

Review Article

Development Suggestion and Hotspots Analysis of Medical Undergraduate Scientific Research Training at Home and Abroad Based on CiteSpace Software

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Abstract: *Objective:* To study the current situation and hotspots of medical undergraduate research training at home and abroad, and to provide suggestions for the development of medical undergraduate research training in China. *Methods:* PubMed and CNKI were used as data sources to retrieve literature related to medical undergraduates scientific research training from January 2000 to July 2021. Based on CiteSpace software, visualized analysis was performed on the literature of age, country, author, institution and keyword. Use Excel to make statistics of CiteSpace running results. *Results:* The number of domestic and foreign literature was on the rise. The United States published the most English literature in this field, and Beijing and Jiangsu have published the most Chinese literature in this field. The distribution of core authors at home and abroad is discrete, and some core authors have cooperated with each other. Domestic research institutions are mainly medical colleges and universities, while foreign research institutions are mainly medical institutions. There are 5 cluster label words in English literature and 9 cluster label words in Chinese literature. There are 11 burst terms in foreign countries and 20 burst terms in Chinese. The historical evolution process of foreign research can be divided into theoretical education and practical education, while the historical evolution process of domestic research can be divided into exploration, development, continuous research and deepening research. *Conclusion:* There are great differences between domestic and foreign research hotspots. Domestic research focuses on research ability and quality, while foreign research focuses on the combination of theory and practice. There are certain problems in teaching, practice, system, influence and other aspects. It is suggested that the teaching methods should be diversified based on practice, the scientific training system should be improved, and the cooperation between domestic and foreign institutions and authors should be strengthened to further deepen the research in this field and lay a good foundation for the future scientific research and training system.

Keywords: Medical Undergraduates, Scientific Research Training, Visual Analysis, CiteSpace

1. Background

Scientific research training is a way to cultivate students' scientific research ability, scientific research quality and innovation ability. Undergraduate scientific research training provides a new way of thinking for national talent training programs, and can be combined with teaching reform and teaching innovation to cultivate innovative talents [1]. In 1969, undergraduate research training became popular at MIT. It was called the Undergraduate Research Opportunity Program

(UROP). This program was proposed to provide undergraduates with research training opportunities. In this program, undergraduates can participate in faculty projects or their own projects [2]. Since then, undergraduate scientific research training has become popular in universities in the United States, Britain and other countries. In 1995, Chinese universities introduced undergraduate scientific research training, and Tsinghua University took the lead in implementing it [3]. Subsequently, undergraduate scientific research training began to expand in China. In 2007, the

Ministry of Education launched undergraduate scientific research training programs in universities across the country, such as Physician education and training program of excellence, New medical construction program, Undergraduate innovation and entrepreneurship Training program, Undergraduate Academic Research Funding Program of Fudan University, etc. Up to now, through unremitting exploration and development, undergraduate scientific research training has become one of the important links in cultivating new talents, which plays a key role in cultivating students' independent learning ability and innovative thinking [4].

With the continuous improvement of people's living standards and health awareness, people's demand for health is gradually diversified, which puts forward higher professional requirements for health service providers, and more stringent requirements for the quality of medical talents. Medical talents must have strong scientific research and innovation ability [5] to provide better healthy service. Therefore, the cultivation of scientific research ability and quality of medical students has become an indispensable part of modern medical education.

CiteSpace document metrology tool is a Java application that uses clustering and emergence methods to visually analyze documents [6], and it can make visual analysis of a large number of literature, and identify hot research topics and development trends [7]. The chronological distribution and national and regional distribution of documents can explain the research trend of this field. Core authors are the backbone of the research in this field, and have certain influence. They can attract more researchers to devote themselves to the research in this field, strengthen the communication and cooperation between authors, and maximize the use of resources. Research institutions provide basic research conditions for scholars to conduct long-term, organized and planned research. The keyword clustering network analysis can summarize the research hotspots in recent years and point out certain research status for researchers. Keyword burst detection can be used as a sign of sudden change of hot spots in the research field, which plays an important role in predicting the development trend of the topic [8]. At present, the application of CiteSpace in the field of scientific research training mainly includes the research hotspots analysis of scientific research management in a university, the knowledge map of scientific research data, the visual analysis of scientific research status, scientometrical analysis of SIRT6 studies, the research trend of acupuncture treatment, and the research of domestic medical education informatization, etc [9-14].

In this study, the knowledge map drawn by CiteSpace software and the establishment of keyword co-word network were used to visualize the knowledge structure of medical undergraduate scientific research training, analyze the status quo and hot topics of medical undergraduate scientific research training research at home and abroad, and provide suggestions for the development of medical undergraduate scientific research training in China.

2. Methods

2.1. Data Source

The Data of English literature in this study were from PubMed database, while the data of Chinese literature were from CNKI, and the retrieval period was from January 2000 to July 2021.

2.2. Retrieval Strategy

The retrieval strategy of PubMed is "medical undergraduate scientific research training" [All Type], [Free full text] AND English [lang]. The time interval is set from January 2000 to July 2021, with a total of 163 papers. CNKI uses "medical undergraduate scientific research training" as the "subject" field in advanced search, and the time interval is set from January 2000 to July 2021, with 106 articles in total. A total of 163 English and 106 Chinese literatures were screened through independent retrieval and comprehensive discussion.

2.3. Data Processing

CiteSpace 5.7.R5 software was used to process the documents. CiteSpace 5.7.R5 software was used to analyze the key words in literature related to scientific research training of medical undergraduates at home and abroad. Select Title, Abstract, Author keywords (ID) from 2000 JAN to 2021 JUL years per slice =1 for Text processing. The node type is selected as "keyword". Through keywords analysis, the main words in English literature are: medical student, undergraduate and medical undergraduate students; the main words in Chinese literature are: scientific research training, scientific research ability, scientific research quality, medical undergraduate, undergraduate, medical student. In the keyword clustering network, the module value (Q) of CiteSpace network structure and the modularity (Q) is 0.6066, and the silhouette (S) is 0.8738. $Q > 0.300$ means the partition structure is reasonable, and $S > 0.500$ means the clustering is reasonable.

3. Results

3.1. Research on Scientific Research Training of Medical Undergraduates at Home and Abroad

3.1.1. Chronological Distribution of Literature Publication

After importing Chinese and English literature into Citespace 5.7.R5 for processing, 160 English literature and 106 Chinese literature were obtained. The earliest research paper of medical undergraduate research training abroad was published in 1985, and the earliest research paper of medical undergraduate research training in China was published in 2000. Since the total number of literature in 2021 cannot be counted completely, the number of domestic and foreign papers from January 2000 to July 2021 shows that: The number of domestic and foreign literature showed an increasing trend, and the number of domestic literature tended to be stable, while the number of foreign literature increased

substantially. The number of foreign literature changed with a peak in three years. The number of foreign literature increased rapidly in 2014 and 2019, and reached the peak in 2020. From 2001 to 2004, the number of domestic literature was very

small. From 2013 to 2017, the number of domestic literature increased greatly. In 2018, the number of domestic literature achieved a breakthrough (Figure 1).

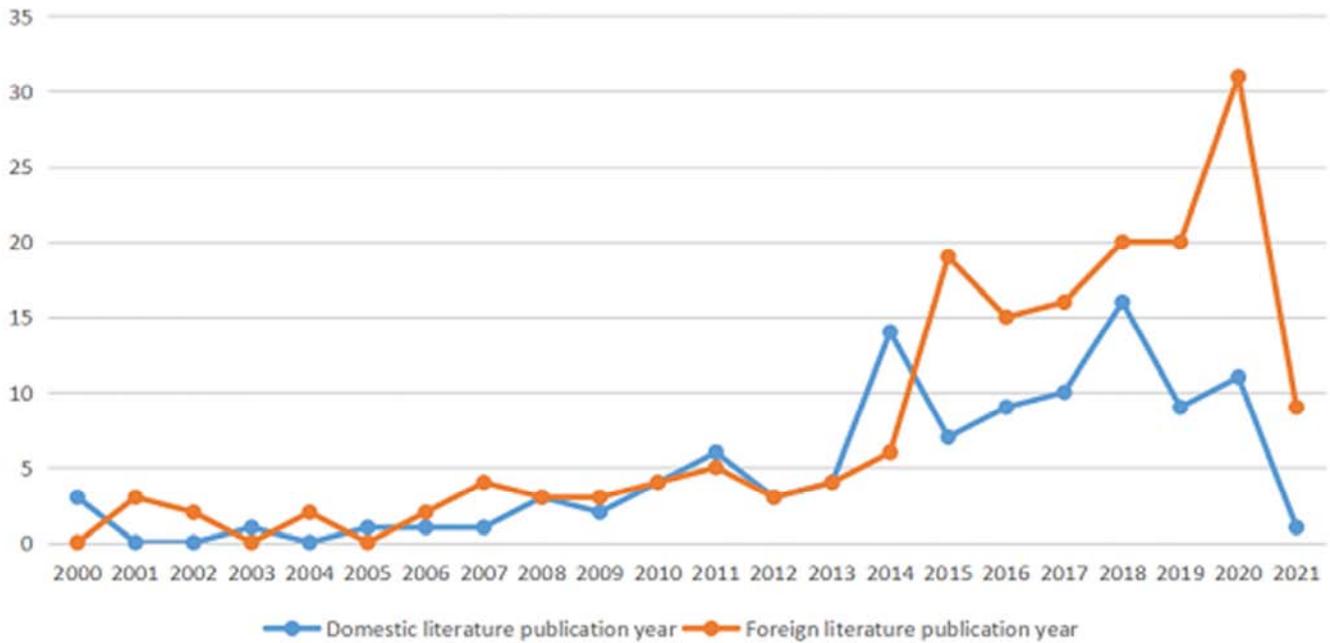


Figure 1. Time series distribution of medical undergraduate scientific research training from 2000 to 2021.

3.1.2. Country Distribution

The United States published the most English literature in the field of medical undergraduate scientific research training (57 articles), accounting for 34.97% of the total. Followed by Canada (14 articles) and China (13 articles), China's English literature accounted for 7.98% of the total (Figure 2).

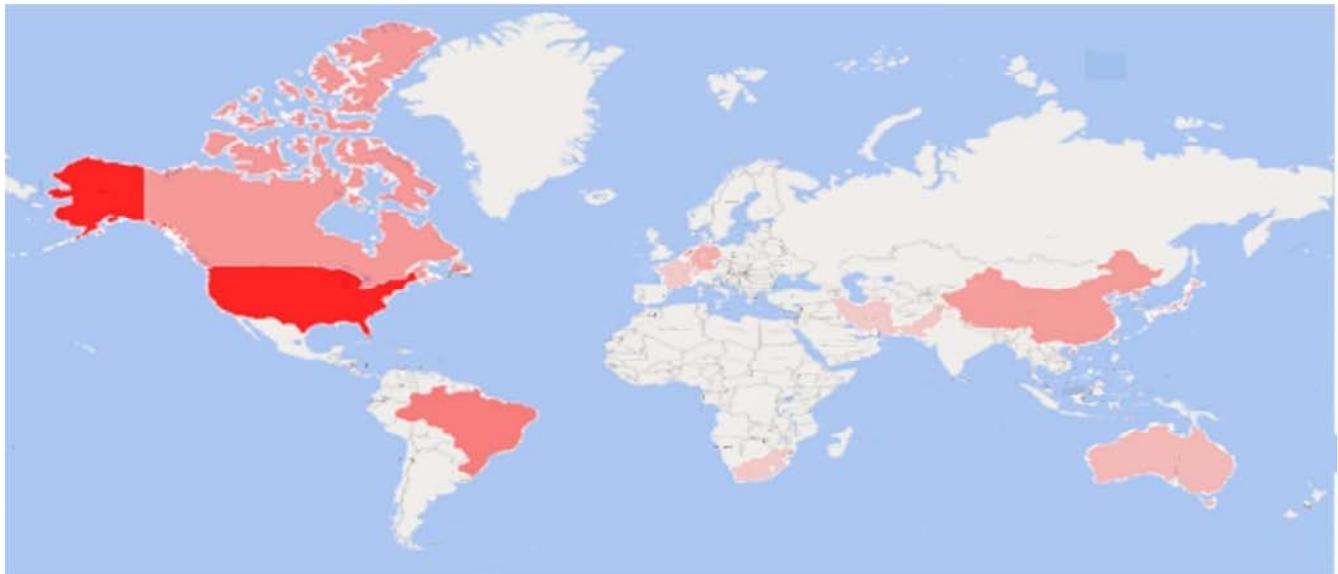


Figure 2. Global distribution of published literature on medical undergraduate research training.

3.1.3. Regional Distribution

Jiangsu and Beijing published the most Chinese literature in the field of medical undergraduate scientific research training (12 articles), accounting for 11.43% of the total. Followed by Guangdong (8), Liaoning, Anhui, Jilin and Sichuan (7)(Figure 3)

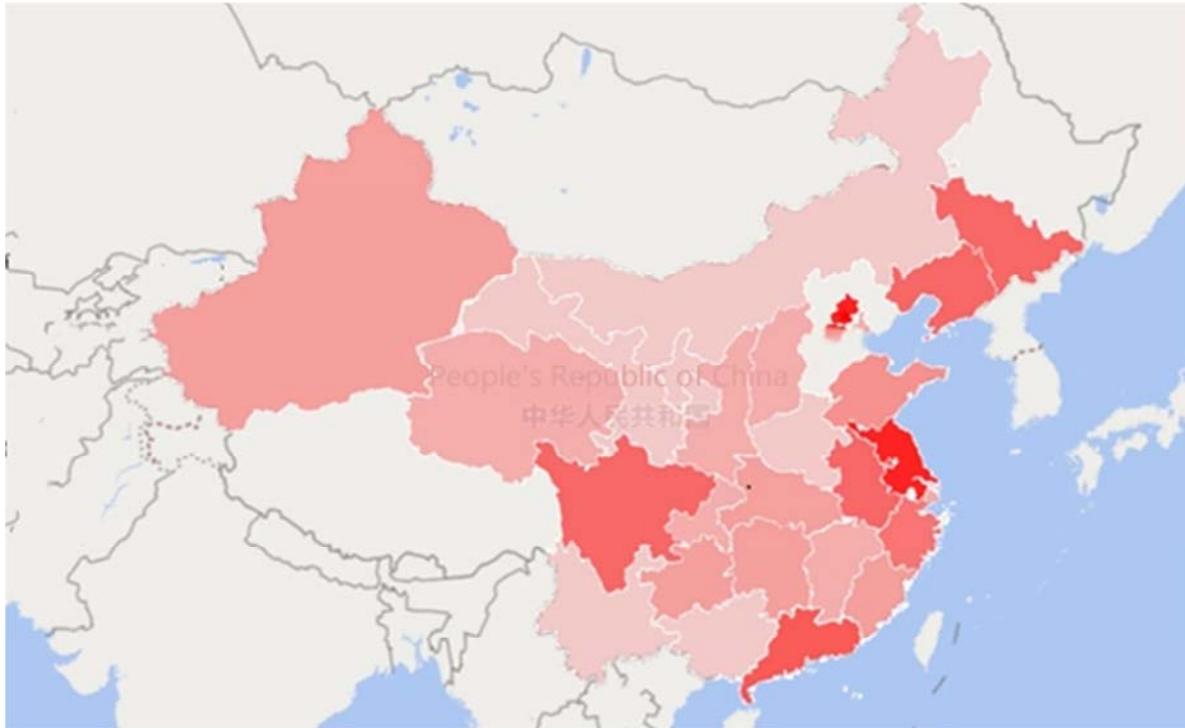


Figure 3. Domestic distribution of published literature on scientific research training of medical undergraduates.

3.2. Core Authors and Research Institutions

3.2.1. Core Authors

Core authors are the ones who drive the rapid development of a field, and can also increase the popularity and influence of a field. According to Price's law, it can be expressed as $M \approx 0.749 \sqrt{n_{max}}$, where n_{max} is the number of most frequently published papers among the study authors. When an author publishes more than M , it is the core author. According to the statistics of the number of articles published by authors using CiteSpace software. According to the formula, $m_{abroad} \approx 1$ and $m_{domestic} \approx 2$. Therefore, the 26 authors in Table 1 and the 18 authors in Table 2 can be referred to as core authors.

Table 1. Some foreign core authors of medical undergraduate scientific research training (papers ≥ 1).

Serial number	Name	Year	Article Number
1	FIONA WEBSTER	2012	2
2	LALIT KUMAR RADHA KRISHNA	2020	2
3	SHARON E STRAUS	2014	2
4	THOMAS BRUCKNER	2017	2
5	PATRICIA A CARNEY	2007	2
6	MEREDITH E YOUNG	2008	2
7	GABRIELLE M FINN	2018	2
8	ANNELISSA MIEN CHEW CHIN	2020	2
9	YUN TING ONG	2020	2
10	KEVIN POTTIE	2015	2
11	LIANG ZHOU	2015	2
12	SASKIA M PEE RDEMAN	2019	2
13	RASHMI A KUSURKAR	2019	2
14	JOHANNES CF KET	2019	2
15	STEPHEN MALONEY	2016	2
16	MIRCO FRIEDRICH	2017	2

Serial number	Name	Year	Article Number
17	ALIKI THOMAS	2018	2
18	LORRAINE HUI EN TAN	2020	2
19	MALOU STOFFELS	2019	2
20	DOUGLAS ARCHIBALD	2015	2
21	HESTER E M DAELMANS	2019	2
22	FELIX NICKEL	2017	2
23	KARLFRIEDRICH KOWALEWSKI	2017	2
24	STEPHEN MASON	2020	2
25	WOLF E HAUTZ	2015	2
26	TOBIAS RAUPACH	2015	1

Note: Two data with large experimental error have been excluded

Table 2. Some domestic core authors of medical undergraduate scientific research training (papers ≥ 2).

Serial Number	Name	Year	Article Number
1	Wei Zhang	2010	3
2	Bo Peng	2014	3
3	Ting Zhao	2014	3
4	Huan Liu	2017	2
5	Dan Wang	2014	2
6	Jin-Shun Qi	2014	2
7	Yan Qi	2014	2
8	Qiang Tao	2018	2
9	Pin-Yi Dai	2020	2
10	Tao Shen	2010	2
11	Shu-Zhen Chen	2020	2
12	ShunWang	2016	2
13	Chao Liu	2016	2
14	Xiu-Jun Zhang	2010	2
15	Wei Yang	2014	2
16	Mei-Na Wu	2014	2
17	Jing-Yan Ge	2014	2
18	Ye-Huan Sun	2010	2

CiteSpace can generate a collaboration map to visually

analyze the collaboration between authors. Each node or label in the collaboration map represents each author, the size of the label is proportional to the number of articles published by the author, and the line represents the collaboration. As shown in Figure 4, the distribution of foreign core authors is relatively discrete on the whole, but some core authors have cooperated for many times, forming three groups initially. As shown in

Figure 5, the overall distribution of domestic core authors is relatively discrete, but some core authors have cooperated for many times, and initially formed four groups. In this research field, they have published the most papers and are the main researchers in this field, but the total number of papers in this research field is far from enough.



Figure 4. Cooperation map of foreign core authors on research training of medical undergraduates.



Figure 5. Cooperation map of domestic core authors on research training of medical undergraduates.

3.2.2. Research Institutions

Through CiteSpace analysis, the results of each research institution are obtained, and the top 18 major research institutions are summarized as Table 3 and Table 4. CiteSpace software was used to generate the cooperation map of research institutions, as shown in Figure 6 and Figure 7. Domestic medical undergraduate scientific research training institutions are mainly medical undergraduate universities; Foreign medical undergraduate scientific research training institutions are mainly medical institutions. Although the number of domestic research institutions is large, the number of cooperative relations between institutions is few and relatively scattered. The number of foreign research institutions is large, and the relationship between foreign research institutions and domestic research institutions is closer in terms of cooperative research.



Figure 6. Cooperation map of major foreign research institutions for medical undergraduate research training.

Table 3. Major foreign research institutions for scientific research training of medical undergraduates (top 18).

Serial Number	Name	Year	Article Number
1	Department of Medical Education	2004	3
2	Department of Psychology	2008	3
3	Department of Medicine	2001	2
4	Department of Family Medicine	2007	2
5	Lurie Children's Hospital of Chicago	2018	2
6	Yong Loo Ln School of Medicine	2020	2
7	Faculty of Medicine	2018	2
8	Michael's Hospital	2014	2
9	Department of General	2017	2
10	Department of Oncology Department of Critical Care Medicine	2020	1
11	Centre for Synthetic Biology and Innovation	2015	1
12	Mental Health	2000	1
13	Portugal Department of Biomedicine	2017	1
14	Division of Neurosurgery	2001	1
15	Harvard Medical School	2020	1
16	Department of Rehabilitation Medicine	2020	1
17	Undergraduate Medical Student	2000	1
18	Estroff is professor	2016	1

Table 4. Major domestic research institutions for scientific research training of medical undergraduates (top 18).

Serial Number	Name	Year	Article Number
1	Department of Clinical Medicine, Xuzhou Medical College	2014	2
2	School of Public Health, Nanjing Medical University	2011	2
3	School of Biomedical Engineering, Capital Medical University	2018	2
4	Department of Physiology, Shanxi Medical University	2014	2
5	Department of Neurobiology, School of Basic Medicine, Capital Medical University	2018	2
6	College of Veterinary Medicine, China Agricultural University	2020	1
7	School of Pharmacy, Binzhou Medical College	2014	1
8	School of Public Health, Capital Medical University	2018	1
9	Department of Basic Medicine, Xiamen Medical College	2020	1
10	School of Basic Medicine, Jilin University	2017	1
11	Department of Basic Medicine, Xiamen Medical College	2020	1
12	School of Basic Medicine, Shandong University of Traditional Chinese Medicine	2015	1
13	Teacher Teaching Development Center of Guilin Medical College	2014	1
14	Anhui Medical University	2010	1
15	Department of Stomatology, Zhuhai Campus, Zunyi Medical University	2014	1
16	School of Basic Medicine, Zhengzhou University	2018	1
17	School of Basic Medicine, Nanjing Medical University	2019	1
18	Department of Preventive Medicine and Health Management, Hebei University	2016	1

**Figure 7.** Cooperation map of major domestic research institutions for medical undergraduates scientific research training.

3.3. Statistical Analysis of Research Hotspots

3.3.1. Keyword Clustering

Q value > 0.3, S value > 0.5 in the cluster diagram, which indicates that the clustering of this study is reasonable.

Among them, the effect of clinical study of clustering in "medical education" LLR is larger, virus infection of clustering in "undergraduate medical education" LLR is larger, the health service reform of clustering in "teaching" and "undergraduate" LLR is larger, the medical of clustering in "training", "education" LLR is larger, education of clustering in "undergraduate medical education", "independent learning" LLR is larger. (Figure 8, Figure 9).

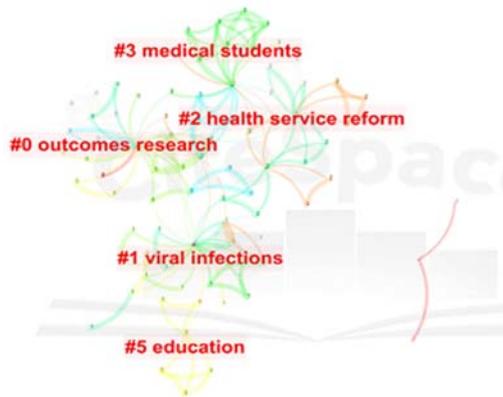


Figure 8. Keyword clustering map of foreign medical undergraduate research training.

Among them, the medical undergraduate of clustering "medical undergraduates", "medical education", "continuous line service" constantly LLR is larger, the medical students of clustering in "medical students", "research practice" LLR is

larger, in students' clustering "education", "medical", "scientific" LLR is larger, clustering in clinical medicine "clinical medicine", "medical talent", "medical colleges" LLR is larger, LLR of "talent training" is larger in the research quality cluster, LLR of "teaching reform", "innovation ability" and "tutorial system" is larger in the teaching reform cluster, LLR of "research ability" is larger in the research capability cluster, LLR of "research innovation" is larger in the research innovation cluster, LLR of "phased assessment" and "training" is larger in the knowledge cluster.

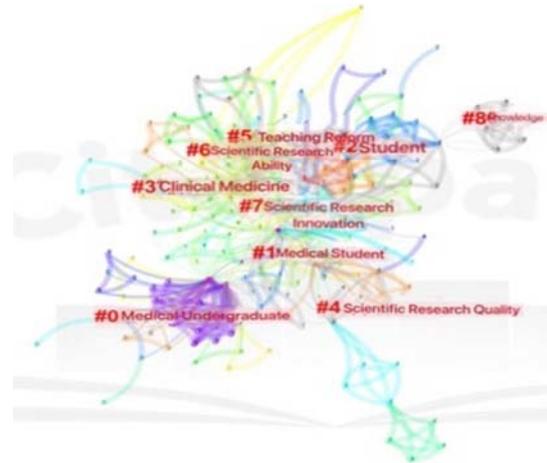


Figure 9. Keyword clustering map of research field of medical undergraduate research training in China.

3.3.2. Keyword Burst Detection

The domestic and foreign burst terms from January 2000 to July 2021 are shown in Figure 10 and Figure 11.

Keywords	Year	Strength	Begin	End	2000 - 2021
viral infection	2000	2.88	2000	2014	[Red bar]
tuberculosis	2000	2.88	2000	2014	[Red bar]
youth with special health care need	2000	2.88	2000	2014	[Red bar]
transition	2000	2.88	2000	2014	[Red bar]
south america	2000	2.88	2000	2014	[Red bar]
pathology	2000	2.35	2000	2014	[Red bar]
outcomes research	2000	2.35	2000	2014	[Red bar]
postgraduate	2000	2.35	2000	2014	[Red bar]
constructivism	2000	0.86	2015	2018	[Red bar]
anatomy	2000	0.96	2016	2018	[Red bar]
medical student	2000	1.71	2020	2021	[Red bar]
teaching	2000	1.61	2020	2021	[Red bar]
education & training (see medical education & training)	2000	1.2	2020	2021	[Red bar]
medical education & training	2000	1.2	2020	2021	[Red bar]
veterinary medicine	2000	1.2	2020	2021	[Red bar]
general medicine (see internal medicine)	2000	1.2	2020	2021	[Red bar]
undergraduate medical education	2000	1.08	2018	2019	[Red bar]
education	2000	1.26	2017	2017	[Red bar]
self-directed learning	2000	1.25	2019	2019	[Red bar]
undergraduate nursing education	2000	1.25	2019	2019	[Red bar]
learning in practice	2000	1.25	2019	2019	[Red bar]
training	2000	1.24	2017	2017	[Red bar]
serious gaming	2000	1.24	2017	2017	[Red bar]
literature review	2000	1.24	2018	2018	[Red bar]
medical education	2000	1.03	2018	2018	[Red bar]

Figure 10. Burst terms in research field of foreign medical undergraduate scientific research training.

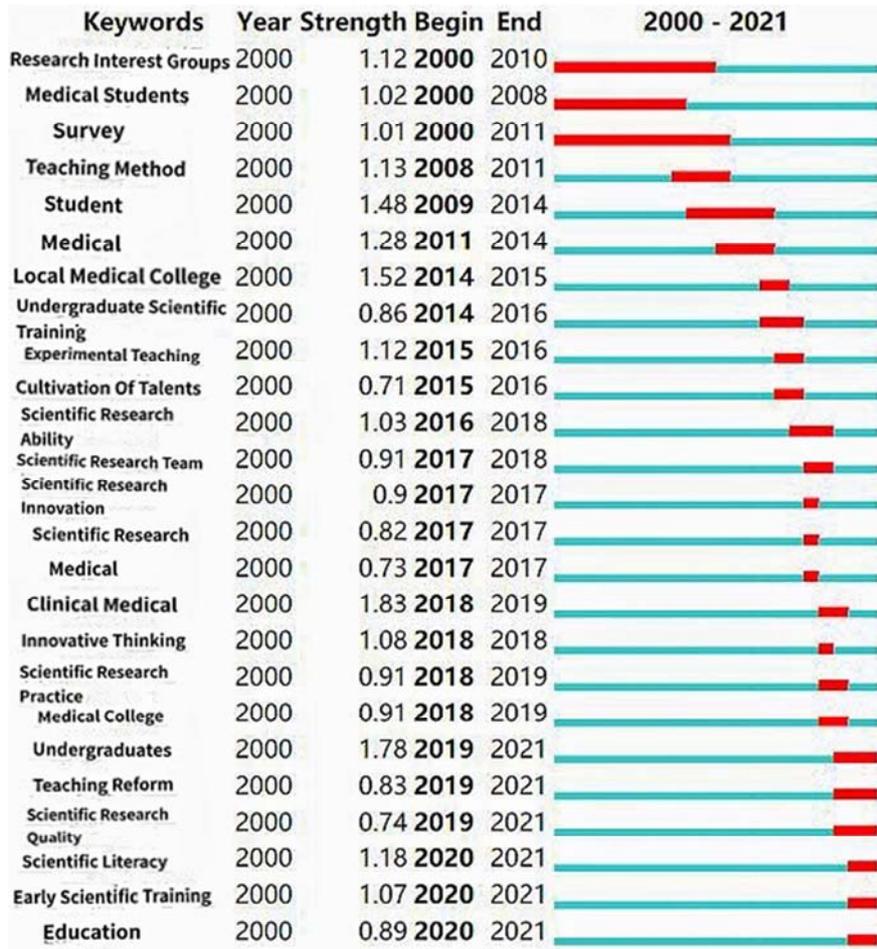


Figure 11. Burst terms in research field of do medical undergraduate scientific research training.

3.3.3. Research Trends

Set the threshold value of (C, CC, CCV) of CiteSpace software as (2, 2, 20), (4, 3, 20), (4, 3, 20), and select the Timezone View interface in the Layout of the Control Panel to generate the time distribution map of keywords. See Figure 12 and Figure 13 for details.

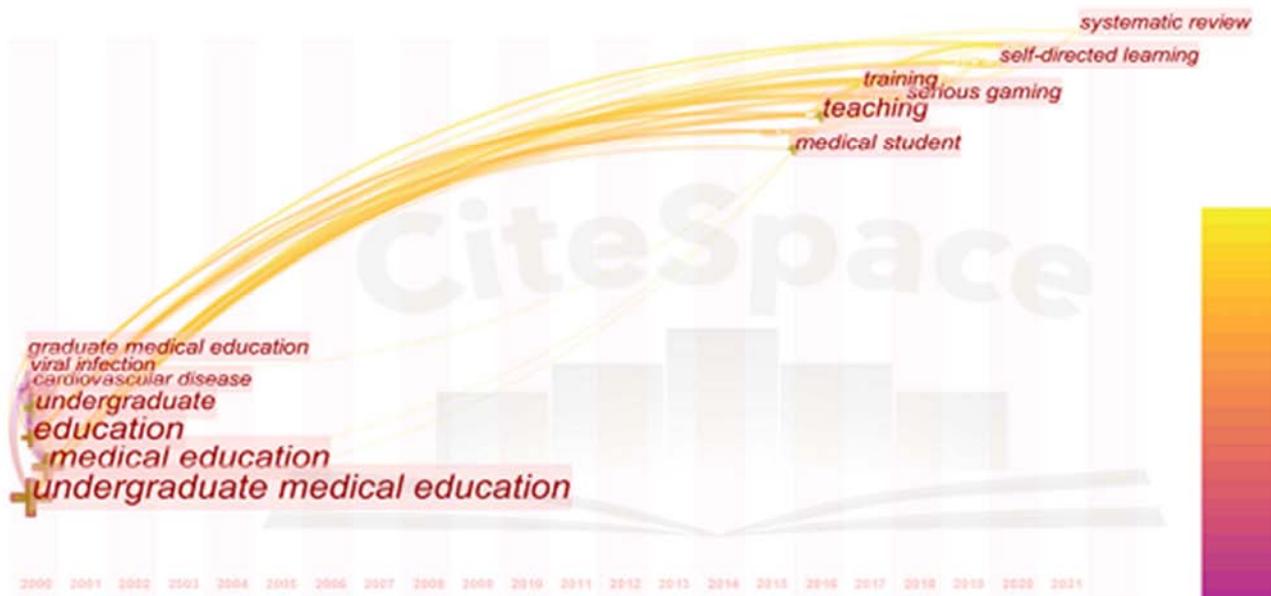


Figure 12. Key time distribution map of the research and training of foreign medical undergraduates.

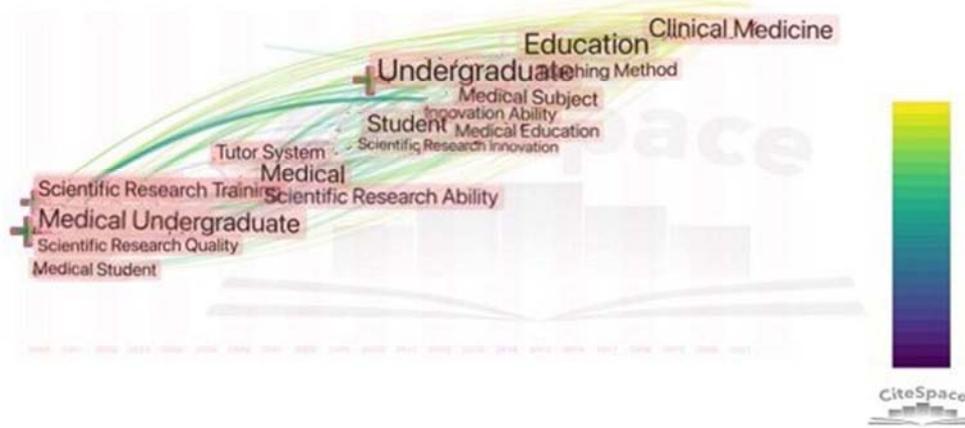


Figure 13. Key time distribution map of the research and training of domestic medical undergraduates.

It can be seen from Figure 12 that the historical evolution of foreign medical undergraduate research training can be divided into two stages.

The first stage is from 2000 to 2015. The total number of published papers is 60. Since foreign researchers attach great importance to medical education at this stage [15-17], the research at this stage is more focused on "undergraduate medical education", "medical students" and other related aspects.

In the second stage, from 2016 to 2021, the research fields of medical undergraduates' scientific research training gradually widened [18, 19], and the number of papers reached 111. The main research direction is "education" and "training". On the whole, this stage of research reflects the development trend from theory to practice.

It can be seen from Figure 13 that the historical evolution of research and training of medical undergraduates in China can be divided into four stages.

The first phase is the exploration period (2000 ~2006). The total number of published papers is 6. Since the Ministry of Education launched undergraduate scientific research training programs in universities nationwide in 2007, researchers mainly conducted research on undergraduate scientific research training [20-22] and scientific research quality at this stage to lay a research foundation for the upcoming undergraduate scientific research training programs.

The second stage is the development period (2007-2010). In this stage, the number of medical undergraduates' scientific research training research papers increased to 10. The main research direction is "undergraduate" and "scientific research innovation". On the whole, this stage of research reflects the development trend from theory to practice.

The third stage lasts a period (2011-2015). During the continuous period, the research field of medical undergraduate scientific research training has been continuously expanded, and the number of articles published has risen sharply, reaching 34 articles. At this stage, researchers gradually combine medical education with scientific research innovation [23-25], and research becomes more diversified and in-depth, thus providing theoretical significance and practical experience for improving the quality of research in

this field.

The fourth stage is the deepening research period (2016-2021). In this stage, the number of published papers is 56, and the research field is gradually widened [26-28]. Compared with the previous three stages, this research stage is deeper and broader. The researchers focused their research on the field of clinical medicine and carried out the research on teaching reform from the beginning to lay a good foundation for practical teaching of clinical medicine.

By reason of the foregoing, the research of medical undergraduate scientific research training presents a research trend of diversification of research fields, practice of research methods and precursor of research scope. With the continuous advancement of medical undergraduate research training, researchers will deepen their thinking on research training and education, and the related research trend will be more diversified and added.

4. Discussion

4.1. Date of Literature Release

In recent years, medical undergraduate scientific research training has gradually become a research focus of medical education in China. The results of this study show that the number of domestic and foreign literature is increasing. The number of foreign literature has increased significantly. In 2014, the number of foreign literature increased, and in 2020, the number of foreign literature reached the peak. The reason is that in 2020, foreign literature began to conduct in-depth research on how to integrate scientific research and training into medical education [29]. The number of domestic literature tended to be stable. From 2013 to 2017, the number of domestic literature continued to rise, and a breakthrough was realized in 2018. This may be related to the fact that the Ministry of Education did not carry out undergraduate research training programs in universities until 2007 [30]. In 2018, the Ministry of Education issued the Opinions on Accelerating the Construction of High-level Undergraduate Education and Comprehensively Improving the Ability of Personnel Training, and the "new medical science" was put

forward, requiring universities to research and cultivate new talents that meet the needs of the new era [31]. With the introduction of this new concept, scientific research training of medical undergraduates has been paid more and more attention. From 2000 to 2004, China has not paid much attention to the training of innovation ability and scientific research ability of medical undergraduates, and the training method is not mature, so there are few research papers on scientific research training of medical undergraduates in China. In recent years, as China pays more attention to the scientific research training of medical undergraduates, a large number of scholars begin to study, which may lead to the increase of literature.

4.2. Issued Quantity by Country and Region

The United States has the largest number of English papers in the field of medical undergraduate research training (57 articles), possibly because the United States is the first country to implement medical undergraduate research training. The number of domestic and foreign literature published in China is higher than that in other countries, which may be related to the large educational system and volume in China. Beijing is one of the regions with the largest number of publications in China, which may be related to the fact that Tsinghua University is the first university to cultivate undergraduate research ability. Jiangsu province is a coastal area with close communication with the world and open information. Among them, Nanjing Medical University has done a lot of research on the management, system, mode and information of scientific research [32-35], which has provided many experiences for the scientific research training of medical undergraduates. The research training for medical undergraduates in China was not put forward until 2000, which is relatively late, and there is a certain gap between the research training of medical undergraduates in China and that of foreign countries.

4.3. Core Authors and Institutions

The distribution of core authors at home and abroad is relatively discrete, but there have been three or four groups at home and abroad. Domestic research and training institutions for medical undergraduates are mainly medical universities, while foreign research and training institutions for medical undergraduates are mainly medical institutions, indicating that the categories of domestic and foreign research institutions are relatively single, which may be related to the special nature of this field. Most of the scientific research training for medical undergraduates at home and abroad is carried out by medical colleges and their affiliated hospitals. Such institutions have low fault tolerance rate, strong professionalism and strict requirements on their partners. It is difficult for general institutions to form cooperation with them, which may be the reason for the single research institutions in this field at home and abroad.

4.4. Keywords Analysis

Clustering analysis, keywords research in the field of

foreign medical undergraduate research training keywords are grouped into six categories, clustering label word for English literature: clinical effectiveness study, virus infection, health services, medical students, the education reform, and it can be seen that the foreign pay more attention to combining theory and practice, attach importance to the development of applications [36-38].

Keywords in the research field of domestic medical undergraduate research training were clustered into 9 categories. The clustering tags of Chinese literature were medical undergraduate, medical student, student, clinical medicine, scientific research quality, teaching reform, scientific research ability, scientific research innovation, and knowledge. This shows that domestic emphasis on scientific research ability, scientific research quality and other aspects [39-42].

Keywords by above analysis, the research focus of medical undergraduate research training at home and abroad have similarities, including medical students, medical education, the difference is that foreign research focus mainly include clinical effectiveness study, virus infection, health service reform, domestic research focus mainly includes the research quality, scientific research training method, the medical students' ability training, the unknown. Among them, foreign countries emphasize the application of education in scientific research training, which may be due to the early development of foreign scientific research training programs, early hardware conditions are more advanced; In terms of scientific research training in China, more emphasis is placed on scientific research ability, which reflects from the side that the methods of scientific research training in Chinese universities are not mature, and medical undergraduates do not have good scientific literacy and scientific research ability. The burst terms show that medical students and undergraduates are in the leading position in this field in the past three years.

4.5. Research Trends

The foreign research trend can be divided into two stages, and the domestic research trend can be divided into three stages. From the development of each stage, the research training research of medical undergraduates presents the research trend of diversification of research fields, practice of research methods, and precursor of research scope. Therefore, the future research on scientific research training can be carried out from the training of medical talents, and promote the scientific research training of medical undergraduates to play a greater role in the field of medical education.

5. Conclusions

5.1. The Teaching Method of Scientific Research Training for Medical Undergraduates Is Relatively Simple

Compared with the existing diversified teaching methods such as peer education [43] and peer feedback [44] in foreign countries, the teaching methods of scientific research training in China are mainly phased assessment and tutorial system.

Therefore, it can be found that the teaching methods in foreign countries mainly focus on the communication and cooperation between students, while teachers are the main teaching methods in China. Generally speaking, the way is relatively single. In this regard, the school can carry out student-centered lectures and actively hold scientific research training report competitions, so that students can independently conduct scientific research training and enhance their enthusiasm for scientific research training, which can provide diversified ideas for enriching teaching methods. In addition, the medical students' scientific research training, due to its unique professional limitation, while the existing teaching method can satisfy the basic teaching requirements, but with the rapid development of medical education, the teaching way also need to be more diversified, so teachers should merge teaching resources in many areas, and universities in the world communicate with each other, draw on existing teaching achievements abroad, to broaden the way of teaching.

5.2. Lack of Scientific Research Training Practice for Medical Undergraduates

It can be seen from the burst terms of keywords that the key word of scientific research practice in China only turned in 2018, which shows that the scientific research training practice of medical undergraduates in China is not sufficient. In addition, some studies show that some universities in China can not fully meet the needs of hardware facilities for students' scientific research training, and there is a large gap in practical operation learning [45-48]. In order to enhance students' ability in practice, colleges and universities should meet the hardware requirements of medical undergraduates' scientific research training. The site, equipment, teachers and other aspects can be optimized. In this regard, we should increase the openness of laboratories, build practice bases, strengthen the construction of off-campus practice bases, increase the number of equipment and ensure the high quality of equipment. At the level of teachers, universities can employ experts to guide students' scientific research training, set up relevant lectures, establish special funds for medical undergraduate scientific research training, and actively introduce social resources to participate in the training of medical undergraduates' practical ability.

5.3. The Scientific Research Training System for Medical Undergraduates Needs to Be Improved

As can be seen from the chronological distribution map of literature release, domestic and foreign scholars have little research literature on this field. It can be seen from the burst terms of keywords, foreign scholars with "research training" as the key word of the literature is relatively small; As can be seen from the map of core authors' cooperation, domestic and foreign scholars' cooperation and communication are not close enough. The above problems can show that the scientific research training system of medical undergraduates is not perfect, the operation mechanism is not perfect, and the system is not mature enough. To establish and improve the

operation mechanism of scientific research training, we can start from the aspects of project application, project conclusion, research funds and rewards and punishment system of scientific research training, so as to form strict organizational discipline, flexible and efficient mechanism system, and facilitate medical undergraduates to conduct scientific research training in an orderly and efficient manner. In addition, the government should also promote the issuance of relevant laws, regulations and policy support, from the macro incentive, to ensure the smooth implementation of scientific research training.

5.4. Domestic and Foreign Research Institutions Do Not Pay Enough Attention to Medical Undergraduates Scientific Research Training

From 2000 to 2021, the number of published papers at home and abroad is small, the number of authors and research institutions are few and scattered, and the participation of researchers from different countries is low. Compared with other hot research fields, there is a gap in the quantity and quality of literature, which can be inferred that research institutions at home and abroad pay less attention to scientific research training. It is suggested that well-known experts at home and abroad in this field should be invited to conduct online and offline publicity or training on scientific research training. Publicity channels such as educational platforms, online media, newspapers and periodicals, and Wechat Official Accounts can be fully used to publicize the importance, theoretical knowledge, training methods, existing problems, and organization of scientific research training. Quality research training experience can improve medical undergraduates' awareness of scientific research training, promote medical undergraduates to actively invest in scientific research training, improve their own research ability and research level, and establish a good foundation for providing excellent medical and health services in the future.

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