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LITERATURE STUDY

Papers published from 1995 to 2012 by six Traditional Chinese Medicine universities in China: a bibliometric analysis based on science citation index

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Abstract

OBJECTIVE: The quality and quantity of published research papers are important in both scientific and technology fields. Although there are several bibliometric studies based on citation analysis, very few have focused on research related to Traditional Chinese Medicine in China.

METHODS: The bibliometric method used in this study included the following focuses: publication outputs for each year, paper type, language of publication, distribution of internationally collaborative countries, sources of funding, authorization number, distribution of institutes regarding collaborative publications, research fields, distribution of outputs in journals, citation data, and h-index.

RESULTS: A total of 3809 papers published from 1995 to 2012 were extracted from the science citation index (SCI). The cumulative number of papers from all six universities is constantly increasing. The United States attained the dominant position regarding complementary and alternative medicine research. The Chinese Academy of Sciences was the greatest participator in collaborative efforts. Research field analysis showed that the research mainly focused on pharmacology pharmacy, chemistry, integrative complementary medicine, plant sciences, and biochemistry molecular biology. The Shanghai University of Chinese Medicine had the most citations.

CONCLUSION: In recent years, in terms of SCI papers, the six Traditional Chinese Medicine universities studied here have made great advances in scientific research.

Key words: Bibliometrics; Publications; Universities of Traditional Chinese Medicine; Scientific citation index

INTRODUCTION

The quality and quantity of academic papers are important indications of success in the fields of science and technology. With the development of research in China, more and more researchers have their study results published in international journals. However, this rais-

es the question, how can we measure the quality of published papers on TCM research? The science citation index (SCI)[1] has been widely used as an evaluation tool for the impact of published articles.[2,3]

As a method for systematic analysis, bibliometrics, which provides a quantitative method to measure the contribution of academic papers to the advancement of knowledge,[4] has been used in many fields including radiology,[5] social medicine,[6] liquid crystals,[7] limnology,[8] cancer,[9] and human resources.[10]

Although there are several bibliometric studies on papers in China based on the SCI database, previous research has only focused on the number of articles, publication journals, journals' impact factors (IFs), and citation data during a certain period, for example, 2000 to 2009,[11] 2003 to 2010[12] and 2003 to 2008.[13] In addition to such studies, it is equally important to study those papers published by Traditional Chinese Medicine (TCM) universities in China, and to include more items, such as paper type, authorization number, distribution of internationally collaborative countries, distribution of institutes regarding collaborative publications, sources of funding, and universities' h-index.

In this study, a bibliometric analysis was conducted on papers from six TCM universities in China: Beijing University of Chinese Medicine, Shanghai University of Chinese Medicine, Nanjing University of Traditional Chinese Medicine, Guangzhou University of Chinese Medicine, Chengdu University of Traditional Chinese Medicine, and Tianjin University of Traditional Chinese Medicine. These findings may help us to better understand the trends and development of TCM research.

MATERIALS AND METHODS

The articles used in this study were sourced from the database of the Institute of Scientific Information (ISI). All papers published by these universities were extracted using the online version of the SCI. The search terms used were as follows: beijing univ chinese med or beijing univ tradit chinese med for Beijing University of Chinese Medicine, shanghai univ chinese med or shanghai univ tradit chinese med for Shanghai University of Chinese Medicine, nanjing univ chinese med or nanjing univ tradit chinese med for Nanjing University of Traditional Chinese Medicine, guangzhou univ chinese med or guangzhou univ tradit chinese med for Guangzhou University of Chinese Medicine, chengdu univ tradit chinese med for Chengdu University of Traditional Chinese Medicine, and tianjin univ tradit chinese med for Tianjin University of Traditional Chinese Medicine. The search was conducted on January 15, 2013. The IF of each journal was determined for corresponding papers as reported by the ISI in 2011. The Journal Citation Reports were the most up-to-date data available online. The citation frequency of all papers was also obtained on January 15, 2013 when the SCI search process for this study was conducted. Collaboration type was determined by the addresses of the authors, where the term single country publication was assigned if the researchers' addresses were from China only. The term internationally collaborative publication was assigned if researchers' addresses were from two or more countries. The term single institute publication was assigned if the researchers' addresses were from the same institute. The term inter-institutional collaborative publication was designated to those papers that were coauthored by researchers from different institutes.

All published papers from the six universities from 1995 to 2012 were assessed in terms of publication output for each year, paper type, language of publication, distribution of internationally collaborative countries, sources of funding, authorization number, distribution of institutes regarding inter-institutional collaborative publications, research fields, distribution of outputs in journals, citation data, and h-index.

The h-index,[14] an evaluating indicator, was applied to characterize the publications of the six universities. The h-index attempts to measure both the productivity and impact of a researcher's published works. The index is based on a set of the researcher's most cited papers and the number of those papers cited by other publications. The index can also be applied to the productivity and impact of a group of scientists, such as a department, university, or country, as well as a scholarly journal. With both quantity and quality, the h-index is new and simple measure that has a number of advantages over other bibliometric measures to estimate academic level.[15,16]

RESULTS

In total, 3809 papers were listed in the SCI database from 1995 to 2012 under the six universities mentioned above.

Beijing University of Chinese Medicine

There were 921 papers in total from the Beijing University of Chinese Medicine: 99 papers (10.75% of all papers from this university) in 2009, 123 papers (13.36%) in 2010, 169 papers (18.35%) in 2011, and 241 papers (26.17%) in 2012. The growth rate was 50% in 2009, 24% in 2010, 37% in 2011, and 43% in 2012. The first paper was published in 1995.

Shanghai University of Chinese Medicine

There were 1051 papers in total from the Shanghai University of Chinese Medicine: 134 papers (12.75% of all papers from this university) in 2009, 142 papers (13.51%) in 2010, 186 papers (17.70%) in 2011, and 291 papers (27.69%) in 2012. The growth rate was 38% in 2009, 6% in 2010, 31% in 2011, and 56% in 2012. The first paper was published in 1995.

Nanjing University of Traditional Chinese Medicine

There were 673 papers in total from the Nanjing University of Traditional Chinese Medicine: 82 papers (12.18% of all papers from this university) in 2009, 107 papers (15.90%) in 2010, 155 papers (23.03%) in 2011, and 215 papers (31.95%) in 2012. The growth rate was 116% in 2009, 30% in 2010, 45% in 2011, and 39% in 2012. The first paper was published in 1996.

Guangzhou University of Chinese Medicine

There were 433 papers in total from the Guangzhou University of Chinese Medicine: 63 papers (14.55% of all papers from this university) in 2009, 56 papers (12.93%) in 2010, 76 papers (17.55%) in 2011, and 126 papers (29.10%) in 2012. The growth rate was 26% in 2009, 0% in 2010, 36% in 2011, and 66% in 2012. The first paper was published in 1998.

Chengdu University of Traditional Chinese Medicine

There were 330 papers in total from the Chengdu University of Traditional Chinese Medicine: 45 papers (13.64% of all papers from this university) in 2009, 56 papers (16.97%) in 2010, 69 papers (20.91%) in 2011, and 91 papers (27.58%) in 2012. The growth rate was 114% in 2009, 24% in 2010, 23% in 2011, and 32% in 2012. The first paper was published in 2000.

Tianjin University of Traditional Chinese Medicine

There were 401 papers in total from the Tianjin University of Traditional Chinese Medicine: 53 papers (13.22% of all papers from this university) in 2009, 60 papers (14.96%) in 2010, 88 papers (21.95%) in 2011, and 121 papers (30.18%) in 2012. The growth rate was 8% in 2009, 13% in 2010, 47% in 2011, and 38% in 2012. The first paper was published in 2003.

Paper types

According to ISI document classifications, the 3809 publications consisted of eight types of papers. The most common was articles, followed by meeting abstracts and then reviews. The others, though less numerous, were proceedings, editorial material, book chapters, and correspondence.

The types of papers from each university are shown in Table 1.

Approximately 80% of article-type papers focused on experimental or clinical research. The other paper types did not focus on experimental or clinical research to the same extent.

Language of publications

Ninety-four percent of publications were published in English and the remainder were in Chinese (Table 2).

Distribution of internationally collaborative countries

Table 3 shows the top 10 collaborative countries to work with the six TCM universities. Among those countries, the United States ranked first in terms of total cooperation, followed by Japan and then the United Kingdom.

In terms of international cooperation, the Beijing University of Chinese Medicine ranked first and the Shanghai University of Chinese Medicine second; greater international cooperation means more ideas, methods, and technical support from organizations engaged in relatively advanced modern medicine.

Funding

The top 10 sources of funding for the universities are

Table 1 Types of SCI papers from the six TCM universities in China [*n* (%)]

Paper type	Beijing	Shanghai	Nanjing	Guangzhou	Chengdu	Tianjin
Total	921	1051	673	433	330	401
Article	727 (78.94)	927 (88.20)	609 (90.49)	392 (90.53)	302 (91.52)	347 (86.53)
Meeting abstract	102 (11.08)	70 (6.66)	22 (3.27)	13 (3.00)	3 (0.91)	21 (5.24)
Review	74 (8.04)	41 (3.90)	20 (2.97)	16 (3.70)	14 (4.24)	24 (5.99)
Editorial material	12 (1.30)	9 (0.86)	5 (0.74)	8 (1.85)	7 (2.12)	1 (0.25)
Letter	5 (0.54)	3 (0.29)	16 (2.38)	3 (0.69)	4 (1.21)	4 (1.00)
Proceedings paper	4 (0.43)	6 (0.57)	2 (0.30)	1 (0.23)	10 (3.03)	2 (0.50)
Correction	1 (0.11)	1 (0.10)	1 (0.15)	1 (0.23)	-	4 (1.00)
Book chapter	-	1 (0.10)	-	-	-	1 (0.25)

Notes: TCM: Traditional Chinese Medicine; SCI: science citation index.

Table 2 Publication language of SCI papers from the six TCM universities in China [*n* (%)]

Languge	Beijing	Shanghai	Nanjing	Guangzhou	Chengdu	Tianjin
English	877 (95)	1030 (98)	653 (97)	423 (98)	315 (95)	375 (94)
Chinese	44 (5)	21 (2)	20 (3)	10 (2)	15 (5)	26 (6)

Notes: TCM: Traditional Chinese Medicine; SCI: science citation index.

shown in Tables 4-1 to 4-6. The National Natural Science Foundation of China ranked first for all six universities (more than 23.56%), followed by the National Basic Research Program of China 973 Program in terms of total publications.

Authorization number

The top 10 authorization numbers for each university are shown in Table 5-1 to 5-6. Each authorization number corresponds to a research project.

Among the top 10 authorization numbers, E03008 and J50302 from Shanghai University of Chinese Medicine and 06KJA36022, NCET-09-0163, and ysxk-2010 from Nanjing University of Traditional Chinese Medicine had a higher output rate of SCI papers than other numbers.

Table 3 Distribution of internationally collaborative countries [*n*(%)]

Country	Beijing	Shanghai	Nanjing	Guangzhou	Chengdu	Tianjin
USA	131 (14.22)	146 (13.89)	41 (6.09)	22 (5.08)	23 (6.97)	15 (3.74)
Japan	50 (5.43)	24 (2.28)	9 (1.34)	20 (4.62)	-	16 (3.99)
England	44 (4.78)	36 (3.43)	1 (0.15)	5 (1.16)	6 (1.82)	10 (2.49)
Canada	17 (1.85)	9 (0.86)	4 (0.59)	5 (1.16)	1 (0.30)	-
South Korea	17 (1.85)	-	7 (1.04)	-	-	1 (0.25)
Australia	15 (1.63)	10 (0.95)	3 (0.45)	18 (4.16)	2 (0.61)	-
France	13 (1.41)	-	-	6 (1.39)	1 (0.30)	3 (0.75)
Germany	12 (1.30)	11 (1.05)	2 (0.30)	-	6 (1.82)	4 (1.00)
Singapore	-	7 (0.67)	5 (0.74)	5 (1.16)	5 (1.52)	1 (0.25)
Italy	-	-	-	4 (0.92)	1 (0.30)	5 (1.25)

Table 4-1 Top 10 sources of funding for Beijing University of Chinese Medicine

Rank	Supporting fund	Number	Rate (%)
1	National Natural Science Foundation of China	217	23.56
2	National Basic Research Program of China 973 Program	92	9.99
3	Ministry of Science and Technology of China	38	4.13
4	Chinese Academy of Sciences	36	3.91
5	Beijing University of Chinese Medicine	25	3.71
6	National Institutes of Health	15	1.63
7	Program for New Century Excellent Talents in University	12	1.30
8	China Postdoctoral Science Foundation	10	1.09
9	China Scholarship Council	10	1.09
10	International Science and Technology Cooperation of China	10	1.09

Table 4-2 Top 10 sources of funding for Shanghai University of Chinese Medicine

Rank	Supporting fund	Number	Rate (%)
1	National Natural Science Foundation of China	288	27.40
2	Shanghai Municipal Education Commission	183	17.41
3	National Basic Research Program of China 973 Program	117	11.13
4	Shanghai Leading Academic Discipline Project	80	7.61
5	Shanghai Science and Technology Committee	54	5.14
6	Shanghai Rising Star Program	36	3.43
7	National Institutes of Health	22	2.09
8	Shanghai Education Committee	17	1.62
9	National Science and Technology Major Project of China	13	1.24
10	China Postdoctoral Science Foundation	11	1.05

Table 4-3 Top 10 sources of funding for Nanjing University of Traditional Chinese Medicine

Rank	Supporting fund	Number	Rate (%)
1	National Natural Science Foundation of China	214	32.84
2	Ministry of Education	54	8.02
3	Priority Academic Program Development of Jiangsu Higher Education Institutions	46	6.84
4	Jiangsu College and University	39	5.79
5	Construction Project for Jiangsu Engineering Center of Innovative Drug from Blood Conditioning TCM Formulae	23	3.42
6	Program for Excellent Scientific and Technological Innovation Team of Jiangsu Higher Education	22	3.27
7	Nanjing University of Chinese Medicine	18	2.67
8	Natural Science Foundation of Jiangsu Province	16	2.38
9	Construction Project for Jiangsu Key Laboratory for High Technology Research of Tcm Formulae	15	2.23
10	National Basic Research Program of China 973 Program	15	2.23

Table 4-4 Top 10 sources of funding for Guangzhou University of Chinese Medicine

Rank	Supporting fund	Number	Rate (%)
1	National Natural Science Foundation of China	121	27.94
2	National Basic Research Program of China 973 Program	30	6.93
3	Natural Science Foundation of Guangdong Province	22	5.08
4	Guangzhou University of Chinese Medicine	14	3.23
5	Ministry of Education of China	12	2.77
6	Fundamental Research Funds for the Central Universities	5	1.15
7	Science and Technology Planning Project of Guangdong Province	5	1.15
8	China Postdoctoral Science Foundation	4	0.92
9	Research Fund for the Doctoral Program of Higher Education of China	4	0.92
10	Scientific Development Project of Guangdong China	4	0.92

Table 4-5 Top 10 sources of funding for Chengdu University of Traditional Chinese Medicine

Rank	Supporting fund	Number	Rate (%)
1	National Natural Science Foundation of China	109	33.03
2	National Basic Research Program of China 973 Program	45	13.64
3	State Key Laboratory Breeding Base of Systematic Research Development and Utilization of Chinese Medicine Resources	11	3.33
4	Chinese Academy of Sciences	11	3.03
5	Ministry of Science and Technology of China	9	2.73
6	Foundation of State Youth Science	8	2.42
7	Fundamental Research Funds for the Central Universities	8	2.42
8	Sichuan Provincial Education Department	7	2.12
9	China Postdoctoral Science Foundation	6	1.82
10	Industry Research Program of Traditional Chinese Medicine	5	1.52

Distribution of institutes for collaborative publications

The top 10 productive collaborative institutes to work with the universities are shown in Tables 6-1 to 6-6.

The Beijing University of Chinese Medicine and the Shanghai University of Chinese Medicine were the only universities to collaborate with international institutes. With the exception of collaboration between the China Japan Friendship Hospital and the Beijing University of Chinese Medicine, the Guangdong Provincial Hospital Traditional Chinese Medicine and the Guangzhou University of Chinese Medicine, and the Sichuan Provincial People's Hospital and the Chengdu University of Traditional Chinese Medicine, all other

Table 4-6 Top 10 sources of funding for Tianjin University of Traditional Chinese Medicine

Rank	Supporting fund	Number	Rate (%)
1	National Natural Science Foundation of China	129	37.66
2	Ministry of Science and Technology of China	37	9.23
3	National Basic Research Program of China 973 Program	32	7.98
4	Program for Changjiang Scholars and Innovative Research Team in University	24	5.99
5	China Postdoctoral Science Foundation	13	3.24
6	Program for New Century Excellent Talents in University	13	3.24
7	Ministry of Education of China	12	2.99
8	Municipal Natural Science Foundation of Beijing	9	2.24
9	International S T Cooperation Project of China	4	1.00
10	Tianjin Committee of Science and Technology China	4	1.00

Table 5-1 Top 10 authorization numbers for Beijing University of Chinese Medicine

Rank	Authorization number	Number	Rate (%)
1	2009DFA31460	17	1.85
2	30902020	13	1.41
3	90508002	13	1.41
4	2007CB914503	12	1.30
5	200807007	12	1.30
6	2010CB833800	12	1.30
7	2010CB912103	12	1.30
8	2011CB505106	12	1.30
9	30973679	12	1.30
10	20902094	11	1.19

Table 5-2 Top 10 authorization numbers for Shanghai University of Chinese Medicine

Rank	Authorization number	Number	Rate (%)
1	E03008	40	3.81
2	J50302	29	2.76
3	2006CB504704	22	2.09
4	S30304	21	2.00
5	2009ZX09311-003	18	1.71
6	30530840	18	1.71
7	2009CB522900	16	1.52
8	J50305	16	1.52
9	E 03008	15	1.43
10	J50301	15	1.43

Table 5-3 Top 10 authorization numbers for Nanjing University of Traditional Chinese Medicine

Rank	Authorization number	Number	Rate (%)
1	06KJA36022	52	7.73
2	NCET-09-0163	45	6.69
3	ysxk-2010	43	6.39
4	07KJA36024	24	3.57
5	BM2010576	21	3.12
6	30873235	17	2.53
7	30672678	15	2.23
8	2008BAI51B01	14	2.08
9	10KJA360039	13	1.93
10	2.00932E+13	10	1.49

Table 5-4 Top 10 authorization numbers for Guangzhou University of Chinese Medicine

Rank	Authorization number	Number	Rate (%)
1	2006CB504505	8	1.85
2	30772861	8	1.85
3	30371837	7	1.62
4	90709027	7	1.62
5	10771220	6	1.39
6	2.00811E+11	6	1.39
7	2010CB530500	6	1.39
8	2003C34403	5	1.16
9	2007B031404008	5	1.16
10	2008A050200005	4	0.92

collaborative institutes were either universities, colleges, or research institutions. Therefore, these six universities should also focus on establishing collaborative relationships with clinical hospitals to better integrate both TCM theory and practice.

The Chinese Academy of Sciences was the only institute to appear in the top 10 lists as a productive collaborative institute for all six universities. Thus, it was the most participatory institute in terms of scientific TCM research.

Research fields

The top 10 active research fields of the universities are

Table 5-5 Top 10 authorization numbers for Chengdu University of Traditional Chinese Medicine

Rank	Authorization number	Number	Rate (%)
1	30625042	23	6.97
2	2007CB512607	17	5.15
3	2006CB504501	11	3.33
4	2012CB518501	11	3.33
5	30772740	10	3.03
6	30930112	10	3.03
7	30973947	10	3.03
8	2009ZX09502-022	9	2.73
9	30970774	9	2.73
10	2011CB707702	7	2.12

Table 5-6 Top 10 authorization numbers for Tianjin University of Traditional Chinese Medicine

Rank	Authorization number	Number	Rate (%)
1	2008DFB30070	14	3.49
2	2009ZX09311-002	14	3.49
3	30873378	13	3.24
4	2005CB523404	12	2.99
5	7090001	10	2.49
6	2009ZX09103-362	9	2.24
7	2005 DKA21000	8	2.00
8	30830121	8	2.00
9	06TXTJJC13600	6	1.50
10	10SYSYJC28900	6	1.50

Table 6-1 Top 10 productive collaborative institutes to work with Beijing University of Chinese Medicine

Rank	Institute	Number	Rate (%)
1	Chinese Academy of Medical Sciences	128	13.90
2	Chinese Academy of Sciences	87	9.45
3	Peking University	57	6.19
4	Capital Medical University	52	5.65
5	Tsing Hua University	48	5.21
6	Morehouse School of Medicine	29	3.15
7	University of Science Technology China	24	2.61
8	China Japan Friendship Hosp	22	2.39
9	Hong Kong Baptist University	22	2.39
10	University of Manchester	22	2.39

shown in Tables 7-1 to 7-6.

According to ISI research field classifications, pharmacology, pharmacy, chemistry, integrative complementary medicine, plant sciences, and biochemistry molecu-

Table 6-2 Top 10 productive collaborative institutes to work with Shanghai University of Chinese Medicine

Rank	Institute	Number	Rate (%)
1	Chinese Academy of Sciences	151	14.37
2	Shanghai Jiao Tong University	108	10.28
3	Fudan University	87	8.28
4	China Pharmaceutical University	68	6.47
5	Shanghai R&D Centre for Standardization of Chinese Medicines	59	5.61
6	Second Military Medical University	58	5.52
7	East China University of Science Technology	34	3.24
8	London Metropolitan University	31	2.95
9	University of Rochester	28	2.66
10	Chinese University of Hong Kong	25	2.38

Table 6-3 Top 10 productive collaborative institutes to work with Nanjing University of Traditional Chinese Medicine

Rank	Institute	Number	Rate (%)
1	China Pharmaceutical University	113	16.79
2	Nanjing University	69	10.25
3	Nanjing Medical University	55	8.17
4	Southeast University China	19	2.82
5	Chinese Academy of Sciences	17	2.53
6	Jiangsu University	17	2.53
7	Zhejiang Chinese Medicine University	15	2.23
8	Nanjing University of Technology	11	1.63
9	Fudan University	9	1.34
10	Nanjing Agricultural University	9	1.34

Table 6-4 Top 10 productive collaborative institutes to work with Guangzhou University of Chinese Medicine

Rank	Institute	Number	Rate (%)
1	Sun Yat Sen University	84	19.40
2	Chinese Academy of Sciences	22	5.08
3	Chinese University of Hong Kong	22	5.08
4	Central South University	21	4.85
5	Southern Medical University China	21	4.85
6	Jinan University	20	4.62
7	Guangdong Province Hospital Traditional Chinese Medicine	13	3.00
8	Peking University	13	3.00
9	South China University of Technology	13	3.00
10	Hong Kong Baptist University	12	2.77

Table 6-5 Top 10 productive collaborative institutes to work with Chengdu University of Traditional Chinese Medicine

Rank	Institute	Number	Rate (%)
1	Sichuan University	82	24.85
2	302 Military Hospital China	40	8.18
3	Chinese Academy of Sciences	37	11.21
4	Jiangxi Nuiversity Traditional Chinese Medicine	18	5.46
5	Second Military Medical University	14	4.24
6	Xidian University	10	3.03
7	Chinese Academy of Medical Sciences Peking	9	2.73
8	Union Medical College Hunan University Traditional Chinese Medicine	9	2.73
9	Sichuan Province Peoples Hospital	8	2.42
10	Ministry Education	8	2.42

Table 6-6 Top 10 productive collaborative institutes to work with Tianjin University of Traditional Chinese Medicine

Rank	Institute	Number	Rate (%)
1	Tianjin University	82	20.45
2	Academy of Military Medical Sciences China	34	8.48
3	Nankai University	30	7.48
4	China Academy Chinese Medicine Science	27	6.73
5	Tianjin Institution Pharmaceutics Research	27	6.73
6	Tianjin Medical University	19	4.74
7	Zhejiang University	16	3.99
8	Chinese Academy of Sciences	15	3.74
9	Chinese Academy of Medical Sciences Peking	14	3.49
10	Union Medical College Beijing University Chinese Medicine	11	2.74

Note: where institutes have more than one name, the most recent name is used as listed in Intellectual Property & Science

lar biology were the hottest research fields for the six universities. However, research on the basic theories of TCM received much less attention.

Distribution of journal outputs

Tables 8-1 to 8-6 list the top 10 journals with the greatest number of published papers for each university.

Over 70% of these journals were published in China, with relatively low IFs ranging from 0 to 3.

Citation data

Table 9 and Figure 1 lists the citation data of the six universities

According to the above data, the earliest cited papers

Table 7-1 Top 10 active research fields at Beijing University of Chinese Medicine

Rank	Research field	Number	Rate (%)
1	Pharmacology Pharmacy	219	23.78
2	Chemistry	212	23.02
3	Integrative Complementary Medicine	178	19.33
4	Biochemistry Molecular Biology	110	11.94
5	Plant Sciences	97	10.53
6	Neurosciences Neurology	75	8.14
7	Cell Biology	57	6.19
8	General Internal Medicine	47	5.10
9	Spectroscopy	26	2.82
10	Science Technology Other Topics	23	2.50

Table 7-2 Top 10 active research fields at Shanghai University of Chinese Medicine

Rank	Research field	Number	Rate (%)
1	Pharmacology Pharmacy	329	31.30
2	Chemistry	236	22.46
3	Biochemistry Molecular Biology	171	16.27
4	Integrative Complementary Medicine	145	13.80
5	Plant Sciences	106	10.09
6	Neurosciences Neurology	60	5.71
7	Gastroenterology Herpetology	59	5.61
8	Cell Biology	45	4.28
9	Oncology	37	3.52
10	Research Experimental Medicine	37	3.52

Table 7-3 Top 10 active research fields at Nanjing University of Traditional Chinese Medicine

Rank	Research field	Number	Rate (%)
1	Pharmacology Pharmacy	260	38.63
2	Chemistry	206	30.61
3	Biochemistry Molecular Biology	89	13.22
4	Integrative Complementary Medicine	85	12.63
5	Plant Sciences	82	12.18
6	Oncology	41	6.09
7	Neurosciences Neurology	31	4.61
8	Science Technology Other Topics	20	2.97
9	Toxicology	20	2.97
10	Cell Biology	18	2.68

(1997) were from the Beijing University of Chinese Medicine and the Nanjing University of Traditional Chinese Medicine. The Beijing University of Chinese

Table 7-4 Top 10 active research fields at Guangzhou University of Chinese Medicine

Rank	Research field	Number	Rate (%)
1	Pharmacology Pharmacy	119	27.48
2	Chemistry	86	19.86
3	Integrative Complementary Medicine	69	15.94
4	Biochemistry Molecular Biology	52	12.01
5	Plant Sciences	45	10.39
6	Cell Biology	39	9.01
7	Neurosciences Neurology	35	8.08
8	Oncology	15	3.46
9	Science Technology Other Topics	13	3.00
10	Food Science Technology	12	2.77

Table 7-5 Top 10 active research fields at Chengdu University of Traditional Chinese Medicine

Rank	Research field	Number	Rate (%)
1	Pharmacology Pharmacy	90	27.27
2	Chemistry	89	26.97
3	Integrative Complementary Medicine	59	17.88
4	Plant Sciences	40	12.12
5	Biochemistry Molecular Biology	29	8.79
6	Science Technology Other Topics	17	5.15
7	Neurosciences Neurology	15	4.55
8	Cell Biology	11	3.33
9	Research Experimental Medicine	11	3.33
10	Food Science Technology	10	3.03

Medicine and the Shanghai University of Chinese Medicine had the highest number of citations, which was in accord with the trends of total publications. Based on Figure 1, the citations of the six universities have been steadily increasing in number since 1997, with the Shanghai University of Chinese Medicine enjoying the greatest increase in recent years.

Table 7-6 Top 10 active research fields at Tianjin University of Traditional Chinese Medicine

Rank	Research Field	Number	Rate (%)
1	Chemistry	127	31.67
2	Pharmacology Pharmacy	116	28.93
3	Integrative Complementary Medicine	52	12.97
4	Biochemistry Molecular Biology	48	11.97
5	Plant Sciences	46	11.47
6	Neurosciences Neurology	37	9.23
7	Food Science Technology	26	6.48
8	Cell Biology	21	5.24
9	Cardiovascular System Cardiology	17	4.24
10	Spectroscopy	16	3.99

The most frequently cited paper was "Biomimetic surface modification of poly (L-lactic acid) with chitosan and its effects on articular chondrocytes *in vitro*", published by the Tianjin University of Traditional Chinese Medicine in Biomaterials (IF=7.404) by Cui *et al* (2003); it has been cited 98 times as of 2012. To conclude, the most frequently cited papers have had a significant influence on the global attention paid to modern research on TCM; it is hoped that this will increase in the future.

Both the Beijing University of Chinese Medicine and the Shanghai University of Chinese Medicine had relatively higher h-indexes than the others, revealing that their SCI papers were of a higher quality overall.

DISCUSSION

In conducting our bibliometric analysis of SCI papers from the six universities, we obtained some significant

Table 8-1 Top 10 active journals to publish papers from Beijing University of Chinese Medicine

Rank	Name of Journals	Number	Rate (%)	IF	Country
1	Evidence-Based Complementary and Alternative Medicine	45	4.89	4.774	England
2	Chinese Journal of Integrative Medicine	34	3.69	0.799	China
3	Journal of Traditional Chinese Medicine	30	3.26	0.589	China
4	Acta Pharmacologica Sinica	25	2.71	1.953	China
5	Journal of Ethnopharmacology	23	2.50	3.014	Ireland
6	Journal of Asian Natural Products Research	21	2.28	0.944	England
7	Planta Mdica	20	2.17	2.153	Germany
8	Spectroscopy and Spectral Analysis	19	2.06	N/A	China
9	Cochrane Database of Systematic Reviews	18	1.95	5.715	England
10	World Journal of Gastroenterology	15	1.63	2.471	China

Note: IF: impact factor.

Table 8-2 Top 10 active journals to publish papers from Shanghai University of Chinese Medicine

Rank	Name of Journals	Number	Rate (%)	IF	Country
1	Journal of Ethnopharmacology	41	3.90	3.014	Ireland
2	Evidence-Based Complementary and Alternative Medicine	36	3.43	4.774	England
3	Acta Pharmacologica Sinica	27	2.57	1.953	China
4	World Journal of Gastroenterology	27	2.57	2.471	China
5	Chinese Journal of Integrative Medicine	20	1.90	0.799	China
6	Journal of Traditional Chinese Medicine	16	1.52	0.589	China
7	Planta Mdica	16	1.52	2.153	Germany
8	Biomedical Chromatography	15	1.43	1.966	England
9	Drug Metabolism Reviews	13	1.24	6.4	USA
10	Neural Regeneration Research	13	1.24	0.216	China

Note: IF: impact factor.

Table 8-3 Top 10 active journals to publish papers from Nanjing University of Traditional Chinese Medicine

Rank	Name of Journals	Number	Rate (%)	IF	Country
1	Journal of Ethnopharmacology	34	5.05	3.014	Ireland
2	Fitoterapia	27	4.01	1.848	Netherlands
3	Molecules	18	2.68	2.386	Switzerland
4	Journal of Pharmaceutical and Biomedical Analysis	15	2.23	2.967	Netherlands
5	Planta Mdica	14	2.08	2.153	Germany
6	Acta Pharmacologica Sinica	13	1.93	1.953	China
7	Chromatographia	13	1.93	1.195	Germany
8	Evidence-Based Complementary and Alternative Medicine	11	1.63	4.774	England
9	Journal of Chromatography B Analytical Technologies in the Biomedical and Life Sciences	11	1.63	2.888	Netherlands
10	Neural Regeneration Research	11	1.63	0.216	China

Note: IF: impact factor.

Table 8-4 Top 10 active journals to publish papers from Guangzhou University of Chinese Medicine

Rank	Name of Journals	Number	Rate (%)	IF	Country
1	Chinese Journal of Integrative Medicine	24	5.54	0.799	China
2	Journal of Ethnopharmacology	19	4.39	3.014	Ireland
3	Neural Regeneration Research	19	4.39	0.216	China
4	Plos One	9	2.08	4.092	USA
5	Evidence-Based Complementary and Alternative Medicine	8	1.85	4.774	England
6	Journal of Traditional Chinese Medicine	8	1.85	0.589	China
7	World Journal of Gastroenterology	8	1.85	2.471	China
8	Fitoterapia	7	1.62	1.848	Netherlands
9	Molecules	7	1.62	2.386	Switzerland
10	Acta Pharmacologica Sinica	6	1.39	1.953	China

Note: IF: impact factor.

findings on TCM scientific research performance throughout the period of 1995 to 2012. English was the dominant language, with Chinese used in only 6% of papers. The United States attained the dominant position in TCM international cooperative scientific research by contributing to the greatest number of internationally collaborative papers. With regard to inter-institutional collaborations, the Chinese Academy of Sciences was the most prolific organization in terms of cooperation. Research field analysis showed that TCM re-

Table 8-5 Top 10 active journals to publish papers from Chengdu University of Traditional Chinese Medicine

Rank	Name of Journals	Number	Rate (%)	IF	Country
1	Plos One	13	3.94	4.092	USA
2	Journal of Ethnopharmacology	12	3.64	3.014	Ireland
3	Journal of Traditional Chinese Medicine	12	3.64	0.589	China
4	Chinese Journal of Integrative Medicine	8	2.42	0.799	China
5	Evidence-Based Complementary and Alternative Medicine	8	2.42	4.774	England
6	Spectroscopy and Spectral Analysis	7	2.12	N/A	China
7	Food Chemistry	6	1.82	3.655	England
8	Planta Mdica	6	1.82	2.153	Germany
9	American Journal of Chinese Medicine	5	1.52	1.979	USA
10	European Journal of Drug Metabolism and Pharmacokinetics	5	1.52	0.356	France

Note: IF: impact factor.

Table 8-6 Top 10 active journals to publish papers from Tianjin University of Traditional Chinese Medicine

Rank	Name of Journals	Number	Rate (%)	IF	Country
1	Journal of Ethnopharmacology	22	5.49	3.014	Ireland
2	Neural Regeneration Research	14	3.49	0.216	China
3	Spectroscopy and Spectral Analysis	10	2.49	N/A	China
4	Chinese Journal of Integrative Medicine	9	2.24	0.799	China
5	Drug Metabolism Reviews	8	2.00	6.4	USA
6	Journal of Chromatography B Analytical Technologies in the Biomedical and Life Sciences	8	2.00	2.888	Netherlands
7	Chromatographia	7	1.75	1.195	Germany
8	Journal of Agricultural and Food Chemistry	7	1.75	2.823	USA
9	Journal of Pharmaceutical and Biomedical Analysis	7	1.75	2.967	Netherlands
10	Journal of Traditional Chinese Medicine	7	1.75	0.589	China

Note: IF: impact factor.

Table 9 Citation data of the six universities

University	TP	TC	TC (by others)	PC	MC	MC (per year)	H-index
Beijing	921	4383	3932	4.76	78	8.67	28
Shanghai	1051	5659	5109	5.38	77	8.71	32
Nanjing	673	2303	1990	3.42	55	7.71	20
Guangzhou	433	1817	1699	4.20	79	6.33	19
Chengdu	330	1437	1265	4.35	49	8.17	18
Tianjin	401	1439	1315	3.59	98	8.91	17

Notes: TP: total publications; TC: total citations; PC: per citations for each paper; MC: most citations.

search mainly focused on pharmacology, pharmacy, chemistry, integrative complementary medicine, plant sciences, and biochemistry molecular biology. The most frequently cited paper was "Biomimetic surface modification of poly (L-lactic acid) with chitosan and its effects on articular chondrocytes *in vitro*", which was published in Biomaterials (IF=7.404) by Cui *et al* (2003) and as of 2012 has been cited 98 times. The Shanghai University of Chinese Medicine had the most citations and the highest h-index (32) of the six universities (Table 9).

After 2008, the increase in total publication output was greater than that from 1995 to 2008 for all six universities. This increase is possibly related to the Beijing Olympic Games in 2008, which helped to boost the profile and acceptance of TCM worldwide.[17]

According to the theory of He,[18] universities go through three stages of scientific research development. In the first stage, it is important for institutions to increase the number of published papers, in the second

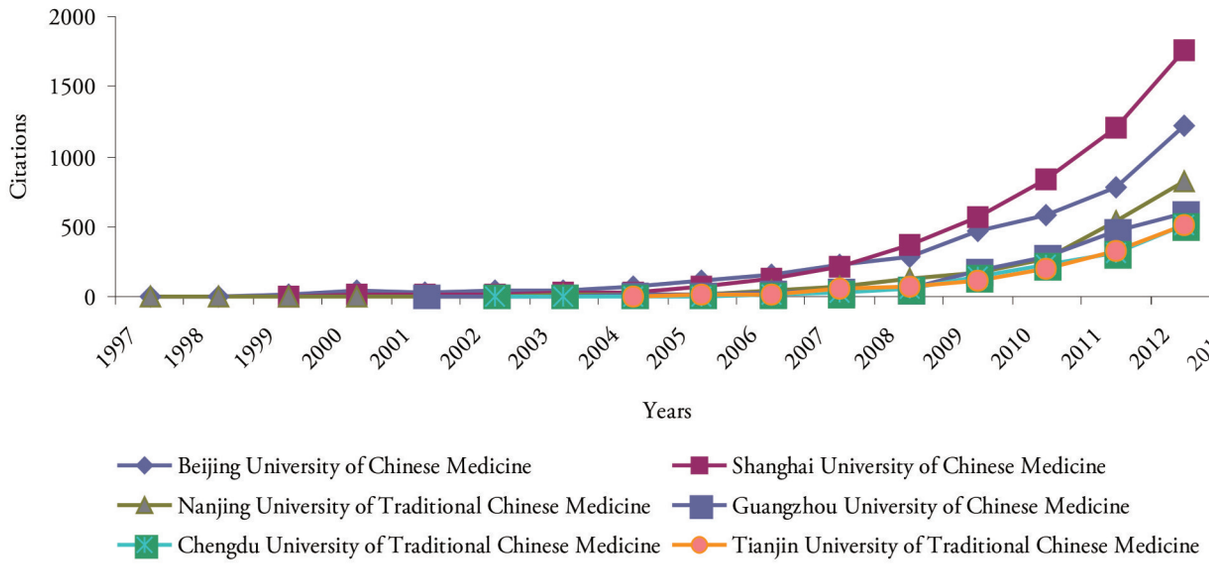

Figure 1 Citations/years for the six universities from 1997 to 2012

there is a focus on improving the quality of the papers, and in the final stage, the development of innovative ideas and major achievements is essential.

In terms of SCI papers, the six TCM universities studied here have made many recent advances in their research. They have reached the primary level of the second stage of research development, and therefore governments and society as a whole should offer greater support to maintain this trend.

According to our analysis, although there have been some advances in the scientific research on TCM in China, there remain a number of issues that require attention as follows.

(a) As 94% of all publications are published in English, researchers should try to improve their written English. (b) The six universities should develop stronger incentive policies to attract international collaboration. (c) Although the cumulative number of SCI papers is steadily increasing for all of the universities studied here, most were published in journals with relatively low IFs. None of the papers in our study were published in Nature or Science. Furthermore, the number of citations for each paper of the six universities ranged from just 3.42 to 5.38, which is significantly lower than the international average of 10.57.[19] Researchers should be encouraged to produce more original research outcomes for publication in journals with higher IFs.

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