

# Insight into Dysmenorrhea Research from 1992 to 2022: A Bibliometric Analysis

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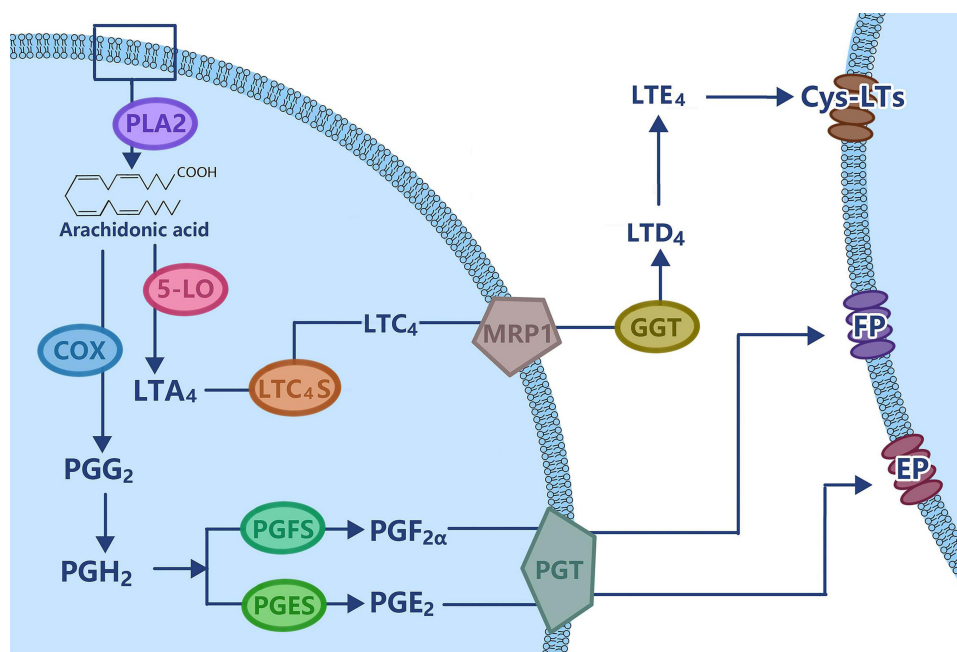
**Abstract:** Dysmenorrhea, classified as primary dysmenorrhea and secondary dysmenorrhea, is a common gynecological symptom that seriously affects female daily life. At present, studies on dysmenorrhea are numerous and complex. To better reflect the trend and innovative progress of dysmenorrhea-related research, this study screened papers on the Web of Science from January 1, 1992, to December 31, 2022. A total of 1012 papers were selected and analyzed for their affiliated countries, institutions, authors, keywords, etc. China is the country with the most academic output, Beijing University of Traditional Chinese Medicine is the most influential institution, and Yang Jie, from Chengdu University of Traditional Chinese Medicine, China, is the scholar with the most papers. We consider that the current research focus is on pathogenesis, treatment, epidemiology, and self-management. With increasing research on functional connectivity between dysmenorrhea and various brain regions, functional connectivity has gradually become the forefront of research. We hope our study can promote the further study of dysmenorrhea.

**Keywords:** pathogenesis, treatment, management, traditional Chinese medicine

## Introduction

Dysmenorrhea, defined as painful cramps that occur with menstruation, is the most common gynecologic problem for women of all ages and races and one of the most common causes of pelvic pain. The history of dysmenorrhea dates back to the Greeks who defined the word as “painful menstrual flow”.<sup>1</sup> In the modern medical system, dysmenorrhea can be classified into primary dysmenorrhea (PD) and secondary dysmenorrhea (SD).<sup>2</sup> PD refers to pain with no definite cause in the menstrual cycle, which usually starts within 1 year after menarche. The main pathogenesis is related to the secretion of prostaglandin F<sub>2α</sub> (PGF<sub>2α</sub>) (Figure 1). SD is associated with an underlying pelvic disease and manifests later than PD, usually more than 2 years after menarche. For reasons including endometriosis, pelvic inflammatory disease, chronic salpingitis, ovarian cysts, use of intrauterine devices, cervical stenosis, submucosal fibroma, uterine fibroids, uterine polyps, adenomyosis, and early pregnancy, most commonly endometriosis.<sup>3–5</sup> Regarding the external factors of dysmenorrhea, there is no systematic study to date.

According to studies, the prevalence of dysmenorrhea varies greatly in different regions, age groups. The overall prevalence is 15% to 94%.<sup>9</sup> The prevalence in married women is generally lower than that in unmarried women.<sup>10–13</sup> The prevalence in young women aged 17–24 years has been investigated and ranges from 67% to 90% and begins to decline after the age of 25 years.<sup>5,9</sup> Dysmenorrhea has been shown to affect women's quality of life, reflected mainly in school and work performance, including lack of energy for daily activities, higher level of stress, absenteeism and decreased efficiency, sports participation, and socialization, which causes a great deal of lost productivity.<sup>14–18</sup> As menstrual health



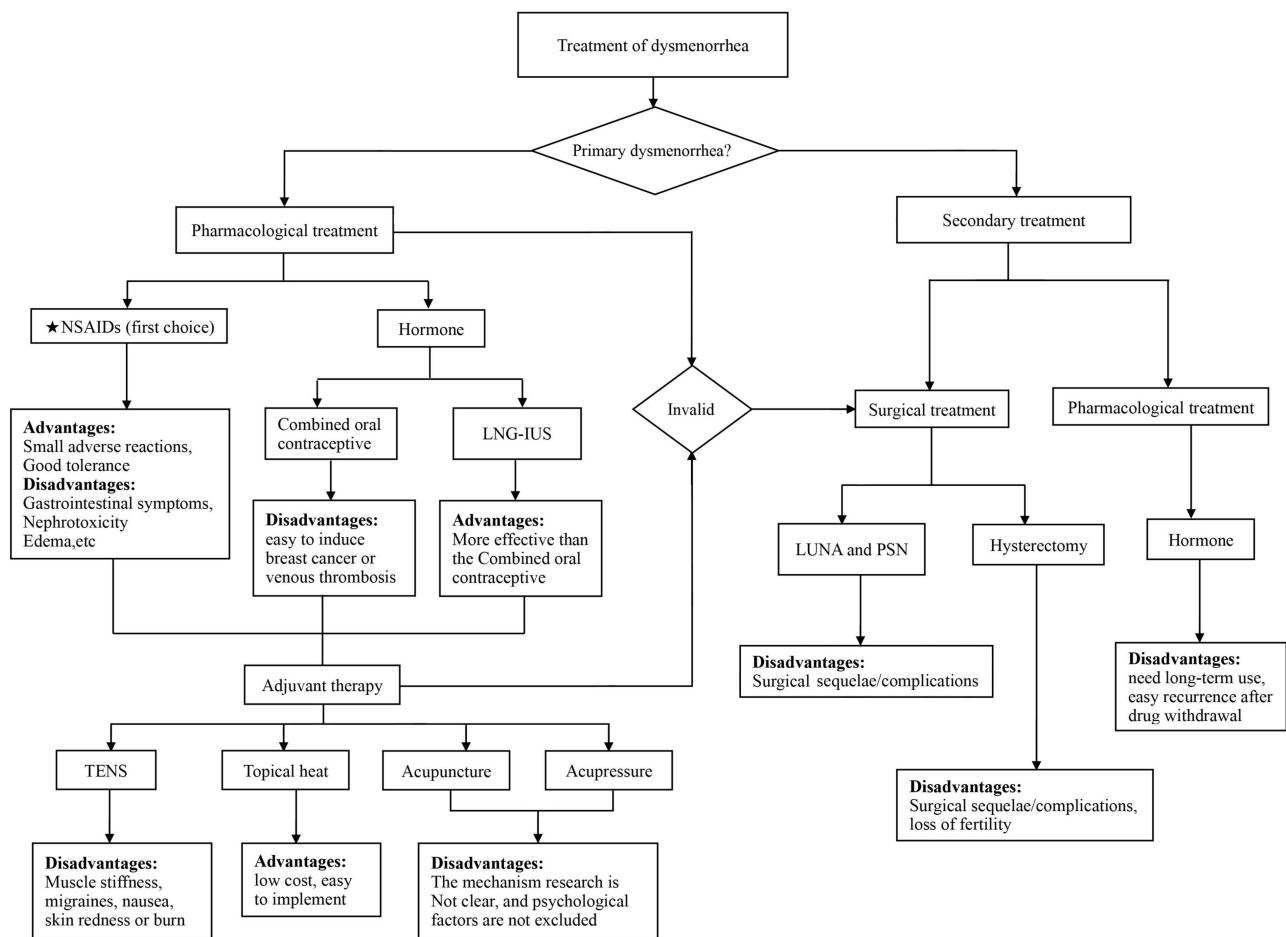
**Figure 1** The main mechanism of PD. Arachidonic acid is metabolized through the cyclooxygenase (COX) and 5-lipoxygenase (5-LO) pathway to produce prostaglandins and Leukotriene (LT) A<sub>4</sub> respectively, and is transported out of cells through corresponding transporters (prostaglandin transporters (PGT), multidrug resistance related proteins (MRP1)). After extracellular metabolism, PGF<sub>2α</sub>, PGE<sub>2</sub> and LTE<sub>4</sub> act on the corresponding cell receptors (the G protein-coupled receptor (EP, FP), cysteinyl leukotriene receptors (Cys-LTs)), causing potent vasoconstriction and myometrial contractions, and leading to ischemia and pain.<sup>6–8</sup>

problems cause consequences for women's lives, the World Health Organization stated that menstrual health to be recognized, framed, and addressed as a health and human rights issue.<sup>19</sup>

There are many treatments for PD, but pharmacological treatment may be the most effective (Figure 2), including nonsteroidal anti-inflammatory drugs (NSAIDs), hormonal contraceptives, tocolytics, vitamins, and omega-3, among which NSAIDs are the prime choice. Nonpharmacological treatments include lifestyle changes, transcutaneous electrical nerve stimulation (TENS), local heating, acupuncture, and acupressure. Surgical treatment, which includes laparoscopic uterosacral nerve association (LUNA), presacral neurectomy (PSN), and hysterectomy, is only applicable to a few women with severe or refractory dysmenorrhea, but there are few relevant studies.<sup>4</sup>

Although pharmacological treatment is the most effective, a considerable number of women tend to perform self-management and nonpharmacological treatment strategies during the menstrual period, such as hot compress, rest, hot shower/bath and exercise.<sup>22,23</sup> At present, many researchers have made great progress in interventions for dysmenorrhea. However, some of these interventions still lack experimental evidence. Among them, the levonorgestrel releasing intrauterine system (LNG-IUS) has a good therapeutic effect in dysmenorrhea in women of all ages and has great advantages in the treatment of adolescent endometriosis.<sup>24</sup> Bibliometrics, known as an effective method for exploiting statistical approaches for quantitatively analyzing scientific documents, provides a solution to systematically review relatively large-scale documents and explore objective results while minimizing subjective bias.<sup>25</sup> This study uses bibliometric methods to collect data (including countries, institutions, journals, authors, keywords and citations). The bibliometric method simplifies the process of extracting key information from massive literature information so that we can search for features with visual significance in the visual network and extract clear directional information. The analysis of these visual networks makes it possible to study the research hotspots, research trends, cooperative networks, and the development direction of the whole discipline in each period.<sup>26,27</sup> This study aims to explore some questions for discussion, such as pathogenic factors other than prostaglandins and relatively effective therapies, and to examine future research trends.

In the current article, compared to Fu et al,<sup>28</sup> the treatment methods for dysmenorrhea are supplemented and analyzed, and the etiology, pathogenesis, epidemiology, and self-management of dysmenorrhea are discussed. Compared to Liu et al,<sup>29</sup> this article selects a larger time range and provides explanations on treatment methods and pathogenesis.



**Figure 2** The treatment of dysmenorrhea and their advantages and disadvantages.<sup>4,20,21</sup>

To further understand the development of dysmenorrhea, we seek answers to the following research questions:

RQ1: What effective methods are available for treating or alleviating dysmenorrhea?

RQ2: What are the hotspots in research on dysmenorrhea-related fields in the past thirty years?

RQ3: What is the current pioneering research in the field of dysmenorrhea?

RQ4: What are the possible future research directions in the field of dysmenorrhea?

## Materials and Methodology

### Data Retrieval and Data Collection

This cross-sectional study retrieved literature information from the Web of Science core collection (WOSCC) (<https://www.webofscience.com>). All searches were completed within one day to avoid deviations from daily database updates. The edition we selected was Science Citation Index Expanded (SCI-EXPANDED). The search formula was “TS=(dysmenorrhea) OR TS=(dysmenorrheal) OR TS=(dysmenorrhoea)”, including different expressions of “dysmenorrhea”. The index date range was from January 1, 1992, to December 31, 2022. After selecting the type “article and review” in the search results, we obtained 4220 paper results. By investigating the title, abstract and content, we excluded repetitive literature or literature unrelated to “dysmenorrhea” and ultimately included 1012 articles in the research scope. The filtered data with “Full record and Cited references” were exported from WOSCC as a plain text file, Excel file and tab-delimited file.

### Data Analysis and Network Mapping

The bibliometrics and visual analysis of this study were mainly based on CiteSpace (Version 6.1.R2/5.7. R2, USA), VOSviewer (version 1.6.18, USA), Scimago Graphics (USA) and <https://bibliometric.com/app>. We uploaded the tab-

delimited file data to the website to analyze the annual overall publication trends and publication trends for countries around the world. The data, processed by VOSviewer, were used in Scimago graphics to generate a national cooperative network. The rest of the analysis, including institutions, author collaboration network, subject co-occurrence analysis, keywords co-occurrence analysis, and literature co-citation analysis, were completed through CiteSpace using the data of the plain text file.

Except where noted, the parameters for CiteSpace settings were as follows: Time slices from January 1992 to December 2022, with 1 year per slice. The Links Strength was “Cosine”; the Links Scope was “Within Slices”. The selection used a modified  $g$  index in each slice where the scale factor  $k = 25$ .<sup>30</sup> The “Pathfinder”, “Pruning sliced networks”, and “Pruning the merged network” options were selected in the “Pruning window” to obtain a concise and clear visual network without changing any other details. The choice of node type depends on the project being analyzed.

## Results

### Annual Publication Trend

There were 882 articles and 130 review articles. First, we counted the number of annual publications related to dysmenorrhea from January 1, 1992, to December 31, 2022. As shown in Figure 3A, the overall publications show a steady upward trend. This is due to the growing concern about women’s health. In addition, we examined the statistics of the number of dysmenorrhea-related papers published in various countries every year. As shown in Figure 3B. The top 10 most productive countries or regions are presented in Table 1. The main evaluation indicators include the number of documents, the first publicized year, and citations. The top 3 countries are China, the United States and Iran. Relevant papers have been published annually in the United States since 1992, but the trend has fluctuated. Regardless, the United States ranked first in the total number of citations, far surpassing other countries, indicating the leading position of the United States in the research of dysmenorrhea-related fields; China has been cited less frequently than the United States, but in terms of annual publications, China has ranked first in annual publication volume since 2010, showing an increasing yearly trend. The trend of literature publication shows that research related to dysmenorrhea is increasing, and researchers around the world are paying increasing attention to it every year.

### Analysis of Published Journals

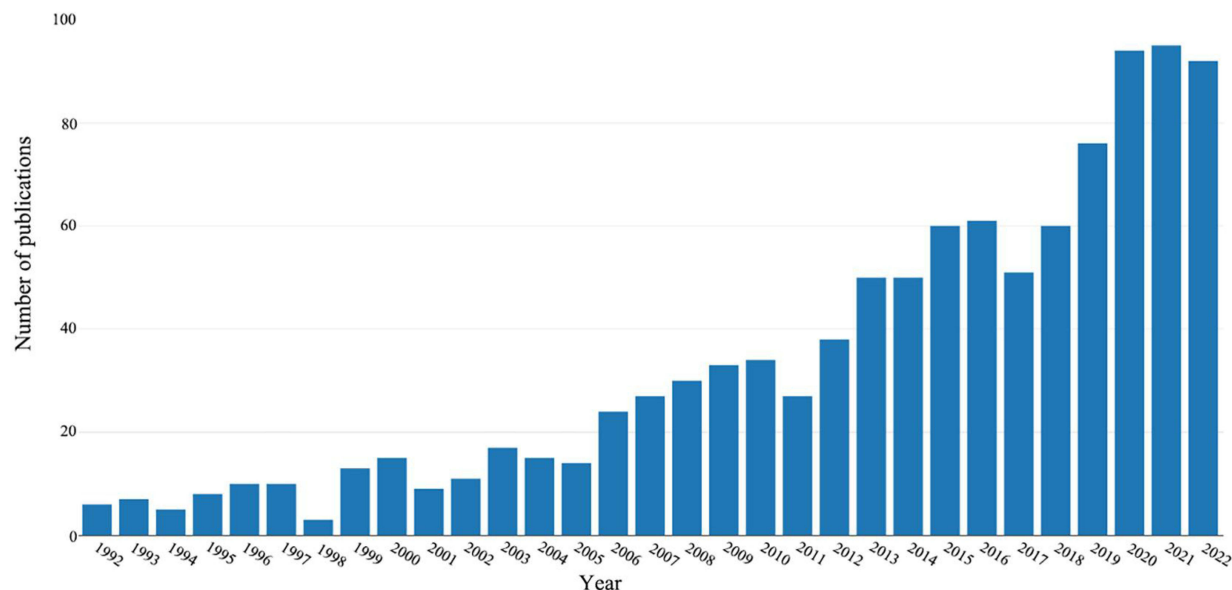
By analyzing publications related to dysmenorrhea in 331 journals, 228 publications belonging to the top 10 journals accounted for 21.46% of the overall number. Table 2 lists their publications, citations, average citations, impact factors (IF) in 2022, journal citation reports (JCR) (<https://www.webofscience.com>), and publishers. Of the publications, Medicine ranked first, with 28 publications. Journal of Pediatric and Adolescent Gynecology ranked second, with 27 publications. The average citation reflects, to a certain extent, the authority and recognition of these publications in journals in the area of dysmenorrhea. The average citations in Medicine were only 4.36. In contrast, the total number of publications in Obstetrics and Gynecology was 17, but the average citations reached 79.24, ranking first, which indicates that Obstetrics and Gynecology has high authority in the research of the dysmenorrhea-related area. The impact factor (IF) is an internationally accepted journal evaluation index. Table 2 shows the IF of each journal in 2022, ranging from 1.6 to 7.4, with an average value of 3.89. Among them, the IF of Pain is 7.4, ranking first, demonstrating that it has a great influence in dysmenorrhea-related fields. The journals with larger articles are located in Q3 or Q4, which have potential for growth.

### Analysis of Cooperation Network Countries

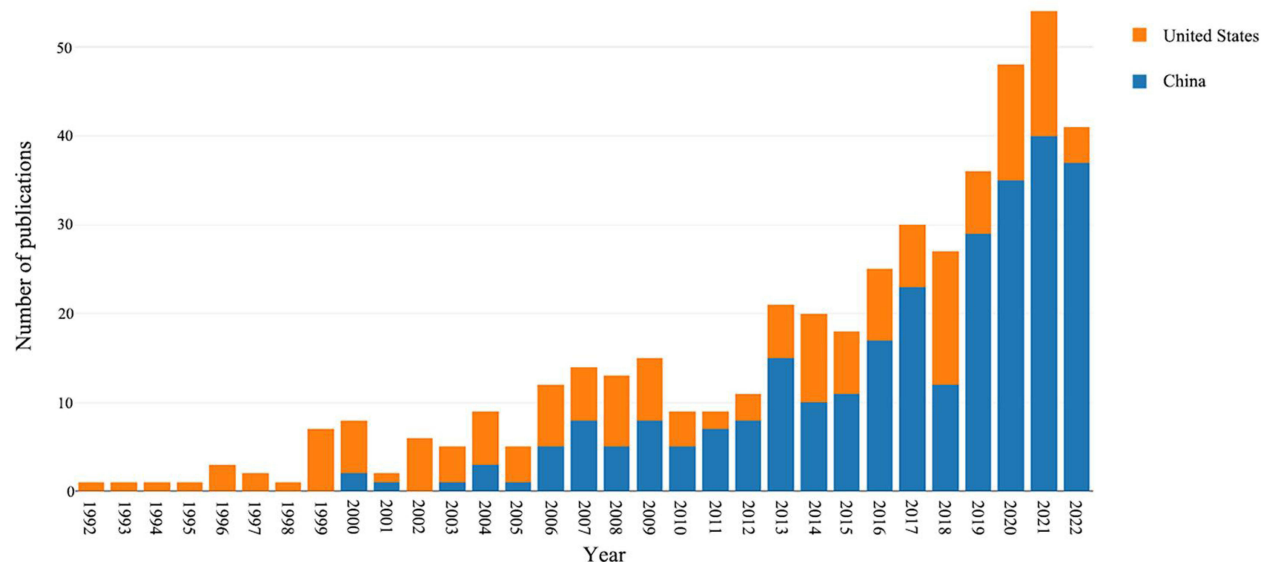
The cooperation between different countries or institutions is of far-reaching significance. The cooperation network between countries can show us the influence and cooperation attitude of countries or regions. To this end, we used VOSviewer and Scimago Graphic together to visualize cooperation in countries or regions. A total of 69 countries or regions were included. The results are shown in Figure 4. Forty-nine of the 69 countries had international cooperation, the United States had cooperated with 25 countries (Figure 4A), and the total number of cooperation occurrences was 56 (Figure 4B), ranking first. The United Kingdom conducted international cooperation with 16 countries, ranking second.



A



B



**Figure 3 (A)** The number of annual publications on dysmenorrhea from 1992 to 2022. **(B)** The number of publications per year on dysmenorrhea in the United States and China from 1992 to 2022.

Australia ranked third and cooperated with 15 countries. However, China has shown a higher trend of cooperation. It has conducted 42 international cooperations, ranking second in the world, surpassing 35 in the United Kingdom and 23 in Australia. It is worth noting that among the countries that have participated in international cooperation, nearly one-third of the countries have only cooperated with one country, and nearly half of the countries have cooperated with less than two countries, which indicates that research in dysmenorrhea-related fields is more conducted through domestic cooperation. More extensive international cooperation can be expected in the future.

### Institutions

A total of 1273 institutions participated in research related to dysmenorrhea. Table 3 lists the total number of publications of the top 10 institutions and their related content, the number of citations and their countries. Table 4 lists the total

**Table 1** The Top 10 Countries or Regions on Publications on Dysmenorrhea from 1992 to 2022

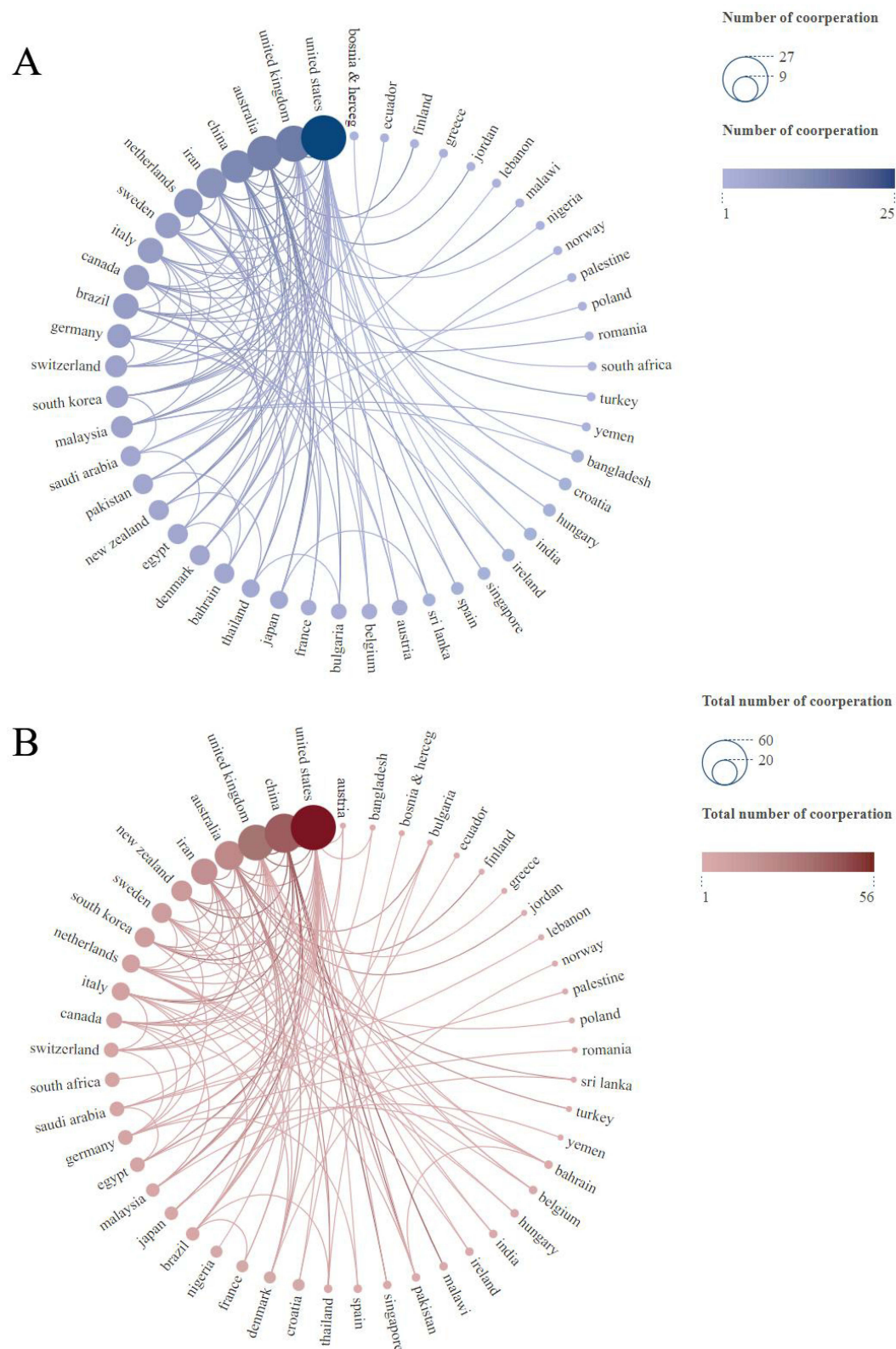
Rank	Publications	First Publicized Year	Citations	Countries or Regions
1	288	1995	4089	China
2	177	1992	6355	United States
3	87	2001	1513	Iran
4	81	1995	1179	Turkey
5	51	1992	956	Japan
6	56	1996	1243	United Kingdom
7	47	2006	716	South Korea
8	46	1997	1438	Australia
9	36	1992	1286	Italy
10	23	2002	374	Spain

**Table 2** The Top 10 Journals of Publications Volume on Dysmenorrhea from 1992 to 2022

Rank	Journals	Publications	Cited	Average Citation	IF (2022)	JCR	Publisher
1	Medicine	28	110	4.36	1.6	Q3	Lippincott Williams & Wilkins
2	J Pediatr Adol Gynec	27	539	20.56	1.8	Q4/Q3	Elsevier
3	Eur J Obstet Gyn R B	24	429	18.25	2.6	Q3/Q3	Elsevier
4	J Obstet Gynaecol Re	21	362	17.33	1.6	Q4	Wiley
5	Fertil Steril	19	1117	59.42	6.7	Q1	Elsevier
6	Int J Gynecol Obstet	18	449	25.06	3.8	Q2	Wiley
7	Arch Gynecol Obstet	17	262	15.94	2.6	Q3	Spring Nature
8	Complement Ther Med	17	287	17.06	3.6	Q2	Integrative Complementary Medicine
9	Obstet Gynecol	17	1338	79.24	7.2	Q1	Obstetrics Gynecology
10	Pain	17	1165	70.94	7.4	Q1	Lippincott Williams & Wilkins

number of papers, the number of citations and the average number of citations published by these institutions as the first finishers. Half of the top 10 institutions in total publications are from China. Beijing University of Chinese Medicine has the largest number of publications, with 25 publications, and Chengdu University of Traditional Chinese Medicine has 22 publications in total, ranking second. In addition, more than half of the publications in dysmenorrhea-related fields of these 2 institutions are published by the first author, indicating that the relevant literature of the 2 institutions occupies a dominant position in this field. The average number of citations of National Yang-Ming University ranked first, with 30.68. The number of papers issued by the first author of the organization varied. Half of the institutions were from China, and the other institutions were from South Korea, South Africa and Australia. It is worth noting that the average number of citations of the first author of Witwatersrand University was 32.2, ranking first, and far exceeding the 19.36 of National Yang-Ming University, which ranked second, indicating that the first author of this organization has a high worth and great influence in the field of dysmenorrhea. Whether it is the total number of publications or the number of first author publications, institutions from China account for a large proportion, while research institutions from the United States and Iran are relatively rare on the list. We checked the number of relevant institutions, and a total of 335 US institutions and 83 Iranian institutions have published literature in the field of dysmenorrhea, indicating that they have a large number of institutions and relatively scattered research.

The results from the CiteSpace institutional cooperation network analysis are shown in Figure 5. Among the institutions with a large number of publications, Taipei Veterans General Hospital, China Medical University and National Yang-Ming University constituted the cooperation triangle. The China Academy of Chinese Medical Sciences and Capital Medical University, Beijing University of Chinese Medicine showed more cooperation. These



**Figure 4 (A)** Network of cooperation in dysmenorrhea. Each circle represents a country or region, the size of the circle and the shade of the color inside represent the number of countries to work with, and the lines represent cooperative relationships. **(B)** Network of countries' total cooperation in dysmenorrhea. Each circle represents a country or region, the size of the circle area and the shade of the color inside represent the total number of collaborations, and the lines represent collaborative relationships.

**Table 3** The Top 10 Institutions of Publications Volume on Dysmenorrhea from 1992 to 2022

Rank	Institutions	Publications	Cited	Average Citation	Country
1	Beijing Univ Chinese Med	25	354	15.68	China
2	Chengdu Univ Tradit Chinese Med	22	143	7.45	China
3	Natl Yang Ming Univ	22	605	30.68	China
4	Nanjing Univ Chinese Med	19	325	18	China
5	Capital Medical Univ	17	318	19.47	China
6	Kyung Hee Univ	17	237	14.41	South Korea
7	Tehran Univ of Medical Sciences	16	109	7.13	Iran
8	Harvard Univ	15	289	19.6	United States
9	Taipei Veterans General Hospital	15	462	35.4	China
10	Shahid Beheshti Univ Med Sciences	14	309	22.71	Iran

**Table 4** Number of Publications in First-Author Units at the Top 10 Institutions in the Northeast in Terms of Number of Publications from 1992 to 2022

Rank	First-Author Affiliation	Publications	Cited	Average Citation	Country
1	Chengdu Univ Tradit Chinese Med	19	52	2.74	China
2	Nanjing Univ Chinese Med	16	71	4.44	China
3	Natl Yang Ming Univ	14	271	19.36	China
4	Beijing Univ Chinese Med	13	92	7.08	China
5	Univ Witwatersrand	10	322	32.2	South Africa
6	Indiana Univ	9	26	2.89	United States
7	Xidian Univ	9	88	9.78	China
8	Islamic Azad Univ	9	47	5.22	Iran
9	Kyung Hee Univ	8	46	5.75	South Korea
10	Korea Inst Oriental Med	8	38	4.75	South Korea

universities seem to constitute two relatively independent cooperation systems, and there is no correlation between the two cooperation systems. Closer cooperation efforts are mostly from within the same country, and there is less cooperation between institutions from different countries.

## Authors

Through the analysis of the number of articles published by the authors, the citation of the articles and the cooperative network, we found that 3859 authors have studied dysmenorrhea. Combining the analysis of the top 10 authors in Table 5, we found that most of the authors are from China. Among them, Jie Yang, from Chengdu University of Traditional Chinese Medicine, has published the largest number of articles, with 28 articles published and 207 citations. His research directions include Neurosciences Neurology, Integrated Comprehensive Medicine, Anesthesiology, and General Internal Medicine. The second is Professor Hsieh, Jen-Chuen from National Yang-Ming Chiao Tung University, who published 14 articles and was cited 462 times. His research directions include Neurosciences, Medicine Research Experimental, Integrative Complementary Medicine, and Neuroimaging.

Through the analysis of the cooperative relationship network, it can be found that most scholars have relatively fixed partners, and their cooperative relationships are intertwined to form several cooperative networks (Figure 6). Cooperation between Yu Chen and Ling Chen and between Hsieh Jen-Chuen, three scholars, is more frequent; Hellman Kevin and Tu Frank, Liang Fanrong and Jie Yang have also established close collaborations and published a large number of articles; and authors such as Yong-xiang Wang, Chen, Chen X. and Ji-xin Liu are more inclined to collaborate with different authors.



**Figure 5** Network of institutions' cooperation in dysmenorrhea research. Each circle represents an institution. The size of the circle is positively related to the number of articles published by the organization, and thickness of the line is positively correlated with the frequency of cooperation.

## Analysis of Co-Occurrence Network

### Interdisciplinary

To study the combination and development of various disciplines in the field of dysmenorrhea, we conducted a co-occurrence analysis of disciplines, as shown in Figure 7. Dysmenorrhea, as a gynecological symptom, easily affects women's lives. It has many inducements and various treatment methods, of which research involves multiple disciplines. Dysmenorrhea is a pain caused by uterine muscle spasms or organic lesions. Therefore, obstetrics and gynecology is the most important subject category of dysmenorrhea, which can directly indicate the pathological characteristics of dysmenorrhea.

Integrative and complementary medicine, general and internal medicine, pharmacology and pharmacy, neurosciences and neurology, and reproductive biology are also important disciplines for dysmenorrhea. The subject areas include mechanism exploration, incentive analysis, treatment and efficacy, clinical trials, and other aspects. In addition, public, environmental and occupational health is also a subject that cannot be ignored, including epidemiological investigation of dysmenorrhea, and health management.

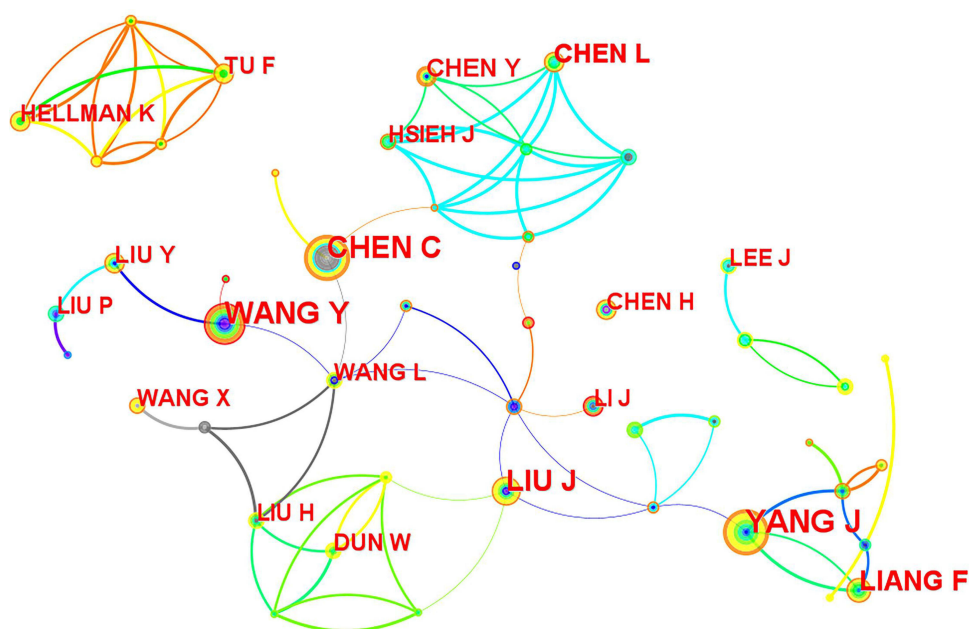
### Keywords

Figures 8–10 are the charts related to the keywords we exported. Keywords are used to express the theme and research direction of articles. Figure 8 shows the main keywords of the literature we collected and the complex relationship

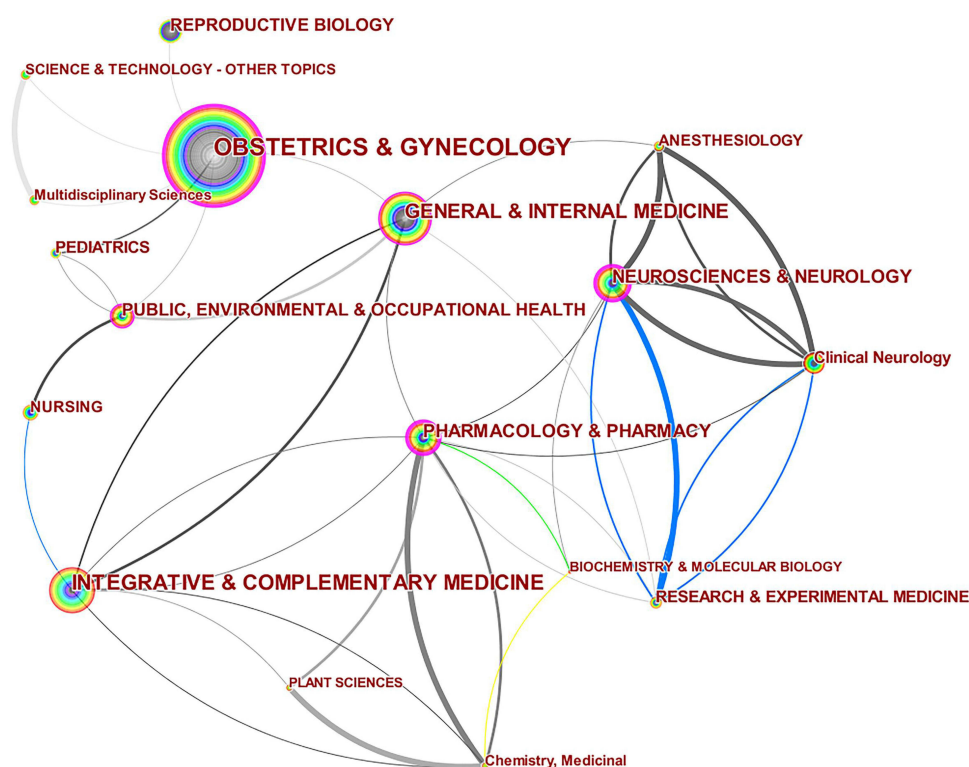
**Table 5** The Top 10 Authors of Publications Volume on Dysmenorrhea from 1992 to 2022

Rank	Authors	Publications	Cited	Average Citation	Affiliations	Countries
1	Yang, J	28	207	9.39	Chengdu University of Traditional Chinese Medicine	China
2	Hsieh, JC	14	462	37.93	National Yang Ming Chiao Tung University	China
3	Yu, SY	14	97	8.07	Beijing University of Chinese Medicine	China
4	Liu, P	13	340	27.15	Nanjing University of Chinese Medicine	China
5	Yang, L	13	126	10.4	Northshore University Health System	United States
6	Chao, HT	12	465	43	National Yang Ming Chiao Tung University	China
7	Chen, LF	12	324	31.08	National Yang Ming Chiao Tung University	China
8	Tu, FF	12	148	14.5	Northshore University Health System	United States
9	Hellman, KM	12	148	14.5	University of Chicago	United States
10	Dun, WH	11	113	12	Xi'an Jiaotong University	China



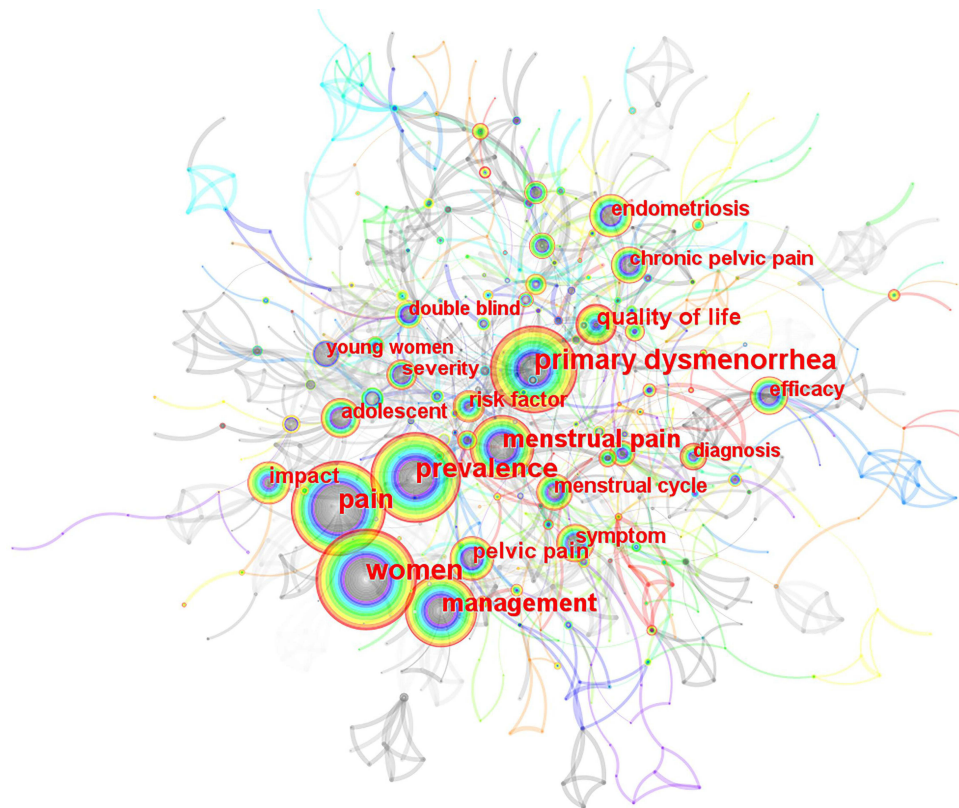


**Figure 6** Network of authors' cooperation in dysmenorrhea research. Each circle represents an author. The size of the circle is positively related to the number of articles published by the author, and thickness of the line is positively correlated with the frequency of cooperation.

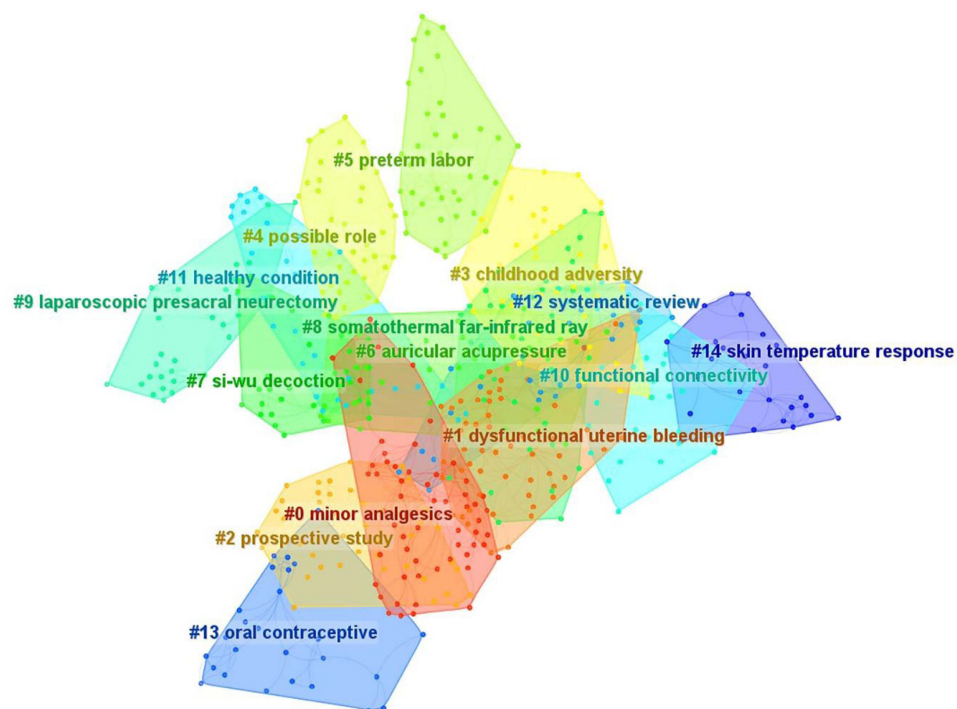


**Figure 7** Network disciplinary in dysmenorrhea research. Each circle represents a subject. The size of the circle is positively related to the frequency of subject, and thickness of the line is positively correlated with degree of association.

network between them. We used CiteSpace to filter articles related to keywords. We used dysmenorrhea as the key word to filter different expressions of dysmenorrhea, dysmenorrhoea, dysmenorrhea, menalgia, and dysmenorrhoeic. Table 6 shows the 20 most popular keywords. Among them, “women”, “adolescent”, “pain”, “menstrual pain” and “pelvic pain” were found to be the basic features of dysmenorrhea; “primary dysmenorrhea” and “endometriosis” represent different

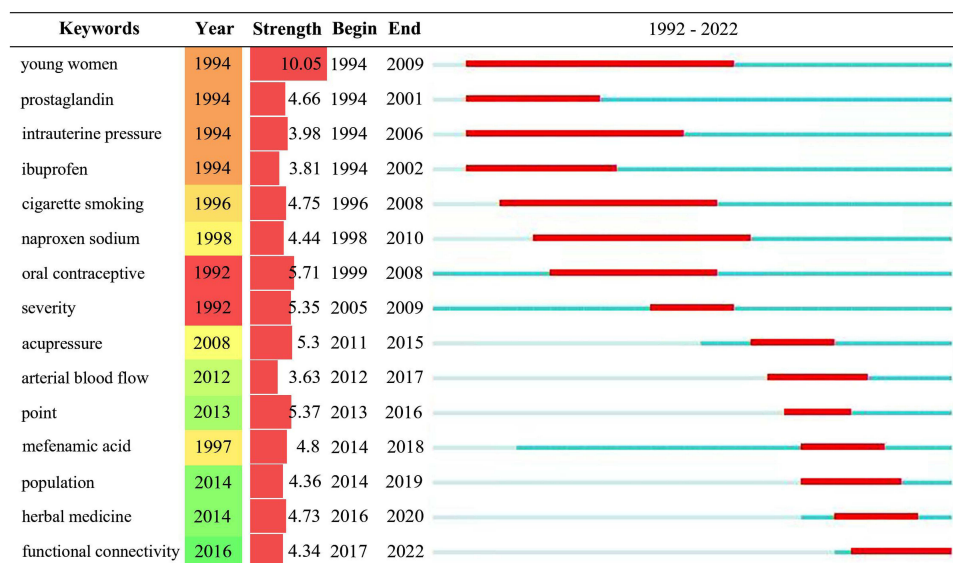


**Figure 8** Network keywords occurrence in dysmenorrhea research. Each circle represents a subject. The size of the circle is positively related to the frequency of keyword, and thickness of the line is positively correlated with degree of association. The connection between each node is numerous and jumbled, indicating that the links between each keyword are close, and also reflecting the cooperative relationship at the corresponding level.



**Figure 9** Clustered networks of keywords. Each color represents a cluster. The smaller the clustering label, the more articles in the cluster.

### Top 15 Keywords with the Strongest Citation Bursts



**Figure 10** Top 15 Keywords with the Strongest Citation Bursts. The keyword marked in red indicates a sudden increase in the frequency of the keyword during this period. Keywords marked in blue indicate a period of relative unpopularity.

pathogenic mechanisms of dysmenorrhea; “efficacy” and “double blind” relate to studies on the efficacy of dysmenorrhea drugs; and “prevalence”, “management”, “quality of life”, “impact”, etc., are related to epidemiology, self-health management and other aspects. These are the most important keywords.

Clustering tags are important noun phrases extracted from article titles. We used CiteSpace to construct a visual network map and analyze co-occurrence keyword clustering to obtain the status of each research topic of dysmenorrhea from 1992 to 2022. As shown in Figure 9, the co-occurrence keywords were divided into 15 groups, including # 0 minor analgesics, # 1 dysfunctional uterine bleeding, # 2 prospective study, # 3 childhood adversity, # 4 possible role, # 5 preterm labor, # 6 auricular acupressure, # 7 si-wu decoction, # 8 somatothermal far-infrared ray, # 9 laparoscopic presacral neurectomy, # 10 functional connectivity, # 11 healthy condition, # 12 systematic review, # 13 oral contraceptive, and # 14 skin temperature response.

We also conducted keywords burst detection; that is, keywords that have been cited many times in a certain period are usually considered indicators of cutting-edge topics. According to Figure 10, young women have a high outbreak intensity. Younger women, intrauterine pressure, cigarette smoking and naproxen sodium last the longest. The earliest keywords were in 1994: young women, prostaglandin, and intrauterine pressure. Moreover, basically every one or two years, new salient keywords emerged. After 2015, mefenamic acid, population, herbal medicine and functional

**Table 6** The Top 20 Keywords Related to Dysmenorrhea from 1992 to 2022

Rank	Keywords	Counts	Rank	Keywords	Counts
1	Dysmenorrhea	373	11	Adolescent	75
2	Women	294	12	Symptom	74
3	Primary dysmenorrhea	283	13	Quality of life	69
4	Pain	265	14	Efficacy	64
5	Prevalence	262	15	Severity	57
6	Management	161	16	Chronic pelvic pain	56
7	Menstrual pain	137	17	Risk factor	53
8	Endometriosis	124	18	Menstruation	51
9	Impact	88	19	Double blind	49
10	Pelvic pain	85	20	Ibuprofen	49

connectivity gradually came into use. The results indicate that researchers are further exploring other mechanisms and treatment methods of dysmenorrhea while paying more attention to group research.

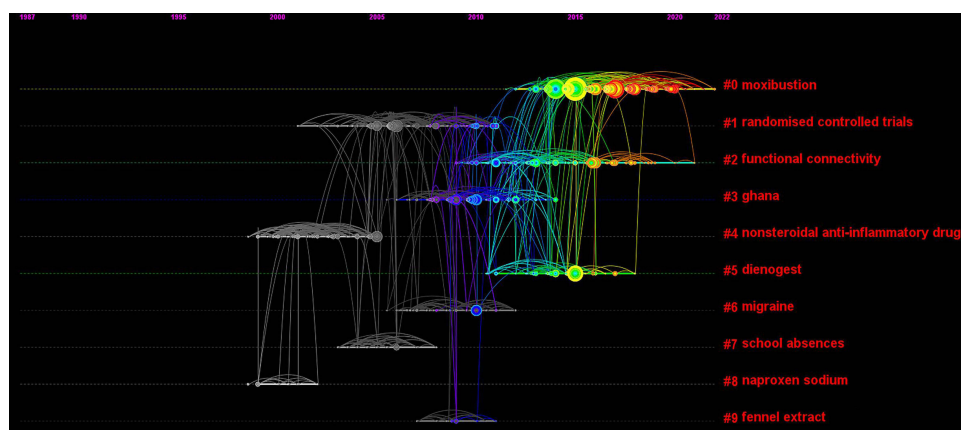
## Analysis of Reference Co-Citation Network

The co-citation of literature as a research method to measure the relationship between documents was first proposed by American intelligence scientist Henry Small in 1973.<sup>31</sup> We used CiteSpace to analyze the co-cited articles and obtained the network of co-cited references, the timeline map and the charts of the top ten most frequently cited articles. We found that the top 8 most cited documents can be classified into two categories: the first is a consensus guide for dysmenorrhea, and the second is a common treatment plan. These articles provide sufficient and reliable theoretical support for us to understand the mechanism, impact and clinical treatment of dysmenorrhea, which is convenient for us to study dysmenorrhea. We hope to identify influential and landmark research on dysmenorrhea through co-citation literature analysis.

We selected the top ten most frequently cited articles and tabulated their first authors, titles and publication years, citations, DOI and publishers (Table 7). These ten articles represent different types, including six papers and four review articles. Among them, the most frequently cited is the literature published by Riley, JL: A meta-analytic review of pain perception across the menstrual cycle. This article reviews and summarizes the correlation between women's menstrual cycle stages and experimentally induced pain perception in previous studies and confirms the conclusion that the menstrual cycle has a significant impact on human pain perception. It also systematically analyzes the article and raises issues that have not been addressed or noted in the article, such as whether subjects have clinical pain syndrome.<sup>32</sup> The second most cited article is Primary dysmenorrhea - Advances in pathogenesis and management by Dawood, MY in obstetrics and gynecology. This article introduces the prevalence, pathogenesis, treatment, and detection methods of dysmenorrhea, providing convenience for the understanding and management of primary dysmenorrhea.<sup>33</sup> Next is What we know about primary dysmenorrhea today: a critical review by Iacovides, S at Human Reproduction Update. Compared to the previous article, the author added a study on the effects and consequences of recurrent menstrual pain on pain sensitivity, mood, quality of life, and sleep in women with

**Table 7** The Top 10 Most Highly Cited Documents in the Field of Dysmenorrhea

Rank	First Author	Title and Publication Year	Citations	DOI	Journals
1	Riley, JL	A meta-analytic review of pain perception across the menstrual cycle (1999) <sup>32</sup>	384	10.1016/S0304-3959(98)00258-9	Pain
2	Dawood, MY	Primary dysmenorrhea - Advances in pathogenesis and management (2006) <sup>33</sup>	360	10.1097/01.AOG.0000230214.26638.0c	Obstet Gynecol
3	Iacovides, S	What we know about primary dysmenorrhea today: a critical review (2015) <sup>34</sup>	341	10.1093/humupd/dmv039	Hum Reprod Update
4	Ju, H	The Prevalence and Risk Factors of Dysmenorrhea (2014) <sup>9</sup>	275	10.1093/epirev/mxt009	Epidemiol Rev
5	Jamieson, DJ	The prevalence of dysmenorrhea, dyspareunia, pelvic pain, and irritable bowel syndrome in primary care practices (1996) <sup>36</sup>	261	10.1016/0029-7844(95)00360-6	Obstet Gynecol
6	Proctor, M	Diagnosis and management of dysmenorrhoea (2006) <sup>37</sup>	232	10.1136/bmj.332.7550.1134	BMJ-Brit Med J
7	French, L	Dysmenorrhea (2005) <sup>38</sup>	223	/	Am Fam Physician
8	Chapron, C	Deep infiltrating endometriosis: relation between severity of dysmenorrhoea and extent of disease (2003) <sup>35</sup>	211	10.1093/humrep/deg152	Hum Reprod
9	Banikarim, C	Prevalence and impact of dysmenorrhea on Hispanic female adolescents (2000) <sup>17</sup>	207	10.1001/archpedi.154.12.1226	Arch Pediatr Adolesc Med
10	Vercellini, P	Continuous use of an oral contraceptive for endometriosis-associated recurrent dysmenorrhea that does not respond to a cyclic pill regimen (2003) <sup>39</sup>	199	10.1016/S0015-0282(03)00794-5	Fertil Steril



**Figure 11** Timeline view of the top 10 largest clusters of citing articles in the field of dysmenorrhea. The highlighted and thickened timeline indicates that the cluster theme is a hot spot during this period.

primary dysmenorrhea and concluded that the quality of life in women with primary dysmenorrhea significantly decreased during menstruation, with poor mood.<sup>34</sup> In addition, Chapron, C's article published in Human Reproduction on Deep infiltrating endometriosis: relation between severity of dysmenorrhoea and extent of disease examined other variables associated with more severe PD and confirmed that the extent of subperitoneal infiltration and extensive attachment were the only factors associated with the severity of PD.<sup>35</sup>

The timeline view reflects the time span over which the literature was cited. Each line is a collection of similar articles, so the novelty and continuity of the research topic can be determined. Figure 11 shows the 10 components of 985 cited papers clustered by keywords, including # 0 moxibustion, # 1 randomized controlled trial, # 2 functional connectivity, # 3 Ghana, # 4 nonsteroidal anti-inflammatory drugs, # 5 dienogest, # 6 migraine, # 7 school absences, # 8 naproxen sodium, # 9 fennel extract. The higher the cluster tag is, the more documents are referenced. According to Figure 11, we find that the earliest research hotspot is naproxen sodium, a nonsteroidal anti-inflammatory drug. NSAIDs can relieve dysmenorrhea in most women, one of which is naproxen sodium.<sup>40</sup> With the gradual increase in the number of published papers on dysmenorrhea, coupled with the emphasis on the study of the causes and clinical mechanisms of dysmenorrhea, dienogest, functional connectivity, randomized controlled trials, the relationship between migraine and dysmenorrhea, etc., gradually became research hotspots between 2010 and 2015. At the same time, with the continuous development and promotion of traditional Chinese medicine, Chinese herbal medicine and some traditional Chinese medicine treatment methods gradually entered people's vision and have been applied to the relief treatment of dysmenorrhea. Since 2015, moxibustion has gradually become a research hotspot, and the number of studies has gradually increased in the past two year.

## Discussion

### General Information

In this study, we screened the literature in the field of dysmenorrhea in WOSCC and ultimately selected 1012 studies. Through the combination of bibliometrics and visual analysis, we studied the overall research content, research hotspots and development trends of dysmenorrhea in the past 30 years.

Dysmenorrhea has always been the most common gynecological disease, and it is also a disease with a high incidence. However, few women with dysmenorrhea have sought medical treatment in the past, and so people have not paid much attention to it. However, with the development of society, people's awareness has begun to change, and increasing attention has been given to gynecological diseases. During the 30 years from 1992 to 2022, the total number of published studies increased, and the growth rate increased year by year. There were great differences in the number of literature publications in various countries, and their development trends were also different. Judging from the publishing trend in the current year, China and the United States are globally leading dysmenorrhea



research, with China achieving a higher influence in the research due to its larger annual increase of academic publications.

It has become increasingly common for different countries, institutions and authors participate in joint research. To date, the United States is the most active country in cooperation and has cooperated with 25 countries 56 times. The top 3 cooperating institutions are Beijing University of Chinese Medicine, Chengdu University of Traditional Chinese Medicine, and National Yang-Ming Chiao Tung University. Six of the top 10 institutions are from China, indicating that China occupies an important position in international cooperation. The perspective of institutional cooperation networks indicates that most institutions are still more inclined to cooperate with domestic institutions, and international cooperation still needs to be strengthened. In any case, such cooperation will further promote academic progress and exchanges and contribute to further research on dysmenorrhea.

## Research Hotspots

Keywords co-occurrence analysis and clustering can reflect the research hotspots in related fields. Through the visualized map, four related research hotspots can be found: pathogenesis, epidemiology, self-management and treatment.

### Pathogenesis

The first theme is pathogenesis. Dysmenorrhea is classified into PD and SD, and there are essential differences between them. At present, modern medicine has recognized that increased prostaglandin is the main pathogenesis of PD and has been widely accepted. A large number of research papers on the mechanism of dysmenorrhea have been published.<sup>3,34</sup> Oxytocin,<sup>41,42</sup> Leukotriene,<sup>43,44</sup>  $\beta$ -endorphin,<sup>45</sup> and psychological factors<sup>46</sup> have also been shown to be associated with dysmenorrhea, but there seems to be little research on them. It is noteworthy that the mechanism of the effect of serum vasopressin on dysmenorrhea is still controversial. Ekstrom believes that elevated serum vasopressin can lead to vasoconstriction and pathological uterine contraction.<sup>47,48</sup> However, Valentin believes that vasopressin has nothing to do with the pathogenesis of dysmenorrhea.<sup>49</sup> Ekstrom's study contained ten healthy nulliparous women, and Valentin's study contained eight nulligravida with primary dysmenorrhea and eight nulligravida controls. The number of subjects in both groups was small, which may lead to the differentiation of conclusions. Further studies need to expand the sample size to prove that there is a correlation between serum vasopressin and dysmenorrhea. The pathogenesis of SD is different due to the different diseases that cause pain. A study proved that the most common cause of SD is endometriosis.<sup>4</sup> Keyword analysis showed that the frequency of endometrium was high, which confirmed its popularity in recent years. In existing studies, it is hypothesized that the postulated origins of endometriotic tissue are retrograde menstruation, coelomic metaplasia, and lymphatic and vascular metastasis. Retrograde transplants of endometrial tissue and cells attach to the surface of the peritoneum, invading nearby structures and causing an inflammatory response that can lead to dysmenorrhea.<sup>50,51</sup> Research related to pain and risk factors for dysmenorrhea<sup>52</sup> has been used to study the effects and management strategies of PD in college students.<sup>23</sup>

### Epidemiology and Self-Management

The epidemiology of dysmenorrhea and self-management research is also a hot spot. Many countries have studied the incidence of dysmenorrhea in people of different occupations and ages.<sup>53–55</sup> These studies aim to support epidemiologists in understanding disease-related patterns of occurrence, thereby helping to inform research on the etiology, risk factors and treatment of dysmenorrhea. It also helps to develop targeted and effective prevention programs, design more reliable diagnostic models and interventions, and guide protocols appropriate for dysmenorrhea research and treatment. According to the study, different ages and different regions of women have different prevalence. Among them, the prevalence in young women is generally higher.<sup>55,56</sup> No more than 30% of women seek help from a doctor when they have dysmenorrhea.<sup>57</sup> Approximately 70% of women practice self-management.<sup>58,59</sup> In women's self-management of dysmenorrhea, they use bed rest, herbal preparations, heating pads, and dietary supplements, which can relieve the symptoms of most people.<sup>60</sup> Among them, the use of heat is a popular measure. Heating pads have a significant effect on the lower abdomen.<sup>61,62</sup> Drinking tea is also one of the self-management methods used by many women experiencing dysmenorrhea,<sup>63</sup> but there is still controversy about whether it alleviates or aggravates dysmenorrhea.<sup>64,65</sup> After studying different types of tea drinking, some scholars found that moderate drinking of green tea and oolong tea could alleviate

dysmenorrhea, while black tea aggravates it.<sup>66</sup> In addition, smartphone apps are also used to help women relieve dysmenorrhea.<sup>67,68</sup> During our analysis, we found that a large part of the epidemiological research subjects were young women, which may be because dysmenorrhea symptoms will slow down or disappear with age.<sup>9</sup> There are few epidemiological studies on SD and no comprehensive description, so it is difficult to evaluate and judge.

## Treatment

At present, the most commonly used treatment for dysmenorrhea is nonsteroidal anti-inflammatory drugs (NSAIDs).<sup>50</sup> NSAIDs exert their effect by blocking the production of prostaglandins, which play a role by inhibiting cyclooxygenase (COX). NSAIDs include the common painkillers aspirin, naproxen, ibuprofen, and mefenamic acid.<sup>69</sup> Researchers such as Jane Marjoribanks have systematically studied the efficacy and safety of NSAIDs, which provides strong evidence for NSAIDs as the first-line treatment for PD.<sup>70,71</sup> For women whose nonsteroidal anti-inflammatory drugs do not reduce dysmenorrhea, hormone therapy is optional, including a combination of oral contraceptives, injectable contraceptive depot medroxyprogesterone acetate (DMPA), and other long-acting progestin-only hormonal contraceptives (such as Mirena LNG-IUS). The most widely used are combined oral contraceptives (OCPs).<sup>72</sup> Aslam N's study has shown that there is a 92% improvement in dysmenorrhea with the LNG-IUS.<sup>73</sup> In addition, research on traditional Chinese medicine and herbal medicine for dysmenorrhea treatment has also been a hotspot in recent years.<sup>74</sup> Among them, Shaofu-Zhuyu decoction can effectively relieve menstrual pain.<sup>75,76</sup> Transcutaneous electrical nerve stimulation, acupuncture, and surgical interventions have also been shown to relieve menstrual pain.<sup>77,78</sup> The effect of acupuncture proved to be significant and rapid.<sup>79</sup> Moxibustion is also used to treat dysmenorrhea, but Yang Mingxiao and other researchers believe that the effectiveness of moxibustion in treating menstrual pain cannot exclude the influence of psychological factors.<sup>80</sup> Note that as traditional Chinese medical treatments, acupuncture and moxibustion need dialectical typing as the basis.

## Research Frontiers

In recent years, the increased prevalence of “herbal medicine” and “functional connectivity” has emphasized the importance of both. Herbal medicine, as an ancient method of health care, has been widely used throughout human history. Currently, there is still a certain failure rate in the conventional treatment of dysmenorrhea, which is contraindicated or intolerant for some women. Herbal therapy, as a complementary and alternative medicine, has received increasing scholarly attention in recent years and has been shown to have a better effect.<sup>81,82</sup> Among them, Chinese herbal medicine is one of the most widely used herbal treatments, and the herbal prescription contains a unique herbal formula that can effectively treat dysmenorrhea by eliminating qi stagnation, dissolving blood stasis, and decomposing masses in blood vessels, thus promoting the flow of Qi and blood.<sup>83</sup> Categories of herbs such as herbs “regulating the Qi and Blood”, “warming the Interior”, “tonifying the Kidney and Liver” and “reinforcing Qi and Blood” are most commonly used, and clinical practice proves that TCM has an effective duration of up to three months.<sup>84,85</sup> Dang-Gui-Shao-Yao-San, Si-Wu-Tang and their appendages are commonly used formulas after preliminary clinical experiments demonstrating their efficacy.<sup>86,87</sup> Some commonly used Chinese herbal medicines, such as *Corydalis Rhizoma* (*Yanhusuo*) and *Cyperus Rhizoma* (*Xiangfu*), have multitarget effects on primary dysmenorrhea, such as analgesia, emotion regulation, and hormone regulation.<sup>85,88</sup> Currently, some promising evidence has been found to support the use of herbal medicine for the treatment of primary dysmenorrhea. RCTs have shown beneficial effects of Chinese herbal medicine on pain compared with placebo control, such as Ge-Gen decoction, Si-Wu-Tang and Dang-Gui-Shao-Yao-San.<sup>84,86,89,90</sup> However, there is still a lack of consistent and systematic evidence-based data to support efficacy and safety.

The study of the relationship between dysmenorrhea and functional connectivity between brain regions is receiving increasing attention. Primary dysmenorrhea is characterized by menstrual spasms without organic lesions, and there have been several findings suggesting that periodic menstrual pain is associated with structural and functional changes in relevant areas of the brain.<sup>91–93</sup> Current studies of functional connectivity have focused on the interactive interactions between primary dysmenorrhea and the neural central mechanisms associated with it. For example, the results from Cheng-Hao Tu and his team demonstrate that abnormal gray matter volume changes are present in PD patients. These changes may underpin a combination of impaired pain inhibition, increased pain facilitation and increased affect.<sup>94</sup> There are also research teams that explore the mechanism and effectiveness of treatments through related central

mechanisms.<sup>95,96</sup> The increase in functional connections has continued since 2017 and is a leading edge in the field of dysmenorrhea in recent years. At present, the mechanisms linking primary dysmenorrhea to altered neural centers are in their infancy, and future research will continue.

## Limitations

First, we only searched the relevant literature in WOSCC, which may lead to the omission of articles from other sources. Because the WOS is an English language database, it may omit other literature related to dysmenorrhea. Second, the screening process of articles was manual, and there may be deviations in understanding, leading to the omission of some documents. In addition, dysmenorrhea is classified as PD and SD. SD is caused by pelvic organic diseases, and most of its research focuses on diseases. We screen dysmenorrhea as a disease rather than a symptom, so we may have omitted some important literature.

## Conclusions

This study systematically summarizes and analyzes the research progress of dysmenorrhea in various countries, institutions, disciplines and researchers from 1992 to 2022 by means of bibliometrics. The literature on dysmenorrhea is increasing yearly. Prostaglandins are the main pathogenesis of dysmenorrhea, which has been widely recognized by the academic community. However, the mechanism of other substances affecting dysmenorrhea is not completely clear, such as serum vasopressin, which needs further research.

At present, the effect of NSAIDs on dysmenorrhea has been widely recognized. However, there is no clear treatment plan for patients who experience no effect on NSAIDs. Traditional Chinese medicine (such as acupuncture or moxibustion, prescriptions of traditional Chinese medicine) is used as a complementary and alternative medicine and has been proven to have a good therapeutic effect on dysmenorrhea. However, due to the difference in thinking and theoretical basis between Chinese traditional medicine and Western medicine, there is less combination between the two and a lack of strong evidence. In general, the research in this paper is based on the existing dysmenorrhea literature database. The treatment plan for dysmenorrhea in patients with ineffective nonsteroidal anti-inflammatory drugs and the treatment of traditional Chinese medicine need further research, hoping to aid the future research of dysmenorrhea.

## Abbreviations

PD, primary dysmenorrhea; SD, secondary dysmenorrhea; PGF<sub>2α</sub>, prostaglandin F<sub>2α</sub>; NSAIDs, nonsteroidal anti-inflammatory drugs; TENS, transcutaneous electrical nerve stimulation; LUNA, laparoscopic uterosacral nerve association; PSN, presacral neurectomy; LNG-IUS, levonorgestrel releasing intrauterine system; WOSCC, Web of Science core collection; SCI-EXPANDED, Science Citation Index Expanded; IF, impact factors; JCR, journal citation reports; NSAIDs, nonsteroidal anti-inflammatory drugs; COX, cyclooxygenase; DMPA, depot medroxyprogesterone acetate; OCPs, oral contraceptives.

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## Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

## Disclosure

None of the authors have conflicts of interest with respect to this work.

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