


# Comprehensive Analysis of Global Research on Erectile Dysfunction from 2002 to 2021: A Scientometric Approach

Yahia Ali Kaabi<sup>1</sup>, Siddig Ibrahim Abdelwahab<sup>2</sup>, Osama Albasheer<sup>3</sup> 

<sup>1</sup>Medical Laboratory Technology Department, College of Applied Medical Sciences, Jazan University, Jazan, Saudi Arabia; <sup>2</sup>Medical Research Centre, Jazan University, Jazan, Saudi Arabia; <sup>3</sup>Family and Community Medicine Department, College of Medicine, Jazan University, Jazan, Saudi Arabia

Correspondence: Osama Albasheer, Family and Community Medicine Department, College of Medicine, Jazan University, Jazan, Saudi Arabia, Tel +966536827923, Fax +173297003, Email oalbasheer@jazanu.edu.sa

**Background:** Erectile dysfunction (ED) is a multifaceted yet prevalent male-related sexual dysfunction that manifests as a change in any of the erectile response components, including relational, psychological, and biological. We aimed to use bibliometric analyses to determine how ED research has progressed and define the future trends necessary to contribute to scholarly literature.

**Methods:** Two tools, VOSviewer and MS Excel, were used, and the study was conducted in May 2022. A total of 16,114 records were selected for in-depth analyses. We examined the most eminent authors, highly cited papers within journals, and the institutions that have provided the greatest number of articles regarding ED, and demonstrated that ED research has increased over the last two decades.

**Results:** The total number of research documents published between 1971 and 2021 was 16,114, with a growth rate of 5%. Montorsi, Maggi, and Mulhall shared the top spot in the number of publications ( $n = 164$ ). The Journal of Sexual Medicine has the most papers ( $N = 1839$ ), followed by the International Journal of Impotence Research ( $N = 780$ ), the Journal of Urology ( $N = 557$ ), and Urology ( $N = 489$ ).

**Conclusion:** The study revealed increased ED research in the past two decades, with notable authors and sources identified. The top three countries contributing to ED are the UK, Italy, and the USA. Recommendations include interdisciplinary collaboration, novel therapeutic approaches, addressing psychological and relational factors, conducting longitudinal studies, and publishing in reputable journals. Implementing these can advance understanding, improve treatment options, and enhance ED management.

**Keywords:** erectile dysfunction, bibliometrics, co-authorship, trends, citations

## Introduction

Erectile dysfunction (ED) is the inability to successfully achieve and/or sustain a penile erection of adequate strength for satisfactory sexual performance.<sup>1,2</sup> ED affects one of every two men older than 40 years. Other types of sexual dysfunction can include problems with orgasm, sexual interest (libido), or ejaculation.<sup>3</sup> There are two varieties of ED; Primary variety, where the man has never been able to achieve or maintain an erection and secondary variety, where an ED acquired later in life by a man who previously was able to attain erections.<sup>4</sup> ED can be due to neurological, vasculogenic, as well as cardiovascular and metabolic diseases, inflammatory/infectious, and iatrogenic and mechanical causes.<sup>5</sup> The equilibrium of blood flow into and out of the penile tissue causes erections, and ED is often caused by conditions that induce alterations in penis blood flow. Atherosclerosis (hardening of the arteries) and diabetes are the two most frequent medical conditions that may cause ED. Obesity is also linked to alterations in blood vessels and hormones that have a deleterious impact on erections. Damage to the nerves involved in erections is another cause of ED. This may occur due to nervous system diseases (eg, Parkinson's disease, multiple sclerosis) or surgery (eg, for prostate cancer).<sup>6</sup> ED may also be caused by hormonal issues, such as low testosterone, and pharmaceutical side effects, such as those utilized to treat high blood pressure.<sup>7</sup> Several common lifestyle variables, such as obesity and physical inactivity and lower urinary tract symptoms, have been connected with the development of ED, in addition to the conventional causes of ED, such as hypertension and diabetes mellitus.<sup>8</sup>

Investigations into the link between ED and cardiovascular disease have progressed significantly.<sup>9</sup> ED is a well-known predictor of coronary artery disease, and non-cardiac patients with ED should be evaluated for cardiovascular disease.<sup>10</sup> Significant progress has been made in the knowledge of the pathophysiology of ED, which has led to the discovery of effective oral treatments, such as phosphodiesterase type-5 inhibitors. Oral phosphodiesterase type-5 inhibitors, however, have drawbacks; thus, current research focuses on cutting-edge treatment techniques, such as cell and gene-based technologies, in the hopes of finding a solution for ED.<sup>11</sup>

By utilizing statistical techniques of the expanding number of intellectual contributions, bibliometric analyses have gradually grown as a technique that creates a reliable mapping of the evolution of an area of knowledge. The quantitative analysis of bibliographic data is utilized to assess the current state of knowledge and the progress of a particular research subject, and its use in all fields is steadily expanding. Bibliometric examination of published data is used by numerous academic disciplines to examine and analyze the development, trajectory, and knowledge structure of diverse topics. This form of research aids in tracing important intellectual contributions and authors, and identifying networks and scientific contributions across nations and organizations.<sup>12</sup> Furthermore, extensive bibliometric evaluations are critical to harmonize academic fields in social and behavioral science. Evidently, the use of bibliometric techniques is motivated by the need to assess scientific output and make the findings accessible to policymakers, scientists, and other stakeholders. However, one may question if the increasing number of publications is a result of a true need for these sorts of analyses and whether the studies fulfill their stated goal. Hopefully, the growth and distribution over time of the number of bibliometric analyses published, as well as the citation or influence of these in various sectors, will reveal the patterns and offer the required answers.

Bibliometric evaluations and extensive search in the subject of ED are limited. Therefore, the current study was designed to analyze global research in ED and identify high-yield authors, journals, institutions, nations, and keywords, exposing hotspots and trends.

## Methods

### Database Selection and Search Strategy

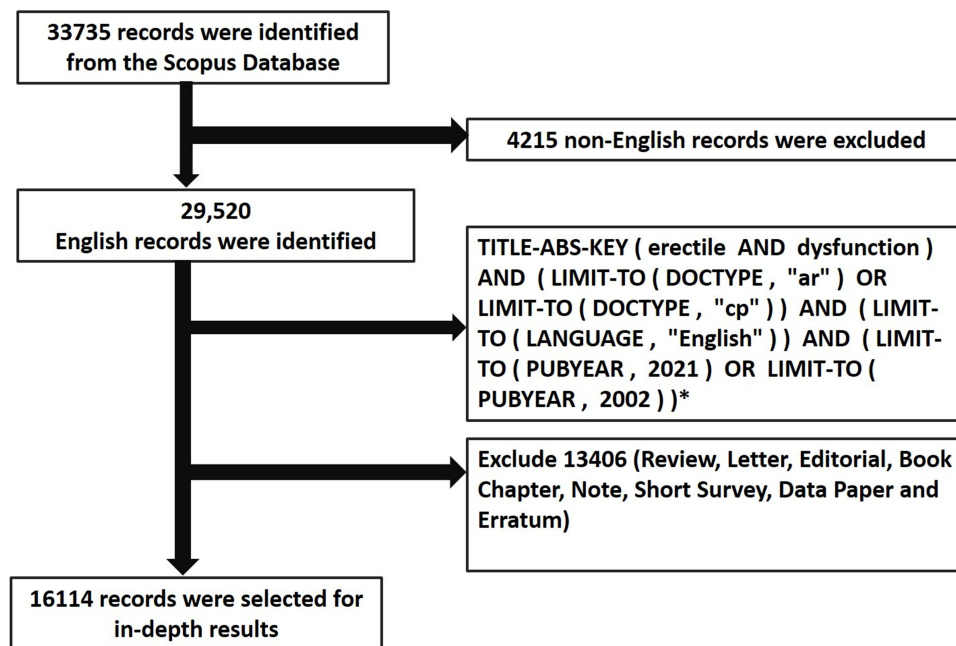
Indexing of journals by international bibliographic databases has significant consequences for research, science, and development. Researchers and academics use bibliographic databases to thoroughly and methodically analyze papers in their reviews and research. They use lists of indexed sources from interdisciplinary and specialized databases to find relevant publications that will provide their work with worldwide prominence and distribution. To achieve and maintain global competitiveness rankings, research and academic organizations are likewise concerned with the bibliographic records of their academics and scientists and aim to develop indexing of their own journals.<sup>13</sup> Scopus, which began as an Elsevier database in 2004 and now includes 22,800 active titles and over 77 million bibliographic items, has outperformed several other indexing systems. Scopus provides expanded altimetric and scientometric data at the article level, thanks to powerful analytical tools and integration with social media analytics.<sup>14</sup> Scopus searches make it possible to trace the evolution of knowledge across academic fields and synthesize new scientific findings.<sup>14</sup> Figure 1 and Table 1 show the search strategy we adopted to retrieve the required bibliographic data. The keywords “(erectile AND dysfunction)” were used, based on Scopus standards.

### Exclusion and Inclusion Criteria

English was chosen as the search language for bibliographic data published from 2002 to 2021. Only journal and conference papers were utilized. Books, review papers, book chapters, and editorials were excluded. Geographical location and options for open access were not used as a selection factor for bibliographic data.

### Descriptive Analyses and the Regression Function

The number of yearly publications, study types, and journal articles were analyzed using Excel 2013. The numbers of yearly publications were estimated using a world density map. Research kinds were categorized and descriptively assessed, and the top ten journals with the most articles were screened for citations, impact factor (IF) of 2020, and CiteScore (CS).



**Figure 1** Search strategy and selection of data from the Scopus database. \*Search terms and abbreviations were copied from Scopus.

**Abbreviations:** Ar, article; cp, conference paper.

## Visualization of Bibliometric Analyses

Virtual bibliometric networks are literature networks and can be built using Visualization of Similarities viewer (VOSviewer) software. These networks may be built via citations, co-citations, bibliographic coupling, or co-authorship relationships. VOSviewer also has text mining capabilities to build and display co-occurrence networks of key phrases from the scientific literature. VOSviewer, from the University of Leiden's Centre for Science and Technology Studies, works with Web of Science, PubMed, RIS, Scopus, and Crossref JSON files. Research hotspots and trends have been studied extensively using VOSviewer. Co-citation analysis is the technique of mining a document's co-citation connection.<sup>15</sup> Mining the co-citation relationship is thought to allow for the evaluation of the evolutionary potential dynamic processes of connected research topics as well as the detection of field development boundaries. Co-citation analysis quantifies complicated and varied information,

**Table 1** Primary Database Search (1945–2022)

| Type of Document  | Number | %     |
|-------------------|--------|-------|
| Article           | 21,058 | 62.42 |
| Review            | 6742   | 19.99 |
| Note              | 1702   | 5.05  |
| Editorial         | 1016   | 3.01  |
| Letter            | 980    | 2.90  |
| Conference Paper  | 780    | 2.31  |
| Short Survey      | 738    | 2.19  |
| Book Chapter      | 575    | 1.70  |
| Erratum           | 105    | 0.31  |
| Book              | 29     | 0.09  |
| Retracted         | 5      | 0.01  |
| Conference Review | 2      | 0.01  |
| Undefined*        | 3      | 0.01  |
| Total             | 33,735 | 100   |

**Notes:** \*These documents are unidentified in the Scopus database in terms of their countries of origin.

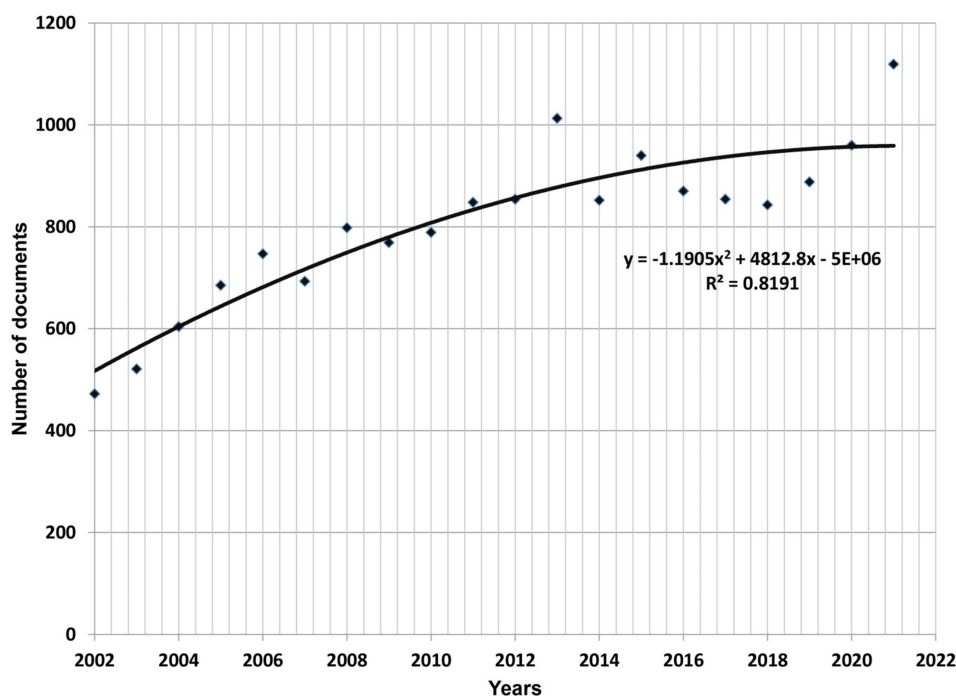
revealing the underlying significance of internal correlation and complex information features. Pure quantitative analysis, which may not fully portray the underlying context of discipline growth, is indisputable since it heavily relies on statistics. However, quantitative analysis has a clear advantage: it can clearly depict a field's overall growth trend, network structure, and research hotspots.<sup>16</sup> By quantifying linkages between high-yield authors, journals, institutions, nations, and keywords, VOSviewer may uncover innovations and trends in numerous sectors. Keyword clustering analyses were also performed in this review to differentiate between the cognitive domains<sup>17</sup> related to ED.

## Results

### Temporal Networking

In 1945, the first scientific production on ED was published. This study by Bergler appeared in the *Psychiatric Quarterly* journal and signposted the genetic survey of psychic impotence. It was also the year when Podolsky released an article regarding sexual neurosis not being an uncommon condition in soldiers. In total, 33,735 research documents were disseminated between 1945 and 2022, with an average of 438 per year. The number of articles published annually was low ( $n = 50$ ) from 1945 to 1965. In contrast, there has been a remarkable growth of 41.7% over the last decade. The total number of research documents published between 1971 and 2021 was 16,114, with a growth rate of 5%. This growth rate has increased rapidly during the previous decade, reflecting the new emergence of studies regarding ED (Figure 2). Since the year 2000, the increase in academic contributions has been driven by the major scholarly work of a number of writers who have studied the epidemiology of ED, the regulation of cAMP and cGMP signaling, and phosphodiesterases.<sup>18</sup> The highest number of contributions in one year ( $n = 1720$ ) on ED was seen in 2021. In the same year, the candidate genes associated with ED were studied using genome-wide sequencing.<sup>19</sup> Another study also addressed male sexual wellbeing in the wake of the COVID-19 outbreak.<sup>20</sup>

Identifying the most influential contributors within a certain topic area assists in locating researchers who contribute considerably to a particular field of study.<sup>21</sup> This study recognized the top ten researchers who have had the most substantial contribution to ED research (Table 2). It is apparent from Table 2 that Montorsi, Maggi, and Mulhall have the highest number of publications collectively ( $n = 164$ ). In terms of citations, Montorsi, leads with 10,192 citations, followed by Maggi, who has 8881 ( $n = 164$ ). The first paper was published by Barnett on recommendations to treat ED,



**Figure 2** Annual scientific production of research documents.

**Table 2** Top ten Researchers Based on the Number of Articles ( $\geq 888$ )

| Rank | Author Name       | Institutional Affiliation   | N   | TOC    | CA    |
|------|-------------------|---|-----|--------|-------|
| 1st  | Montorsi, F.      | Università Vita-Salute San Raffaele, Milan, Italy   | 164 | 8881   | 54.15 |
| 2nd  | Maggi, M.         | Università degli Studi di Firenze, Department of Experimental and Clinical Biomedical Sciences, Florence, Italy | 157 | 10,192 | 62.15 |
| 3rd  | Mulhall, J.P.     | Memorial Sloan-Kettering Cancer Center, Sexual & Reproductive Medicine Program, New York, USA                   | 141 | 5374   | 38.11 |
| 4th  | Burnett, A.L.     | Johns Hopkins School of Medicine, Department of Urology, Baltimore, USA   | 136 | 6261   | 46.38 |
| 5th  | Corona, G.        | Ospedale Bellaria, Department of Medicine, Bologna, Italy   | 132 | 7437   | 56.77 |
| 6th  | Hellstrom, W.J.G. | Tulane University School of Medicine, New Orleans, USA  | 107 | 1327   | 12.64 |
| 7th  | Salonia, A.       | IRCCS San Raffaele Scientific Institute, Milan, Italy   | 95  | 3642   | 38.74 |
| 8th  | Forti, G.         | Università degli Studi di Firenze, Endocrinology Unit, Florence, Italy  | 93  | 3628   | 38.60 |
| 9th  | Lue, T.F.         | UCSF School of Medicine, Department of Urology, San Francisco, USA  | 89  | 7119   | 76.55 |
| 10th | Rosen, R.C.       | New England Research Institutes, Watertown, USA   | 87  | 6135   | 70.51 |

**Abbreviations:** N, Number of total publications; TOC, Total citations; CA, Average citations per article.

sexual dysfunction in men, and early ejaculation.<sup>22</sup> With an average of more than 62.14 citations per article throughout his 164 works, he has the greatest citation rate, highlighting his significant contribution over the last 20 years.

Table 3 lists the ten ED contributions with the highest citation counts. With a total of 10,192 citations, Maggi is the third most-cited author, but remarkably was not on the list of most-cited articles. The intellectual contributions of the authors/

**Table 3** Top ten “Highly Cited” Publications (Citations  $\geq 700$ )

| Rank | Article                 | Title of Publication   | Source                            | C    | T/C    |
|------|-------------------------|--|-----------------------------------|------|--------|
| 1st  | Ponikowski, P. (2016)   | 2016 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure: The Task Force for the diagnosis and treatment of acute and chronic heart failure of the European Society of Cardiology (ESC). Developed with the special contribution of the Heart Failure Association (HFA) of the ESC | European Journal of Heart Failure | 4107 | 783.5  |
| 2nd  | Montalescot, G. (2013)  | ESC guidelines on the management of stable coronary artery disease   | European Heart Journal            | 3495 | 388.33 |
| 3rd  | Dahlöf, B. (2005)       | Prevention of cardiovascular events with an antihypertensive regimen of amlodipine adding perindopril as required versus atenolol adding bendroflumethiazide as required, in the Anglo-Scandinavian Cardiac Outcomes Trial-Blood Pressure Lowering Arm (ASCOT-BPLA): A multicentre randomised controlled trial   | Lancet                            | 2491 | 166.06 |
| 4th  | Mottet, N. (2017)       | EAU-ESTRO-SIOG Guidelines on Prostate Cancer. Part 1: Screening, Diagnosis, and Local Treatment with Curative Intent   | European Urology                  | 1942 | 485.5  |
| 5th  | McConnell, J. D. (2003) | The Long-Term Effect of Doxazosin, Finasteride, and Combination Therapy on the Clinical Progression of Benign Prostatic Hyperplasia  | New England Journal of Medicine   | 1538 | 80.94  |
| 6th  | Halder, P. (2009)       | Mepolizumab and exacerbations of refractory eosinophilic asthma  | New England Journal of Medicine   | 1455 | 111.92 |
| 7th  | Tesfaye, S. (2010)      | Diabetic neuropathies: Update on definitions, diagnostic criteria, estimation of severity, and treatments  | Diabetes Care                     | 1434 | 119.50 |
| 8th  | Wilt, T.J. (2012)       | Radical prostatectomy versus observation for localized prostate cancer   | New England Journal of Medicine   | 1398 | 139.80 |
| 9th  | Lindau, S.T. (2007)     | A study of sexuality and health among older adults in the United States  | New England Journal of Medicine   | 1376 | 91.70  |
| 10th | Wang R. (2012)          | Physiological implications of hydrogen sulfide: A whiff exploration that blossomed   | Physiological Reviews             | 1231 | 123.10 |

**Abbreviations:** TC, Total citations; TC/Y, Total citations per year.

researchers give substantial evidence concerning their effect on the development and growth of a certain research area. Similarly, it is critical to recognize the most cited or important works that have formed the knowledge structure of the given study topic. Citation analysis is regarded as an effective instrument and criterion to evaluate the quality of research contributions. Publications that have been referenced more than 100 times are deemed to be “highly cited” or “classic” academic contributions.<sup>21</sup> The top ten influential papers based on citations that fit this criterion are displayed in Table 3. None of these leading articles concentrated on a specific topic of debate, but rather offered a wide perspective of the various facets of ED. Ponikowski is the co-author of the most prominent scholarly work on the list, which was published jointly with 63 group members on behalf of the European Society of Cardiology (ESC), and details research guidelines for the diagnosis and treatment of heart failure. Since heart failure is directly related to ED, this research has represented a focus of knowledge for researchers in the field of male sexual health.<sup>23</sup> The second most-cited (3495) contribution by Motanlescot focused on ESC guidelines for managing stable coronary artery disease. Notably, both contributions were cited more than 3000 times. Most of the top ten cited documents were indirectly associated with ED research in terms of hypertension, prostatectomy, prostate cancer, heart and coronary artery disease, diabetes mellitus, asthma, neuropathies, lifestyle and physical exercise, and abdominal aortic aneurysm.<sup>24,25</sup> The ninth most-cited (1376) contribution by Lindau (2007) focused on sexuality and health among the elderly in the USA. A sole-authored article by Wu (2012) is located at 13 on the list, and contributed to the identification of late-onset hypogonadism in men. The twentieth most-cited article by Hatzimouratidis (2010) stated the guidelines and procedures regarding male sexual dysfunction: ED and premature ejaculation.

In addition to identifying the most notable authors and significant influences, it is also critical to determine the journals that produce articles on a certain field, particularly when deciding which journals to read and cite while performing a literature review. It also assists the researcher in becoming acquainted with publications that concentrate on their relevant academic and research topic.<sup>26</sup> Table 4 shows the top ten journals that have produced the most papers on ED, as well as their impact factors. These metrics assist scholars in determining the journal’s importance within a certain topic field. It also helps in the determination of the effect of the journal at the category level by demonstrating the link between citing and cited publications. Furthermore, CiteScore evaluates the number of citations for a title from all journal articles in the first year to all articles published in the preceding three years. This provides a comprehensive and accurate measure of the effect of a journal. The key distinction between these two measures is the computation period; while the journal impact factor generates the metric using the two previous years as a baseline for the citation count, CiteScore employs three years.<sup>27</sup>

Table 4 shows that the Journal of Sexual Medicine has the most papers (N = 1839), followed by the International Journal of Impotence Research (N = 780), the Journal of Urology (N = 557), and Urology (N = 489). The Journal of Sexual Medicine covers interdisciplinary fundamental science and clinical research aimed at defining and comprehending the scientific underpinnings of male, female, and couple sexual function and dysfunction. The remaining six journals on this list have produced more than 100 articles. European Urology has the highest impact factor (20.096), followed by

**Table 4** Top 10 Journals and Their Metrics Based on the Number of Articles ( $\geq 140$ )

| Rank | Source                                      | N    | TOC    | CA    | CiteScore 2020 | IF-2020      |
|------|---|------|--------|-------|----------------|--------------|
| 1st  | Journal of Sexual Medicine                  | 1839 | 57,595 | 31.32 | 4.6            | 3.802        |
| 2nd  | International Journal of Impotence Research | 780  | 19,282 | 24.72 | 2.9            | 2.433        |
| 3rd  | Journal of Urology                          | 557  | 27,494 | 52.77 | 9.6            | 7.450        |
| 4th  | Urology                                     | 489  | 13,682 | 27.98 | 3.0            | 2.649        |
| 5th  | BJU International                           | 484  | 17,088 | 35.31 | 8.4            | 5.588        |
| 6th  | Andrologia                                  | 268  | 1931   | 7.21  | 3.4            | 2.775        |
| 7th  | European Urology                            | 252  | 22,889 | 90.83 | 34.7           | 20.096       |
| 8th  | Asian Journal of Andrology                  | 212  | 3232   | 15.25 | 4.5            | 3.285        |
| 9th  | Sexual Medicine                             | 177  | 1010   | 5.71  | 2.6            | 2.491        |
| 10th | Aging Male                                  | 141  | 2256   | 16.00 | 4.4            | <b>5.892</b> |

**Abbreviations:** N, Number of total publications; TOC, Total citations; CA, Average citation per article; IF, Impact factor.

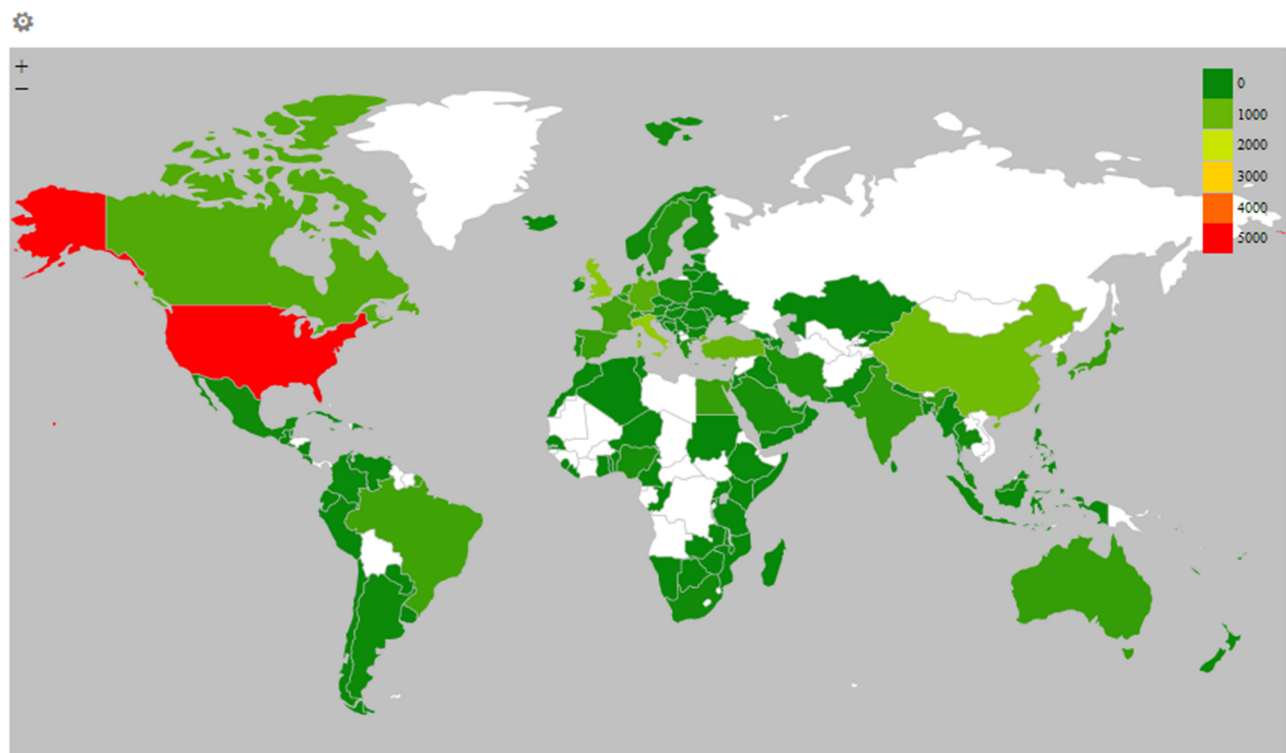


Journal of Urology (7.450), Aging Male (5.892), and BJU International (5.588), whereas all the others have impact factors of more than 2.0. In terms of CiteScore, European Urology has secured the highest CiteScore of 34.7. None of the other journals on this list has an h-index greater than two. Both the impact factor and the h-index place European Urology at the top. Only three of the top ten journals have published any of the recognized highly significant literature (Table 3). However, despite publishing five of the most-cited articles regarding ED, the New England Journal of Medicine does not rank among the top ten journals. The New England Journal of Medicine is not the leading publisher on this subject, despite receiving far more citations than the other publications on this list. Table 4 demonstrates a correlation between the Journal of Urology and European Urology in terms of citations. According to this criterion, scholarly journals that publish fewer articles on a single topic may have a greater effect and influence in that field than larger general-interest publications. It also suggests that as the field evolves, journals like European Urology, which publish fewer articles but get more citations per piece, will rise to prominence.

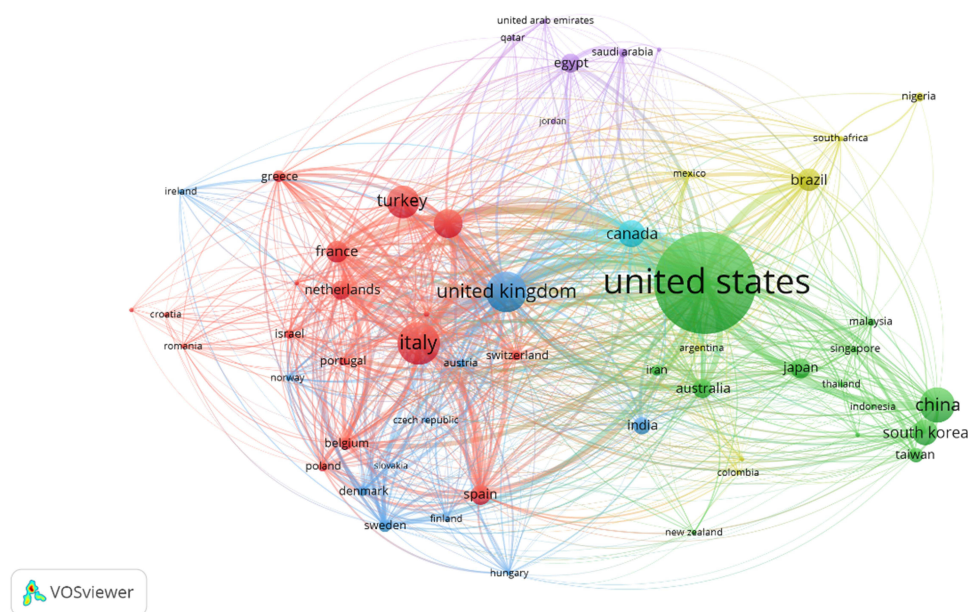
## Spatial Analysis

The top nations (N = 283) ranked by the quantity of articles are shown in Figure 3. The countries that have written papers focused on ED are represented by the red-green scale in this graph, while the nations without any publications in this field of study are represented by the white hue. The most productive nations are represented by the dark red hue, while the least productive nations are represented by the dark green color. With 4936, 1445, 1338, and 1100 scholarships, respectively, the latest studies of ED shows that the USA, Italy, the UK, and China are the most prolific nations. Additionally, findings show that among the top ten nations and across the board, universities in Italy and the USA have given the majority of the scholarships (39.52%) to advancing ED research. Table 2 also reveals that nine of the top ten (or 11, if the tenth spot is shared by two authors) researchers in this field are associated with academic organizations in the USA and Italy. Six have affiliations with various American universities.

Co-authored works on the subject are shown in Figure 4 and are organized according to nations. In VOSviewer, one of the most potent, rapid, and effective community recognition algorithms, we used association strength normalization



**Figure 3** Scientific production by country.



**Figure 4** Network of co-author collaborations based on country.

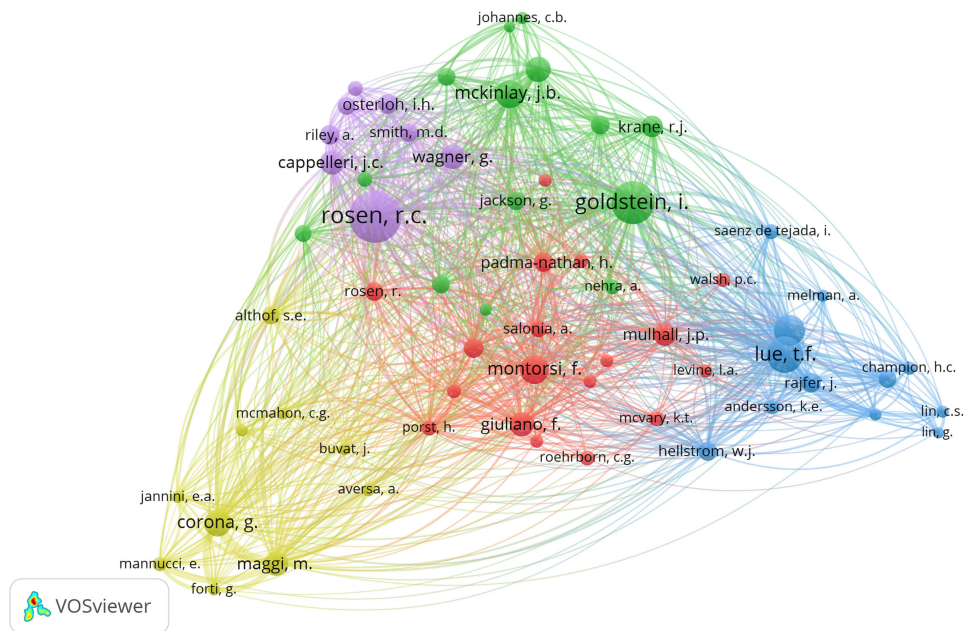
and ten iterations as a clustering technique to comprehend and disclose large and complex networks.<sup>28</sup> Using this tool and country collaboration, we discovered noteworthy networks among the authors. The minimum edges for author nationality wise collaborations were thought to produce 55 nodes (collaborative countries), with a minimum number of 20 co-authored articles demonstrating a significant level of country collaboration. The analysis produced six clusters with 892 links and a total strength of 9427. **Figure 4** demonstrates that almost all the collaboration masses were centered around four countries: USA (green); UK (dark blue), Italy (red), and Turkey (red). The USA and Italy lead the biggest two clusters cooperating with 53 and 49 countries, respectively. The third large cluster in the dataset is the UK cooperating with 53 nations, whereas Egypt is the leader of the fourth cluster with 40 nations. The existence of Canada (light blue) in **Figure 4** demonstrates the presence of a tiny cluster that collaborated effectively with other nations.

A co-citation network among scholars is a frequently used bibliometric tool that facilitates the comprehension of the links or interactions between authors. Co-citation, formerly known as “co-cited”, happens when a third author simultaneously cites two writers.<sup>29</sup> A map of this network places the most-cited writers geographically. To create a meaningful and understandable network, we required a minimum of 1000 co-citations for each author, and the results reveal that 62 out of 369,747 writers satisfied this requirement. Red, green, yellow, purple, and blue are the five distinct co-citation networks among the writers (**Figure 5**). Here, the nodes (with the author’s name) that are near together and share the same color speak to how similar the writers are.<sup>30</sup> The co-citation structure among the authors is inordinately scattered, as seen in **Figure 5**. The red cluster, the smallest in the dataset, is led by Montorsi and Giuliano, who have a disproportionately large number of citations in comparison to other clusters. The purple cluster co-citation network is headed by Rosen. Notably, this is our dataset’s top author (**Table 2**) and has one of the most often mentioned scientific contributions (**Table 3**). The research indicates that the top authors in each cluster share a great deal in common.

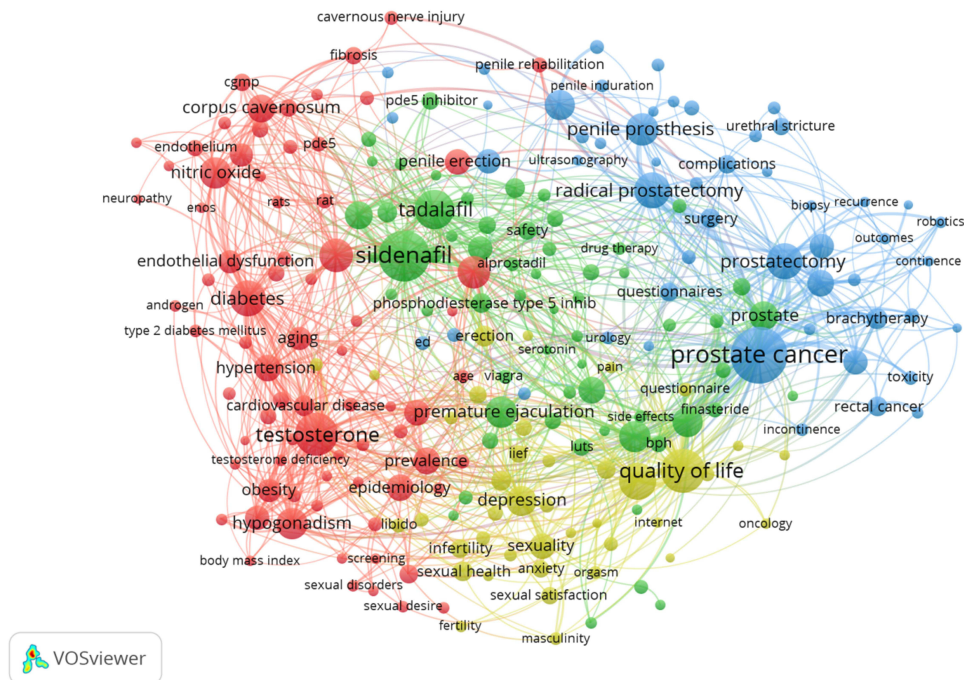
## Syntactic Network of ED Research

We utilized the keywords of the authors to prepare the syntactic network analyses where the lowest co-occurrence measured was five times. Findings show that out of 17,403 author keywords, only 1521 and 228 met the threshold of 5 and 25 times, respectively. “Erectile dysfunction” and some common words have been omitted to give other keywords a chance to appear in the syntactic network. The author keywords co-occurrence network (N = 228) was then evaluated and is shown in **Figure 6**, which aids in the identification of the most significant themes and their linkages. It was discovered that there were 5029 links between the terms, with a total link strength of 13,746. The amount of co-occurrence interconnection terms is referred to as





**Figure 5** Co-citation networking based on scholars.



**Figure 6** Co-occurrence network among author keywords.

a link, while the link strength refers to the overall number of connections and how strong the relationships are. If the strength number is higher, it indicates that there are strong links.<sup>31</sup> Mapping of author keywords revealed that 47 keywords (erectile dysfunction, prostate cancer, sildenafil, sexual dysfunction, testosterone, quality of life, impotence, penis, tadalafil, prostatectomy, diabetes, radical prostatectomy, sexual function, lower urinary tract symptoms, hypogonadism, vardenafil, nitric oxide, depression, risk factors, prevalence, benign prostatic hyperplasia, prostate, urinary incontinence, erectile function, penile prosthesis, prostatic neoplasms, premature ejaculation, metabolic syndrome, hypertension, epidemiology, corpus



## Discussion

Our bibliometric analysis revealed four key ED knowledge structure components. A temporal network analysis was used to determine how ED research has evolved over the past three decades, focusing on the average number of annual publications. The timeline shows that ED research is old, and researcher interest has grown over the past decade. Even though the first article on ED was published in 1945, the number of scholarly contributions has increased over the last century, reflecting the growing global burden of ED. Red keywords represent more recent additions to ED, while blue keywords appeared in 2002.

A source network analysis enabled us to identify the most famous writers, their impactful contributions, and the most used academic sources within the relevant time period. When other researchers comprehend the contributions of the most significant scholars and the impact they have had on a study field, they will have more opportunities to contribute.<sup>32</sup> Concurrently, this investigation contributes to the process of determining the important future sources of ED scholarship. It is possible that it will assist physicians and researchers in contributing to pertinent management concerns in a defined area of interest.<sup>33</sup>

Using spatial analysis, we determined the geographical distributions of authors, their linked institutions, and the nations that have participated in ED research through scientific production. This was done by identifying where academic contributions originated. Co-collaboration and co-citation also examine the links between contributors and their research, institutions, and countries. The high number of published studies implies that the contributions to ED are sufficient; nonetheless, greater investigation is needed in a range of areas, such as the development of new pharmacotherapies and regenerative medicine.<sup>34</sup> Moreover, the spatial distribution of the academic publications suggests that the expansion of this research is distributed globally. Moreover, the USA, Italy, and the UK have been identified as the top three contributing countries in the ED literature. Since the 1990s, there has been an extraordinary increase in the number of publications on geographical analysis, and spatial analysis has been incorporated into several academic fields.<sup>35</sup>

Finally, using syntactic network analysis, we were able to determine the most pertinent research themes and keywords that shaped the development of ED research and knowledge. This allowed us to point out the existing research areas as well as the potential future scope of contributions to the body of scientific knowledge pertaining to this field. Based on the findings of the investigation, it was discovered that writers of academic works on ED make use of a wide variety of keywords.

## Limitations of the Study

This bibliometric study had some limitations. First, we analyzed data from a single database (Scopus). Adding more significant databases will likely expand the scope of this evaluation. Second, our research focused only on English-language publications, and there may be a considerable number of ED studies in other languages that were not included. Third, our study focused only on peer-reviewed journal papers; including other publications such as books, book chapters, and so on would provide additional information. Fourth, our research omitted local periodicals that do not have internet access, which might have resulted in more valid conclusions. Finally, since the nature of the search keywords restricts the review's output, it is possible that if other words or texts, such as specific nation names, were included, the review's scope would be expanded.

## Conclusions

The chronology demonstrates that ED research is ancient and has increased in the last two decades. Montorsi, Maggi, and Mulhall are the most prolific authors. This research helps determine future ED scholarship sources. It may help doctors and researchers contribute to relevant management problems. The high number of published papers suggests that ED contributions are sufficient; nonetheless, further research is needed in areas like as novel pharmacotherapies. The spread of scholarly publications implies this study is worldwide. The USA, Italy, and the UK are the top three ED contributors. Since the 1990s, the quantity of publications on geographical analysis has skyrocketed, and spatial analysis has been incorporated into various academic domains. Using syntactic network analysis, we identified the most influential research topics and terms in ED. This allowed us to identify existing study fields and prospective scientific contributions in this discipline. According to the study, ED academic authors employ many keywords.

## Data Sharing Statement

The dataset used and analyzed during the current study is available from the corresponding author on reasonable request.

## Acknowledgments

The authors are grateful to the Saudi Digital Library for their generous support in providing full access to their database. The authors also extend their appreciation to the Deanship of Scientific Research, Jazan University, for supporting this research through the Research Unit Support Program (Support Number: RG-2-6).

## Funding

This research was funded by the Deputyship for Research and Innovation, Ministry of Education in KSA (grant number RG-2-6).

## Disclosure

The authors declare that they have no competing interests in this work.

## References

- Ismail AM, Abdelghany AI. Abdelghany, Effect of adding a 2-month consequent continuous and interval elliptical aerobic training to once-daily 5-mg tadalafil administration on erectile dysfunction in obese men. *Sexual Disabil.* **2022**;1:1–11.
- Ismail AMA. Erectile dysfunction: the non-utilized role of exercise rehabilitation for the most embarrassing forgotten post-COVID complication in men. *Aging Male.* **2022**;25(1):217–218. doi:10.1080/13685538.2022.2108013
- Rew KT, Heidelbaugh JJ. Erectile Dysfunction. *Am Fam Physician.* **2016**;94(10):820–827.
- Ismail AMA, Hamed DE. Erectile dysfunction and metabolic syndrome components in obese men with psoriasis: response to a 12-week randomized controlled lifestyle modification program (exercise with diet restriction). *Irish J Med Sci.* **2023**;3:1–7.
- Mazzilli F. Erectile dysfunction: causes, diagnosis and treatment: an update. *J Clin Med.* **2022**;11(21):6429. doi:10.3390/jcm11216429
- Aita G, Ros CTD, Lorenzini F, et al. Erectile dysfunction: drug treatment. *Rev Assoc Med Bras.* **2019**;65(9):1133–1142. doi:10.1590/1806-9282.65.9.1133
- Barbonetti A, D'Andrea S, Francavilla S. Testosterone replacement therapy. *Andrology.* **2020**;8(6):1551–1566. doi:10.1111/andr.12774
- Shamloul R, Ghanem H. Erectile dysfunction. *Lancet.* **2013**;381(9861):153–165. doi:10.1016/S0140-6736(12)60520-0
- Moreira ED, Bestane WJ, Bartolo EB, et al. Prevalence and determinants of erectile dysfunction in Santos, southeastern Brazil. *Sao Paulo Med J.* **2002**;120(2):49–54. doi:10.1590/S1516-31802002000200005
- Sayadi M, Elmafshar R, Razeghian-Jahromi I, et al. Detection of coronary artery disease by an erectile dysfunction questionnaire. *Cardiol Res Pract.* **2021**;2021:6647995. doi:10.1155/2021/6647995
- Lau DH, Kommu SS, Siddiqui EJ, et al. Gene therapy and erectile dysfunction: the current status. *Asian J Androl.* **2007**;9(1):8–15. doi:10.1111/j.1745-7262.2007.00224.x
- Maggio LA, Costello JA, Norton C, et al. Knowledge syntheses in medical education: a bibliometric analysis. *Perspect Med Educ.* **2021**;10(2):79–87. doi:10.1007/S40037-020-00626-9
- Huang CK, Neylon C, Brookes-Kenworthy C, et al. Comparison of bibliographic data sources: implications for the robustness of university rankings. *Quantit Sci Stud.* **2020**;1(2):445–478.
- Gasparyan AY, Kitas GD. Editorial strategy to get a scholarly journal indexed by Scopus. *Mediterr J Rheumatol.* **2021**;32(1):1. doi:10.31138/mjr.32.1.1
- Van Eck NJ, Waltman L. Text mining and visualization using VOSviewer. *arXiv.* **2011**. doi:10.48550/arXiv.1109.2058
- Lin H, Wang X, Huang M, et al. Research hotspots and trends of bone defects based on Web of Science: a bibliometric analysis. *J Orthopaed Surg Res.* **2020**;15(1):1–15. doi:10.1186/s13018-020-01973-3
- Spreng RN, Wojtowicz M, Grady CL. Reliable differences in brain activity between young and old adults: a quantitative meta-analysis across multiple cognitive domains. *Neurosci Biobehav Rev.* **2010**;34(8):1178–1194. doi:10.1016/j.neubiorev.2010.01.009
- Braun M, Wassmer G, Klotz T, et al. Epidemiology of erectile dysfunction: results of the 'Cologne Male Survey'. *Int J Impot Res.* **2000**;12(6):305–311. doi:10.1038/sj.ijir.3900622
- Kazemi E, Zargooshi J, Kaboudi M, et al. A genome-wide association study to identify candidate genes for erectile dysfunction. *Briefings Bioinf.* **2021**;22(4). doi:10.1093/bib/bbaa338
- Sansone A, Mollaioli D, Ciocca G, et al. Addressing male sexual and reproductive health in the wake of COVID-19 outbreak. *J Endocrinol Invest.* **2021**;44(2):223–231. doi:10.1007/s40618-020-01350-1
- Ghosh RC, Orchiston C, Mallick B. Climate migration studies in the Pacific (CMSP)-A bibliometric analysis. *Curr Res in Environ Sustainabil.* **2022**;4:100132. doi:10.1016/j.crsust.2022.100132
- Hatzimouratidis K, Amar E, Eardley I, et al. Guidelines on male sexual dysfunction: erectile dysfunction and premature ejaculation. *Eur Urol.* **2010**;57(5):804–814. doi:10.1016/j.eururo.2010.02.020
- Jonikowski P, Voors AA, Anker SD, et al. 2016 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure: the Task Force for the diagnosis and treatment of acute and chronic heart failure of the European Society of Cardiology (ESC). Developed with the special contribution of the Heart Failure Association (HFA) of the ESC. *Eur J Heart Fail.* **2016**;18(8):891–975. doi:10.1002/ehf.592
- Wang R. Physiological implications of hydrogen sulfide: a whiff exploration that blossomed. *Physiol Rev.* **2012**;92(2):791–896. doi:10.1152/physrev.00017.2011



25. Wilt TJ, Brawer MK, Jones KM, et al. Radical prostatectomy versus observation for localized prostate cancer. *N Engl J Med*. 2012;367(3):203–213. doi:10.1056/NEJMoa1113162
26. Snyder H. Literature review as a research methodology: an overview and guidelines. *J Busine Res*. 2019;104:333–339. doi:10.1016/j.jbusres.2019.07.039
27. Roldan-Valadez E, Salazar-Ruiz SY, Ibarra-Contreras R, et al. Current concepts on bibliometrics: a brief review about impact factor, eigenfactor score, citescore, scimago journal rank, source-normalised impact per paper, H-index, and alternative metrics. *Irish J Med Sci*. 2019;188(3):939–951. doi:10.1007/s11845-018-1936-5
28. Au-Yong-Oliveira M, Pesqueira A, Sousa MJ, et al. The potential of big data research in healthcare for medical doctors' learning. *J Med Sys*. 2021;45(1):1–14. doi:10.1007/s10916-020-01691-7
29. Benckendorff P. Themes and trends in Australian and New Zealand tourism research: a social network analysis of citations in two leading journals (1994–2007). *J Hospitality Tourism Manage*. 2009;16(1):1–15. doi:10.1375/jhtm.16.1.1
30. Van Nunen K, Li J, Reniers G, et al. Bibliometric analysis of safety culture research. *SafeSci*. 2018;108:248–258. doi:10.1016/j.ssci.2017.08.011
31. Guo Y-M, Huang Z-L, Guo J, et al. Bibliometric analysis on smart cities research. *Sustainability*. 2019;11(13):3606. doi:10.3390/su11133606
32. Gregor S, Hevner AR. Positioning and presenting design science research for maximum impact. *MIS Quarterl*. 2013;37(2):337–355. doi:10.25300/MISQ/2013/37.2.01
33. Gong B, Ma M, Xie W, et al. Direct comparison of tadalafil with sildenafil for the treatment of erectile dysfunction: a systematic review and meta-analysis. *Int Urol Nephrol*. 2017;49(10):1731–1740. doi:10.1007/s11255-017-1644-5
34. Yafi FA, Jenkins L, Albersen M, et al. Erectile dysfunction. *Nat Rev Dis Primers*. 2016;2(1):16003. doi:10.1038/nrdp.2016.3
35. de Queiroz AP. Spatial analysis: a bibliometric approach (1950–2019). *Earth Sci Inf*. 2021;14(1):277–289. doi:10.1007/s12145-020-00546-6

International Journal of General Medicine

Dovepress

## Publish your work in this journal

The International Journal of General Medicine is an international, peer-reviewed open-access journal that focuses on general and internal medicine, pathogenesis, epidemiology, diagnosis, monitoring and treatment protocols. The journal is characterized by the rapid reporting of reviews, original research and clinical studies across all disease areas. The manuscript management system is completely online and includes a very quick and fair peer-review system, which is all easy to use. Visit <http://www.dovepress.com/testimonials.php> to read real quotes from published authors.

Submit your manuscript here: <https://www.dovepress.com/international-journal-of-general-medicine-journal>