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Original Article

Research hot spots in the treatment of pediatric cerebral palsy based on bibliometric analysis

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Abstract: Background: Cerebral palsy is the most common cause of physical disability in children and there is currently no cure. This study aimed to explore potential hot spots and trends in the treatment field of pediatric cerebral palsy. Methods: Based on PubMed, global relevant literature was searched without language limits on pediatric cerebral palsy and treatment up to the end of April 27th, 2018. Through Bibliographic Item Co-Occurrence Matrix Builder (BICOMB), high-frequency MeSH terms were identified. Biclustering analysis results were visualized by gCLUTO software. Finally, a strategy diagram was created. Results: A total of 2435 articles relevant pediatric cerebral palsy and treatment were selected from PubMed that were published within the past five years. A total of 40 high-frequency MeSH terms were identified. "Cerebral Palsy/rehabilitation", "Cerebral Palsy/complications", "Cerebral Palsy/physiopathology" were the top three high-frequency MeSH terms. Then these high-frequent major MeSH terms were classified into 3 clusters based on biclustering analysis. After calculating the density and centricity of each cluster, a strategy diagram was made and 3 clusters were divided into 7 smaller topics. Conclusion: A total of 3 clusters and 7 topics were created for cerebral palsy and its treatment. Several treatment approaches of children with cerebral palsy are located at the second quadrant with low centricity and high density, which could become potential hot spots on pediatric cerebral palsy and treatment for in-depth research in the future. Therefore, greater progression is expected in the treatment of pediatric cerebral palsy.

Keywords: Hotspot, treatment, pediatric cerebral palsy, bibliometrics, co-word analysis

Introduction

Cerebral palsy is a group of motor and posture disorders caused by non-progressive brain damage, which is the most common cause of disability in children with cerebral palsy [1]. Cerebral palsy is a permanent movement and posture disorder due to a damage to developing brain, with a prevalence ranging from 1.7 to 3 per 1000 births [2, 3]. Though early brain development occurs at first 18 months, all non-progressive brain lesions that occur until 6 years may be defined as cerebral palsy. Brain damage that causes cerebral palsy may occur during prenatal, perinatal, or postnatal periods [4]. However, there is still no specific diagnostic method. In addition to motor function, cerebral palsy also affects cognitive, emotional and behavioral performance [5]. Thus far, a single cerebral palsy treatment has not been reached, but early treatment interventions can improve the motor function of patients. Various treatments seem to be effective, including physical therapy, occupational therapy, medication, surgery and orthoses [6-8]. Through appropriate treatment, the function and quality of life of children with cerebral palsy can be significantly improved. Therefore, more effective treatments are expected to relieve muscle spasms [9].

Studying the treatment approaches of pediatric cerebral palsy is essential for curing the disease. Based on bibliometrics, we performed a bibliometric analysis of pediatric cerebral palsy

and treatment. Bibliometrics is an area in which quantitative measurements are used to assess academic productivity. This analytical method has been applied in many fields because it has quantitative basic characteristics [10, 11]. Furthermore, bibliometric parameters have become an important part of modern academic productivity assessment [12]. Then a co-word analysis was developed by French bibliometric scientists [13]. The principle is that when two or more professional keywords represent a research topic appearing in the same paper, the relationship between the two keywords is proportional to the co-occurrence frequency [14]. With the development of bibliometric methods and tools, it is possible to analyze the hotspots and trends of pediatric cerebral palsy as accurately as possible. In this study, all research directions in pediatric cerebral palsy were considered to be part of the treatment of pediatric cerebral palsy. The research direction was closely related to the fundamental purpose of treatment.

Materials and methods

Data collection

The data related to pediatric cerebral palsy and treatment was from PubMed without the restrictions of languages. The reason the PubMed database was chosen is as follows: (i) PubMed is a free Medline search service containing the titles and abstracts of more than 4,900 biomedical journals in over 70 countries, which is the most authoritative medical database around the world; (ii) Due to the timeliness of the Internet, PubMed keeps updated one day; (iii) PubMed indexes most of the literature MeSH term, which reflects the content of the literature more accurate than keywords. Articles were collected concerning pediatric cerebral palsy and treatment until April 27th, 2018 and the search detail was as follows: (“pediatrics” [MeSH Terms] OR “pediatrics” [All Fields] OR “pediatric” [All Fields]) AND (“cerebral palsy” [MeSH Terms] OR (“cerebral” [All Fields] AND “palsy” [All Fields]) OR “cerebral palsy” [All Fields]) AND (“therapy” [Subheading] OR “therapy” [All Fields] OR “treatment” [All Fields] OR “therapeutics” [MeSH Terms] OR “therapeutics” [All Fields]). Publication trends was retrieved from GoPubMed (http://www.gopubmed.org).

Criteria for literature screening

According to the above search detail, 2450 publications were downloaded from PubMed. Two researchers independently checked all papers by title, abstract and the full text, which met the following criteria: (i) the type of study was an original article; (ii) the articles searched were related to pediatric cerebral palsy and treatment. Additionally, literature criteria were excluded as follows: (i) the study type was not an article but media coverage or science briefings; (ii) the main contents of the study were not related to pediatric cerebral palsy and treatment. One researcher excluded 25 articles, and the other researcher excluded 24 articles. Agreement was 96% and the title, author, institution, country, publication year, and MeSH terms of available articles were saved into a new file in XML.

Data extraction and analysis

XML file was imported into BICOMB for data extraction [16-18]. According to H index, the terms were first sorted in descending order of terms. Then the high-frequency major MeSH terms were identified if a term with frequency greater than or equal to its sequence number (h) from the list of high frequency terms, and h was the threshold for intercepting high frequency terms. Then the relationships between the high-frequency major MeSH terms and the source literature were identiifed by biclustering analysis. Then a binary matrix was produced by use of the source literature set generated by BICOMB and the high-frequency MeSH terms as columns and rows. The function of BICOMB is to accurately extract and count the bibliographic information from different databases. Furthermore, it come outs a co-occurrence matrix, which provides the basic data for subsequent statistical analysis. The gCLUTO is an interactive software for clustering low and high dimensional datasets, which analyzes the characteristics of various clusters [19].

Cluster analysis

The term matrix was used to perform co-occurrence double cluster analysis on gCLUTO, and select “repeated dichotomy”, “cosine” and “standard function” in “similarity function” and “I2”. The highest average Isim (intra-class similarity) clustering results and the lowest average

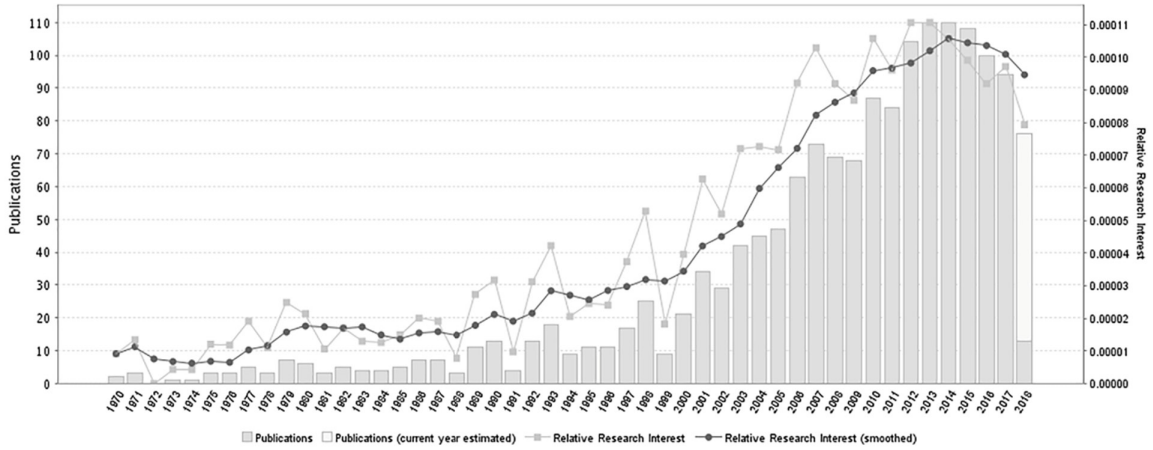


Figure 1. Volume of publications concerning the treatment of pediatric cerebral palsy.

Esim (inter-class similarity) were defined as the best outcomes from which to obtain a dual clustering mountain map. The double clustering mountain map was utilized to perform the clustering results. Different colors usually include red, yellow, green, light blue and dark blue hills. The color of the peak is significant, red indicates low standard deviation, and dark blue suggests high standard deviation. The height of the mountain was proportional to the similarity within the class. At the same time, the size of the mountain was proportional to the number of items. Additionally, a visualized matrix biclustering of high-frequent major MeSH terms and PubMed Unique Identifiers (PMIDs) was generated for articles on the application of stents in pancreatic diseases.

Strategic diagram analysis

By GraphPad Prism 7.0.0, we made a strategic diagram. The diagram is depicted based on centricity and density [20]. The X-axis represents for centrality, suggesting the closeness between keywords within this category and those within other categories. It indicates the degree of interaction between a subject area and other subject areas. The Y-axis stands for density, suggesting the closeness of the keywords within each category. This indicates that this category maintains and develops its own capabilities [21, 22].

Results

Overall evaluation

Based on GoPubMed, the literature information was obtained according to the search strategy: "pediatrics" [mesh] and "cerebral palsy" [mesh]. As shown in **Figure 1**, as time went by, the volume of publications increased year by year. By 2014, it had a downward trend. **Figure 2** shows the volume of paper outputs concerning the treatment of pediatric cerebral palsy in first 20 countries such as United States, Canada and Australia and so on and author relationship network was shown in **Figure 3**.

High-frequency MeSH terms

In this study, 2435 articles were obtained that met our research criteria. The MeSH terms occurring over 40 times were identified as high-frequency major MeSH terms. Then 40 high-frequency MeSH terms were analyzed, with a cumulative percentage of 29.2289. The top 3 high-frequency MeSH terms were "Cerebral Palsy/rehabilitation", "Cerebral Palsy/complications", "Cerebral Palsy/physiopathology" (**Table 1**). **Table 2** depicts the validity of the high-frequency major MeSH terms in the source papers. A "1" implies that there are major MeSH terms in the article, while "0" means no (**Table 2**).

Cluster analysis

The peak and matrix visualizations demonstrated the biclustering results for the high-frequency major MeSH term source matrix. **Figure 4** depicts that every cluster stood for a peak by cluster number 0, 1 and 2. The height, volume, and color of the peaks were used depict information about the associated clusters. The peak is the position on the plane related to the other peaks. The distance between a pair of

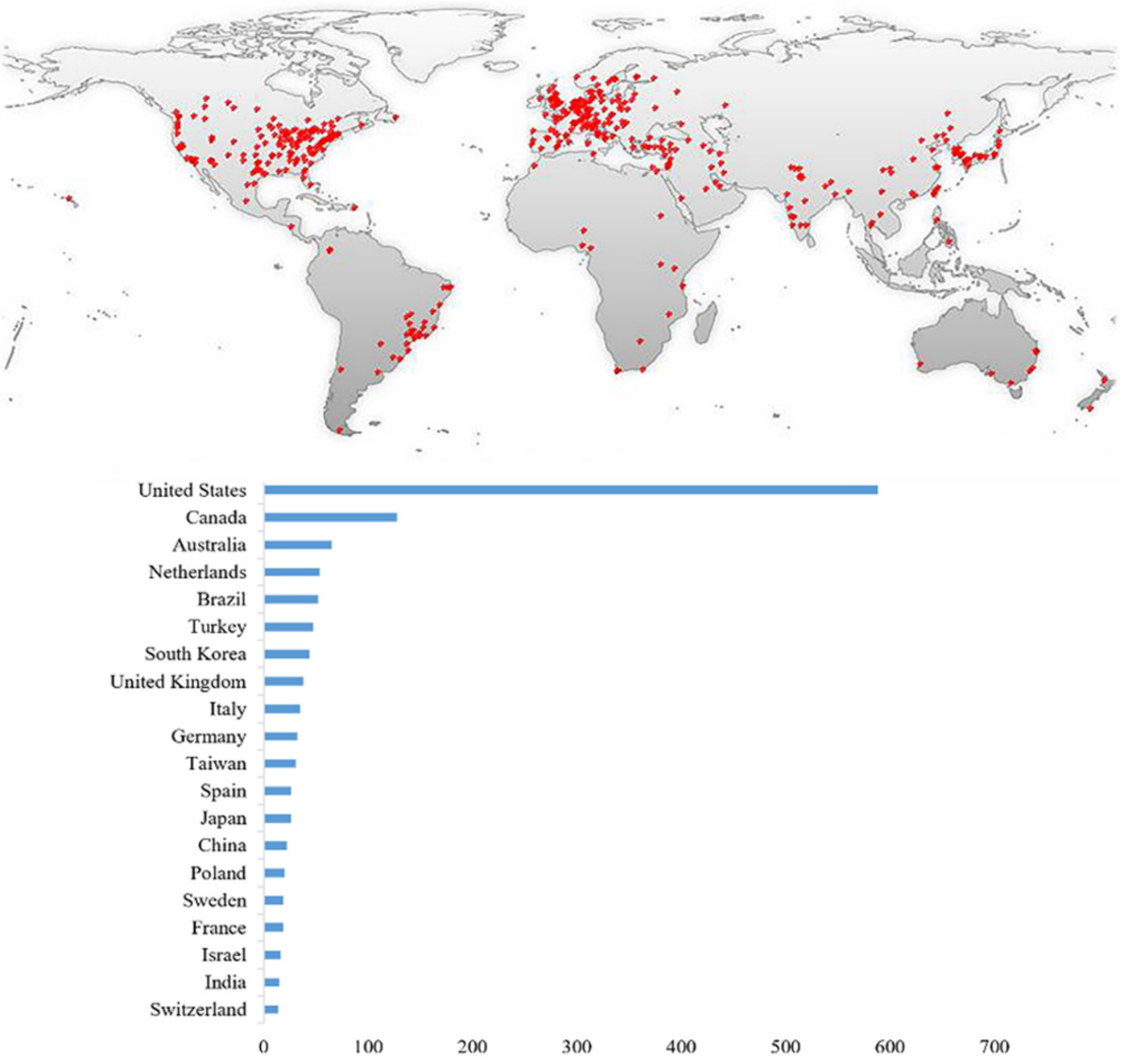

United States
Canada
Australia
Netherlands
Brazil
Turkey
South Korea
United Kingdom
Italy
Germany
Taiwan
Spain
Japan
China
Poland
Sweden
France
Israel
India
Switzerland
0
100
200
300
400
500
600
700

Figure 2. Top 20 countries of publication volume concerning the treatment of pediatric cerebral palsy.

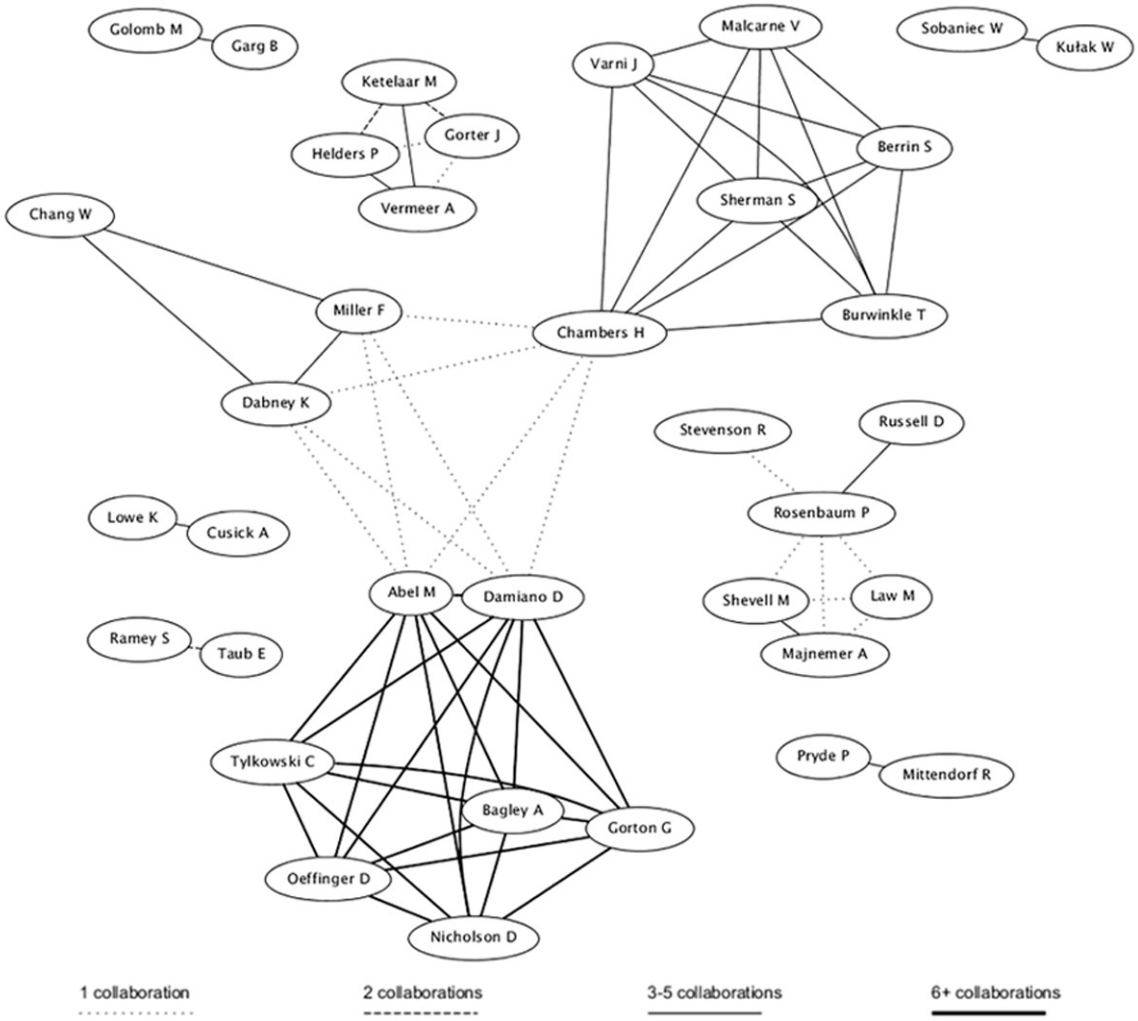


Figure 3. Author relationship network concerning the treatment of pediatric cerebral palsy.

peaks in a plane suggests the relative similarity of their clusters. The higher the peak, the more internal similarity of the cluster. The volume of the peak was directly proportional to the amounts of MeSH terms included in the cluster and the color of the peak depicted the internal standard deviation of a clustered object. Red color indicated a low deviation, while blue indicated a high deviation.

Figure 5 shows a visualized matrix biclustering of high-frequent major MeSH terms and PMIDs of articles on pediatric cerebral palsy and treatment. In **Figure 5**, the row labels stand for the major MeSH terms that are high-frequent and the column labels at the bottom and right of the matrix are PMIDs of the source items. The color of each grid expresses the relative the occurrence frequency of major MeSH terms in a particular article. The darker the red, the larger the values. Also white showed that the values were zero. The top hierarchical tree exhibited the relationship of the articles and the left hierarchical tree depicts the relation of the major high-frequent MeSH terms. Additionally, it also manifests the corresponding articles for every high-frequency MeSH entry in every cluster. The descriptive and discriminating features of representative articles in each cluster are shown in **Table 3**.

Additionally, the 3 clusters could be divided into smaller topics that met the following criteria: (i)

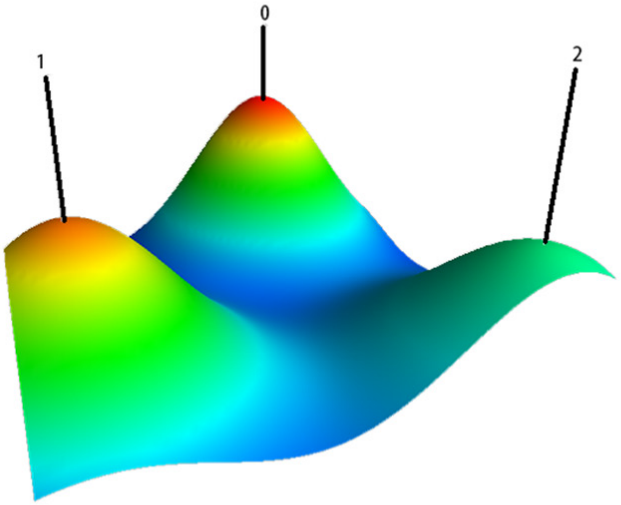
Table 1. High-frequency MeSH terms from the included publications on pediatric cerebral palsy and treatment (n=2435)

No.	MeSH terms	Frequency n (%)	Cumulative percentage, %
1	Cerebral Palsy/rehabilitation	627 (4.201)	4.201
2	Cerebral Palsy/complications	433 (2.9012)	7.1022
3	Cerebral Palsy/physiopathology	361 (2.4188)	9.5209
4	Cerebral Palsy/therapy	296 (1.9832)	11.5042
5	Cerebral Palsy/surgery	255 (1.7085)	13.2127
6	Cerebral Palsy/drug therapy	174 (1.1658)	14.3786
7	Physical Therapy Modalities	150 (1.005)	15.3836
8	Cerebral Palsy/diagnosis	115 (0.7705)	16.1541
9	Botulinum Toxins, Type A/therapeutic use	98 (0.6566)	16.8107
10	Gait	87 (0.5829)	17.3936
11	Disability Evaluation	85 (0.5695)	17.9631
12	Exercise Therapy/methods	84 (0.5628)	18.526
13	Neuromuscular Agents/therapeutic use	83 (0.5561)	19.0821
14	Cerebral Palsy/psychology	78 (0.5226)	19.6047
15	Cerebral Palsy/epidemiology	74 (0.4958)	20.1005
16	Hip Dislocation/surgery	69 (0.4623)	20.5628
17	Cerebral Palsy/etiology	67 (0.4489)	21.0117
18	Gait/physiology	66 (0.4422)	21.4539
19	Quality of Life	65 (0.4355)	21.8894
20	Activities of Daily Living	65 (0.4355)	22.325
21	Muscle Spasticity/drug therapy	64 (0.4288)	22.7538
22	Osteotomy/methods	62 (0.4154)	23.1692
23	Infant, Premature	62 (0.4154)	23.5846
24	Scoliosis/surgery	62 (0.4154)	24
25	Motor Skills	61(0.4087)	24.4087
26	Child Development	57 (0.3819)	24.7906
27	Disabled Children/rehabilitation	53 (0.3551)	25.1457
28	Baclofen/administration & dosage	51 (0.3417)	25.4874
29	Motor Skills/physiology	51 (0.3417)	25.8291
30	Walking/physiology	49 (0.3283)	26.1575
31	Infant, Very Low Birth Weight	49 (0.3283)	26.4858
32	Parents/psychology	47 (0.3149)	26.8007
33	Cerebral Palsy/prevention & control	47 (0.3149)	27.1156
34	Motor Activity/physiology	45 (0.3015)	27.4171
35	Femur/surgery	45 (0.3015)	27.7186
36	Cerebral Palsy	44 (0.2948)	28.0134
37	Hemiplegia/rehabilitation	43 (0.2881)	28.3015
38	Rhizotomy/methods	41 (0.2747)	28.5762
39	Botulinum Toxins, Type A/administration & dosage	41 (0.2747)	28.8509
40	Cerebral Palsy/nursing	40 (0.268)	29.1189

The semantic relationship between MeSH terms and larger clusters; (ii) The year of MeSH terms are introduced into MeSH terms; (iii) The categories of MeSH terms. Each smaller topic is aggregated into several separate topics. Finally, the 7 topics were obtained in the fields of pediatric cerebral palsy and treatment: (i) Botulinum toxin type A injection (cluster 0); (ii) Scoliosis surgery in children with cerebral palsy (cluster 0); (iii) Femoral derotation osteotomy in

Table 2. High-frequency MeSH terms in the source articles matrix

No	Major MeSH terms	PubMed Unique Identifiers of source article				
		100077	10023163	10050489		9974100
1	Cerebral Palsy/rehabilitation	0	0	1	...	0
2	Cerebral Palsy/complications	0	1	0	...	1
3	Cerebral Palsy/physiopathology	0	0	0	...	0
4	Cerebral Palsy/therapy	0	0	0	...	1
...	...	...	...	...	...	...
40	Cerebral Palsy/nursing	0	0	0	...	0



Cluster	Mesh Terms
0	Neuromuscular Agents / therapeutic use
	Botulinum Toxins, Type A / therapeutic use
	Cerebral Palsy / drug therapy
	Baclofen / administration & dosage
	Muscle Spasticity / drug therapy
	Botulinum Toxins, Type A / administration & dosage
	Scoliosis / surgery
	Cerebral Palsy / complications
	Hip Dislocation / surgery
	Osteotomy / methods
	Femur / surgery
	Rhizotomy / methods
	Cerebral Palsy / surgery
1	Gait
	Cerebral Palsy / physiopathology
	Motor Activity / physiology
	Motor Skills / physiology
	Disability Evaluation
	Disabled Children / rehabilitation
	Physical Therapy Modalities
	Cerebral Palsy / rehabilitation
	Hemiplegia / rehabilitation
	Exercise Therapy / methods
	Walking / physiology
	Gait / physiology
	Motor Skills
	Activities of Daily Living
2	Cerebral Palsy / therapy
	Cerebral Palsy / diagnosis
	Cerebral Palsy / psychology
	Cerebral Palsy / epidemiology
	Cerebral Palsy / etiology
	Quality of Life
	Infant, Premature
	Child Development
	Infant, Very Low Birth Weight
	Parents / psychology
	Cerebral Palsy / prevention & control
	Cerebral Palsy
	Cerebral Palsy / nursing

Figure 4. Mountain visualization biclustering of high-frequency MeSH terms and articles on pediatric cerebral palsy and treatment.

children with cerebral palsy (cluster 0); (iv) Selective dorsal rhizotomy in children with cerebral palsy (cluster 0); (v) Motor control (cluster 1); (vi) Rehabilitation treatment technology (cluster 1); (vii) Social support (cluster 2).

Strategic diagram

Table 4 shows the centrality and density of the 3 clusters. As shown in **Figure 6**, x-axis represents the centrality, and y-axis stands for the density on the strategy diagram. **Figure 6** depicts that cluster 1 locates in the first quadrant, suggesting that the density and centrality degrees are both high. The MeSH terms in cluster 1 are closely linked, and research tends to be mature and the orientation is high, suggesting that it is at the center of the research network. Cluster 0 is located in the second quadrant with high density and low centrality, indicating that internal links are close together with a clear topic. The research on this topic is relatively mature, with little correlation with other research. The research on this topic has potential value. However, more research is required. Cluster 2 is located in the third quadrant, with

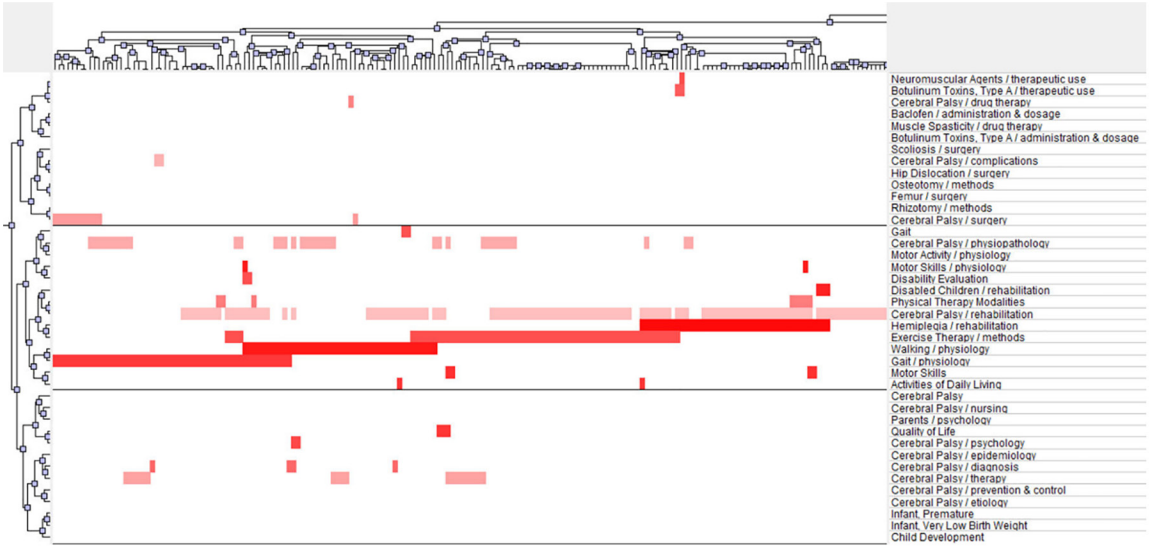


Figure 5. Visualized matrix biclustering of high-frequency MeSH terms and PMIDs of articles on pediatric cerebral palsy and treatment.

Table 3. Descriptive and discriminating features

Descriptive and discriminating features				
Cluster 0 size: 13 ISim: 0.153 ESim: 0.008				
Descriptive	16791078	26588835	20502236	20104162
Discriminating	16791078	26588835	2358491	20104162
Cluster 1 size: 14 ISim: 0.134 ESim: 0.013				
Descriptive	26643822	18226648	23651175	19406307
Discriminating	26643822	18226648	23651175	19406307
Cluster 2 size: 13 ISim: 0.107 ESim: 0.011				
Descriptive	15530713	15292886	23643762	9088760
Discriminating	15530713	15292886	9088760	18524743

Table 4. The centrality and density of the 3 clusters

Cluster	Intra-class link averages	Density-Y	Inter-class link average	Centrality-X
0	20.30128205	1.785409035	1.03988604	-0.299586216
1	23.02197802	4.506105006	1.656593407	0.31712115
2	12.22435897	-6.291514042	1.321937322	-0.017534934
Average	18.51587302		1.339472256	

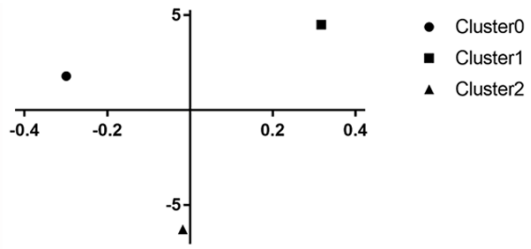


Figure 6. Strategic diagram of the 3 clusters.

low density and low centrality. MeSH terms of Cluster 2 are the margins of the entire field. The internal structure is relatively loose and research is not yet mature.

Discussion

There have been few papers on the hot spots and trends of pediatric cerebral palsy and treatment by use of bibliometrics. Therefore, our

research fills this gap. Here, papers related to pediatric cerebral palsy and treatment from PubMed in the past five years were analyzed. After screening, 2435 relevant publications were obtained via checking title, abstract and the full text and 40 high-frequency MeSH terms such as Cerebral Palsy/rehabilitation, Cerebral Palsy/complications, Cerebral Palsy/physiopathology were identified, which were the most popular words in the fields of pediatric cerebral palsy and treatment. Through the co-word analysis, 3 clusters were obtained and the 3 clusters were divided into smaller 7 topics. Among them, motor control and rehabilitation treatment technology are the research center and current research hot spots of cerebral palsy and its treatment. Botulinum toxin type A injection, scoliosis surgery in children with cerebral palsy, femoral derotation osteotomy in children with cerebral palsy, selective dorsal rhizotomy in children with cerebral palsy are located at the second quadrant with high centrality and low density, indicating that these topics are not yet mature and could become potential hotspots in the future. Social support is located at the fourth quadrant with low centricity and low density. Then the above 7 topics were introduced.

Botulinum toxin type A injection

Spastic type is the most common subtype of cerebral palsy. Spasticity is defined as a velocity-dependent increase in tonic stretch reflexes with exaggerated tendon jerks, which results from hyperexcitability of the stretch reflex, as a part of the upper motor neuron syndrome. Botulinum toxin type A is a safe and effective therapy to control spasticity in children with cerebral palsy, which may increase range of motion, improve function, and even reduce pain [22]. However, there are common side effects in botulinum toxin type A injection [23]. Several factors have been considered to influence the efficacy of botulinum toxins, such as dosage, proper muscle selection and application, age and concomitant therapy [24]. Most children with cerebral palsy receive botulinum toxin type A to reduce muscle tone, but there is a knowledge gap in understanding the changes in neurological and non-neural components of the sputum state after injection [25].

Scoliosis surgery in children with cerebral palsy

Children with cerebral palsy have an increased risk of scoliosis that is usually considered to be between 20% and 25%. Surgical intervention is the first choice for treating progressive scoliosis in children with cerebral palsy, which can prevent the curve progresses, balance the pelvis, and achieve a good frontal and sagittal balance [26]. Scoliosis surgery in children with cerebral palsy contributes to a significant improvement in health-related quality of life at long-term follow-up [27].

Femoral derotation osteotomy in children with cerebral palsy

Internal rotation gait is one of the most common gait abnormalities in children with cerebral palsy, with prevalence of 60-70% [28]. Femoral rotation osteotomy is the key treatment for children with cerebral palsy and internal rotation gait [29]. Osteotomy can be performed at the level of the sacral or intertrochanteric, with satisfactory results in children with cerebral palsy. Nevertheless, there are high rates of over-correction and under-correction [30]. It has also been reported that femoral rotation osteotomy has high rates of recurrence [31].

Selective dorsal rhizotomy in children with cerebral palsy

Selective dorsal root stenosis is an acceptable treatment for reducing lower extremity spasm in children with spastic bilateral cerebral palsy [32, 33]. The procedure is most extensively performed at the level of the lumbosacral region to reduce paralysis of the lower extremities, including surgical interruption of the incoming input of single synaptic extension reflexes. To reduce the adverse effects on sensory and sphincter function, the dorsal root is divided into separate roots, and only a portion of these dorsal roots are transected to complete the other roots, thereby maintaining sensory function [34, 35].

Motor control

Poor motor control is a hallmark of cerebral palsy. The motor disorders of cerebral palsy are often associated with sensation, perception, cognition, communication, behavior, and mus-

culoskeletal problems [36]. Motion control is important for predictive results, but quantifying motion control is still challenging [37]. Nursing criteria for cerebral palsy disorders include physical therapy provided primarily through prepuberty in early childhood and a series of parallel medical and surgical interventions [38].

Rehabilitation treatment technology

There are obvious individual differences among children with cerebral palsy. Growing evidence has suggested that the effects of cerebral palsy rehabilitation are directly related to the children's sense of self-participation. Therefore, in the process of rehabilitation, it is necessary to train the children's exercise ability and cognitive level. Based on traditional treatment methods, children with cerebral palsy can be rehabilitated through the application of therapeutic strategies. As an example, virtual reality rehabilitation is a novel therapy for motor rehabilitation of children with cerebral palsy [39].

Social support

Children with cerebral palsy are more difficult to participate in games, daily activities and social interactions, so that they are more dependent on their parents [40, 41]. Parenting practice makes a significant contribution to children's developmental outcomes. Positive parent-child interaction contributes to the development of children with cerebral palsy. Regardless of the degree of disability of the child, the parent-child relationship is closely related to parents' pain, instructions and interaction time. Therefore, it is important to concern parental mental health problems in early childhood intervention. Furthermore, it is necessary to in-depth explore how therapists support parents to implement therapeutic strategies to minimize negative influence on the developing parent-child relationship [42, 43].

Conclusion

A total of 2435 articles concerning pediatric cerebral palsy and treatment were analyzed from papers published within the past 5 years and listed on PubMed according to bibliometrics. Finally, 3 larger topics and 7 smaller topics were analyzed for further research. Several treatment approaches of children with cerebral palsy are located at the second quadrant with low centricity and high density, which could become potential hot spots on pediatric cerebral palsy and treatment for in-depth research in the future. Therefore, greater progression is expected in the treatment of pediatric cerebral palsy.

Disclosure of conflict of interest

None.

Abbreviations

BICOMB, Bibliographic Item Co-Occurrence Matrix Builder; PMIDs, PubMed Unique Identifiers.

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