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A bibliometric analysis of penile cancer research

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Abstract

Background: The purpose of this study is to investigate the collaboration among countries, institutions and authors in the field of penile cancer research, as well as to identify the current hot topics in this area. **Methods**: Papers about penile cancer were retrieved from the Web of Science Core Collection (WoSCC). Bibliometric analyses were conducted using VOSviewer and CiteSpace to evaluate collaborations between different keywords, institutions, authors and countries in network maps. **Results**: 2891 articles related to penile cancer were included. The number of publications were gradually increasing the from 1991 to 2023. Journal of Urology (196 papers) owned the highest number of publications and Journal of Urology was the most co-cited journal. Simon Horenblas was identified as the top productive author with 98 papers and received a large number of citations (5383 co-citations) over the past decades. The United States emerged as the leading publisher in this field with 932 papers published. Cooperation between countries and between institutions was observed. The hot topics included matters mainly related to squamous-cell carcinoma, cancer, penile cancer, erectile dysfunction, men, penis and lymphadenectomy. **Conclusions**: This study utilized visualization tools to create a knowledge map of penile cancer research which provides new insights into its time series development context, research hotspots, knowledge network structure and major scholars' contributions in this field.

Keywords

Penile neoplasms; Erectile dysfunction; Bibliometric; Network maps; Squamous-cell carcinoma

Análisis bibliométrico de la investigación del cáncer de pene

Resumen

Antecedentes: El propósito de este estudio es investigar la colaboración entre países, instituciones y autores en el campo de la investigación del cáncer de pene, así como identificar los temas candentes actuales en esta área. **Métodos**: Los documentos sobre el cáncer de pene se recuperaron del Web of Science Core Collection (WoSCC). Se realizaron análisis bibliométricos utilizando VOSviewer y CiteSpace para evaluar colaboraciones entre diferentes palabras clave, instituciones, autores y países en mapas de red. **Resultados**: Se incluyeron 2891 artículos relacionados con el cáncer de pene. El número de publicaciones fue aumentando gradualmente de 1991 a 2023. Journal of Urology (196 artículos) poseía el mayor número de publicaciones y Journal of Urology fue la revista más cocitada. Simon Horenblas fue identificado como el autor más productivo con 98 artículos y recibió un gran número de citas (5383 co-citas) en las últimas décadas. Estados Unidos emergió como la principal casa editorial en este campo con 932 artículos publicados. Se observó la cooperación entre países e instituciones instituciones. Los temas más importantes incluyeron asuntos relacionados principalmente con el carcinoma de células escamosas, el cáncer, el cáncer de pene, la disfunción eréctil, los hombres, el pene y la linfadenectomía. **Conclusiones**: Este estudio utilizó herramientas de visualización para crear un mapa de conocimiento de la investigación del cáncer de pene que proporciona nuevos conocimientos sobre su contexto de desarrollo de series de tiempo, los puntos de interés de la investigación, la estructura de la red de conocimiento y las contribuciones de los principales investigadores en este campo.

Palabras Clave

Neoplasias del pene; Disfunción eréctil; Bibliometric; Network maps; Squamous-cell carcinoma

1. Introduction

A very uncommon malignant tumor of the male genitourinary system is penile cancer. It predominantly affects older males with an average age around 60 years old. Incidence increases with age peaking at approximately 70 years old. Penile cancer incidence varies widely across different regions with some developing nations experiencing higher rates—for example representing up to 10% of male malignancies in certain African and Asian countries [1]. The incidence rate in Europe and North America is less than 1/100,000 [2, 3]. Penile cancer has been linked to phimosis and prepuce overuse, which can result in a persistent inflammatory response in the prepuce and penile head. Other risk factors include multiple sexual partners, genital warts or other sexually transmitted diseases (STDs), some of which are linked to HPV (human papillomavirus) infection. However, due to its unique location, penile cancer can cause significant physical and psychological harm to the individual. Pathology plays a crucial role in diagnosing penile cancer. Squamous cell carcinoma (SCC), is the most common histological form of penile cancer [4]. Lymphatic metastasis is a common mode of metastasis for penile carcinoma; the primary path involves early spread to local femoral and iliac lymph nodes before progressing from superficial to deep pelvic lymph nodes. Surgery remains the main treatment for penile cancer [5]. Due to its rarity and limited research studies available, progress in diagnosis and treatment is slow.

Bibliometrics is a statistical technique used to evaluate the quantity and quality of published literature. VOSviewer (version 1.6.19, Centre for Science and Technology Studies, Leiden University, Leiden, The Netherlands) program was developed by Nees Jan Van Eck and Ludo Waltman at Leiden University Research Centre for Science and Technology in the Netherlands. It can be utilized to analyze research trends as well as cluster, overlay, density perspectives within literature [6, 7]. CiteSpace (version 6.1.R1, Chen Chaomei, Drexel University, Philadelphia, PA, USA) is a visual analysis program built on the Java programming language by Professor Chen Chaomei of Drexel University and his colleagues to examine prospective information found in scientific publications. CiteSpace performs quantitative analysis on pertinent literature using the bibliometrics theory and creates a number of visual maps. It is possible to identify research frontiers, hotspots and development patterns [8]. To gain a comprehensive understanding of the global development process in penile cancer research, it is essential to identify relevant researchers and institutions, assess the current status of research and characterize the trends in this field. In order to explore and summarize the current global research hotspots, frontiers, and trends in penile cancer, we conducted a bibliometric analysis of relevant literature published since the establishment of the global WoSCC database. Visual analysis was carried out using CiteSpace and VOSviewer software programs. This approach provides a scientific basis, fresh perspective and actionable insights for future research on penile cancer.

2. Methods

An online search was conducted from the WoSCC database on 31 December 2023. We used the search queries to retrieve research articles between 1970 and 2023: topic search (TS) = penile AND TS = (cancer OR tumor or carcinoma). The following criteria of papers were included: (1) The time span is between 1970 and 2023; (2) publications were indexed in WoSCC; (3) publications on study of penile cancer, including original research only; the following publications were excluded: editorial material (220 publications); early access (30 publications); book chapter (2 publications); reviews (519 publications); letters (79 publications); note (10 publications); news item (2 publications); meeting abstracts (469 publications); proceedings paper (77 publications); correction (7 publications); reprint (1 publications).

High-frequency keywords, research subjects such as authors, institutions, and countries were analyzed using VOSviewer 1.6.15 and CiteSpace based on our dataset. These operations produced knowledge maps that helped us understand co-occurrence patterns among different elements within the data set. Burst keyword identification was also conducted to identify emerging recurrent keywords. Additionally, individual networks were constructed for each year based on the top 100 cited or discovered publications. Depending on the parameters set while using CiteSpace to investigate the distribution of research hotspots at each step, the timeline view may display the trend of a field through time and reveal global penile cancer research hotspots at different times.

3. Results

In the end, 2891 papers met the search criteria. In Fig. 1, the number of papers by year was displayed. The total number of citations for publications is 72,996, and each piece has been cited an average of 25.25 times. The National Institutes of Health NIH USA, United States Department of Health and Human Services, NIH National Cancer Institute, National Natural Science Foundation of China (NSFC), European Commission, NIH National Institute of Allergy and Infectious Diseases, Merck Company, UK Research Innovation, Centers for Disease Control Prevention USA, Medical Research Council UK (MRC), National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK), *etc.* are some of the organizations that provided financial support for these published works.

3.1 Analysis of leading journals and cited journals

There have been 614 scholarly journals that have published articles regarding penile cancer altogether. The top 15 journals and most referenced articles related to penile cancer were shown in Table 1. The Journal of Urology had the highest number of published articles with 196 papers followed by Urology (109), Journal of Sexual Medicine (98), British Journal of Urology International (114) and Urologic oncology-seminars and original research (64). The most frequently referenced journal was Journal of Urology, which had 11,594 citations,

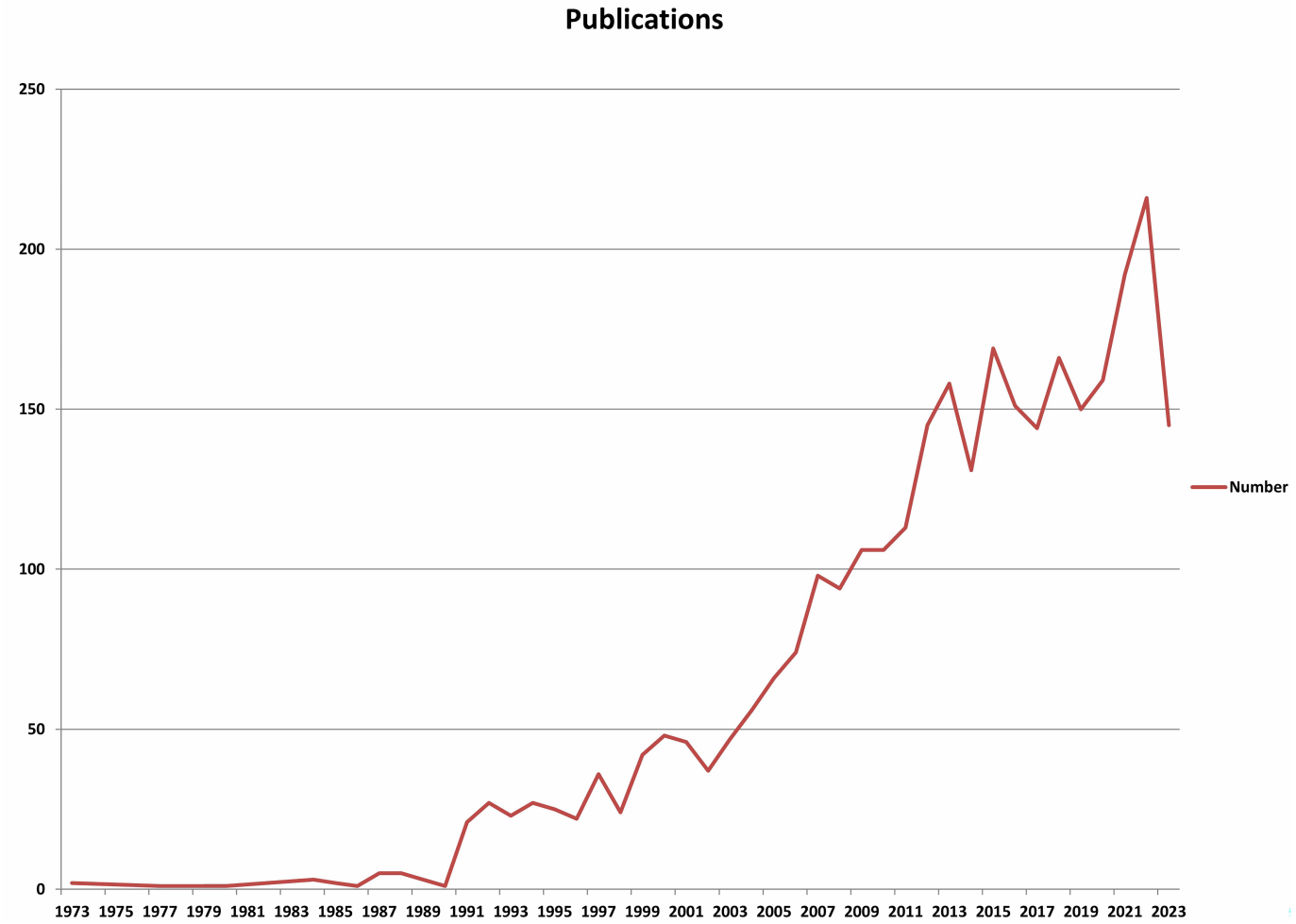


FIGURE 1. The number of publications changes with the year.

TABLE 1. The top 15 productive and cited journals on the research of penile cancer.

Ranking	Journal	Frequency	IF (2020)	Cited (times)
1st	Journal of Urology	196	7.450	11,594
2nd	British Journal of Urology international	114	5.588	3302
3rd	Urology	109	2.649	2565
4th	Journal of Sexual Medicine	98	3.802	2260
5th	Urologic oncology-seminars and original investigations	64	3.498	681
6th	European Urology	55	20.096	3623
7th	Urologe	54	0.639	170
8th	International Journal of Radiation Research	45	0.779	2198
9th	World Journal of Urology	44	4.226	1231
10th	Urologic clinics of north America	41	2.241	834
11th	Cancer	35	6.860	2408
12th	Progres en Urologie	34	0.915	125
13th	International journal of cancer	33	7.396	1953
14th	American journal of surgical pathology	30	6.394	1035
15th	International Braz J Urol	29	1.541	327
15th	PLOS ONE	29	3.240	666
15th	International journal of impotence research	29	2.896	453

IF: Impact Factor.

followed by European Urology (3623), British Journal of Urology International (3302), Urology (2565) and Cancer (2408).

3.2 Analysis of leading institutions and countries

A total of 90 countries and 3017 institutions were identified. The country collaboration network of penile cancer was observed (Fig. 2). Table 2 and Fig. 3 presented the top 15 countries contributing to penile cancer research. The USA contributed the most with the largest number of papers (932 papers) related to penile cancer research, followed by Germany (289 papers), Italy (229 papers), China (201 papers), England (199 papers), Netherlands (184 papers) and Brazil (158 papers). For link strength, the top five countries were USA (609), Germany (338), Netherlands (306), Italy (303), England (262) and France (237). Fig. 4 presented the institutions collaboration network of research on penile cancer.

TABLE 2. The top 15 productive and cited country on the research of penile cancer.

Ranking	Country	Frequency	Cited (times)
1st	USA	932	32,970
2nd	Germany	289	5053
3rd	Italy	229	6070
4th	People's Republic of China	201	1845
5th	England	199	6258
6th	Netherlands	184	9127
7th	Brazil	158	4096
8th	France	154	4915
8th	Canada	122	3392
10th	Spain	88	3246
11th	Japan	78	1044
12th	Sweden	69	2894
13th	Austria	67	1507
14th	Paraguay	63	2332
14th	Denmark	63	3044

3.3 Analysis of authors and co-cited authors

There were 11,621 writers in all found. The penile cancer author collaborative network was seen (Fig. 5). The top five most productive writers, in order of frequency, were Simon Horenblas (98 articles), Philippe E. Spiess (49 papers), Antonio L. Cubilla (42 papers), Oliver W. Hakenberg (40 papers) and Alcides Chaux (37 papers). Analysis was also done on the author citation data. In terms of number of citations, the top five authors with the most co-citations were Simon Horenblas (5383), Morten Frisch (1589), Nubia Muoz (1449), Chris JLM Meijer (1344) and Peter JF Snijders (1317) (Table 3).

TABLE 3. The most productive authors on the research of penile cancer (Top 15).

Ranking	Author	Publications Numbers	Cited (times)
1st	Simon Horenblas	98	5383
2nd	Philippe E Spiess	49	806
3rd	Antonio L Cubilla	42	1065
4th	Oliver W Hakenberg	40	733
5th	Alcides Chaux	37	973
5th	Chris Protzel	37	626
7th	Yao Zhu	35	522
8th	Asif Muneer	32	555
9th	Hui Han	28	269
10th	Kai Yao	26	276
11th	Ding-wei Ye	25	417
12th	Nick Watkin	24	868
13th	John P Mulhall	23	531
14th	Gustavo C Guimarães	22	404
14th	Ademar Lopes	22	798
14th	Anna R Giuliano	22	985
14th	Curtis A Pettaway	22	727

3.4 Analysis of co-occurring keywords and burst term

A total of 6695 keywords were identified and the collaboration network of penile cancer as the presented in Fig. 6. The main hot topics were cancer (795), squamous-cell carcinoma (603), penile cancer (539), erectile dysfunction (258), men (253), penis (250), lymphadenectomy (246), management (234), survival (220), prostate cancer (196), prevalence (185) and penile neoplasms (175).

These words were classified into 8 large clusters: "human papillomavirus", "penile cancer", "erectile dysfunction", "penile squamous cell carcinoma", "neoadjuvant chemotherapy", "urogenital system", "HPV vaccine" and "surgical management". The timeline view from 1990 to 2023 is depicting the keyword time evolution of each cluster, from the initial research focus on "epidemiology, human papillomavirus" to the current research dimension of "neoadjuvant chemotherapy, biomarker, programmed death-ligand 1 (PDL-1), sexual function" research changes. Fig. 7 shows the changes of high-frequency keywords cited in different periods.

3.5 Co-cited references and burst references

We presented the top 9 co-cited references on penile cancer. 5 articles (Bhasin 1992; Parkin 2006, Frisch 2000, Frisch 2001 and Smeets 2007) were co-cited more than 500 times, 4 articles (catalona 1999; welsh 2008; castellsague 2002 and kundu 2004) were co-cited between 400 and 500 times, and 22 articles were also co-cited more than 200 times.

Fig. 8 presented the top 25 references with the strongest citation bursts. Among them, the first reference with citation

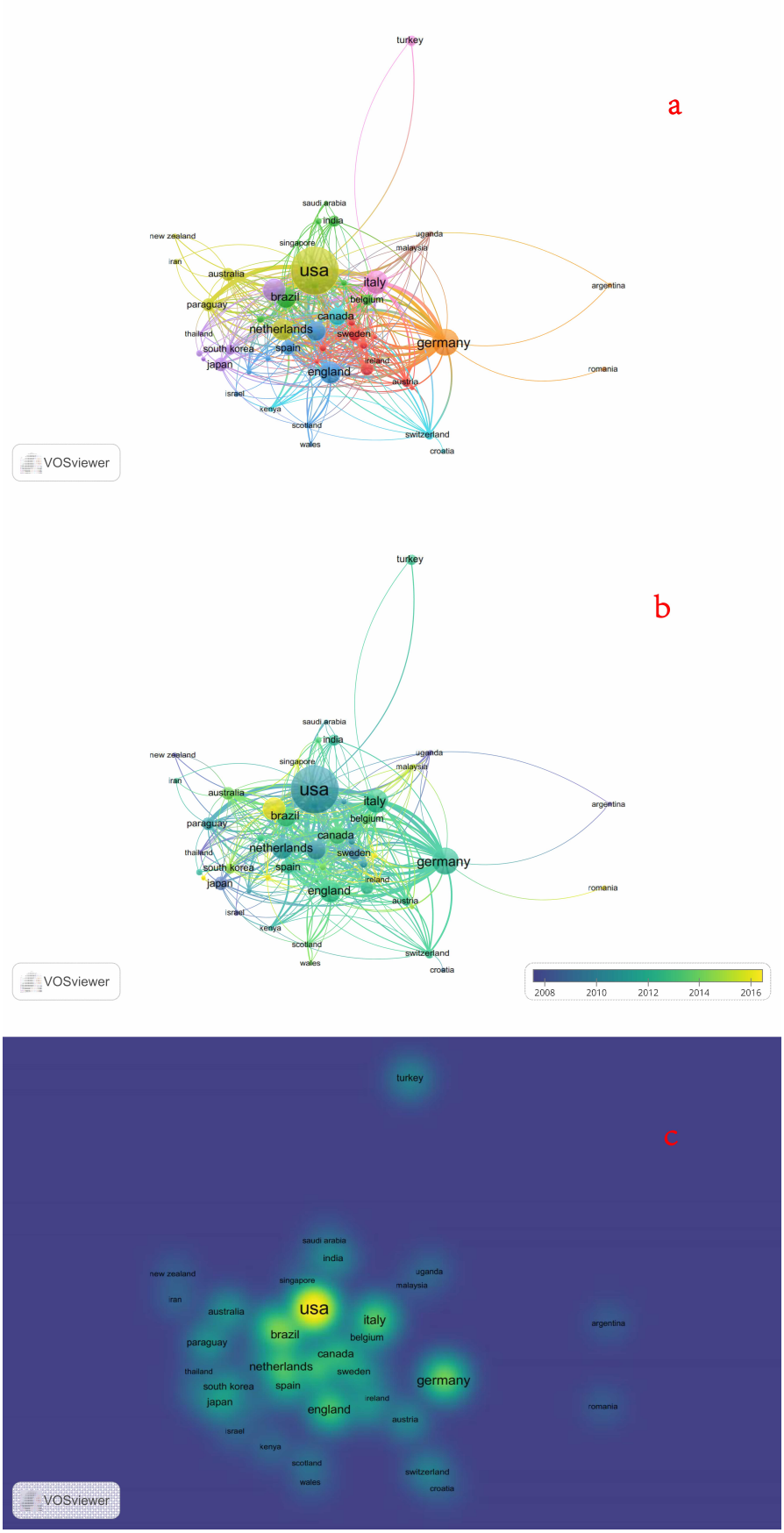


FIGURE 2. The font size represents the number of papers. (a) The country collaboration network of research on penile cancer; (b) different colors inside the circle represent different time intervals; (c) the brighter the color, the more publications for country.

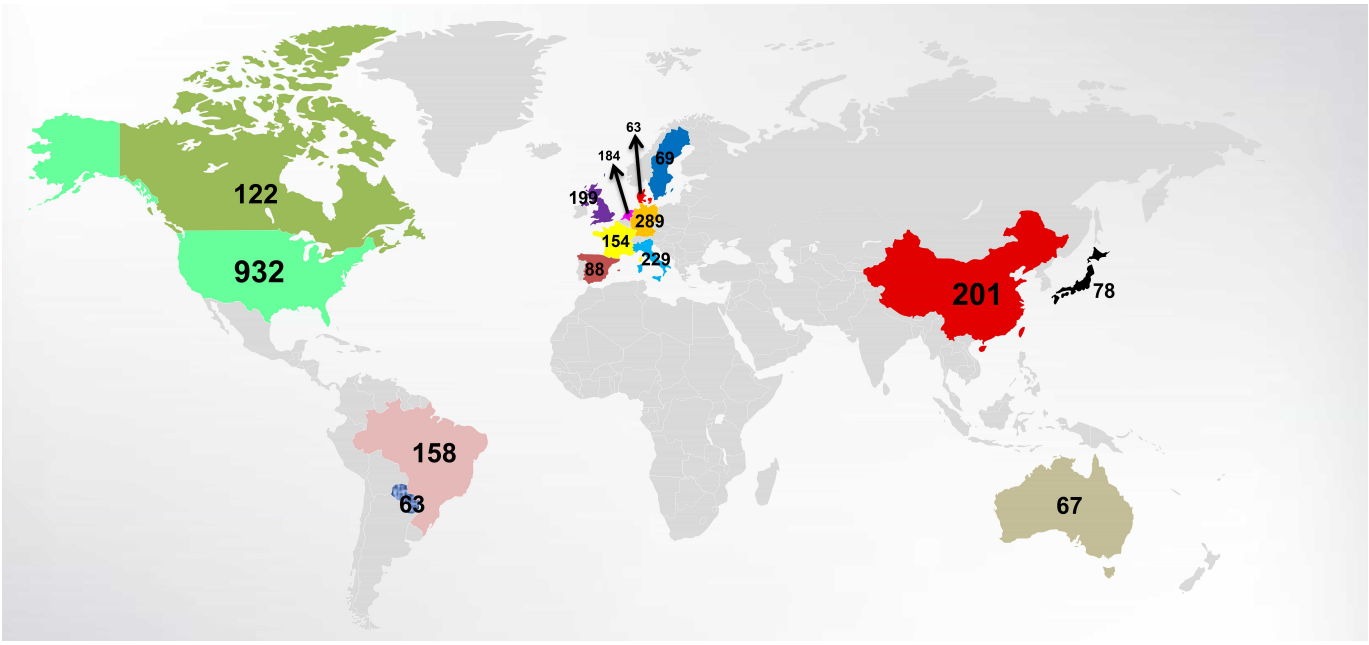


FIGURE 3. The distribution of the world's top 15 paper contributors on study of penile cancer.

bursts appeared in 1984 [9]; Most of the articles appeared citation between 1987 and 2001.

4. Discussion

Penile cancer poses a challenge for many practitioners due to its relatively small patient population. Consequently, various fields have focused on diagnosing and treating this rare tumor. Which nations, cities and organizations are currently conducting active research on penile cancer? How do individuals within this group communicate with one another? What are the current hot topics in research? Answers to these questions not only provide comprehensive knowledge about researchers' composition and changing characteristics in publishing research but may also aid in understanding its developmental patterns and evolutionary trends. This study is pioneering as it examines penile cancer using both quantitative and qualitative bibliometric approaches based on a total of 2891 publications.

With 932 papers published, the United States led all other countries in the field as a publisher, followed by Germany, Italy, China, England and the Netherlands. The top five nations were all developed nations centered in America, Europe and Asia. In spite of the fact that developing nations in regions with a high prevalence of penile cancer, such as Africa and Asia, only China is from Asia among the top 10 nations, and the published literature is generally less mentioned. In order to catch up to the United States and Europe in this area, we need to take the following steps: (a) To increase financing for scientific research and to acknowledge the widespread occurrence of penile cancer in developing countries. The government and media will carry out related missions and education. (b) Strengthen the cooperation between various domestic and various research units and regions. (c) To improve communication and collaboration with established worldwide scientific research teams. Teams working on research have poor connectivity at the moment. In addition to being necessary for the growth of disciplines, improving team communication also fosters higher-quality research.

The distinctive temporal distribution of a discipline's publications can be used to observe a discipline's development tendency across time. Meanwhile, the volume and rate of scientific literature growth may be a good indicator of the level of theory and the rate of development in this area of research. The findings of this study show distinct trends in the volume of publications throughout time. After an early stage and development stage, there has been consistent publications on this study topic over the last ten years. The Journal of Urology published the most articles followed by BJU-International, Urology, and Journal of Sexual Medicine, *etc.*, which are reputable journals focused on urology and andrology topics. Published journals are highly focused. We are aware that the research reported in these articles is of the highest caliber.

The author with the most articles on penile cancer and the most citations is Simon Horenblas. Following Philippe E Spiess, Antonio L Cubilla, Oliver W Hakenberg and Alcides Chaux were the top five most productive authors, and they have cooperative relationships [10–12]. International research teams were found to be mostly concentrated in the andrology and urology departments of university teaching hospitals in the United States and Europe, with the distribution of the teams showing distinct regional characteristics. It is proposed that research teams from diverse fields strengthen their collaboration and exchanges in order to fully leverage the demographic advantages of developing countries and the technical advantages of established countries.

In order to locate the hotspots and research areas of interest in a certain topic, people usually employ keywords, which are the author's condensed and highly concentrated essential ideas and thoughts of the piece. As the analytic object, high-frequency keywords are very helpful. In this study, the high-frequency keywords included cancer, squamous-cell carcinoma, penile cancer, erectile dysfunction, men, penis, lym-

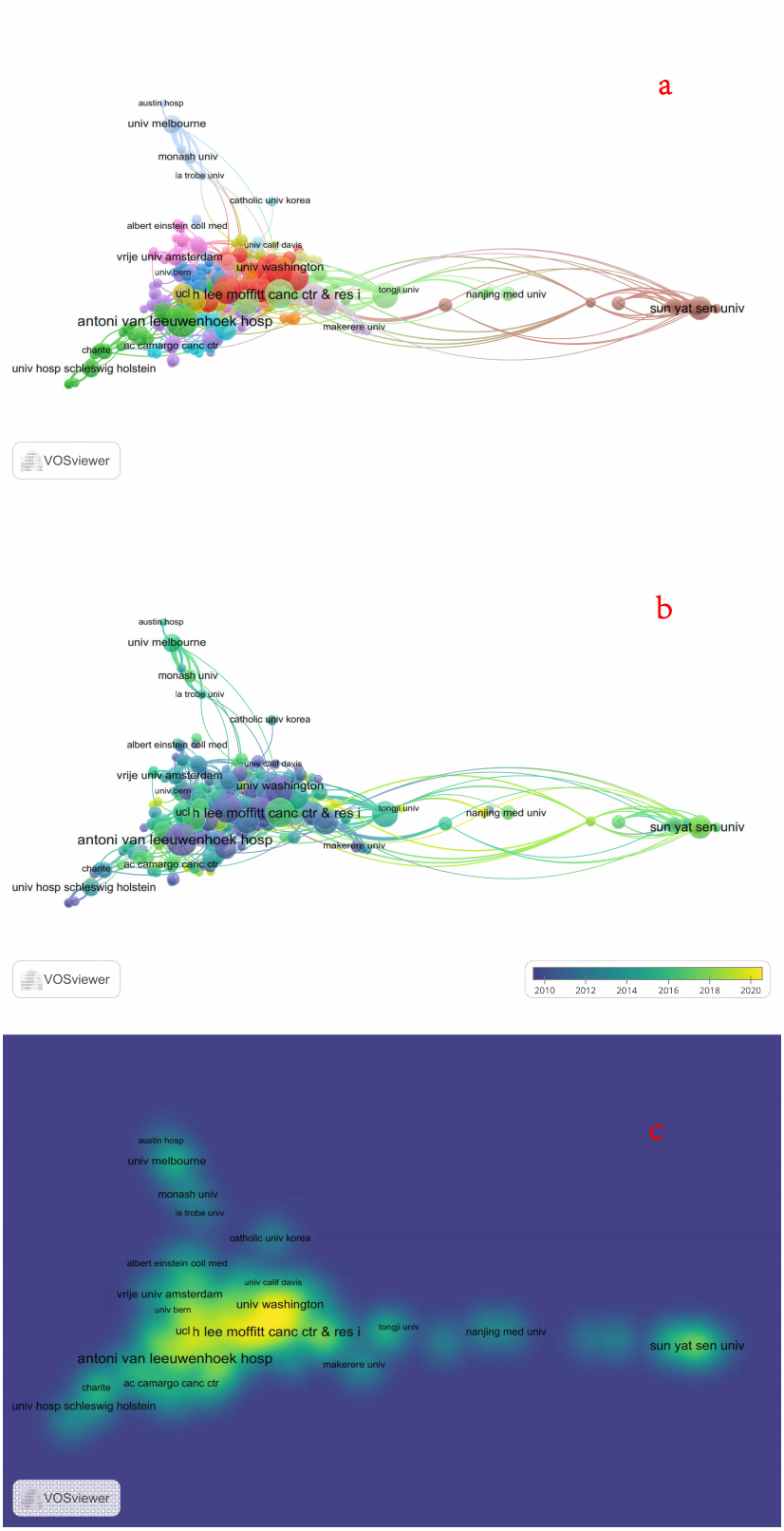


FIGURE 4. The font size represents the number of publications. (a) The institutions collaboration network of research on penile cancer; (b) different colors inside the circle represent different time intervals; (c) the brighter the color, the more publications for institutions. astin hosp: Austin hospital; univ melbourne: University of Melbourne; monash univ: Monash University; la trobe univ: la trobe university; catholic univ korea: The Catholic University of Korea; albert einstien coll med: Albert Einstein College of Medicine; virje univ amsterda: Vrije Universiteit Amsterdam; univ calif davis: University of California, Davis; univ bern: University of Bern; H Lee moffitt canc ctr & res i: H Lee Moffitt Cancer Research Center; univ Washington: University of Washington; tongji univ: Tongji University; Nanjing med univ: Nanjing Medical University; sun yat sen univ: Sun Yat-sen University; antoni van leeuwenhoek hosp: Antoni Van Leeuwenhoek Hospital; makerere univ: Makerere University; ac Camargo canc ctr: A.C.Camargo Cancer Center; univ hosp schleswig holstein: University Hospital Schleswig Holstein.

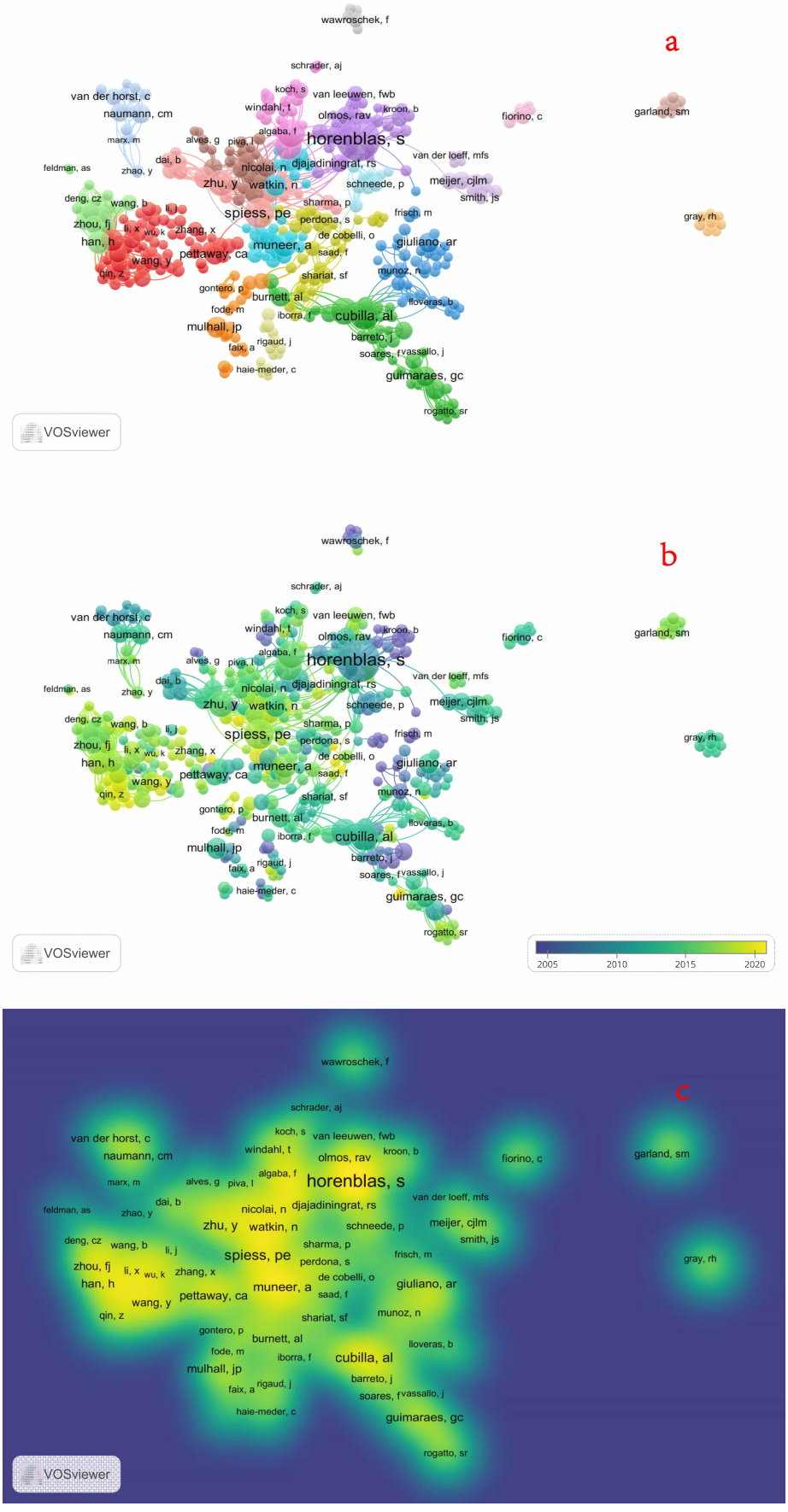
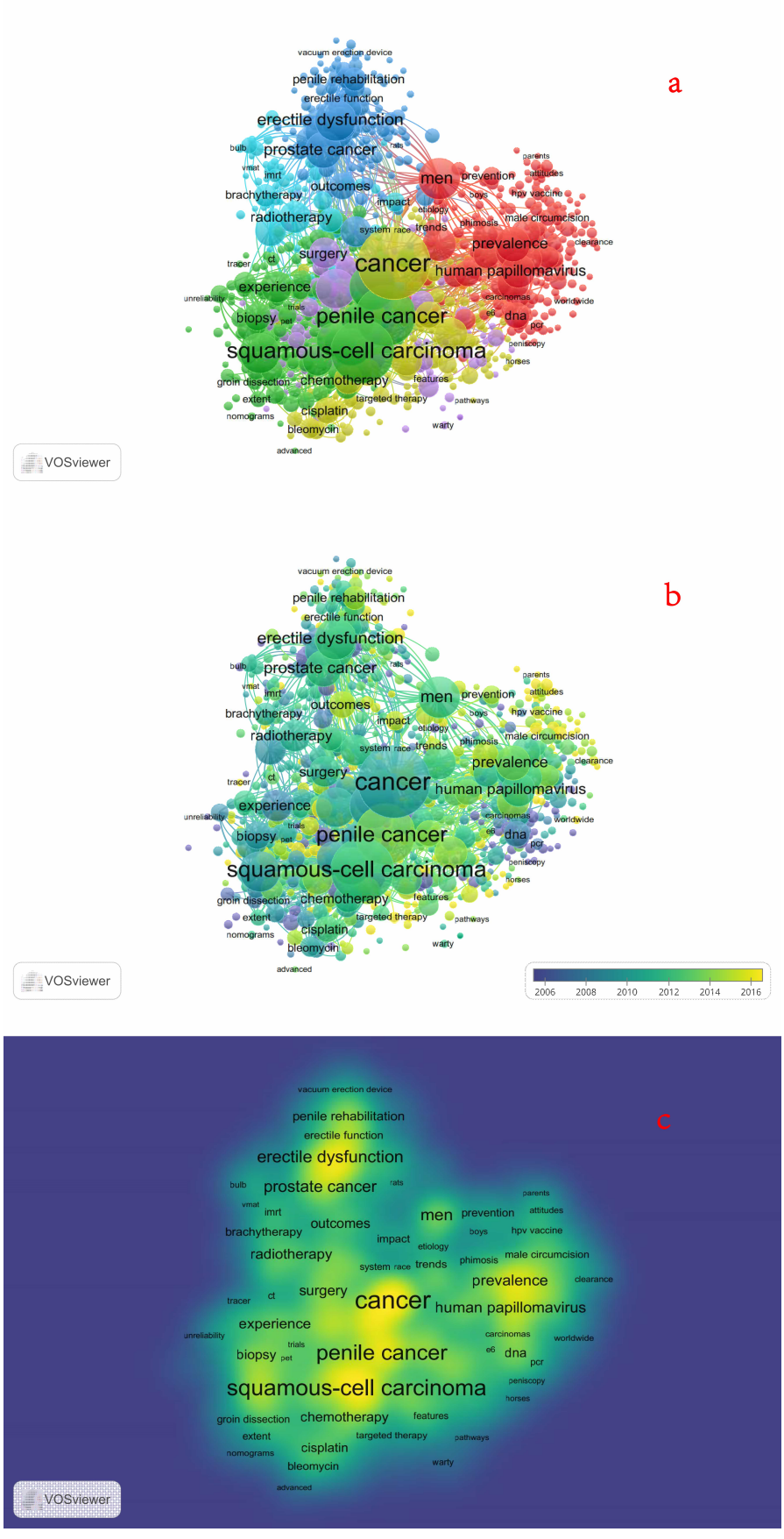


FIGURE 5. The font size of every author represents the number of publications. (a) The authors collaboration network of research on penile cancer; (b) different colors inside the circle represent different time intervals; (c) the brighter the color, the more publications for authors.



F I G U R E 6. The font size of each key word represents the number of publications. (a) The keywords collaboration network of research on penile cancer, and the same color represents the same cluster; (b) different colors inside the circle represent different time intervals; (c) the brighter the color, the more publications about keywords. ct: computed tomography; vmat: volumetric-modulated arc therapy; imrt: intensity-modulated radiation therapy; dna: deoxyribonucleic acid; pcr: polymerase chain reaction.

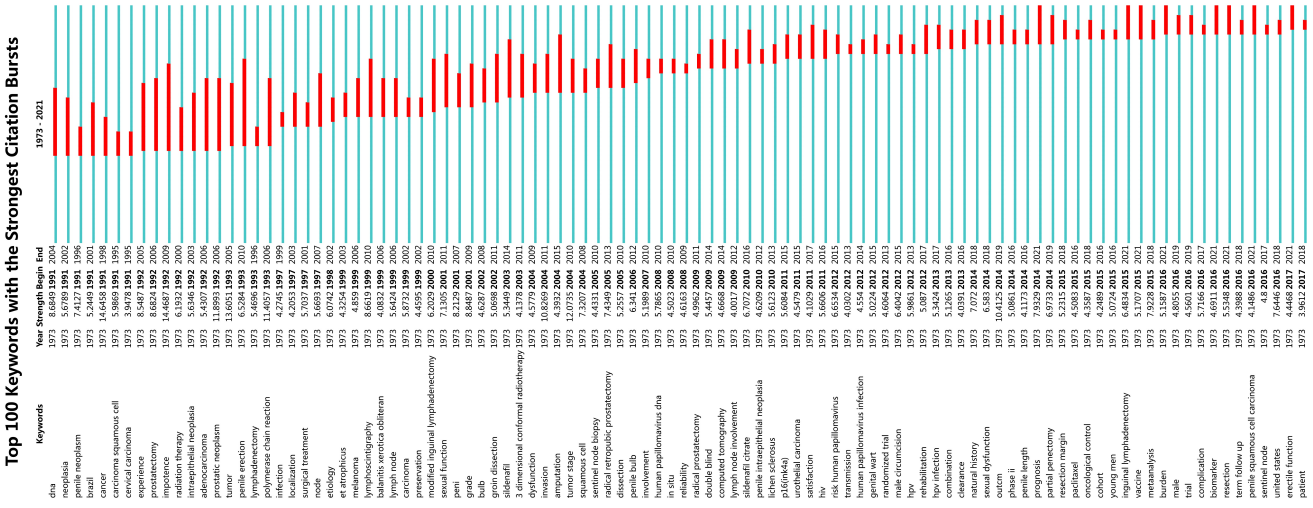


FIGURE 7. The top 100 keywords with the strongest citation bursts in the co-citation network.

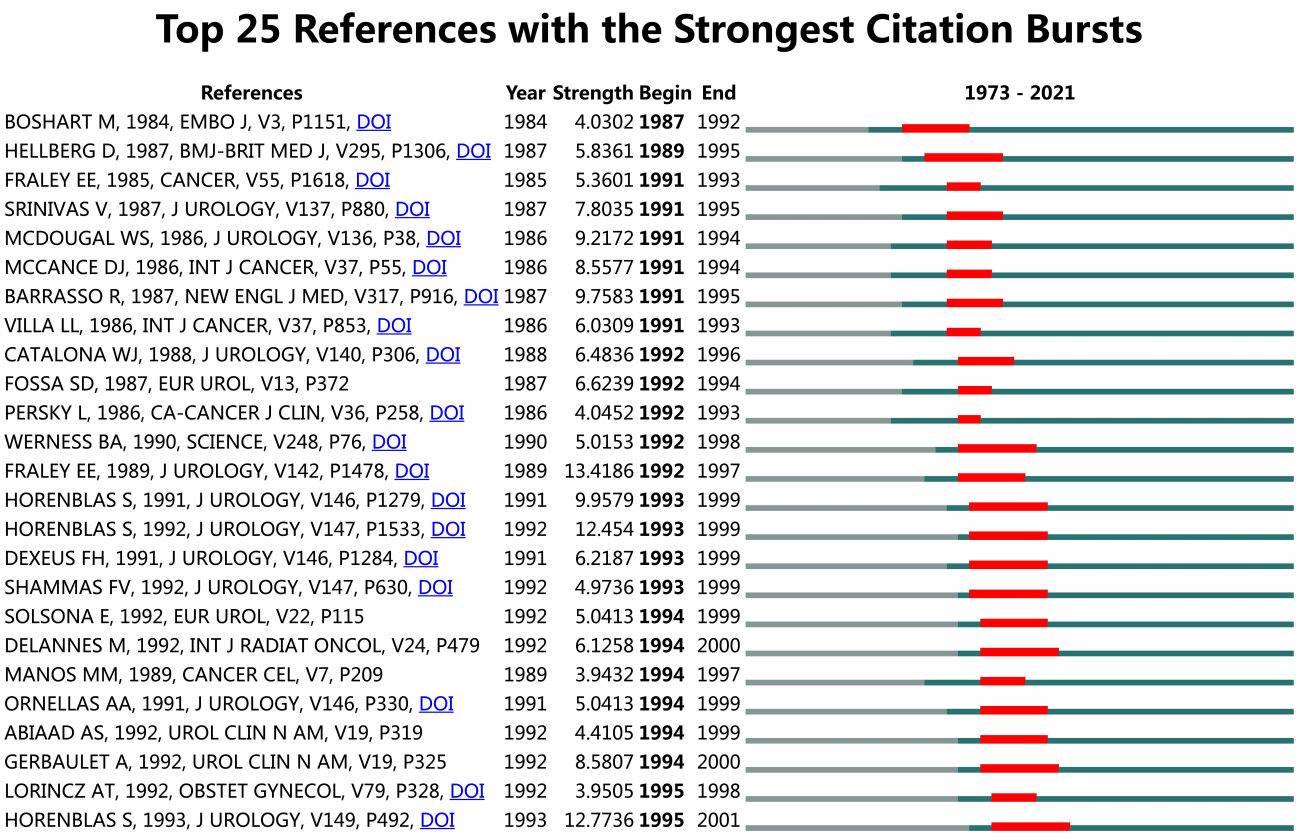


FIGURE 8. In the co-citation network show the top 25 references with the strongest citation bursts.

phadenectomy and management [13–16], indicating a focus on lymphadenectomy and erectile dysfunction (ED) due to penile cancer. Keyword cluster timeline map presented the key word time evolution of each cluster, from the initial study focus on "epidemiology, human papillomavirus" to the current research dimension of "neoadjuvant chemotherapy, biomarker, PDL-1, sexual function" changes [17–21]. This shows that current treatment-level research on penile cancer is being conducted, whereas erectile function research is receiving increasing attention. By utilizing frequent search terms from previous years, researchers can locate relevant studies on penile cancer.

The main research frontiers and hotspots in the field of penile cancer were identified as a result of this study, which also objectively analyzed the temporal and spatial distribution characteristics of domestic papers on penile cancer and provided a crucial reference for accurately understanding the status and development trend of penile cancer research. Despite the fact that China has a large number of research publications published in this field, there is now little institutional interaction and it is still in a precarious position. The discipline

must advance, cooperation and exchanges must be encouraged, and future research hotspots and frontiers must be regularly watched. It is recommended that several departments increase their financial support for research in this area in order to establish the groundwork for promoting penile cancer diagnosis and treatment and making significant advancements.

This article's analysis was based on publications from the WoSCC database. It's probable that certain papers from other databases were left out, which could lead to bias in the selection process. Other restrictions are largely those intrinsic to the bibliometric design of the study, such as the fact that the quantity of citations does not necessarily indicate the caliber of the articles and that citations may be deceptive in and of themselves.

5. Conclusions

Since 1991, there have been fast more publications in this discipline than there have been over the last ten years. The fact that the USA was the industry leader and the majority of the other top nations were from industrialized regions tremendously aided the study of penile cancer. The current research hotspots are neoadjuvant chemotherapy, biomarker, PDL-1 and sexual function. In general, surgery is the major treatment for penile cancer, and PDL-1 offers a fresh approach to the disease. Therefore, we still need to pay attention to this population, aggressively conduct clinical research and advance the detection and treatment of penile cancer.

AVAILABILITY OF DATA AND MATERIALS

The data presented in this study are available on reasonable request from the corresponding author.

AUTHOR CONTRIBUTIONS

PZ and CQM—designed the research study and conducted data collection. CQM—performed the research; analyzed the data; criticized the manuscript before submission. PZ—wrote the manuscript. Both authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

ACKNOWLEDGMENT

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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