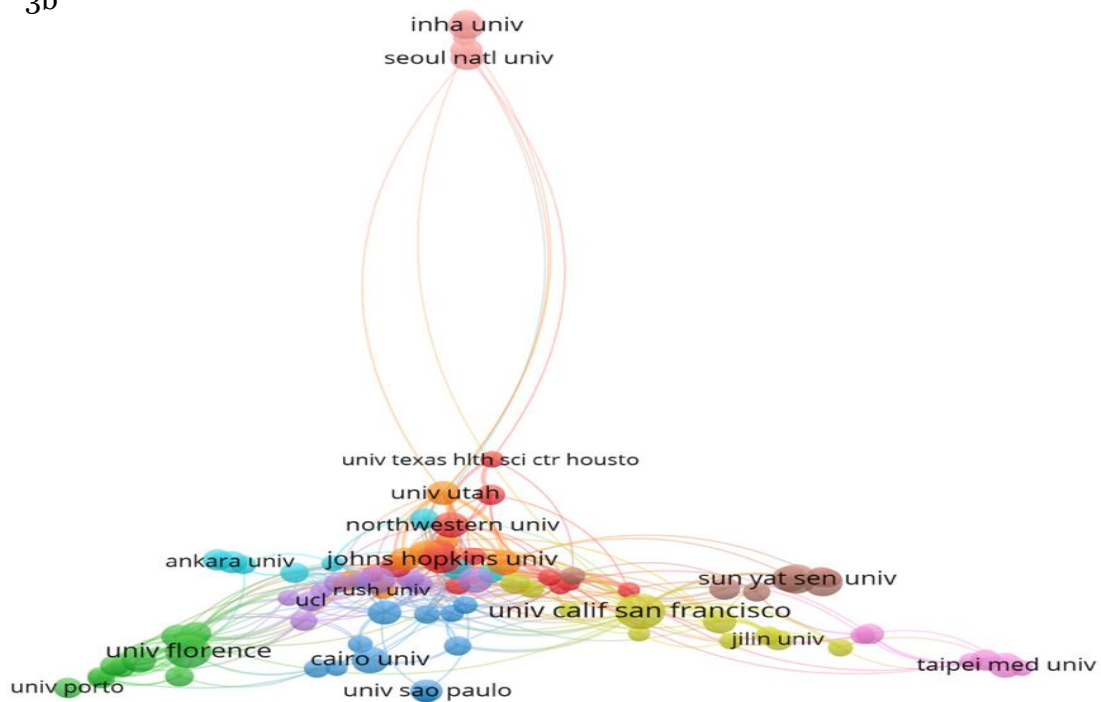


Figure 3. The distribution of countries and institutes. (3a) The network collaboration map of countries; (3b) The network collaboration map of institutes

3b



3.4. Distribution of authors

Interestingly, 10,018 authors conducted field research in the ED and diabetes. According to Table 4, A. L. Burnett (41 publications) was ranked first among the top 15 contributing researchers, followed by M. Maggi (27 publications), G. Corona (26 publications), J. K. Ryu (26 publications), and Y. Zhang (26 publications). Furthermore, T. F. Lue had the largest number of citations (842 times) during the past decades, followed by G. Corona (833 times), M. Maggi (737 times), A. L. Burnett (653 times), and Y. Chen (378 times). In addition, Figure 4 demonstrates the collaborative network among the authors. The collaborative networks among the authors are represented by nodes of different sizes and colors, indicating their centrality and connections within the network. A.L. Burnett was collaborative with several authors such as A. Mararteen and T.J. Bivalacqua.

Table 4. The 15 most productive authors on the research of “diabetes” and “erectile dysfunction”

Rank	Authors	Publication numbers	2021 citations (times)
1	A. L. Burnett	41	653
2	M. Maggi	27	737
3	G. Corona	26	833
3	J. K. Ryu	26	261
3	Y. Zhang	26	212
4	T. Wang	25	369
5	J. K. Suh	24	255
6	S. W. Lee	23	353
6	T. F. Lue	23	842
6	G. N. Yin	23	229
7	J. H. Liu	22	325
7	A. Salonia	22	92
8	H. Li	21	221
9	Y. Chen	20	378
9	S. W. Kim	20	222

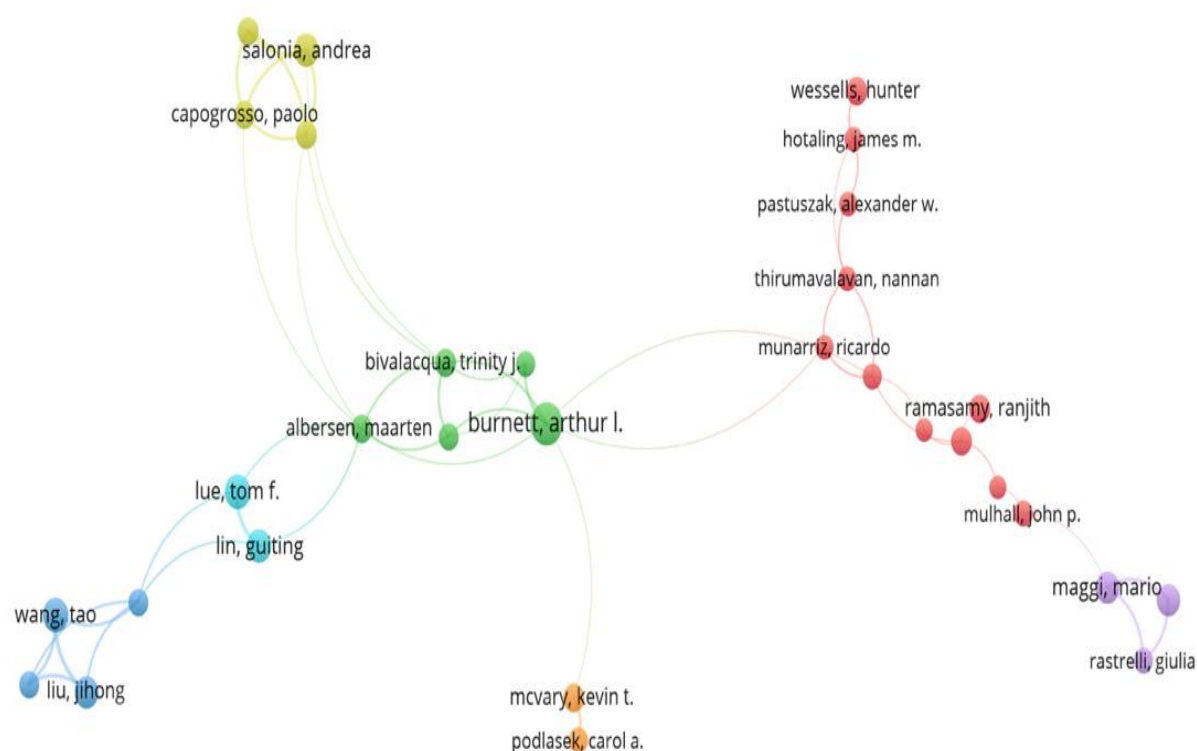


Figure 4. The collaborative network among the authors

3.5. Analysis of keywords

Table 5 revealed that prevalence (436 occurrences with 2,785 of total link strength) led the top 15 keywords involved in ED among diabetes research, followed by impotence (298 occurrences with 1,617 of total link strength), sexual dysfunction (231 occurrences with 1,561 of total link strength), risk-factors (191 occurrences with 1,308 of total link strength), and quality of life (165 occurrences with 1,067 of total link strength).

Table 5. The 15 most keywords on the research of “diabetes” and “erectile dysfunction”

Rank	ID	Keywords	Occurrences	Total Link Strength
1	5433	Prevalence	436	2,785
2	3269	Impotence	298	1,617
3	6234	Sexual dysfunction	231	1,561
4	5978	Risk-factors	191	1,308
5	5678	Quality-of-life	165	1,067
6	6860	Testosterone	146	1,095
7	6897	Therapy	141	949
8	4133	Metabolic syndrome	139	1,065
9	4833	Oxidative stress	118	683
10	2134	Endothelial dysfunction	113	750
11	6336	Sildenafil	112	730
12	1538	Corpus cavernosum	109	732
13	3983	Management	108	477
14	2876	Health	104	678
15	4590	Nitric-oxide	103	651

On the other hand, figure 5 illustrates burst to keywords with a significant citation burst. Excluding terms that were not research priority; the keywords that experienced citation bursts following 2012 were frontiers to physical activities included in therapy, oxidative stress and quality of life.

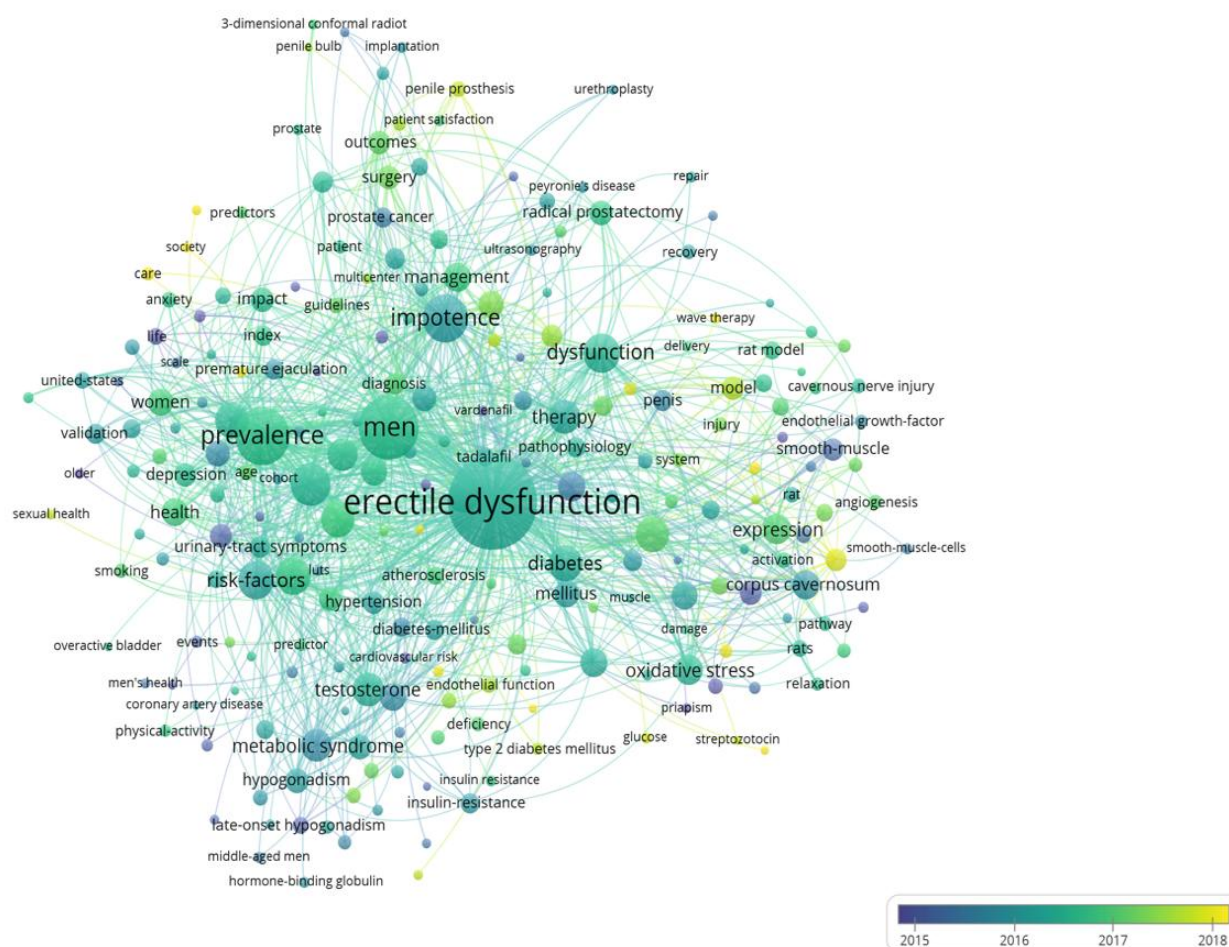


Figure 5. Keywords with a significant citation burst

4. Discussion

This study's objectives included a comprehensive evaluation of erectile dysfunction (ED) research's global scientific outputs from 2012 to 2022 and identified trends and keywords in ED research among individuals with diabetes. A total of 2367 articles on ED and diabetes were identified. Moreover, the global trend was comparatively declining in 2021 and 2022. The possible reason for the decline was due to the global COVID-19 pandemic that halted non-COVID clinical studies, like ED and diabetes, resulting in a reduction of opportunities for data collection. This is supported by Maisonneuve (2022), pointing out that several clinical trials had difficulties recruiting participants during COVID-19 pandemic. A study also estimates that there is a decline of 18% in the number of non-COVID-19 research (Raynaud et al., 2021). The decline in publications on ED and diabetes during 2021–2022 is likely a temporary outcome of the global disruption caused by the COVID-19 pandemic rather than a reflection of decreased scientific interest. As the pandemic wanes and research systems recover, it is plausible that publication volumes will rebound, especially given the persistent global burden of diabetes and its complications. In spite of decreasing, the result indicated that ED in diabetes had still become a concern for health researchers and practitioners, including nurses, in the last decade. Nurses are crucial in delivering comprehensive care for individuals with ED among diabetes. Timely recognition of sexual concerns can be advantageous for nurses, enabling them to strategize appropriate interventions and therapies that can yield improved outcomes for both the patients and their partners. Several studies revealed that individuals with ED had a lack of knowledge, and a low quality of life (Kouidrat et al., 2017; Malavige & Levy, 2009). Hence, it is crucial to enhance

the patient's understanding and consciousness regarding ED as a result of diabetes complications. Consequently, assessing patients' sexual function and recognizing the symptoms of ED with diabetes are the responsibilities of nurses (Getie Mekonnen et al., 2021). The ability to detect ED at an early stage could enable nurses to strategize effective interventions and health education to improve outcomes for individuals with diabetes (Hadisuyatama et al., 2023).

According to the analysis, the publication trend revealed a consistent trajectory throughout the search period. International Journal of Impotence Research had the most articles published. Specifically, the journal addresses psychological and physical issues of sexual dysfunction, with an impact factor of 2.8 and published by Springer Nature (International Journal of Impotence Research, 2024). In terms of the author, A.L. Burnett was the most productive author, and T. F. Lue had the largest number of citations during the past decades. A.L. Burnett and T.F. Lue have made significant contributions to their respective fields, with Burnett being highly productive in terms of publications and Lue having a substantial number of citations. When comparing them to other influential researchers, factors such as citation impact, research breadth, and interdisciplinary influence come into play (Alzharani et al., 2024). The USA and the People's Republic of China were the leading positions in ED research among individuals with diabetes. In fact, the USA and China have a high prevalence of diabetes, with an estimated 140 million cases in 2021, projected to increase to over 174 million by 2045 in China, and similarly, from 32.2 million to 36.3 million within the same timeframe in the USA (Sun et al., 2022).

In the past decade, the number of publications on this subject had increased exponentially. This topic was of a great interest to researchers from all over the world, as ED and diabetes research was a burgeoning field that focuses on oxidative stress, promoting physical activity, and improving quality of life. Remarkably, physical activity is a non-invasive therapeutic strategy that may reduce the burden of erectile dysfunction (Allen, 2019). Previous meta-analysis presented physical activity as a potential therapeutic alternative for ED. It investigates the pathophysiological mechanisms through which physical activities work as a therapeutic agents (Wang et al., 2017). Moreover, a study in Japan revealed that there was a significant correlation between physical activity and ED among individuals with diabetes (Minami et al., 2018). Similarly, an Italian study revealed that physical activity was significantly inversely correlated with ED among individuals with diabetes (Giugliano et al., 2010). The significant association of low physical activity with the high risk of ED might be explained by various reasons. First, low physical activity effectively increases endothelial-derived nitric oxide and high risk of disturbance of vasodilation via peripheral nitrergic nerves, indicating declined function of corpus cavernosum and penile erection mechanism (Allen, 2019; Förstermann & Sessa, 2012). Second, physical activity has a well documented association with low-levels of inflammatory markers such as Interleukins-6 and C-reactive protein (Maiorino et al., 2018). Notably, C-reactive protein and Interleukins-6 are contributed to the high prevalence of low testosterone levels (Esposito et al., 2007; Kapoor et al., 2007). Lastly, a high-moderate level of physical activity significantly decreased the malondialdehyde and advanced glycation end products among individuals with diabetes (Rias et al., 2020). Erectile dysfunction was indicated with a high level of malondialdehyde and advanced glycation end products (Gurbuz et al., 2022). This mechanism could provide insights on the mechanisms that affect physical activities on ED among diabetes patients.

Low quality of life was strongly correlated with ED among individuals with diabetes (Brooke et al., 2014; Malavige et al., 2014). Moreover, evaluating the quality of life in individuals with diabetes is crucial to adopting treatment of ED (Rahmanian et al., 2019). ED is a significant issue affecting millions of individuals and their quality of life, including diabetes. It has recently attracted substantial studies as population life expectancy grows, and has the linked issue of establishing sexual interest (Panwar et al., 2022). Indeed, low quality of life has an adverse effect on an individual's happiness and their job performance and behavior, on the adherence to a recommended therapy, and hence on socio-economic status expenditures (Mitkov et al., 2013). Previous research has also highlighted the necessity of monitoring patients' physical and emotional well-being with deterioration in these elements of quality of life, which might predict the onset of sexual issues and contribute to worsening subjective health assessment (De Berardis et al., 2005). ED substantially influenced physical functioning, depressive symptoms, overall health perception, and social functioning. As expected, the most severely impacted dimension of quality of life was the quality of sexual life, which showed a substantial reduction due to ED onset

(Malavige et al., 2014; Mitkov et al., 2013). Patients might be hesitant to share their sexual problems (De Berardis et al., 2005), which indicates that the health professionals, including nurses, should carefully study all domains of quality of life and ED among individuals with diabetes.

Oxidative stress-mediated neurovascular alterations in diabetic patients likely play a crucial role, influencing inhibited endothelial functions in diabetes men's corpus cavernosum (De Young et al., 2004). Hyperglycemia-induced overactivated oxidative stress obstructs penile endothelial function and vascular homeostasis (Castela et al., 2015), caused an underlying antioxidative problems; impaired the role of the endothelium in vascular and cavernous vasodilator function; and affected blood flow perfusion, which indicated high risk of ED in diabetes (Tang et al., 2023). In fact, stress oxidative markers such as malondialdehyde, advanced glycation end products, and superoxide dismutase were related to ED (Gurbuz et al., 2022; Tang et al., 2023). In response to changes in the levels of oxidative stress, there is a predicted high level of malondialdehyde, and its activity should indirectly demonstrate the high level of oxidative stress. Moreover, superoxide dismutase is an essential way for the body to get rid of free radicals, and the way it works could indirectly show how much oxidative stress there is (Tang et al., 2023). Morano et al. (2007) also found that patients with diabetes who also had ED had higher levels of oxidative activity in their circulating monocytes than diabetic patients who did not have ED. Consequently, large-scale prospective studies are expected to clarify the mechanism in ED among individuals with diabetes.

Indeed, most of these keywords were significant core terms because they recognized areas of research interest in this field. In recent years, research on ED among individuals with diabetes has focused on quality of life, oxidative stress, and physical activity. These keywords could be used to examine nursing care, to increase the physical activity and quality of life, as well as to decrease oxidative stress among diabetic people with ED. This research demonstrates the dynamic development process and structural connection of practical scientific knowledge through the online map of scientific insights by systematically integrating the relevant literature.

5. Implication and limitation

The novelty and unique point of this review is a comprehensive bibliometric analysis of the global scientific trends and research keywords in the field of ED and diabetes over a decade (2012-2022). This kind of extensive analysis over a long duration has been rare and provides valuable insights into the evolution of the research in this field. The review utilized multiple analytical tools such as VOS viewer, Cite Space, and Excel 2019 to examine various aspects of the literature, including journal title, research frontiers, authors, institutions, countries, and citation reports. The use of multiple tools offered a more robust and holistic understanding of the research landscape. Moreover, the review identified the main keywords and exciting research frontiers in this field, such as the links between oxidative stress, physical activity, and quality of life in patients with ED and diabetes. These findings provide a valuable resource and can guide future research directions in this field. The findings should raise awareness among nurses about the significance of evaluating erectile dysfunction in males with diabetes mellitus. Nurses could benefit from early detection of these sexual difficulties as it would enable them to plan appropriate interventions and therapies, leading to improved outcomes for both the patients and their partners. Consequently, nursing practice should consider examining oxidative stress and implementing nursing care to increase the physical activity and quality of life among diabetes with ED, based on the identified research trends. Trend analysis in this review not only examined research outputs but also highlighted changes over time. This trend analysis is crucial for understanding the shifts in research focus and could help policymaking. Interestingly, based on the analysis, the review calls for more research on the links between oxidative stress, physical activity, and quality of life in patients with ED and diabetes. This highlights gaps in the current research and underscores the need for further studies in these areas.

This study's analysis was based on articles from the WoSCC database. Although most research papers on diabetes and erectile dysfunction were included in this database, other databases, such as PubMed and Scopus, might provide more comprehensive coverage, which is a limitation of this paper. The included studies could be considered a follow-up update. As a result, they would cite previous studies on the same cohort, and co-occurrence analyses could disclose collaboration involved in serial studies of the same dataset. Simultaneously, multiple studies could be derived from the same dataset. In addition, this review's results were generated using

softwares, and the machine algorithm was not as intelligent as the human brain when it came to solving problems, which made it susceptible to bias.

6. Conclusions

The number of publications in diabetes and ED-related research has increased over the past decade. However, it declined from 2020 to 2022 during the coronavirus disease. The United States, China, and Italy were the leading contributors to this field. A. L. Burnett, M. Maggi, and G. Corona could be ideal candidates for the academic partnerships for joint publications. Physical activity, quality of life, and oxidative stress were uncharted territories in this field, and researchers should pay close attention to these keywords in related research in future investigations. It is recommended that researchers in the field of diabetes and ED use scientific keywords strategically, and that research institutions strengthen interactions and partnerships to accelerate academic growth in this field. In addition, large-scale prospective studies are expected to clarify the mechanism of ED among individuals with diabetes.

Acknowledgments

The authors would like to thank Ratchadapisek Somphot Fund, Chulalongkorn University, Institut Ilmu Kesehatan Bhakti Wiyata Kediri, Universitas Negeri Surabaya, Universitas Gadjah Mada, Yogyakarta, Indonesia, Politeknik Kesehatan Karya Husada Yogyakarta, Indonesia, and Universitas Diponegoro, Indonesia.

Author contribution

Conceptualization: YAR, RT, HTT

Data curation: ZA, RT, HTT

Formal analysis: ZA; YAR

Validation: RT, HTT

Visualization: NRM, IP, SI

Writing original manuscript draft: YAR, NRM

Writing, reviewing, and editing the manuscript: YAR, RT, HTT

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, funding, and/or publication of this article.

References

- Allen, M. S. (2019). Physical activity as an adjunct treatment for erectile dysfunction. *Nature Reviews Urology*, 16(9), 553-562. <https://doi.org/10.1038/s41585-019-0210-6>
- Alzharani, A.A.Y., Alshami, A.M., Khan, M.A. *et al.* (2024). A bibliometric analysis of the scientific research on erectile dysfunction. *Sexuality and Disability*, 42, 701-715. <https://doi.org/10.1007/s11195-024-09849-8>
- Bao, B., Ke, M., Guo, J., Pan, Z., Huang, H., Ke, Z., Zhou, X., & Liu, B. (2022). Bibliometrics and visualisation analysis of literature on varicocele: From 2002 to 2021. *Andrologia*, 54(10), e14537. <https://doi.org/10.1111/and.14537>
- Belba, A., Cortelazzo, A., Andrea, G., Durante, J., Nigi, L., Dotta, F., Timperio, A. M., Zolla, L., Leoncini, R., Guerranti, R., & Ponchietti, R. (2016). Erectile dysfunction and diabetes: Association with the impairment of lipid metabolism and oxidative stress. *Clinical Biochemistry*, 49(1), 70-78. <https://doi.org/10.1016/j.clinbiochem.2015.10.004>
- Brooke, J. C., Walter, D. J., Kapoor, D., Marsh, H., Muraleedharan, V., & Jones, T. H. (2014). Testosterone deficiency and severity of erectile dysfunction are independently associated with reduced quality of life in men with type 2 diabetes. *Andrology*, 2(2), 205-211. <https://doi.org/10.1111/j.2047-2927.2013.00177.x>
- Castela, A., Gomes, P., Domingues, V. F., Paíga, P., Costa, R., Vendeira, P., & Costa, C. (2015). Role of oxidative stress-induced systemic and cavernosal molecular alterations in the progression of diabetic erectile dysfunction. *Journal of Diabetes*, 7(3), 393-401. <https://doi.org/10.1111/1753-0407.12181>

- Corona, G., Isidori, A. M., Aversa, A., Bonomi, M., Ferlin, A., Foresta, C., La Vignera, S., Maggi, M., Pivonello, R., Vignozzi, L., & Lombardo, F. (2020). Male and female sexual dysfunction in diabetic subjects: Focus on new antihyperglycemic drugs. *Reviews in Endocrine and Metabolic Disorders*, 21(1), 57-65. <https://doi.org/10.1007/s11154-019-09535-7>
- De Berardis, G., Pellegrini, F., Franciosi, M., Belfiglio, M., Di Nardo, B., Greenfield, S., Kaplan, S. H., Rossi, M. C., Sacco, M., & Tognoni, G. (2005). Longitudinal assessment of quality of life in patients with type 2 diabetes and self-reported erectile dysfunction. *Diabetes Care*, 28(11), 2637-2643. <https://doi.org/10.2337/diacare.28.11.2637>
- De Young, L., Yu, D., Bateman, R. M., & Brock, G. B. (2004). Oxidative stress and antioxidant therapy: Their impact in diabetes-associated erectile dysfunction. *Journal of Andrology*, 25(5), 830-836. <https://doi.org/10.1002/j.1939-4640.2004.tb02862.x>
- Defeudis, G., Mazzilli, R., Tenuta, M., Rossini, G., Zamponi, V., Olana, S., Faggiano, A., Pozzilli, P., Isidori, A. M., & Gianfrilli, D. (2022). Erectile dysfunction and diabetes: A melting pot of circumstances and treatments. *Diabetes/Metabolism Research and Reviews*, 38(2), e3494. <https://doi.org/10.1002/dmrr.3494>
- Esposito, K., Ciotola, M., Giugliano, F., Schisano, B., Improta, L., Improta, M., Beneduce, F., Rispoli, M., De Sio, M., & Giugliano, D. (2007). Endothelial microparticles correlate with erectile dysfunction in diabetic men. *International Journal of Impotence Research*, 19(2), 161-166. <https://doi.org/10.1038/sj.ijir.3901500>
- Förstermann, U., & Sessa, W. C. (2012). Nitric oxide synthases: Regulation and function. *European Heart Journal*, 33(7), 829-837. <https://doi.org/10.1093/eurheartj/ehr304>
- Getie Mekonnen, E., Yeshita, H. Y., & Bishaw Geremew, A. (2021). Sexual dysfunction among men with diabetes mellitus attending chronic out-patient department at the three hospitals of Northwest Amhara region, Ethiopia: Prevalence and associated factors. *PLoS One*, 16(8), e0256015. <https://doi.org/10.1371/journal.pone.0256015>
- Giugliano, F., Maiorino, M., Bellastella, G., Gicchino, M., Giugliano, D., & Esposito, K. (2010). Determinants of erectile dysfunction in type 2 diabetes. *International Journal of Impotence Research*, 22(3), 204-209. <https://doi.org/10.1038/ijir.2010.1>
- Gurbuz, N., Gurkan, R., Ender Caylan, A., Surmen Usta, S., & Usta, M. F. (2022). The therapeutic effect of ALT-711 on erectile function in rats treated with high-level AGEs (advanced glycation end products) containing diet. *International Journal of Impotence Research*, 34(2), 222-228. <https://doi.org/10.1038/s41443-021-00417-8>
- Gutiérrez-Salcedo, M., Martínez, M. A., Moral-Munoz, J. A., Herrera-Viedma, E., & Cobo, M. J. (2018). Some bibliometric procedures for analyzing and evaluating research fields. *Applied Intelligence*, 48(5), 1275-1287. <https://doi.org/10.1007/s10489-017-1105-y>
- Hadisuyatmana, S., Boyd, J. H., Efendi, F., Malik, G., Bauer, M., Reisenhofer, S. (2023). Non-medical and non-invasive interventions for erectile dysfunction in men with type 2 diabetes mellitus: A scoping review. *Heliyon*, 9(5), e15778. <https://doi.org/10.1016/j.heliyon.2023.e15778>
- Hui, J., He, S., Liu, R., Zeng, Q., Zhang, H., & Wei, A. (2020). Trends in erectile dysfunction research from 2008 to 2018: A bibliometric analysis. *International Journal of Impotence Research*, 32(4), 409-419. <https://doi.org/10.1038/s41443-019-0161-8>
- International Journal of Impotence Research. (2024). *Journal Information*. Springer Nature. <https://www.nature.com/ijir/journal-information>
- Kapoor, D., Clarke, S., Channer, K., & Jones, T. (2007). Erectile dysfunction is associated with low bioactive testosterone levels and visceral adiposity in men with type 2 diabetes. *International Journal of Andrology*, 30(6), 500-507. <https://doi.org/10.1111/j.1365-2605.2007.00744.x>
- Kouidrat, Y., Pizzol, D., Cosco, T., Thompson, T., Carnaghi, M., Bertoldo, A., Solmi, M., Stubbs, B., & Veronese, N. (2017). High prevalence of erectile dysfunction in diabetes: A systematic review and meta-analysis of 145 studies. *Diabetic Medicine*, 34(9), 1185-1192. <https://doi.org/10.1111/dme.13403>
- Maiorino, M. I., Bellastella, G., Giugliano, D., & Esposito, K. (2018). From inflammation to sexual dysfunctions: A journey through diabetes, obesity, and metabolic syndrome. *Journal of Endocrinological Investigation*, 41(11), 1249-1258. <https://doi.org/10.1007/s40618-018-0872-6>

- Maisonneuve H. (2022). COVID-19 as a source of poor publications. *Joint Bone Spine*, 89(6), 105427. <https://doi.org/10.1016/j.jbspin.2022.105427>
- Malavige, L., Jayaratne, S., Kathriarachchi, S., Sivayogan, S., Ranasinghe, P., & Levy, J. (2014). Erectile dysfunction is a strong predictor of poor quality of life in men with type 2 diabetes mellitus. *Diabetic Medicine*, 31(6), 699-706. <https://doi.org/10.1111/dme.12412>
- Malavige, L. S., & Levy, J. C. (2009). Erectile dysfunction in diabetes mellitus. *The Journal of Sexual Medicine*, 6(5), 1232-1247. <https://doi.org/10.1111/j.1743-6109.2008.01168.x>
- Minami, H., Furukawa, S., Sakai, T., Niiya, T., Miyaoka, H., Miyake, T., Yamamoto, S., Kanzaki, S., Maruyama, K., & Tanaka, K. (2018). Physical activity and prevalence of erectile dysfunction in Japanese patients with type 2 diabetes mellitus: The dogo study. *Journal of Diabetes Investigation*, 9(1), 193-198. <https://doi.org/10.1111/jdi.12660>
- Mitkov, M. D., Aleksandrova, I. Y., & Orbetzova, M. M. (2013). Effect of transdermal testosterone or alpha-lipoic acid on erectile dysfunction and quality of life in patients with type 2 diabetes mellitus. *Folia Medica (Plovdiv)*, 55(1), 55-63. <https://doi.org/10.2478/folmed-2013-0006>
- Morano, S., Gatti, A., Mandosi, E., Tiberti, C., Fallarino, M., Cipriani, R., Buchetti, B., Gandini, L., Sgrò, P., & Jannini, E. A. (2007). Circulating monocyte oxidative activity is increased in patients with type 2 diabetes and erectile dysfunction. *The Journal of Urology*, 177(2), 655-659. <https://doi.org/10.1016/j.juro.2006.09.046>
- Nisahan, B., Kumanan, T., Rajeshkannan, N., Peranantharajah, T., & Aravinthan, M. (2019). Erectile dysfunction and associated factors among men with diabetes mellitus from a tertiary diabetic center in Northern Sri Lanka. *BMC Research Notes*, 12, 210. <https://doi.org/10.1186/s13104-019-4244-x>
- Paniagua Cruz, A., Zhu, K. Y., Ellimoottil, C., Dauw, C. A., Sarma, A., & Skolarus, T. A. (2020). Characterizing the benign prostatic hyperplasia literature: A bibliometric analysis. *Urology*, 136, 202-211. <https://doi.org/10.1016/j.urology.2019.11.033>
- Panwar, P., Navriya, S. C., Tendulkar, P., & Khapre, M. (2022). Major sexual function domains affected in the diabetic females: A cross-sectional study from North India. *Indian Journal of Endocrinology and Metabolism*, 26(5), 478-482. https://doi.org/10.4103/ijem.ijem_68_22
- Rahmanian, E., Salari, N., Mohammadi, M., & Jalali, R. (2019). Evaluation of sexual dysfunction and female sexual dysfunction indicators in women with type 2 diabetes: A systematic review and meta-analysis. *Diabetology & Metabolic Syndrome*, 11, 1-17. <https://doi.org/10.1186/s13098-019-0469-z>
- Raynaud, M., Goutaudier, V., Louis, K., Al-Awadhi, S., Dubourg, Q., Truchot, A., Brousse, R., Saleh, N., Giarraputo, A., Debais, C., Demir, Z., Certain, A., Tacafred, F., Cortes-Garcia, E., Yanes, S., Dagobert, J., Naser, S., Robin, B., Bailly, É., Jouven, X., ... Loupy, A. (2021). Impact of the COVID-19 pandemic on publication dynamics and non-COVID-19 research production. *BMC Medical Research Methodology*, 21, 255. <https://doi.org/10.1186/s12874-021-01404-9>
- Rezaee, M., Johnson, H., Munarriz, R., & Gross, M. (2019). 237 Bibliometric analysis of erectile dysfunction publications in urology and sexual medicine journals. *The Journal of Sexual Medicine*, 16(4), S115. <https://doi.org/10.1016/j.jsxm.2019.01.244>
- Rias, Y. A., Kurniawan, A. L., Chang, C. W., Gordon, C. J., & Tsai, H. T. (2020). Synergistic effects of regular walking and alkaline electrolyzed water on decreasing inflammation and oxidative stress, and increasing quality of life in individuals with type 2 diabetes: A community based randomized controlled trial. *Antioxidants*, 9(10), 946. <https://doi.org/10.3390/antiox9100946>
- Shiferaw, W. S., Akalu, T. Y., Petrucka, P. M., Areri, H. A., & Aynalem, Y. A. (2020). Risk factors of erectile dysfunction among diabetes patients in Africa: A systematic review and meta-analysis. *Journal of Clinical & Translational Endocrinology*, 21, 100232. <https://doi.org/10.1016/j.jcte.2020.100232>
- Sun, H., Saeedi, P., Karuranga, S., Pinkepank, M., Ogurtsova, K., Duncan, B. B., Stein, C., Basit, A., Chan, J. C. N., Mbanya, J. C., Pavkov, M. E., Ramachandaran, A., Wild, S. H., James, S., Herman, W. H., Zhang, P., Bommer, C., Kuo, S., Boyko, E. J., & Magliano, D. J. (2022). IDF Diabetes Atlas: Global, regional and country-level diabetes prevalence estimates for 2021 and projections for 2045. *Diabetes research and clinical practice*, 183, 109119. <https://doi.org/10.1016/j.diabres.2021.109119>

- Tang, Z., Song, J., Yu, Z., Cui, K., Ruan, Y., Liu, Y., Wang, T., Wang, S., Liu, J., & Yang, J. (2023). Inhibition of microRNA-92a improved erectile dysfunction in streptozotocin-induced diabetic rats via suppressing oxidative stress and endothelial dysfunction. *The World Journal of Men's Health*, 41(1), 142-154. <https://doi.org/10.5534/wjmh.210177>
- Ventura, A. D., Browne, J. L., Pouwer, F., Speight, J., & Byrne, M. (2018). Emotional well-being factors associated with sexual dysfunction in adults with type 1 or type 2 diabetes: Results from diabetes MILES—Australia. *International Journal of Sexual Health*, 30(3), 237-249. <https://doi.org/10.1080/19317611.2018.1470591>
- Waltman, L. (2016). A review of the literature on citation impact indicators. *Journal of Informetrics*, 10(2), 365-391. <https://doi.org/10.1016/j.joi.2016.02.007>
- Wang, Q. (2018). A bibliometric model for identifying emerging research topics. *Journal of the Association for Information Science and Technology*, 69(2), 290-304. <https://doi.org/https://doi.org/10.1002/asi.23930>
- Wang, W., Fan, J., Huang, G., Zhu, X., Tian, Y., Tan, H., & Su, L. (2017). Meta-analysis of prevalence of erectile dysfunction in mainland China: Evidence based on epidemiological surveys. *Sexual Medicine*, 5(1), e19-e30. <https://doi.org/10.1016/j.esxm.2016.10.001>
- Wang, W., & Lu, C. (2020). Visualization analysis of big data research based on Citespace. *Soft Computing*, 24(11), 8173-8186. <https://doi.org/10.1007/s00500-019-04384-7>
- Zhao, B., Hong, Z., Wei, Y., Yu, D., Xu, J., & Zhang, W. (2019). Erectile dysfunction predicts cardiovascular events as an independent risk factor: A systematic review and meta-analysis. *The Journal of Sexual Medicine*, 16(7), 1005-1017. <https://doi.org/https://doi.org/10.1016/j.jsxm.2019.04.004>