

The Research on Co authorship Network in Medical Information Education in China^{*}

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Abstract—In this paper, CNKI data is the main sources, Chongqing VIP data and Wanfang data are the supplementary sources. Use the method of social network analysis and visualization technology; analyze the characteristics about overall and local structure on Co authorship network in medical information education in China. The study found that the scale of integrated co authorship network is large, the average degree of network is larger, the density of network is smaller, the average clustering coefficient is larger, the centrality of network is smaller; in most cases the co authorship is in the internal agency cooperation in early stage, the partnership is undecided, in recent years, inter-agency co authorship is widespread. The tightness of co authorship network needs to be improved, the cooperation and exchange between the institutions needs to be strengthened.

Keywords—medical information education; co authorship network; social network analysis

I. INTRODUCTION

Scientific cooperation has now become a major trend in promoting the development of Science, and the research on scientific cooperation always based on the analysis of the phenomenon of co authorship. In a certain period, the number and the cooperation of the authors of a research area, reflect the development speed and quality of scientific research cooperation and academic exchanges in this field.^[1] Study co-authorship phenomenon, its essence is the relationship between the author, and social network analysis method is the specializing a method. The research on the scientific co authorship network abroad is earlier. Newman in 2001 in the “structure of scientific collaboration networks the”, did a comparative study on the cooperation of scientists in the fields of biomedicine, physics and computer science for the first time^[2]; Barabasi in 2002 in the “Evolution of the social network of scientific collaboration” studied the time variation of the network in the field of mathematicians^[3]. In 2004, the Yoshikane.F. analyzed the 4 areas of electrical engineering, information processing, polymer and biochemical changes in the areas of cooperation mode of growth and change^[4]. In 2007, Sun.F. studied the status and trend of the cooperation between the Japanese industry and the University, from the perspective of academic publications^[5]. Co authorship network research is mainly divided into the following aspects at home, first, theoretical research, study the structural characteristics of the network, and found a co network model. Such as Liu Jie et al, co

authorship of the network analysis was used in the field of physical chaos theory, revealed that the field of the network with no scaling and local small world.^[6] Xu Ling et al, studied the co authorship of "Science Bulletin" Based on the theory of complex network, and found that the network is a power law distribution.^[7]second, case study, analyzed the characteristics and evolution of the network structure of a certain organization or a field of paper. Such as Liu Shengbo et al. Constructed the co authorship network in the field of science and technology management, and revealed some regularity problems in the field of science and technology management in China.^[8] Li Gang et al. Studied the characteristics of the network structure, which is the research area of computer science, Wuhan University.^[9] Chen Shaolong took school of management, Shanghai University as an example, studied the co authorship network characteristics in the college.^[10]

At present, there are few papers on the subject of cross disciplinary research in China, and the research data source is from important journals in the research field, or from a comprehensive database included in the relevant literature. Through literature research, we have not found the literature on the structure and characteristics of the co authorship network structure and characteristics in the field of medical information education. In this paper, CNKI data is the main sources, Chongqing VIP data and Wanfang data are the supplementary sources, retrieval of all the journals published in the field of medical information education in 1980~2014, Using social network analysis method to study the research of medical information education in our country, in order to find out the pattern of the field and the evolution of the field.

II. RESEARCH PROCESS

A. Data Sources and Processing

The medical information education in China began in 1980s, and was trained by the former State Education Commission and the Ministry of health in the 80's, and then changed its name to "Information Science (medicine, pharmacy)", "information management and information system (medical direction)" and "Medical Informatics". The connotation and extension of the continuous expansion, so only use the "medical", "information", "intelligence" and other search terms in the field of literature may be missing part of the relevant literature. Therefore, combining the characteristics of medical information education, the author

determined the number of main search terms and limited search terms:

Search type 1: the main search terms { (medical information) (medical information) (pharmaceutical information) (TCM) (TCM) (clinical information) (medical information) (medical information) (medical information)}; And limited search terms (training) (Education) (subject) (Professional) (course);

Search type 2: the main search terms {(biological information technology) (Biomedical Engineering) (Biomedical Engineering) } And limited search terms (training) (Education) (Teaching) (subject) (Professional) (course) }

Search type 3: the main search terms {(computer) (Information Management) (Library Information)}; And limited search terms (1) {(training) (Education) (Teaching) (subject) (subject) (course) } (And) limited search terms (2) {(Medicine) }.

Search type 4: the main search terms (Information Literacy); And limited search terms {(Medicine)}

CNKI data is the main sources, Chongqing VIP data and Wanfang data are the supplementary sources. Use the method of the subject, accurate retrieval, the retrieval time is from 1979 to 2014. A total of 6097 papers were retrieved. The retrieval of bibliographic information was import into NoteExpress3.0, construct the literature information management database, using software and manual sorting inspection in a row, excluding notice, manuscripts and other non-primary papers, and finally get relevant literature 5181. According to the mechanism of the location of the same name of the author to distinguish, the same name of the same institution has not been found. Statistical analysis of the number of co authorship and authors, and the first 6 authors only.

B. Research Methods and Tools

The social network analysis method can comprehensively analyze the relationship between the individual and the whole, the local and the whole, and the relationship between the different networks^[10]. Social network analysis method is the main method for the analysis of co authorship network^[13]. Take the author as the nodes, take Co authorship relationship as the edges, construct Co authorship network. The co authorship of the article are equal to the reciprocal relationship. In this paper, the author uses the method of social network analysis to analyze the overall and local structural characteristics of the co authorship in the field of medical information education in China. The overall network structure is analyzed from four aspects: the network degree distribution, the network density, the aggregation coefficient and the network center potential; analyzed from the average path length, clustering coefficient, degree centrality analysis of the three aspects of the largest connected sub graph chart structure. Using the NoteExpress3.0 manage bibliographic information, using pajek draw co authorship network topology mapping, and carries on the analysis of the structure characteristics.

Education Department of Hubei Province in Humanities and social sciences research project "the research on the social needs and employment status of undergraduate students in the information science of TCM"

Education Department of Hubei Province in 2013 the teaching quality project "the comprehensive reform of Chinese medicine information management specialty"

C. Global Network Topology Change

The author of the research field of medical information education in our country is working with the network topology structure in Figure 1.

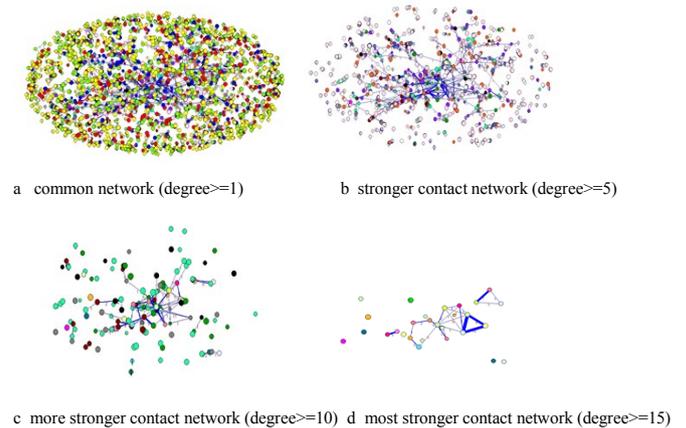


Figure 1 Cooperative network topology graph

In order to facilitate the study of the network topology graph of network topology, we call these 4 networks a, b, c, d. The structural characteristics of these four networks are analyzed from four aspects, such as average, network density, average aggregation coefficient and center potential, as shown in Table 1.

TABLE I. THE BASIC CHARACTERISTICS OF THE OVERALL NETWORK DIAGRAM IN DIFFERENT SITUATIONS

	node number	average degree	network density	average aggregation coefficient	Central potential
a	7242	3.3571	0.0005	0.6317	0.0082
b	1844	4.8416	0.0026	0.7697	0.0137
c	164	2.2927	0.0141	0.5984	0.0541
d	30	1.7333	0.0598	0.7119	0.1207

Degree is a basic and important statistical feature of complex networks. The degree K_i of the i node refers to the number of other nodes connected to the node, which can reflect the importance of the nodes in a certain extent. The arithmetic average of the degree of all nodes is called the average degree of the network. Network density is the ratio of the number of lines (or edges) that are actually present in the network, or the number of lines (or edges) that are most likely to be generated in the network. The density of a network is a measure of the completeness of the network graph, and to a certain extent, the quantity and complexity of the relationship between the network and the network is characterized. The average probability of an aggregate factor representing the average of two nodes connected to the same node in the network. In CO authorship network, the average clustering coefficient reflects the close degree of CO authorship. Central potential describe the center of the whole network.

From Figure 1 and table 1 we can see that the nodes in the network are increasing. The average degree of network increases firstly and then decreases. That is, the average degree of the network is increasing. The average network density increases with the increase of nodes. The average network density of the 4 networks is less than 5. The total network density increases with the increase of the node degree, the average aggregation coefficient of the 4 networks is not small, the network center potential increases with the increase of the node degree, and the overall network center is smaller.

The foregoing analysis shows that, Chinese medical information education research in the field of Co authorship network overall density is not high, center is smaller, average degree and average clustering coefficient is larger, indicating the number and complexity of the relationship between the co authorship network is not high, there is no obvious central tendency. With the increasing of the nodes in the network, the average degree of the network decreases, the density and the center of the network are increasing, which shows that although the overall co authorship degree is not high, there is a group of co authorship in this field. The number of nodes and nodes in the 4 networks is large, but the average clustering coefficient is small, which shows that the "triangle" is higher in the network.

D. Analysis of Network Evolution

For an in-depth understanding of the structural characteristics of Co authorship network in Chinese Medical Information Education, to found out the co authorship network evolution process who playing an important role in the author or group, we have to analyze the evolution of the co authorship network. We take 5 years as a stage and select the most of the co authorship of each phase of the network as the research object. The connected sub graph is a kind of special stator diagram of the reachable path between any two nodes in the sub graph. The local characteristics of the whole network can be reflected by the nature of the largest connected sub graph. Next, we analyze the average path length and the average clustering coefficient of the largest connected sub graph, and evaluate the effect of the authors' node in the network topology by 4 kinds of central index^[11]. Network1~ network7 of the largest connected sub graph are shown in figure 2.

TABLE II. THE AVERAGE PATH LENGTH AND CLUSTERING COEFFICIENT OF THE LARGEST CONNECTED SUB GRAPH

	average path length	average clustering coefficient
the largest connected sub graph 1	0.500	1.000
the largest connected sub graph 2	0.607	0.829
the largest connected sub graph 3	0.700	0.706
the largest connected sub graph4	1.135	0.600
the largest connected sub graph5	0.961	0.583
the largest connected sub graph6	1.550	0.558
the largest connected sub graph7	2.399	0.464

From table 2, with the development of medical information education in China, the average path length of the co network is increasing, which shows that the network information transmission speed decreases with the increase of network size. The average clustering coefficient decreases, which shows that the "triangle" structure in the network gradually decreases. From Figure 2, the number of nodes in the connected sub graph 1~4 is 6, 8, 10, 13, and the number of papers is 1, 2, 3 and 8. Further analysis shows that the nodes in the connected sub graph 1~4 are mostly derived from the same organization. Such as connected sub Figure 1 the author of all from Shanghai first medical college, figure 2 author from West China Medical University and Luzhou Medical College, figure 3 from the Guangdong General Hospital of Guangdong military area command, figure 4 most of the authors belong to the Jilin University School of public health, only one of the authors of the Military Medical Science Academy of the PLA. Thus we can see that the first 4 stages of the largest connected sub graph through a small, simple co authorship, most of the internal co authorship. So we only analyze the 3 connected sub graphs.

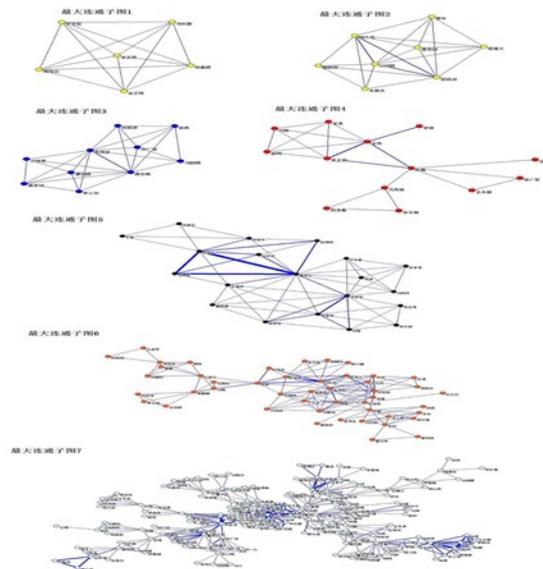


Figure 2 network 1~ network 7 of the largest connected sub graph

TABLE III. THE CENTER OF THE LARGEST CONNECTED SUB GRAPH NODE IN NETWORK 5

NO.	author	nDegree	author	nBetweenness	author	nCloseness	author	nEigenvector
1	Dong Xiuzhen	18.421	Dong Xiuzhen	44.347	Dong Xiuzhen	79.167	Dong Xiuzhen	81.455
2	Zou Huiling	14.737	Qi Jiaxue	19.883	Qi Jiaxue	67.857	Zou Huiling	78.975
3	Qi Jiaxue	9.474	Zou Huiling	13.938	Wang Jianqi	61.29	Yang Guosheng	63.557
4	Yang Guosheng	8.947	Li Xueqi	8.187	Li Xueqi	59.375	Wang Songjun	33.472
5	Li Xueqi	6.842	Wang Jianqi	6.823	Zou Huiling	57.576	Zhao Ruigang	27.849
6	Wang Songjun	4.737	Lin Aihua	6.238	Lu Quncang	55.882	Wang Jianqi	18.178
7	Lu Quncang	4.211	Lu Quncang	1.949	Yan Huachun	54.286	Qi Jiaxue	14.66
8	Zhao Ruigang	4.211	Zhang Jing	0.39	Dong Xiaojian	54.286	Lin Aihua	14.606
9	Wang Jianqi	4.211	Zhao Ruigang	0.195	Li Ruigang	54.286	Li Xueqi	10.076
10	Zhang Jing	3.684	Yang Guosheng	0.195	Li Bing	54.286	Lu Quncang	8.38

From table 3, we can see that the most important part of the network in the 2000-2004, which is the most important part of the network, has increased in the first ten years, and the central index of the top authors, Zou Huiling, Dong Xiuzhen, Qi Jiaxue, played an important role in the field. In the number of centers, the degree of the center of the difference is relatively large between the number of the first Dong Xiuzhen and the second Qi Jiaxue. It shows that Dong Xiuzhen is not only the network of co authorship or co authorship of the largest number of authors, but also in the entire network plays an important role in communication. In the further study, the center of the top ten indicators of the author, the vast majority of The Fourth Military Medical University College of biological engineering, only a part of the Central South University, the school of information science and engineering.

TABLE IV. THE CENTER OF THE LARGEST CONNECTED SUB GRAPH NODE IN NETWORK 6

NO.	author	nDegree	author	nBetweenness	author	nCloseness	author	nEigenvector
1	Liu Zhicheng	9.565	Zhang Xu	41.971	Quan Haiying	50.549	Liu Zhicheng	63.958
2	Quan Haiying	7.826	Quan Haiying	35.725	Zhang Xu	46	Ye Yalin	49.379
3	Deng Junming	7.391	Li Xia	33.527	Liu Zhicheng	44.231	Quan Haiying	49.349
4	Ye Yalin	6.522	Niu Lihong	23.188	Deng Junming	42.593	Li Haiyun	42.987
5	Tao Qiang	6.087	Liu Zhicheng	13.259	Ye Yalin	42.202	Deng Junming	42.089
6	Zhang Xu	5.652	Shan Nana	12.464	Ren Zhaohui	42.202	Duan Yuanmin	34.479
7	Duan Yuanmin	5.652	Zhang Haiyan	8.599	Li Xia	41.818	Zhang Xu	34.446
8	Li Xia	5.217	Zhou Maoxin	8.502	Tao Qiang	41.441	Tao Qiang	28.659
9	Li Haiyun	5.217	Zhao Ling	8.502	Liu Jinghua	40	Tian Xin	26.923
10	Liu Jinghua	4.348	Deng Junming	8.007	Duan Yuanmin	39.316	Ren Zhaohui	23.857

From table 4 we can see that, in 2005-2009 the scale of the largest connected sub graph in the network is more than the previous one, The centrality of the center of the degree of the center of the top ten is not obvious, and the maximum value is only 9.565, indicating that the network is distributed

evenly, and the aggregation of nodes is not obviously. Liu Zhicheng 's degree centrality and feature vector centrality are the largest, but the central and close to the center of the number of the center of the decline, that he may be the network in the paper or co authorship papers with the largest number of nodes. Quan Haiying and Zhang Xu's proximity to the center of the degree and the number of the center are higher, indicating that these two authors are not only close to the other authors in the network, but also the network of the bridge node. In the further study, the network in the vast majority of nodes belonging to the Capital Medical University biomedical engineering college, the mechanism of the internal co authorship is more common.

TABLE V. THE CENTER OF THE LARGEST CONNECTED SUB GRAPH NODE IN NETWORK 7

NO.	author	nDegree	author	nBetweenness	author	nCloseness	author	nEigenvector
1	Wang Wei	4.949	Wang Wei	68.221	Wang Wei	36.617	Wang Wei	72.114
2	Liu Yan	2.284	Lu Hongbing	33.901	Cui Lei	32.242	Cao Jindan	41.137
3	Lu Hongbing	2.157	Cui Lei	28.204	Xu Peiyang	32.137	Lu Hongbing	37.802
4	Liu Yamin	1.904	Xu Peiyang	26.101	hang Shijing	31.723	Jiao Chun	35.721
5	Jiao Chun	1.586	Zhang Shijing	20.828	Lu Hongbing	31.369	Zhang Guopeng	34.148
6	Wang Liwei	1.523	Wang Min	20.693	Cao Jindan	30.926	Chang Xiaohong	34.148
7	Dong Xiuzhen	1.523	Ji Zhenyu	15.362	Li Houqing	30.733	Mou Dongmei	30.809
8	Zhang Guopeng	1.459	Zhang Yanwu	11.447	Jiao Chun	29.58	Jian Weiping	23.812
9	Chang Xiaohong	1.459	Zhang Bin	11.447	Zhang Guopeng	29.535	Duan Lei	22.309
10	Cao Jindan	1.459	Zhang Hao	10.141	Chang Xiaohong	29.535	Wu Xiaoling	22.309

From the above figure 2, the scale and complexity of the network is more complicated than the previous stage in 2010-2014. From the table 5, Wang Wei, Liu Yan, Lu Hongbing their degree of the center is the largest, and the cumulative number of times is as high as 78,36,34 times, it can be inferred that they are the high yield authors in the network. Wang Wei, Lu Hongbing and Cui Lei, their central number is the largest, indicating that They play a role in communicating and connecting other authors of the bridge junction in the network; Wang Wei, Cao Jindan, Lu Hongbing, their central character of the feature vector is the highest. Wang Wei's feature vector center is much higher than other authors and the degree of the center is the largest, he is not only published a large number of papers, he not only has published, and the co-author also have published a number of papers. From Figure 2 we can clearly see that Wang Wei is currently the core of the research field of medical education in China, and he is a bridge to communicate with other authors in the field.

Further analysis revealed that the largest connected sub graph of the co authorship network contains a number of agencies, as represented by Wang Wei Jilin University School of public health, Xiu Zhen Dong as the representative of the Fourth Military Medical University School of Biomedical Engineering, represented by Liu Yamin Shandong medical and health science and technology information research Medical Center for the study of

intelligence, to Cui Lei as the representative of the China Medical University Medical Information Department, Hou Qing Li is on behalf of the Central South University Xiangya School of medicine, represented by Zhang Huazhong University of science and technology, Tongji Medical College School of medicine and health management, represented by Duan Lei Nanjing Medical University School of Basic Medical Sciences, Department of Biomedical Engineering and so on. At this stage, the co authorship have been extended to much more organizations and agencies.

III. CONCLUSION

This paper is based on the previous research results; we did a research of co authorship network in medical information education in China. Through the analysis of the overall structure and local structure characteristics of the co authorship, we find that the cooperation in the field of medical information education in China has the following characteristics:

a) The overall network size is larger (including 7242 nodes, 12157 edges), the average degree of the network is large, but the network density is small, the average clustering coefficient is relatively large, but the overall network centrality is small. Comparison of two groups of seemingly contradictory data shows that China's medical information education and research field of the overall cooperation in large scale, the Co authorship network contains a lot of small co authors, their internal cooperation is more stable and more belongs to the same institution, and there is no significant difference in the production of the article.

b) The co authors are gradually expanded to the outside of the organization, and the scale of the co authors is growing rapidly, and in recent years, the phenomenon of cross agency is common. From the analysis of the paper, we can know that, during the period of 1980~2009, the nodes in each stage of the largest connected sub graph are part of the same organization. The author of the largest connected sub graph of 2010~2014 is from a dozen different organizations. This shows that in recent years, the field of scientific research personnel to enhance cooperation, expand cooperation scope, exchange and cooperation between agencies are increasing.

c) Wang Wei as the representative of the Jilin University School of public health (formerly Bethune Medical University), Dong Xiuzhen, as the representative of the Biomedical Engineering College of The Fourth Military Medical University, Liu Yamin as the representative of the Shandong provincial medical and Scientific Information Research Institute of Medical Information Research Center, Cui Lei as the representative of the Department of medical informatics, Li Houqing as the representative of Central South University Xiangya Medical School , Zhang Shijing as the representative of the Tongji Medical College,

Huazhong University of Science and Technology medical and Health Management School. The researchers in core research institutes are the important nodes of the whole network. some of them are the academic leaders, some of them are the high yield of the field, some of them are the two aspects of both. They not only attracted a large number of co authors, but also played the role of "connecting people" in the network.

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