

Research Progress on Acupuncture Therapy in Infertility: A Bibliometric Analysis from 2000 to 2021

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Abstract

Objective: To investigate the research progress and new trend of acupuncture in the treatment of infertility from 2000 to 2021. **Methods:** The literature review was conducted on acupuncture and moxibustion treatment of infertility from 2000 to 2021 from the Web of Science core collection and PubMed. CiteSpace and VOSviewer were used to analyze the annual number of articles, countries, institutions, authors, journals, references and keywords. Statistical Analysis Toolkit for Informetrics 3.2 (SATI) and IBM SPSS Modeler 18.0 were employed to draw the maps of core acupoints and acupuncture approaches. **Results:** A total of 316 articles were included. From 2000 to 2021 the number of publications has been ever increased with certain fluctuations. The United States was the most productive country. Heilongjiang University of Chinese Medicine was the most active institution. Stener-Victorin E was the highest cited author. Fertility and Sterility was the most prolific journal. Paulus We, 2002 was the highest co-citation literature. SP6 (Sanyinjiao) was the most commonly used acupoint. Manual acupuncture was the most commonly used method. **Conclusions:** The study of acupuncture in the treatment of infertility is characterized by multinational, multi-institutional participation and close regional cooperation. Acupuncture is a potentially effective therapy for infertility. Due to a lack of research quality and difficulties in performing double-blind, high-quality clinical evidence is urgently required. A complete acupuncture therapy system for infertility should be gradually constructed.

Keywords

Acupuncture, Infertility, Bibliometric Analysis, CiteSpace, VOSviewer

1. Introduction

Infertility is characterized by the inability to establish a clinical pregnancy after 12 months of regular and unprotected sexual intercourse. It is estimated that 8% - 12% of couples of childbearing age suffer from infertility, which not only exerts a serious impact on the psychosocial health of couples and their families [1] [2], but also induces potential adverse consequences on the health of future generations [3].

The global census shows that infertility is still a persistent reproductive problem. In China, the prevalence rate of infertility in couples of childbearing age is 25%, and almost half of infertile couples do not seek medical assistance [4] [5]. However, accurate and effective treatment is still urgently required and common diagnosis and treatment decisions are lacking [6]. Reactive oxygen species (ROS) have been shown to be efficacious in the treatment of infertility [7], whereas high levels of ROS can lead to inactivation of enzymes and protein oxidation in spermatozoa, resulting in infertility. Hormone therapy can correct gonadal dysfunction, but multiple pregnancy is still an important complication [8].

Acupuncture has been proven to have potential efficacy for infertility. A survey of the websites of assisted reproductive clinics in the U.S. found that 111 of 456 clinics recommended the use of acupuncture with a high degree of recognition [9]. At present, accumulated studies have shown the beneficial effects of acupuncture, including increasing the pregnancy rate of patients with polycystic ovary syndrome (PCOS) infertility [10], increasing the maximum follicular diameter [11], elevating ovulation rate and endometrial thickness [12], and mitigating anxiety [13]. Clinical randomized controlled trials (RCT) show that acupuncture can improve body mass index (BMI), decrease luteinizing hormone (LH) level and increase ovulation response in patients with PCOS infertility. The efficacy of acupuncture for infertility may ascribe to the changes in the activity of the autonomic nervous system and stimulation of neuropeptides or neurotransmitters related to the pathogenesis of infertility [14], which is a potentially effective treatment of infertility.

Bibliometric analysis has been widely utilized to analyze published scientific literature. In recent years, bibliometric analysis has been increasingly conducted regarding the research progress and trend of global acupuncture treatment of depression [15], tumor [16], obesity [17] and knee osteoarthritis [18]. However, bibliometric analysis of acupuncture in the treatment of infertility has not been carried out. Therefore, this study was designed to evaluate the research trend of acupuncture and moxibustion for infertility through bibliometric analysis by using CiteSpace and VOSviewer based on the co-occurrence network of countries, institutions, authors, journals, references, keywords, the highest frequency of acupoints and acupuncture methods from 2000 to 2021.

2. Materials and Methods

2.1. Literature Review

All data were obtained from the Web of Science core database and PubMed on

February 11, 2022. The search words were “infertility” and “acupuncture” (**Table 1**). The search period was from January 1, 2000 to December 31, 2021 not limited to categories, languages or document types. The search results were analyzed by CiteSpace and VOSviewer.

2.2. CiteSpace Bibliometric Analysis

CiteSpace (Version 5.6.R4) constructs a visual knowledge map to represent references, institutions, authors and countries [19] [20]. The links between map nodes represent cooperation or collaborative relationship, the colors of nodes and lines represent different years, and purple circles represent centrality. The parameters of CiteSpace are set as follows: 1) Time span (2000-2021), years per slice; 2) one node type is selected at a time; 3) selection criteria top 50 objects; 4) pathfinder and pruning sliced networks; 5) look back years (LBY = 8), 6) ink retaining factor (LRF = 2), 7) percentage of nodes to label (PNL = 5%), 8) maximum links per node (MLPN = 10), 9) e for top N (e = 2).

2.3. VOSviewer Bibliometric Analysis

VOSviewer (Version 1.6.14) is employed to analyze the co-occurrence knowledge graph of citation networks of countries, institutions, periodicals and documents [21] [22]. A node represents an element, such as countries, institutions, authors, journals, references and keywords. To ensure unity, the top 50 objects are selected for each element. The greater the link width between nodes is, the closer the cooperation relationship is, and the size of nodes indicates the number of elements represented. The node with high centrality represents the turning point or pivot point related to this field, which is represented by purple.

Two authors independently searched the references and screened these articles. Any differences were resolved by discussing or seeking the help of the third author. A total of 329 articles were identified (**Table 1**). Literature and result analyses indicated that there was no repetition of the literature.

3. Results

3.1. Annual Publications and Trends

From 2000 to 2021, although there were some fluctuations in the number of publications on acupuncture and moxibustion treatment of infertility in the Web of Science, the overall number showed an increasing trend (**Figure 1**). It is predicted that publication output will continue to expand in the future.

3.2. Literature Type Analysis

A total of 329 articles were derived from WOS and reused with Citespace. Finally, 316 articles (**Table 2**) were obtained, and 7 literature types were found. Article (n = 211) was the most frequent literature type, accounting for 66.77%, followed by Review Article (n = 85, 26.89%). “*Influence of acupuncture on the pregnancy*

rate in patients who undergo assisted reproduction therapy [23]” was the most frequently-cited article, with a total of 67 citations. The most frequently cited review was “A systematic review and meta-analysis of acupuncture in in-vitro fertilisation [24]” published by El-Toukhy, T., which is cited 68 times.

Table 1. Literature searching queries.

Set	Result	Search Query
#1	27,744	(TS = ((Acupuncture) OR (Pharmacopuncture) OR (Acupotomy) OR (Acupotomies) OR (Electroacupuncture) OR (Electro-acupuncture) OR (Moxibustion) OR (Acupoints) OR (Meridian))) Indexes = Web of Science, Timespan = 2000-2021
#2	108,405	(TS = ((Infertility) OR (Infertile) OR (Sterile) OR (Reproductive Sterility) OR (Sub-Fertility) OR (Subfertility))) Indexes = Web of Science, Timespan = 2000-2021
#3	346	#1 AND #2

Table 2. Literature types related to acupuncture for infertility.

Ranking	Type	Counts (%)
1	Article	211 (66.77%)
2	Review Article	85 (26.89%)
3	Editorial Material	9 (2.84%)
4	Proceedings Paper	4 (1.26%)
5	Letter	4 (1.26%)
6	Book Chapter	4 (1.26%)
7	Early Access	1 (0.31%)

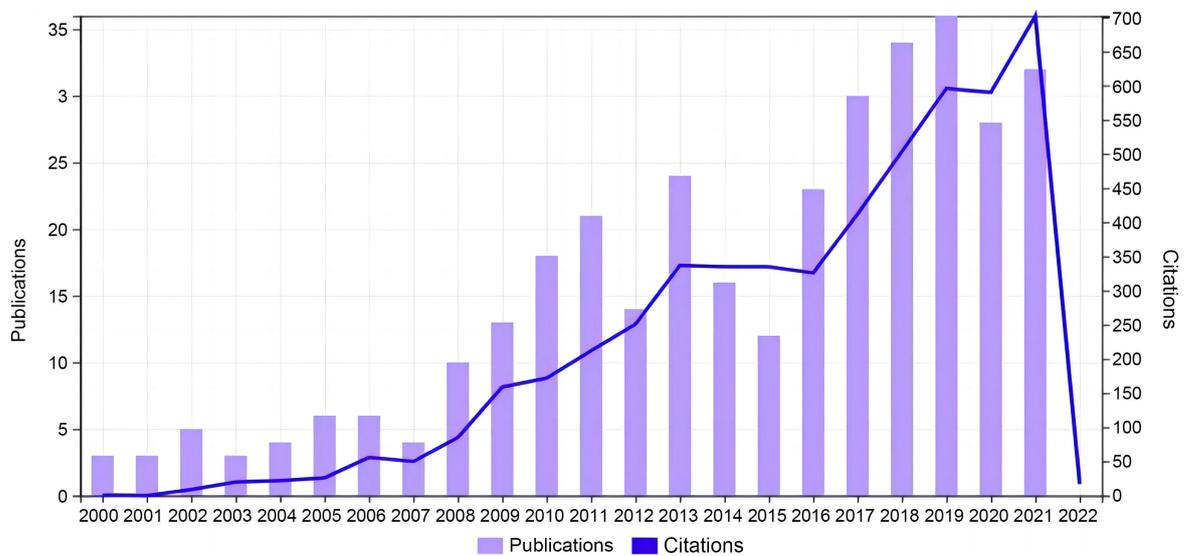
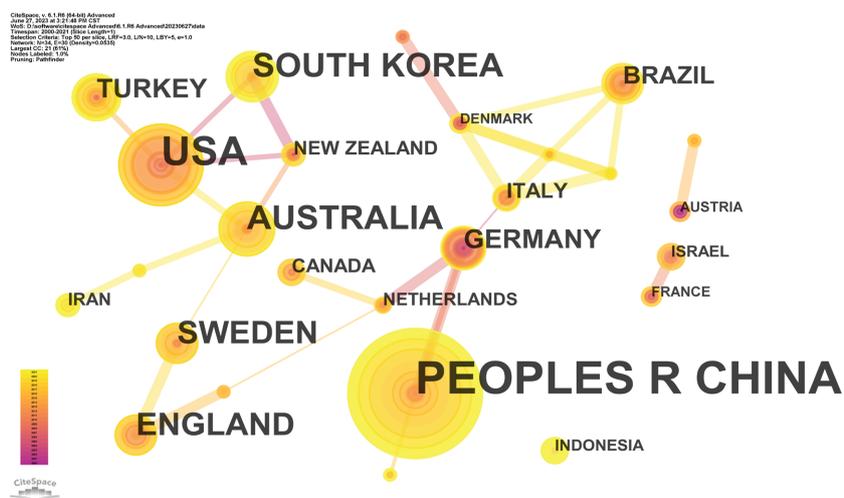


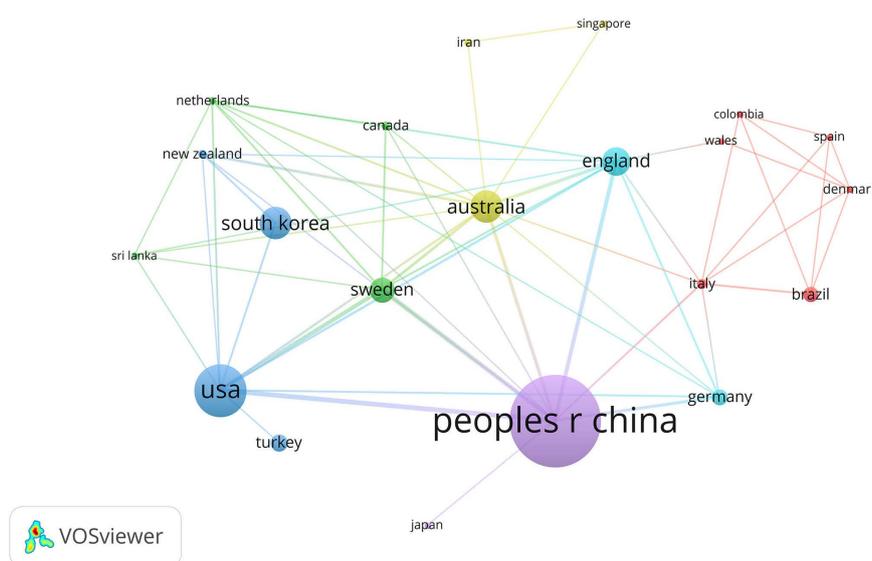
Figure 1. The annual number of publications and citations related to acupuncture for infertility.

3.3. Analysis of Countries

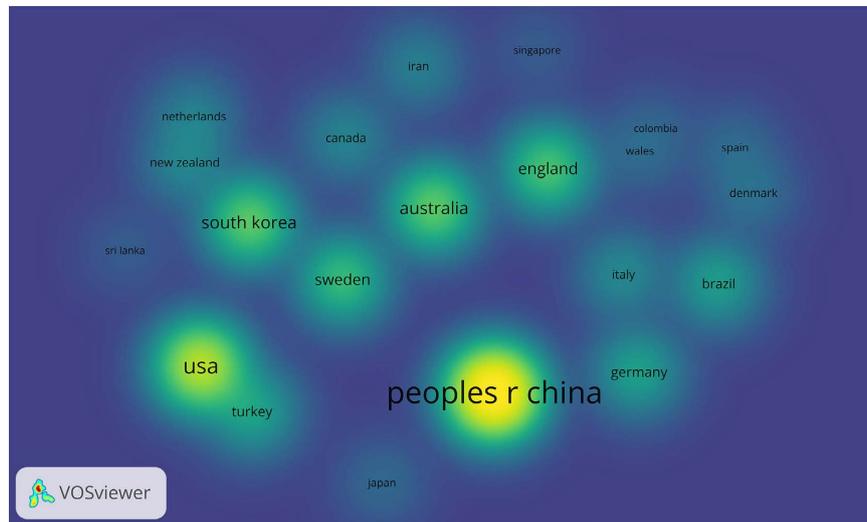
CiteSpace was adopted to analyze the co-occurrence of countries and regions. The combined network consisted of 34 nodes and 56 links, indicating that 34 countries conducted studies of acupuncture treatment of infertility (**Figure 2(a)**). From the perspective of national centrality, China ranked first, followed by U.S., Italy and U.K. In addition, VOSviewer was utilized to build country citation, density, and overlay visualization (**Figures 2(b)-(d)**). Among the top five countries, China ($n = 126$) had the largest number of publications, followed by the U.S. ($n = 64$), South Korea ($n = 32$), Australia ($n = 31$) and the U.K. ($n = 27$), respectively. The most frequently cited articles were from China ($n = 1530$), followed by U.S. ($n = 1466$), U.K. ($n = 1385$), Sweden ($n = 675$) and Australia ($n = 632$), as shown in **Table 3**. Japan, Indonesia and Singapore articles had been cited more frequently in recent years.



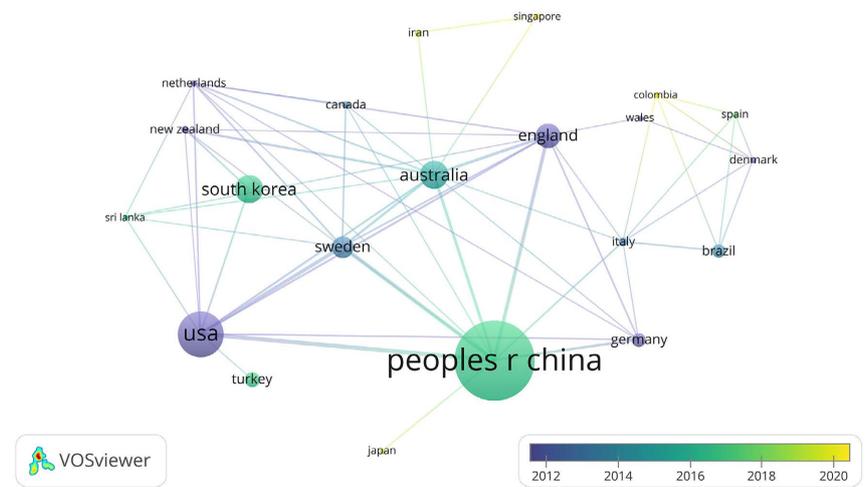
(a)



(b)



(c)



(d)

Figure 2. (a) The collaboration network of countries researching acupuncture on infertility. (b) The network visualization network of countries related to acupuncture on infertility. (c) The density visualization of countries related to acupuncture on infertility. (d) The overlay visualization network of countries related to acupuncture on infertility.

Table 3. Top 10 countries in publications, centrality and citations related to acupuncture for infertility.

Rank	Publications	Countries	Centrality	Countries	Citations	Countries
1	126	China	0.24	U.S.	1530	China
2	64	U.S.	0.21	Australia	1466	USA
3	32	South Korea	0.14	U.K.	1385	England
4	31	Australia	0.11	China	675	Sweden
5	27	U.K.	0.08	Sweden	632	Australia
6	23	Sweden	0.07	Netherlands	459	Germany
7	13	Germany	0.04	Italy	303	Wales
8	12	Turkey	0.04	Germany	270	Netherlands
9	6	Brazil	0.03	Denmark	198	Brazil
10	6	Canada	0.02	Sri Lanka	197	Sri Lanka

3.4. Analysis of Institutions

Among the 345 nodes and 557 links, Heilongjiang University Chinese Med (n = 16) ranked first in publication volume, followed by Korea Institute Oriental Med (n = 14) and Huangzhong University of Science & Technology (n = 12). In terms of centrality, the top three institutions were Beijing University Chinese Med (0.09), Karolinska Institute (0.06) and Heilongjiang University Chinese Med (0.05) (Figure 3(a), Table 4). Visual analysis (Figure 3(b), Figure 3(d)) was performed by VOSviewer. Karolinska Institute was the most cited institution (n = 372), followed by Heilongjiang University Chinese Med (n = 300) and University Adelaide (n = 292). In the knowledge map analyzed by the co-authors, **red** clustering showed that there was a close cooperative relationship among Yale University, Karolinska Institute, Gossberg University, Heilongjiang University of Chinese Medicine and University of Hong Kong. **Blue** clustering revealed cooperation among Shanghai University of Traditional Chinese Medicine, Nanjing University of Traditional Chinese Medicine, Guangzhou University of Traditional Chinese Medicine, Xuzhou Medical University and Nanjing Medical University, while **green** clustering illustrated the cooperative relationship among Beijing University of Traditional Chinese Medicine, West Sydney University and University of New South Wales. **Purple** clustering showed cooperation among Kyunghee University and Korea Institute of Oriental. **Yellow** clustering indicated cooperation among Zhejiang University of Traditional Chinese Medicine, Shandong University of Traditional Chinese Medicine and Peking University. (Figure 3(c)). West Sydney University, Heilongjiang University of Chinese Medicine, Nanjing University of Traditional Chinese Medicine and Zhejiang University were the core members of the cooperative network, promoting extensive cooperation among many institutions.

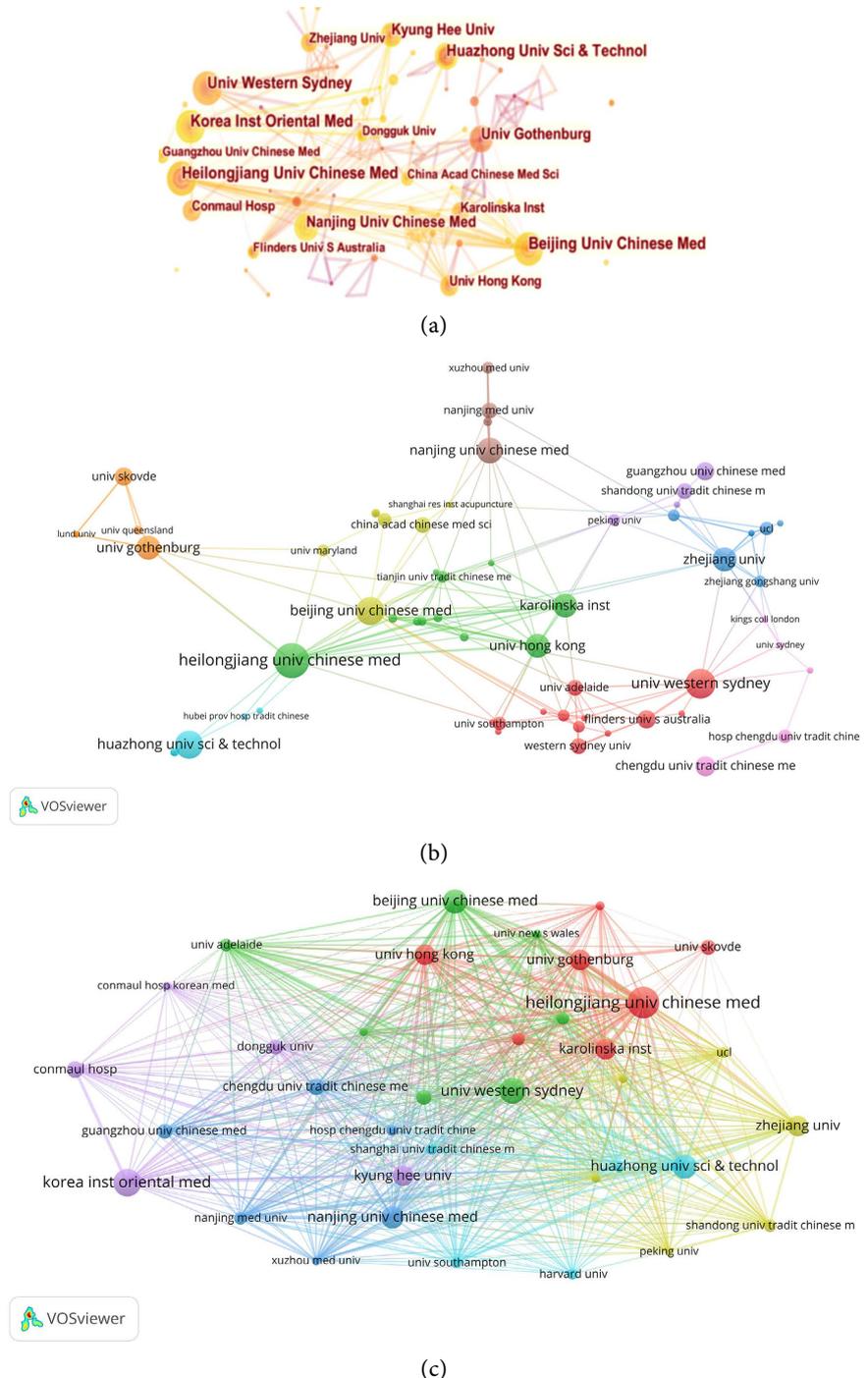
3.5. Analysis of Authors

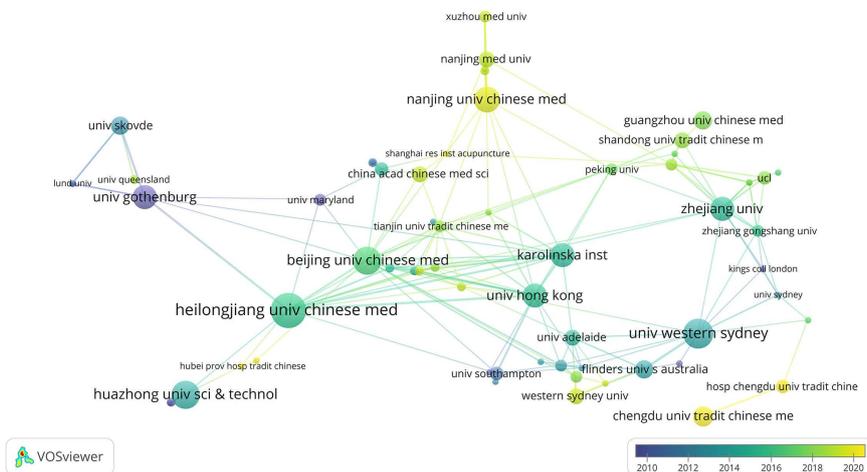
461 authors who have published articles of acupuncture and moxibustion in the treatment of infertility were searched and analyzed. CiteSpace was used to analyze the author's collaboration network and centrality (Figure 4(a)), and VOSviewer

Table 4. Top 10 institutions in publications, centrality and citations related to acupuncture for infertility.

Rank	Publications	Institutions	Centrality	Institutions	Citations	Institutions
1	16	Heilongjiang Univ Chinese Med	0.09	Beijing Univ Chinese Med	366	Karolinska Institute
2	14	Korea Inst Oriental Med	0.06	Karolinska Institute	300	Heilongjiang Univ Chinese Med
3	12	Huazhong Univ Sci & Technol	0.05	Heilongjiang Univ Chinese Med	292	Univ Adelaide
4	12	Univ Western Sydney	0.04	Univ Adelaide	269	Huazhong Univ Sci & Technol
5	12	Beijing Univ Chinese Med	0.03	Univ Western Sydney	231	Univ Gothenburg
6	11	Nanjing Univ Chinese Med	0.03	Univ Gothenburg	178	Christian Lauritzen Inst
7	10	karolinska Inst	0.03	Shanghai Univ Chinese Med	157	Univ Witten Herdecke
8	10	Univ Gothenburg	0.02	Chinese Univ Hong Kong	151	Univ Southamton
9	10	Univ Hong Kong	0.02	Univ Hong Kong	150	Havard Univ
10	10	Zhejiang Univ	0.02	Huazhong Univ Sci & Technol	143	Univ Hong Kong

was utilized to analyze the author's overlay visualization and collaboration network (Figures 4(b)-(d)). The top three authors of cited frequency were Stener-Victorin E (n = 493), Norman Robert J (n = 235), Sterzik, K (n = 178). Stener-Victorin E published the highest number of articles (n = 13, Table 5). Among the co-cited authors, Stener-Victorin E (n = 287) ranked first, followed by Caroline A. Smith (n = 157) and Manheimer E (96). The top three authors of centrality were Stener-Victorin E (0.15), Bae CS (0.11) and Caroline A. Smith (0.11), as shown in Table 6.



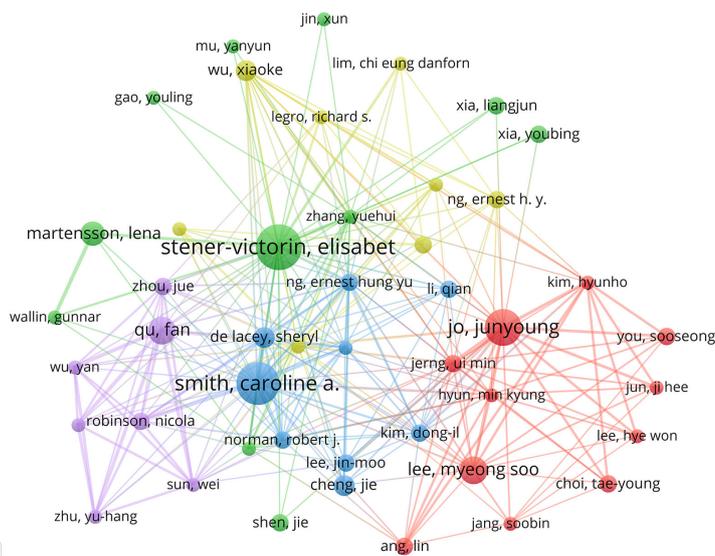


(d)

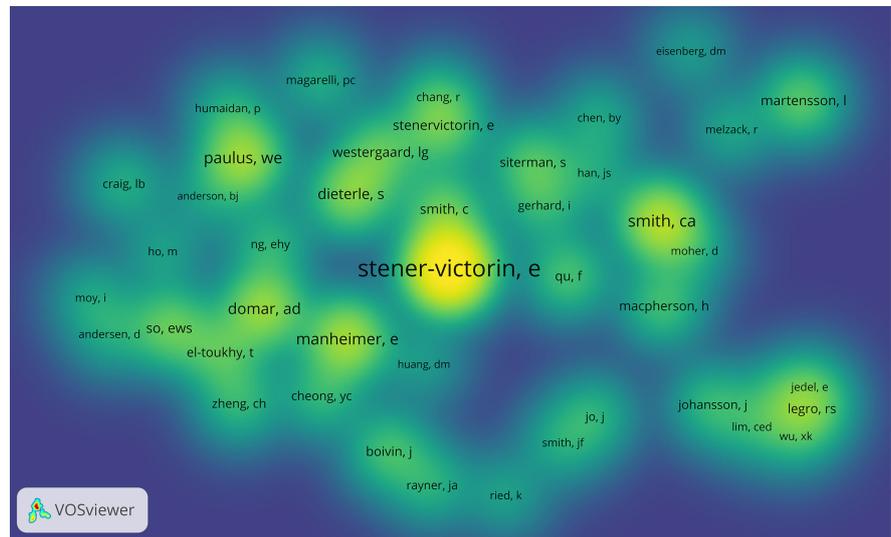
Figure 3. (a) The collaboration of institutions related to acupuncture on infertility. (b) The collaboration network of institutions related to acupuncture on infertility. (c) The bibliographic coupling network between institutions. (d) The overlay visualization network of institutions related to acupuncture on infertility.



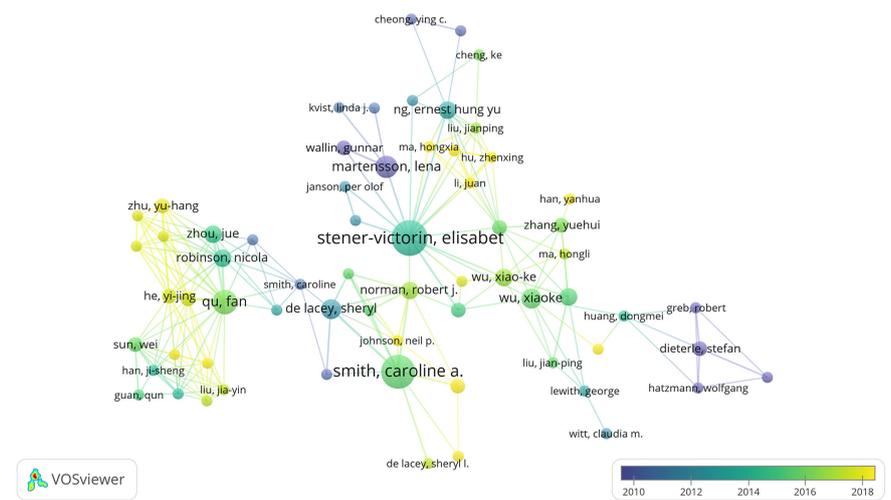
(a)



(b)



(c)



(d)

Figure 4. (a) Collaboration network of authors related to acupuncture for infertility. (b) Collaboration network of authors related to acupuncture on infertility. (c) The density visualization network of cited authors related to acupuncture on infertility. (d) The overlay visualization network of authors related to acupuncture for infertility.

Table 5. Top 10 authors in publications and centrality related to acupuncture for infertility.

Rank	Publications	Author	Rank	Citation	Author
1	13	Stener-Victorin E	1	493	Stener-Victorin E
2	12	Caroline A. Smith	2	235	Norman Robert J
3	10	Junyoung Jo	3	178	Sterzik K
4	7	Fan QU	4	178	Strehler E
5	5	De Lacey Sheryl	5	157	Caroline A. Smith
6	4	Ernest Hung Yu NG	6	157	Dieterle S
7	4	Robinson Nicola	7	141	Ei-Danasouri I
8	4	Zhou Jue	8	141	Paulus WE
9	4	Norman Robert J	9	141	Zhang, MM
10	3	Dieterle S	10	130	Domar AD

Table 6. Top 10 co-cited authors in citation and centrality related to acupuncture for infertility.

Rank	Centrality	Author	Rank	Citation	Author
1	0.15	Stener-Victorin E	1	287	Stener-Victorin E
2	0.11	Bae CS	2	157	Caroline A. Smith
3	0.11	Caroline A. Smith	3	96	Manheimer E
4	0.11	NG Ernest H Y	4	92	Paulus We
5	0.09	Wu Xiaoke	5	87	Domar AD
6	0.09	PAK SC	6	74	Dieterle S
7	0.09	LIM SC	7	59	SO EWS
8	0.09	Strehler E	8	54	Westgaard LG
9	0.09	Sterzik K	9	54	Martensson I
10	0.08	Cheng Jie	10	48	Siterman S

3.6. Analysis of Journals

VOSviewer analysis showed that *Fertility and Sterility* published 22 articles, citing 991 times, accounting for 6.9% of the total number of articles. It was the most effective journal, followed by *Cochrane Database of Systematic Reviews* (n = 465), *Human Reproduction Update* (n = 246) (Table 7, Figure 5(c), Figure 5(d)). VOSviewer was used to determine the total citation. In terms of co-cited frequency, *Fertility and Sterility* ranked first (n = 1252), followed by *Hum Reprod* (n = 716), and *Cochrane Database of Systematic Reviews* (n = 253) (Table 8, Figure 5(b)). The number of articles was not correlated with the amount of citations in academic journals. In terms of centrality, *Acta Obstetricia et Gynecologica Scandinavica* ranked first (0.16), followed by *Acta Anaesthesiologica Scandinavica* (0.13) and *Acupuncture Electro* (0.12), as illustrated in Table 8 (Figure 5(a)).

3.7. Analysis of References

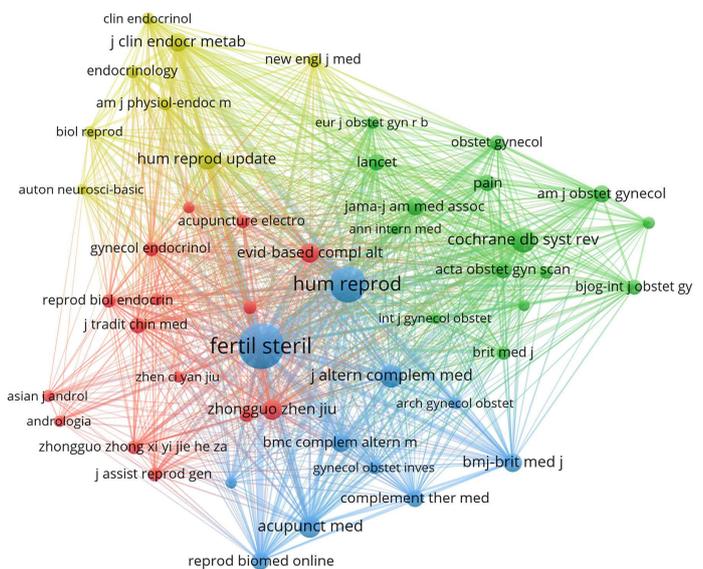
CiteSpace was used to analyze literature centrality and clustering. In terms of centrality, Rashidi BH (2013) ranks first (0.12), and this article also had the highest citation frequency. The research results of Wu XK (2017) and Agarwal A(2015) attracted significant attention. Clustering was obtained from the cited literature by using keywords to analyze the research methods and frontier topics from 2000 to 2021. “Systematic review” was the largest cluster, with 61 members and a silhouette value of 0.85. The most active article under this cluster was “Somatosensory stimulation and assisted reproduction [25]”. The first three clusters were “systematic review”, “polycystic ovary syndrome” and “vitro fertilization”, respectively. “Polycystic ovary syndrome” was the earlier cluster, while “acupuncture pretreatment” was the cluster in recent years (Table 9, Figure 6(a), Figure 6(b)).

VOSviewer was adopted to analyze the citation and co-citation of literature. In 2002, the article entitled “*Influence of acupuncture on the pregnancy rate in patients who undergo assisted reproduction therapy* [23]” published by Paulus, W.E had the highest frequency of citation and co-citation (n = 141, n = 67). The articles published by Jedel (2011) and Dieterle, S (2006) also had higher cited frequency (Figure 6(c), Figure 6(d)). Acupuncture could increase the clinical pregnancy rate by reducing androgen levels [26] [27]. Wu, X.K (2017) [28] re-

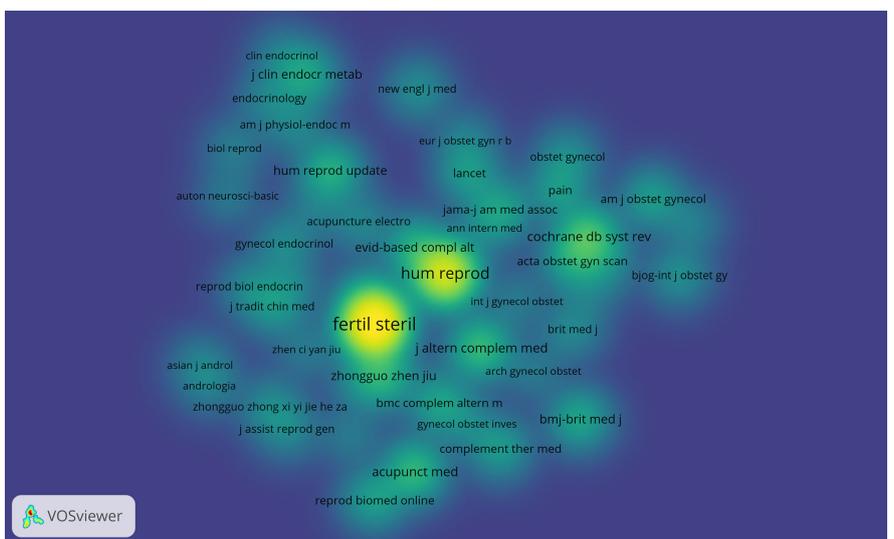
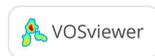
ceived more attention in recent years, which was published in JAMA Internal Medicine. The first 10 references were demonstrated in **Table 10**.



(a)



(b)



(c)

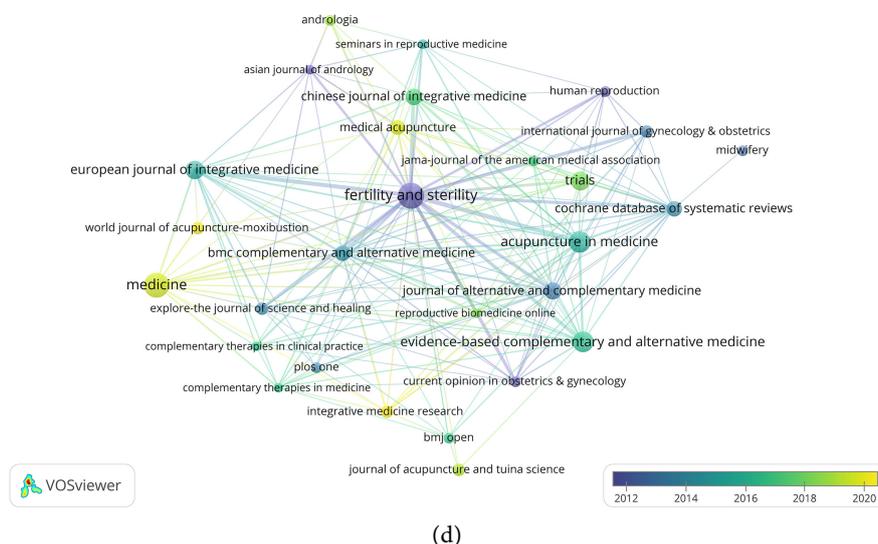


Figure 5. (a) The co-citation network of journals in acupuncture on infertility. (b) The visualization network of journals in acupuncture for infertility. (c) The density visualization network of cited journals in acupuncture on infertility. (d) The overlay network of journals in acupuncture on infertility.

Table 7. Top 10 journals in publications and citations related to acupuncture for infertility.

Rank	Publications	Journal	Citation	Journal
1	22	Fertil Steril	991	Fertil Steril
2	20	Medicine	465	Cochrane Db Syst Rev
3	15	Acupunct Med	246	Hum Reprod Update
4	14	Evid-based Compl Alt	198	Bmc Complem Altern
5	12	Trial	196	Evid-based Compl Alt
6	11	Euro J Intern Med	178	Acupunct Med
7	10	J Altern Complem Med	155	Am J Physiol-Endoc M
8	9	Chinese J Intern Med	131	Plos One
9	8	Cochrane Db Syst Rev	129	Chinese J Intern Med
10	8	Bmc Complem Altern	96	JAMA-J Am Med Assoc

Table 8. Top 10 co-cited journals related to acupuncture for infertility.

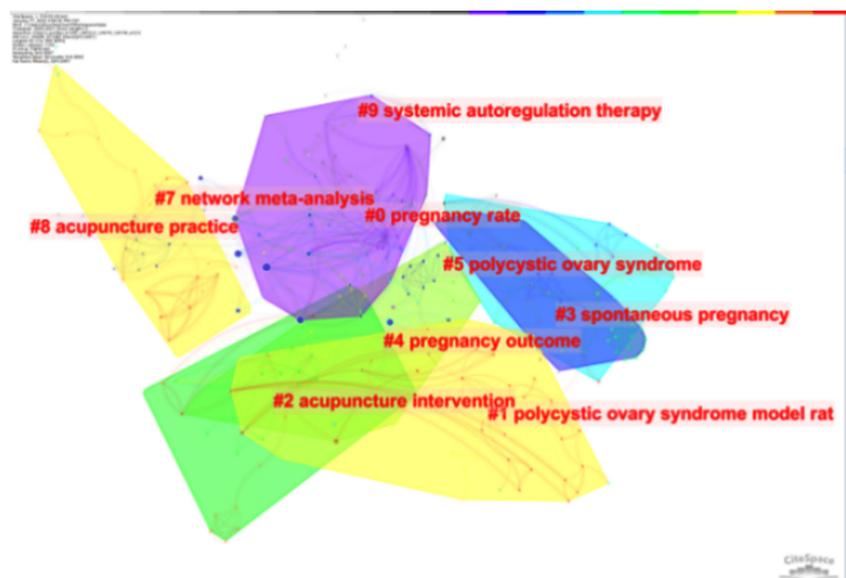
Rank	Co-citation	Journal	Centrality	Journal
1	1252	Fertil Steril	0.16	Acta Obstet Gyn Scan
2	716	Hum Reprod	0.13	Acta Anaesth Scand
3	253	Cochrane Db Syst Rev	0.12	Acupuncture Electro
4	212	J Altern Complem Med	0.10	AM J Chinese Med
5	202	Acupunct Med	0.09	AM J Obstet Gynecol
6	172	Hum Reprod Update	0.09	J Tradit Chin Med
7	166	Zhongguo Zhen Jiu	0.09	AM J Acupunct
8	143	J Clin Endocr Metab	0.09	Altern Ther Health M
9	136	Bmj-brit Med J	0.07	Gynecol Obstet Inves
10	124	Reprod Biomed Online	0.06	Pain

Table 9. Top 10 cited references related to acupuncture for infertility in terms of centrality.

Rank	Centrality	Cited reference	Representative author (publication year)
1	0.13	Effects of acupuncture on the outcome of <i>in vitro</i> fertilization and intracytoplasmic sperm injection in women with polycystic ovarian syndrome	Rashidi BH, 2013 [29]
2	0.08	Randomized controlled trial: effects of acupuncture on pregnancy rates in women undergoing <i>in vitro</i> fertilization	Moy I, 2011 [30]
3	0.08	Effect of acupuncture and clomiphene in Chinese women with polycystic ovary syndrome	Wu XK, 2017 [28]
4	0.07	The relationship between perceived stress, acupuncture, and pregnancy rates among IVF patients: A pilot study	Balk J, 2010 [31]
5	0.07	A unique view on male infertility around the globe	Agarwal A, 2015 [32]
6	0.06	Quantitative evaluation of spermatozoa ultrastructure after acupuncture treatment for idiopathic male infertility	Pei J, 2005 [33]
7	0.05	Effect of acupuncture on the outcome of <i>in vitro</i> fertilization and intracytoplasmic sperm injection: a randomized, prospective, controlled clinical study	Dieterle S, 2006 [27]
8	0.05	Influence of acupuncture stimulation on pregnancy rates for women undergoing embryo transfer	Smith C, 2006 [34]
9	0.05	The impact of acupuncture on <i>in vitro</i> fertilization outcome	Domar Ad, 2009 [35]
10	0.05	Acupuncture and <i>in vitro</i> fertilization: critique of the evidence and application to clinical practice	Anderson B, 2013 [36]



(a)



(b)

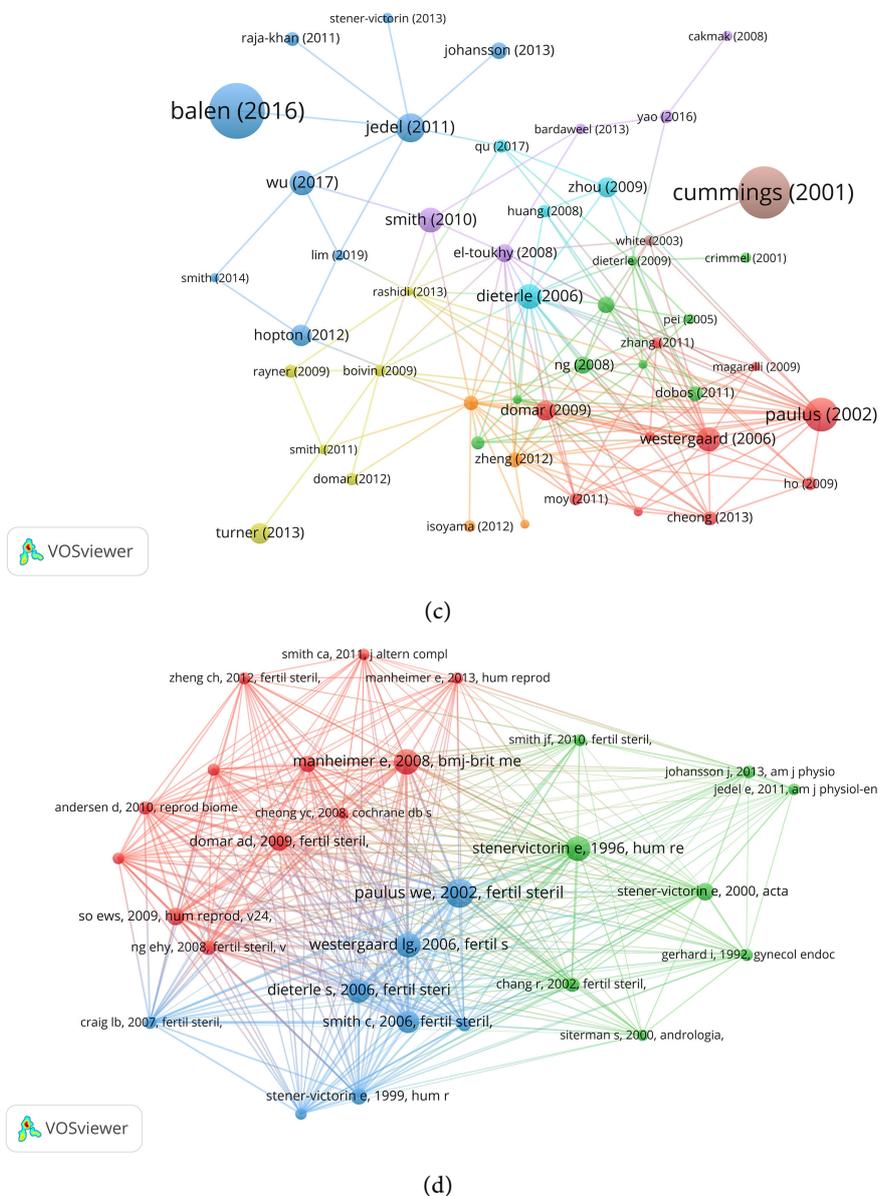


Figure 6. (a) The network of co-cited references related to acupuncture on infertility. (b) The cluster network of co-cited references related to acupuncture on infertility. (c) The overlay network of cited references related to acupuncture on infertility. (d) The network visualization of co-cited references related to acupuncture on infertility.

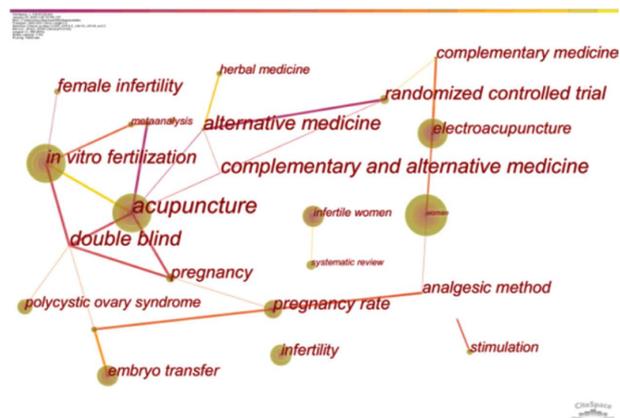
3.8. Analysis of Keywords and Burst Keywords

“Acupuncture” was the most frequent keyword, which was closely related to “infertility” and “*in vitro* fertilization” (Figure 7(a), Figure 7(d)). In terms of centrality, “complementary medicine” had the highest centrality (0.35), as shown in Table 11. Cluster analysis showed that the top three clusters were “vitro fertilization”, “complementary medical therapies” and “polycystic ovary syndrome” (Figure 7(b), Figure 8(a)). In recent years, increasing attention has been paid to the study of acupuncture treatment of infertility. The keyword of “systematic review” had the highest outbreak intensity. In the last five years, the most concerned key-

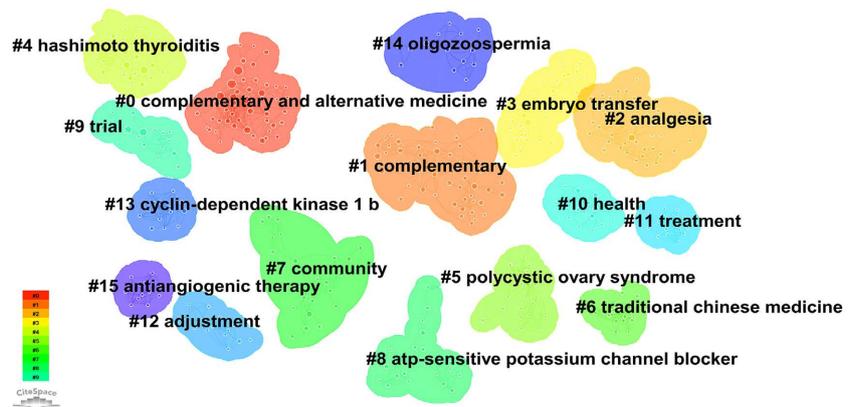
words in this field were “polycystic ovary syndrome”, “quality”, “traditional Chinese medicine” and “outcome” (Figure 7(c), Figure 8(b)).

Table 10. Top 10 co-cited references related to acupuncture for infertility.

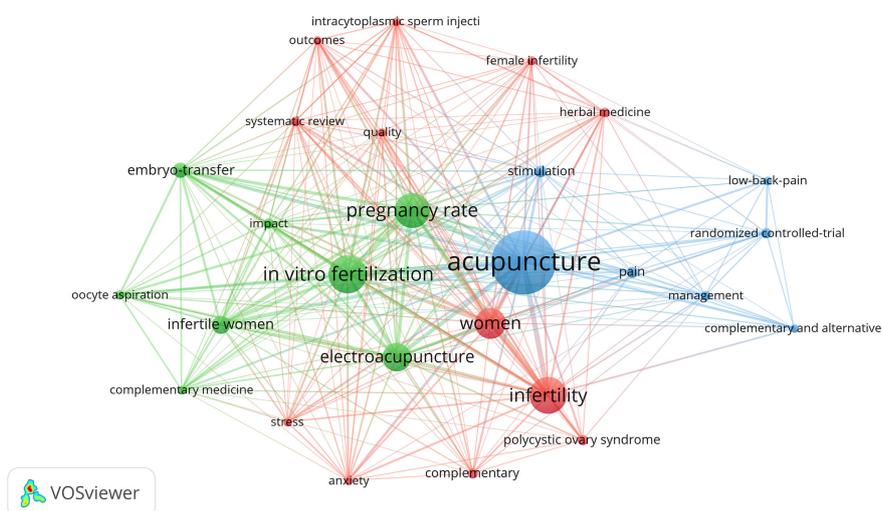
Rank	Co-citation counts	Cited reference	Representative author (publication year)
1	67	Influence of acupuncture on the pregnancy rate in patients who undergo assisted reproduction therapy	Paulus We, 2002 [23]
2	56	Effects of acupuncture on rates of pregnancy and live birth among women undergoing <i>in vitro</i> fertilization: systematic review and meta-analysis	Manheimer E, 2008 [37]
3	54	Acupuncture on the day of embryo transfer significantly improves the reproductive outcome in infertile women: a prospective, randomized trial	Westergaard, 2006 [38]
4	53	Effect of acupuncture on the outcome of <i>in vitro</i> fertilization and intracytoplasmic sperm injection: a randomized, prospective, controlled clinical study	Dieterle S, 2006 [27]
5	47	Influence of acupuncture stimulation on pregnancy rates for women undergoing embryo transfer	Smith C, 2006 [34]
6	37	The impact of acupuncture on <i>in vitro</i> fertilization outcome	Domar Ad, 2009 [35]
7	36	Effects of electro-acupuncture on anovulation in women with polycystic ovary syndrome	Stener-Victorine E, 2000 [39]
8	35	A randomized double blind comparison of real and placebo acupuncture in IVF treatment	So EW, 2009 [40]
9	31	A systematic review and meta-analysis of acupuncture in <i>in vitro</i> fertilization	El-Toukhy T, 2008 [24]
10	29	The role of acupuncture in the management of sub-fertility	Ng EH, 2008 [41]



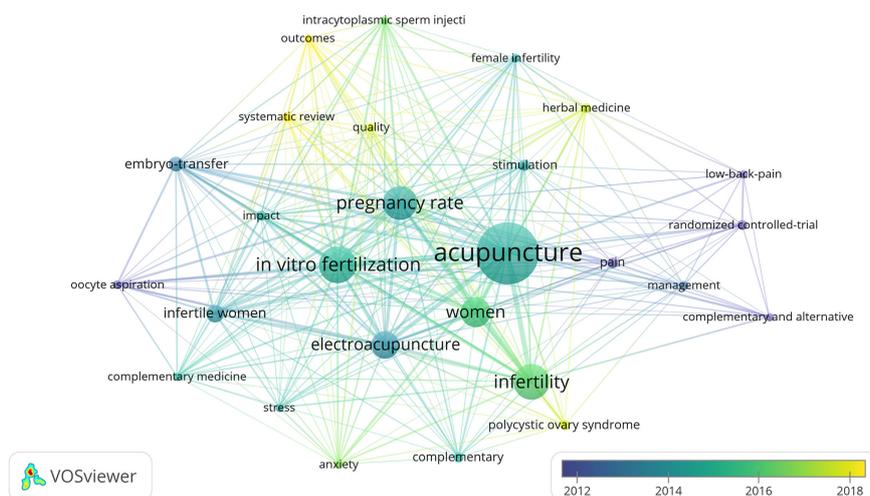
(a)



(b)



(c)

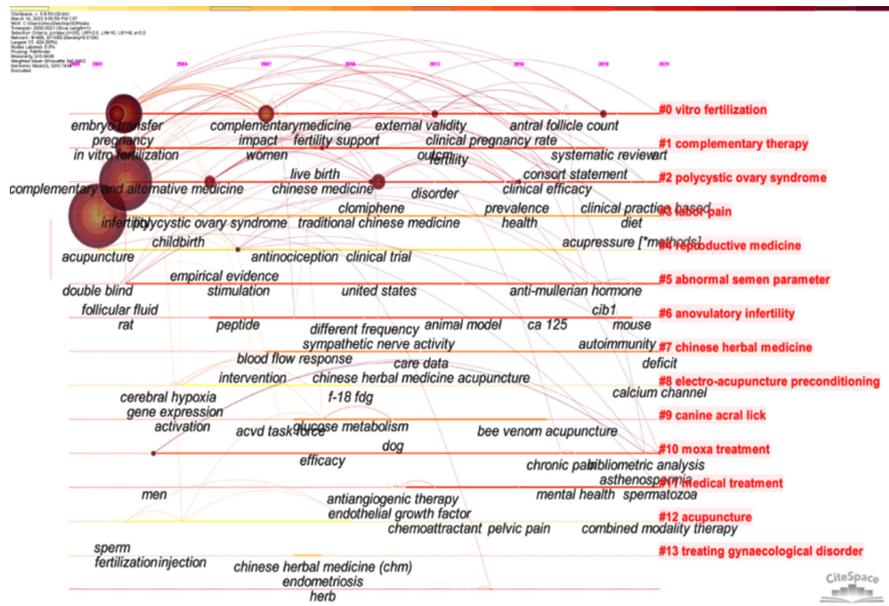


(d)

Figure 7. (a) The network of co-cited references related to acupuncture for infertility. (b) The cluster network of co-cited references related to acupuncture for infertility. (c) The overlay visualization of co-occurrence keywords related to acupuncture for infertility. (d) The network visualization of co-occurrence keywords related to acupuncture for infertility.

Table 11. Top 10 keywords related to acupuncture for infertility.

Rank	Co-occurrence	Keyword	Rank	Centrality	Keyword
1	217	Acupuncture	1	0.35	Complementary medicine
2	152	Infertility	2	0.18	Double blind
3	136	Pregnancy rate	3	0.15	Women
4	99	<i>In vitro</i> fertilization	4	0.15	Analgesia
5	48	Complementary medicine	5	0.15	Efficacy
6	39	Embryo transfer	6	0.15	Embryo transfer
7	39	Traditional chinese medicine	7	0.13	Traditional chinese medicine
8	31	Polycystic ovary syndrome	8	0.09	Blood flow impedance
9	23	Stimulation	9	0.09	Controlled trial
10	22	Meta-analysis	10	0.09	Activation



(a)

Top 15 Keywords with the Strongest Citation Bursts

Keywords	Year	Strength	Begin	End	2000 - 2021
low back pain	2000	3.67	2001	2007	[Red bar from 2001 to 2007]
analgesia	2000	3.38	2002	2008	[Red bar from 2002 to 2008]
sterile water	2000	3.33	2004	2011	[Red bar from 2004 to 2011]
stress	2000	3.85	2007	2010	[Red bar from 2007 to 2010]
therapy	2000	3.75	2009	2014	[Red bar from 2009 to 2014]
metaanalysis	2000	3.09	2010	2012	[Red bar from 2010 to 2012]
impact	2000	3.73	2012	2015	[Red bar from 2012 to 2015]
embryo transfer	2000	3.08	2013	2015	[Red bar from 2013 to 2015]
couple	2000	3.31	2014	2015	[Red bar from 2014 to 2015]
intracytoplasmic sperm injection	2000	2.76	2015	2016	[Red bar from 2015 to 2016]
polycystic ovary syndrome	2000	3.59	2016	2021	[Red bar from 2016 to 2021]
quality	2000	3.2	2016	2021	[Red bar from 2016 to 2021]
traditional chinese medicine	2000	3.01	2016	2021	[Red bar from 2016 to 2021]
outcm	2000	4.34	2018	2021	[Red bar from 2018 to 2021]
systematic review	2000	6.52	2019	2021	[Red bar from 2019 to 2021]

(b)

Figure 8. (a) The cluster timeline view network of keywords related to acupuncture for infertility. (b) The top 15 keywords with the strongest citation bursts related to acupuncture for infertility. The color represents different frequent keywords (red: frequent; green: infrequent).

3.9. Analysis of Acupoints and Acupuncture Methods

To understand the common acupoints and acupuncture methods in the treatment of infertility, the centrality and correlation intensity of acupoints and acupuncture adjuvant therapy were calculated by SATI 4.0 and IBM SPSS Modeler

18.0. In terms of centrality, *GV20* (*Baihui*), *KI3* (*Taixi*), *BL23* (*Shenshu*), *ST36* (*Zusanli*), *SP6* (*Sanyinjiao*), *SP10* (*Xuehai*), *PC6* (*Neiguan*), *LR3* (*Taichong*), *ST29* (*Guilai*), *LI4* (*Hegu*) had the highest centrality among 91 acupoints (**Figure 9(a)**), of which *SP6* (*Sanyinjiao*) had the highest centrality (0.79), as shown in **Table 12**. Regarding acupuncture methods, “*Manual acupuncture*” had the highest centrality (0.79), and “*Electroacupuncture*” “*Chinese herbal medicine*” “*traditional Korean medicine*” also had higher centrality (**Figure 9(b)**). In terms of correlation intensity, *SP6* (*Sanyinjiao*), *KI3* (*Taixi*), *LR3* (*Taichong*), *ST29* (*Guilai*) and *ST36* (*Zusanli*) had the strongest correlation. In addition, *LR3* (*Taichong*), *GV20* (*Baihui*) and *SP10* (*Xuehai*) also had a higher frequency of combined use (**Figure 10(a)**, **Table 12**). In terms of treatment, *Manual Acupuncture* was the most common treatment, followed by *Electroacupuncture*. “*Traditional Korean medicine*” and “*Chinese herbal medicine*” were mainly used as adjuvant therapy for acupuncture treatment of infertility (**Figure 10(b)**).

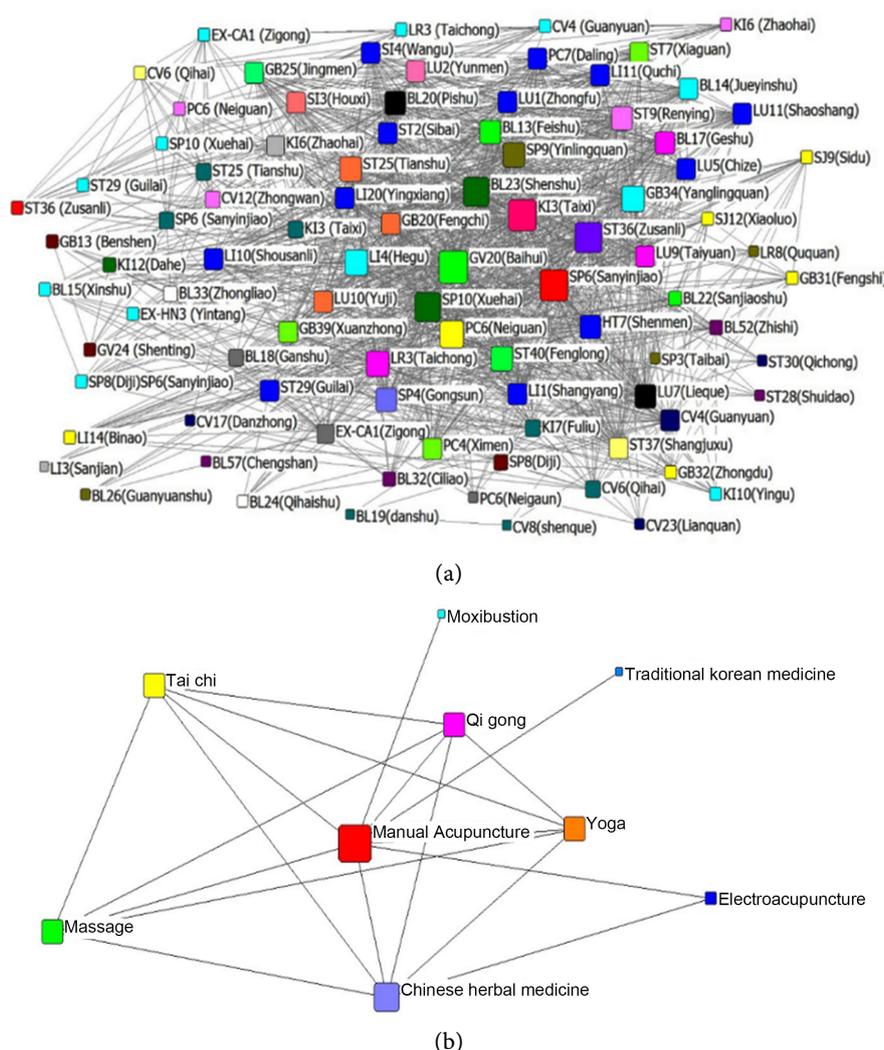


Figure 9. (a) The centrality of acupoints related to acupuncture for infertility. (b) The centrality of therapies related to acupuncture for infertility.

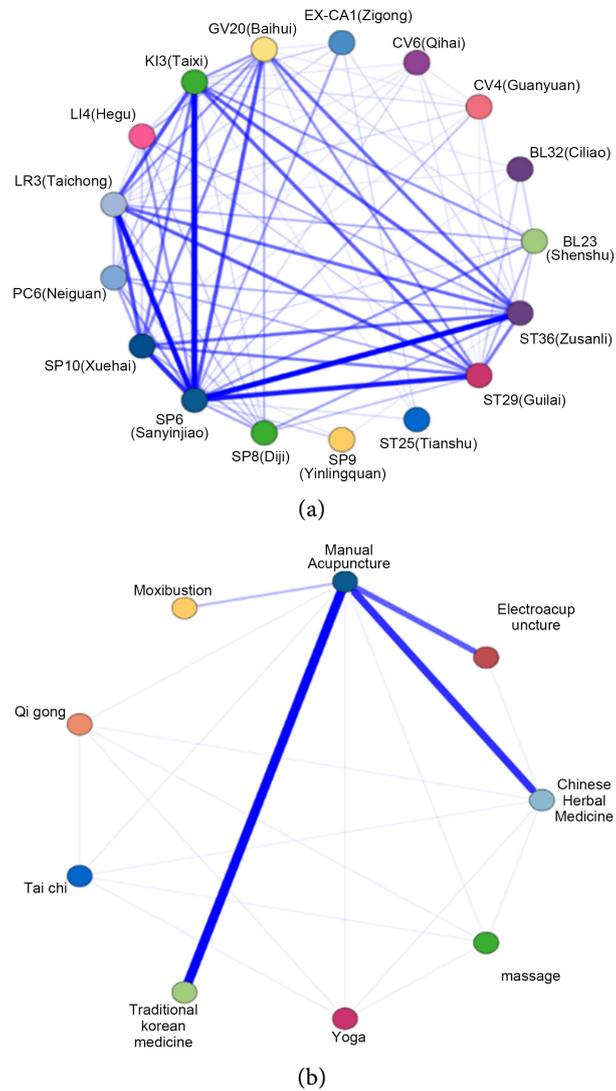


Figure 10. (a) The correlation map of acupoints related to acupuncture for infertility. (b) The correlation map of therapies related to acupuncture for infertility.

Table 12. Top 10 acupoints in correlation strength and centrality related to acupuncture for infertility.

Rank	Centrality	Acupoints	Rank	Correlation strength	Acupoints
1	0.15	SP6 (Sanyinjiao)	1	21	KI3 (Taixi)—SP6 (Sanyinjiao)
2	0.11	ST29 (Guilai)	2	21	SP6 (Sanyinjiao)—ST36 (Zusanli)
3	0.11	ST36 (Zusanli)	3	20	LR3 (Taichong)—SP6 (Sanyinjiao)
4	0.11	KI3 (Taixi)	4	19	SP6 (Sanyinjiao)—ST29 (Guilai)
5	0.09	LR3 (Taichong)	5	18	SP10 (Xuehai)—SP6 (Sanyinjiao)
6	0.09	SP10 (Xuehai)	6	15	KI3 (Taixi)—LR3 (Taichong)
7	0.09	GV20 (Baihui)	7	15	LR3 (Taichong)—SP10 (Xuehai)
8	0.09	BL23 (Shenshu)	8	15	GV20 (Baihui)—SP6 (Sanyinjiao)
9	0.09	LI4 (Hegu)	9	14	KI3 (Taixi)—ST29 (Guilai)
10	0.08	PC6 (Neiguan)	10	14	KI3 (Taixi)—ST36 (Zusanli)

4. Discussion and Conclusion

A growing number of publications show that the application of acupuncture in the treatment of infertility is gaining increasing attention [13] [28] [42]. It is expected that the number of publications will increase significantly in the coming years. As one of the most common complementary and alternative therapy for infertility, acupuncture is widely adopted in the treatment of infertility [43] [44] worldwide. China, the U.S., Germany, the U.K. and Australia have made tremendous contributions to the research on acupuncture treatment of infertility. In addition, China, the U.S., Australia and Switzerland maintain a high degree of cooperation with other countries. In this study, China was found to play a key role in this area, taking into account the number of publications, centrality and citations. In addition, in the past few years, China, South Korea, Türkiye, the U.K. and other countries have played an important role in the research on acupuncture treatment of infertility. In terms of centrality, the cooperation among countries, authors and institutions shows the characteristics of regional cooperation and intra-professional cooperation, while interdisciplinary international cooperation is not sufficiently conducted. Therefore, researchers from different research fields and institutions should strengthen cooperation to carry out high-quality research.

Using CiteSpace to generate institutional maps, 335 nodes and 347 links were generated. 958 publications were distributed among 335 research institutions. *Heilongjiang University Chinese Med* published the largest number of articles, the number of citations was 372 and the centrality was 0.06, indicating that the institution has made significant contribution to the research of acupuncture and moxibustion treatment of infertility. Wu, X.K from *Heilongjiang University Chinese Med* is an important scholar in acupuncture research. RCT on acupuncture in the treatment of infertility was published in *JAMA Internal Medicine* with an IF: 56.272. It is worth noting that in this article, Wu, X.K *et al.* found that in Chinese women with PCOS, acupuncture combined with or without clomiphene did not increase the live birth rate compared with acupuncture and placebo [24]. Interestingly, another article published by this scholar on the treatment of oligoasthenozoospermia with acupuncture pointed out that acupuncture can significantly increase the serum level of testosterone (T), reduce the concentration of follicle stimulating hormone (FSH), LH and estradiol (E2), and increase the pregnancy rate [45]. *Beijing University of Traditional Chinese Medicine* has published 13 articles with 267 citations and 0.05 centrality, indicating that it also plays an important role in this field. In addition, superimposed visualization shows that *Huangzhong University of Science & Technology*, *Korea Oriental Medical College*, *Western Sydney University* and *Xuzhou Medical University* have made significant contributions in this field in recent years.

Based on the network analysis of published articles, co-authors and co-cited authors, influential authors related to acupuncture and moxibustion treatment of infertility, such as Stener-Victorin E, Caroline A. Smith, Junyoung Jo and Fan QU, are important authors of acupuncture-moxibustion treatment of infertility.

Stener-Victorin E, the principal researcher of *Karolinska Institute*, has devoted himself to the study of acupuncture in the treatment of PCOS in the past few years. He has published 17 articles and obtained the highest number of common citations. Among them, a study published by Adam H Balen, published in *Human Reproduction Update* (IF: 15.6), believes that there is no clear evidence that acupuncture exerts a therapeutic effect on women with PCOS [46]. In addition, Jie Cheng, Myeong Soo Lee, Choi Tae-Young and Ang Lin are prominent authors in the field of acupuncture and moxibustion for infertility in the past three years.

In this study, a large number of journals show that the efficacy of acupuncture in the treatment of infertility is receiving widespread attention. The average impact factor of the top ten journals is 4.2665. The top ten journals have published 129 articles, accounting for 39.21% of the total. *Fertility and Sterility* (IF: 7.329) focuses on the field of reproductive medicine. It is worth noting that *Fertility and Sterility* ranks first in terms of publication, citation and co-citation, indicating that the journal plays a key role in this field. In addition, three of the top 10 journals belong to complementary and alternative medicine, namely *Journal of Alternative and Complementary Medicine*, *Evidence Based Complementary and Alternative Medicine* and *BMC Complementary and Alternative Medicine*. A total of 32 articles have been published, accounting for 24.8% of the total number of articles published in the top 10 journals, indicating that more and more attention has been paid to the efficacy of complementary and alternative medicine in the treatment of infertility from 2000 to 2021. In the cooperative network, *Fertility and Sterility* and *Human Reproduction Update* have the highest correlation, indicating that there is a close cooperative relationship between these two journals in the research on acupuncture treatment of infertility.

Acupuncture is the keyword with the highest co-occurrence frequency, which appeared in 2002, with a citation intensity of 1.58, indicating that acupuncture has received extensive attention in the treatment of infertility from 2000 to 2021. In the previously published articles, some studies have shown that acupuncture is a valuable treatment, which exerts a significant effect on improving clinical pregnancy rate and alleviating anxiety [13] [27]. In contrast, alternative studies believe that the efficacy of acupuncture in the treatment of infertility lacks of supporting evidence [46] [47], indicating that the efficacy of acupuncture in the treatment of infertility is not accurate and needs further research. In addition, *in vitro* fertilization also has high centrality and frequency, and the adjuvant effect of acupuncture in *in vitro* fertilization has been widely concerned. Some literature has shown that acupuncture can reduce the pressure of embryo transfer, improve endometrial thickness and improve patient satisfaction [13] [48]. The keyword cluster analysis suggests that “*in vitro fertilization*” is the largest cluster, with 66 members, and the most active reference in this cluster is “*Acupuncture in improving endometrial receptivity: a systematic review and meta-analysis* [49]” published by Zhong Y, *et al.* In 2019, among the first 15 clusters, five are complementary and alternative medicine represented by Chinese traditional med-

icine (“*Chinese herbal medicine*” “*acupuncture*” “*electroacupuncture*” “*moxa treatment*”), indicating that complementary and alternative medicine is receiving increasing attention in the treatment of infertility. Combined with cluster analysis and outbreak keyword analysis, it can be found that infertility with PCOS and traditional Chinese medicine including acupuncture is one of the research directions for the treatment of infertility.

In terms of acupoint selection, *GV20 (Baihui)*, *KI3 (Taixi)*, *BL23 (Shenshu)*, *ST36 (Zusanli)*, *SP6 (Sanyinjiao)*, *SP10 (Xuehai)*, *PC6 (Neiguan)*, *LR3 (Taichong)*, *ST29 (Guiai)*, *LI4 (Hegu)* are the most commonly used acupoints for acupuncture treatment of infertility. Most of these acupoints belong to *The Liver Meridian*, *The Kidney Meridian*, *The Stomach Meridian* and *The Heart Meridian*. These meridians are closely related to the “*qi*” and “*blood*” that regulate human body. Therefore, the occurrence of infertility may be related to the imbalance of “*qi*” and “*blood*”. In terms of acupuncture methods, *manual acupuncture* is the most common acupuncture method. *Electroacupuncture* is also widely applied in acupuncture treatment of infertility. *Chinese herbal medicine* and *traditional Korean medicine* are mainly used as adjuvant interventions for acupuncture treatment of infertility. Interestingly, some studies have also combined acupuncture with *Tai chi*, *Qi gong*, *Yoga* and other oriental traditional medicine to treat male infertility [50], which is considered to improve the sperm parameters and motility, mitigate genital inflammatory conditions, as well as immune system disorders, sexual dysfunction, and varicocele, etc.

Meta-analysis and systematic review have been widely employed to evaluate the efficacy of acupuncture in the treatment of infertility. At present, the evaluation of the efficacy of acupuncture remains to be elucidated. Taken together, the findings in this study provide a research hotspot for potential collaborators and institutions, offer a new perspective on the development trend of acupuncture for infertility, and assist researchers to explore new research directions in this field. The database included in this study is not comprehensive, and the software analysis may have some biases and limitations, which need to be further improved.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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