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Herbal Medicine Research – A Scientometric View

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Abstract:

This article deals with the research productivity on herbal medicine by various countries of the world. The data for this research article were downloaded from Medline database. A total of 91,758 articles published between 1960 and 2012 (both years inclusive) were analyzed by using bibliometric indicators. The bibliometric indicators like trend of research, authorship pattern and publication pattern are used. Bibliometric Laws like Lotka's law, Bradford's law, are applied. In addition to this, the high prolific authors in this field are identified. Kumaravel's prepotency index is used for ranking the authors. The study reveals that there is a tremendous growth in herbal medicine research. Nowadays team research is preferred over individual research and the optimum number of scholars in team research is three authors.

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Key words: Bibliometric Analysis, herbal medicine, Authorship pattern, weightage share system, Kumaravel's prepotency index.

Introduction:

"Publish or Perish" was the mantra of all the academicians and it has now become "Publish and Flourish". The more is the number of publication of research articles by a scholar, the more will be his/her credit in the academic arena. Due to this tremendous growth in the publication of research articles it is essential to measure the various aspects of published literature. Bibliometrics is a tool to measure the published literature to analyse the quality as well as quantity of research literature. This investigation using bibliometric analysis to measure the herbal medicine research helps to understand the trend of research in this discipline thereby enabling the scholars in Herbal Medicine to update their knowledge and to improve their research.

Herbal medicine is the earliest scientific tradition in medical practice, and it remains an important part of medicine to this day - in a line descending directly from those distant beginnings. The early physicians stumbled upon herbal substances of real power, without understanding the manner of their working. Plants had been used for medicinal purposes long before recorded history. Ancient Chinese and Egyptian papyrus writings describe medicinal uses for plants as early as 3,000 BC. In India Herbal medicines dates back in as early as 6th century B.C when Susutra, the founding father of Indian medicine, established a tradition later enshrined in a classic text, the *Susrutasamhita*. He identified 1120 diseases, listed 760 medicinal drugs, and said that the surgeon's equipment amounts to 20 sharp instruments (including knives, scissors, saws and needles) and 101 blunt ones (such as forceps, tubes, levers, hooks and probes). Though there are allopathic

medicines nowadays most people use herbal medicines to try to maintain or improve their health.

In international herbal medicine research, several practical challenges arise in making accurate risk–benefit determinations. Typically, in American pharmaceutical development, a step-wise process of drug testing occurs – a compound is isolated, tested in tissue cultures and animals, and then investigated in phase 1, 2 and 3 clinical trials. However, herbal medicines are already in widespread use, are often used in combination, and are drawn from plant sources with their own variability in species, growing conditions and biologically active constituents. They often come into use by a process of trial and error, or over centuries. Accordingly, in clinical herbal medicine research there is rarely a strong preclinical basis for dosing, and there are significant looming questions about product purity, quality, chemical stability and active constituents at the time herbal medicine trials are proposed.[2].[3] Modern medicine recognizes herbalism/herbal medicine as a form of alternative medicine, as the practice of herbalism is not strictly based on evidence gathered using the scientific method. Modern medicine, does, however, make use of many plant-derived compounds as the basis for evidence-tested pharmaceutical drugs, and phytotherapy works to apply modern standards of effectiveness testing to herbs and medicines that are derived from natural sources. The scope of herbal medicine is sometimes extended to include fungal and bee products, as well as minerals, shells and certain animal parts. Chinese herbal medicine is part of a larger healing system called Traditional Chinese Medicine (TCM), which also includes acupuncture, massage dietary advice and exercise.

[2] Ernst E. 2001/2. "Adulteration of Chinese herbal medicines with synthetic drugs: a systematic review." *J Intern Med*. 252: 107-13.

[3] Ernst E. 2001. "Heavy metals in traditional Chinese medicines: a systematic review." *Clin Pharmacol Ther*. 70: 497-504.

Literature review

Shri Ram[4] used data indexed in the PubMed database for the period of fifteen years (1996–2010) to study the research on Artemisia. He found that publications on this subject grew to 712 percent in 2010 as compared to 1996. China is one of the countries that has contributed a number of publications in this area. Jun-Ying. Et al[5] applied bibliometric analysis to investigate the quantity and citation impact of scientific papers in the field of complementary and alternative medicine (CAM). The data were collected from 19 CAM journals in the Science Citation Index Expanded (SCI-E) database during 1980---2009, and 17,002 papers are identified for analysis. The study shows that CAM papers are mostly published by North America, East Asia, and European countries, of which publications authored in East Asia are cited most. Country-wise, major contributors of CAM papers are from USA, People's Republic of China, India, England and Germany. Most of the bibliometric studies on Herbal Medicine are based on specific species of herbal plants and a very few literature is available on global herbal medicine research.

Methods and Discussion:

Methods:

A literature search in Medline database was performed to retrieve the records indexed to herbal medicine in china. For this investigation 91,758 articles were taken for the period

[4] Shri Ram. 2011. "Research output on Artemisia (Artemisia annua): a bibliometric study." *Annals of Library & Information Science* 58(3): 237-248.

[5] Jun-Ying Fu et al. 2011. "Bibliometric analysis of complementary and alternative medicine research over three decades." *Scientometrics* 88(2): 617-626.

1960-2012.These articles are taken to check the validity of Lotka's Law, Bradford's law of scattering, and the author productivity is measured by weightage share system and Kumaravel's prepotency Index which is supported by S.R.Ranganathan's canon of prepotency. The growth rate of research literature at global level for the period is also analyzed.

Discussion:

This study deals with the scientific performance on herbal medicine in China from the period 1960-2012.(includes both years). From 1960 onwards there is a gradual increase in the research productivity and it is the maximum in the fifth decade (38,530) which contributes nearly 42% of total publications. (See table1). Based on this growth we may conclude that herbal medicine is applied to cure several diseases and people encourage herbal medicine in China. The total number of articles is divided into three zones, each with equal number of (1/3) of total articles. It is found that Bradford law is not applicable for herbal medicine in china. (Table 2) To check author productivity of publications Lotka's law is used as a measure. But the total no. of authors (Y), each producing (X) publications is not inversely proportional to some exponential function of n of X. So Lotka law is also not applicable in this study.(Table 3)

Table 4 shows the authorship pattern in 91,758 articles. Among these articles 69668 articles i.e.76% were contributed by the contribution of two to five authors. 938 articles were contributed by single authors, (1.02%). So the data shows that the researchers in the discipline of herbal medicine show more interest in doing research by team rather than individually. The shared contribution is having the maximum limit with three authors. (17299 articles i.e.18.85%)

Author productivity is a measure for ranking the authors according to their publication output. The most

common methods for ranking authors are Publication count and Equal share. In a collaborative publication it is not necessarily that all the co-authors contribute equal share in the research. In general it is presumed that the author named first might have put maximum effort. As the position of the author name moves from the first to the last position, the effort of the co-authors may decrease. There may be some authors whose name may be included just because of the aforesaid mantra "Publish or Perish". Hence Kumaravel[6] has suggested a new method for ranking of authors is found to be appropriate if each author may be given an ordinal value in the decreasing order according to their position. Hence the authors can be ranked on the basis of weighted share by their position in the author list

Each author named in a publication is given a value according to his/her position in the authors place and this value is termed as potency value (PV). Therefore, prime PV is accorded to the first author and then PV goes decreasing to the second, third and so on.

For example, if there are n authors for a publication, the potency value (PV) of an author in pth position ($p \leq n$) for that publication can be calculated as

$$PV = (n - p + 1) / n\sum \quad \text{where } n\sum = 1+2+3+ \ldots n \quad \text{and } PV \leq 1$$

The prepotency index of an author can be measured by arriving the potency value of the author. The formula for PI is PV/N where N is the total number of publications by the author.

The value of PI ranges from 0 to 1.The PI value nearer to 1 indicates the higher involvement of the author in most of his collaborative publications. The PI value nearer to zero

[6] Kumaravel, J.P.S., A. Manoharan, B. Kanagavel, M. Karthi Rajan and L. Mohamed Idhris. 2012. "Dr. S. R. Ranganathan's Canon of Prepotence applied to Bibliometrics leading to a new indicator – Prepotency index (PI)." Paper presented at 8th International Conference on Webometrics, Informetrics and Scientometrics (WIS) and 13th COLLNET Meeting in Seoul. Korea, October 23-26, 2012.

indicates that the author has been involved in majority of his collaborative publications for name sake. From this index, the potential or specialisation of an author in a subject can be measured.

Author productivity and their ranking was analysed by their publication count, and their position in publications. (table 5) Based on their place in which their name is present, weightage will be given in positional share method. The authors whose names are present in the first place in an article will be given more weightage than the authors in second, third places and so on. Here 30 authors name are taken for analysis and they are ranked according to publication count positional share method. By this ranking we may observed that except four authors remaining 26 author are having same rank in both methods. Thieme, H ranks 139 with 48 publications in publication count , but holds 140th rank in weightage share. Similar changes in rankings are Kozawa, M, (129 th rank in publication count and 134 th rank in weightage share method), Chen, K (71 rank in publication count and 72 rank in weightage share), Liu ,Y (37 th rank in publication count methods and 39 th rank in weightage share system). It is also found that both publication count and weightage share methods are focusing number of articles published with slight changes. Authors who published more articles are in higher rank rather than the authors with less publications.

Table 6 analyses authors and their ranking according to publication count and and positional share method. It is found that among 30 authors some authors rank differ from publication count method and ranking based on potency. Thieme,H holds 139th rank in publication count method(48articles) , but holds 140 th rank in positional share method.(28.00 potency). Chen, J holds 23rd rank in publication count (99 articles), but holds 24th rank in potency method (26.63 potency). Kozawa, M holds 129 th rank in publication count (49 articles), holds 134 rank in potency method (25.29 potency.)

Yoshikawa, M holds 24th rank in publication count (99 articles), but holds 25th position in potency method. (24.33 potency). Zhang, Wei holds 18th rank in publication count method (106 articles), but holds 19th rank in potency method (24.20 potency). It is also found that just like weightage share method both publication count and potency methods are focusing number of articles published with slight changes. Authors who published more articles are in higher rank rather than the authors with less publications.

Author productivity is anaysed and measured according to publication count, potency and prepotency index methods. (Table 7) In this analysis it is observed that the publication count method and potency are mainly focusing number of articles published. Authors who published more articles are in higher rank rather than the authors with less publications. But there is a drastic change in prepotence index and the other methods. In prepotence index method, author who is having more publications has less potency value but the author with less publications has greater value. For example Thieme, H has high prepotence index value i.e 0.58 with less publications (48) while compare with Li, W who has less prepotence index value i.e 0.31 with more publications. (63) So we may say that Kumaravel's prepotency index method again proved that it measures an author in terms of quality rather than his quantity in the case of herbal medicine research area. The ranked list of author's undergone drastic changes if arranged based on potency Index value.

By analyzing the research literature in the discipline worldwide for the period 1960-2012 ,(Table 8) we may find that China holds the first position by publishing 20,929 articles (i.e. 22.81%) of the total articles. Next to chine USA and UK holds the second and third position by publishing 19,175 articles (i.e.20.90%) and 12,143 articles (i.e.13.23%) respectively. Some developing countries like Bosnia, Guatemala, New Guinea, Hong Kong and Cameroon is in the last position.

Table 9 shows the country wise distribution of research articles in herbal medicine. It also shows the authorship trend in research in each and every country (103 countries) and its optimum value. By analyzing the data it is found that among the 103 countries more than 45 countries are showing interest in solo research and nearly 55 countries are showing interest in team work rather than solo research**.**

The roots of Indian medicine were set forth in the sacred writings called the *Vedas*, which date back as far as the 2nd century BC. The Indian system of medicine was called the Ayurveda. The Indian *materia medica*, or list of herbs used as medicines, was quite extensive. As early as 800 BC one Indian writer knew 500 medicinal plants and another knew 760—all indigenous plants of India. Even though Indian herbalism or Ayurveda is still practiced today, and many authentic, traditional formulations are available outside of India, it holds the 11th position in the ranking with 1261 publications. The researchers in India are also interested in team research rather than solo research. Because out of 1261 articles maximum publications i.e. 27.36% is contributed by three authors. The reason may be due to the language of publication or Indians may not show interest in publishing their research work in foreign databases like Scopus/ web of science etc.

Table 10 focuses on the top 25 countries in solo research based on their publication count. By analyzing the data it reveals that there is a contradiction among the total publication count and solo research. For example U.S. published 19175 articles but the optimum range in solo research is 16.94%. But Finland published only 29 articles but the optimum range in solo research is 68.97% and the researchers show interest in team research with maximum of three members. This statement has been proved in the case of Norway (40.15%) (132 articles), South Africa (42.71%) (96 articles) etc.

Conclusion:

While we analyze the research literature and its growth we may conclude that today the research trend is depends on author productivity and their involvement in combined research. While considering the shared authorship pattern we need to find out the ranking of authors based on several techniques and measures. In this aspect Kumaravel's Prepotency Index is a remarkable index to giving weightage to authors who involved in collaborative research. Even though the findings of the study do not justify Bradfords and Lotka's laws, the reason may be the growth of new journals in all subjects.

Although approximately 80 percent of people today depend upon herbal medication as a component of their primary health. According to the world Health organisation, there is still great concern about the safety and efficacy of herbal use.[7] While herbal medicine can potentially contribute to the advancement of healthcare, many major challenges must be overcome prior to the successful integration of herbal remedies into mainstream medicine. One of the major barriers is the current lack of accurate translations and interpretations of Chinese herbal texts and research by Western scientists. Indeed, for the incorporation of safe and effective herbs into the medical system to become a reality, more researchers and doctors need to be trained in both modern medicine and herbal compendium that has been accumulated since ancient times.
both individualizing (the basis of TCM) and standardizing (the basis of modern pharmacology) treatment with herbs must be settled. Once these issues are resolved, the prospect exists for widespread use of herbal medicine as a safe, effective, and affordable form of healthcare.

[7] Herbal Medicine. University of Maryland Medical Centre. http://www.umm.edu/altmed/articles/herbal-medicine-000351.htm#ixzz1i9ZzqMkX

Table 1: Decadewise Growth of research trend in herbal medicine(1960-2012)

Decade	Year	No. of Articles published	Average No of papers per year
I	1960-69	4831	483.1
II)	1970-79	6497	649.7
III	1980-89	9382	938.2
IV	1990-99	18513	1851.3
V	2000-09	38530	3853
2010-12	2010-12	14005	4668.3
Total		91758	

Table2: Validation of Bradford's law:

Zones	No of Journals	No of Publications
1	12	30191
2	193	30572
3	4662	30996

Table 3: Validation of Lotka's law:

No of Papers (X)	**No of Authors (Y)**	**$X^n*Y = K$ (n = 1.6)**
1 Paper	78458	78458
2 Papers	40205	121878.77
3 Papers	12411	71978.17
4 Papers	6908	63481.67
5 Papers	3754	49299.93
6 Papers	2502	43987.5
7 Papers	1708	38427.73
8 Papers	1138	31701.97
9 Papers	901	30304.9
10 Papers	625	24881.7
11 Papers	533	24714.71
12 Papers	406	21637.95
13 Papers	336	20353.95
14 Papers	259	17664.63
15 Papers	215	16375.12
16 Papers	202	17058.6
17 Papers	155	14422.81
18 Papers	139	14172.64
19 Papers	104	11562.16
20 Papers	101	12189.04

Table 4: Authorship Pattern

Authors	Count	Percent
Anon	938	1.02
1	13669	14.9
2	14225	15.5
3	17299	18.85
4	13381	14.58
5	11164	12.17
6	8299	9.04
7	5059	5.51
8	3140	3.42
9	1831	2
10	1240	1.35
11	591	0.64
12	369	0.4
13	229	0.25
14	120	0.13
15	62	0.07
16	53	0.06
17	30	0.03
18	19	0.02
19	11	0.01
20	9	0.01
21	2	0
22	6	0.01
23	1	0
24	2	0
25	1	0
26	1	0
27	1	0
28	4	0
43	1	0
82	1	0
	91758	

Table 5 Author Productivity – Ranking of Authors – According to Publication count and equal share method

Author	Count	Rank According to Publication Count	Positional share	Rank According to weighted Share
Zhang, Y	179	1	52.67	1
Li, X	154	2	45.96	2
Wang, Y	150	3	45.42	3
Li, J	150	4	43.64	4
Zhang, H	122	9	42.74	5
Wang, X	130	8	40.09	6
Chen, Y	119	10	37.53	7
Li, Y	136	7	36.21	8
Wagner, H	91	32	35.02	9
Li, Z	104	20	33.73	10
Matsuda, H	149	5	31.54	11
Yamahara, J	137	6	31.39	12
Wang, J	110	15	30.35	13
Liu, X	102	22	29.53	14
Cordell, G A	99	23	27.95	15
Thieme, H	48	139	27.67	16
Wang, Wei	114	13	27.23	17
Chen, J	99	24	27.19	18
Kozawa, M	49	129	26.97	19
Li, L	89	34	26.56	20
Wang, Z	92	31	25.52	21
Zhang, Li	117	12	25.46	22

Liu, J	106	17	25.35	23
Chen, X	93	29	25.31	24
Farnsworth, N R	87	36	24.74	25
Tanaka, T	94	28	24.58	26
Zhang, J	91	33	23.88	27
Li, Ping	118	11	23.78	28
Chen, K	62	71	23.63	29
Liu, Y	82	37	23.60	30

Table 6 Author Productivity – Ranking of Authors – According to Publication count and positional share method

Author	**Count**	**Rank According to Publication Count**	**Positional share**	**Rank**
Zhang, Y	179	1	52.77	1
Li, J	150	3	44.93	2
Wang, Y	150	4	44.71	3
Li, X	154	2	43.10	4
Zhang, H	122	9	42.75	5
Wang, X	130	8	37.99	6
Chen, Y	119	10	37.09	7
Wagner, H	91	32	35.93	8
Matsuda, H	149	5	35.58	9
Li, Y	136	7	35.26	10
Li, Z	104	20	31.56	11
Wang, J	110	15	30.27	12
Li, L	89	34	29.70	13

Wang, Wei	114	13	28.40	14
Thieme, H	48	139	28.00	15
Yokozawa, T	80	42	27.53	16
Yamahara, J	137	6	27.13	17
Liu, X	102	22	27.09	18
Liu, J	106	17	26.84	19
Chen, J	99	23	26.63	20
Chen, X	93	29	25.96	21
Zhang, Li	117	12	25.49	22
Wang, Z	92	31	25.38	23
Zhang, J	91	33	25.35	24
Kozawa, M	49	129	25.29	25
Zhang, Z	76	45	24.83	26
Yoshikawa, M	99	24	24.33	27
Zhang, Wei	106	18	24.20	28
Farnsworth, N R	87	36	24.15	29
Zhang, L	95	27	23.85	30

Table 7 Author Productivity – Ranking of Authors – According to Publication count and prepotence index

Author	**Count**	**Rank According to Publication Count**	**Positional share**	**Rank**	**Prepotence Index**
Thieme, H	48	139	28.00	15	0.58
Ernst, E	44	173	23.70	32	0.54
Kozawa, M	49	129	25.29	25	0.52
Takagi, K	41	198	19.29	51	0.47

Singh, A	45	165	20.56	45	0.46
Wagner, H	91	32	35.93	8	0.39
Suzuki, M	41	199	15.94	77	0.39
Chen, K	62	71	23.30	35	0.38
Hikino, H	44	174	16.24	74	0.37
Zhang, M	48	140	17.41	63	0.36
Kimura, Y	55	90	19.87	47	0.36
Li, M	54	96	19.32	50	0.36
Wang, S	66	58	23.58	33	0.36
Zhang, H	122	9	42.75	5	0.35
Yokozawa, T	80	42	27.53	16	0.34
Manez, S	42	190	14.38	92	0.34
Phillipson, J D	49	130	16.74	68	0.34
Li, L	89	34	29.70	13	0.33
Chen, L	50	121	16.58	70	0.33
Wang, Q	54	97	17.68	59	0.33
Zhang, Z	76	45	24.83	26	0.33
Li, H	70	53	22.84	37	0.33
Zhou, Y	51	115	16.53	71	0.32
Lin, C C	51	116	16.44	72	0.32
Sun, Y	44	175	14.11	95	0.32
Amagaya, S	54	98	17.31	65	0.32
Bhattacharya, S K	42	191	13.29	109	0.32
Wang, W	46	153	14.47	90	0.31
Chen, Y	119	10	37.09	7	0.31
Li, W	63	69	19.62	48	0.31

Table 8. Country wise Distribution

S.No	Country	Publication Count	Percent
1.	China	20929	22.81
2.	United States	19175	20.9
3.	England	12143	13.23
4.	Germany	6260	6.82
5.	Netherlands	5094	5.55
6.	Japan	4526	4.93
7.	Ireland	3947	4.3
8.	Germany, West	2853	3.11
9.	Switzerland	2342	2.55
10.	USSR	1457	1.59
11.	India	1261	1.37
12.	France	1009	1.1
13.	Italy	808	0.88
14.	Poland	644	0.7
15.	Denmark	637	0.69
16.	Germany, East	573	0.62
17.	Not Available	536	0.58
18.	Australia	514	0.56
19.	Canada	478	0.52
20.	Singapore	443	0.48
21.	Spain	368	0.4
22.	Brazil	366	0.4
23.	Greece	350	0.38
24.	Scotland	341	0.37
25.	Korea (South)	339	0.37
26.	Russia	293	0.32
27.	Austria	233	0.25
28.	Sweden	219	0.24
29.	Hungary	208	0.23
30.	Nigeria	204	0.22
31.	Thailand	203	0.22
32.	Belgium	193	0.21
33.	Pakistan	187	0.2
34.	Venezuela	185	0.2
35.	Czechoslovakia	169	0.18
36.	New Zealand	163	0.18
37.	Czech Republic	142	0.15
38.	Russia (Federation	139	0.15
39.	Norway	132	0.14
40.	Romania	124	0.14
41.	Mexico	118	0.13
42.	Bulgaria	106	0.12
43.	Ukraine	104	0.11
44.	South Africa	96	0.1
45.	Taiwan	78	0.09
46.	United Arab Emira	73	0.08
47.	Egypt	69	0.08
48.	Yugoslavia	53	0.06
49.	Senegal	50	0.05
50.	Israel	45	0.05
51.	Korea	43	0.05
52.	Argentina	40	0.04
53.	Kenya	36	0.04
54.	Lithuania	34	0.04
55.	Iran	33	0.04
56.	Jamaica	33	0.04
57.	Turkey	30	0.03
58.	Zimbabwe	30	0.03
59.	Finland	29	0.03
60.	China (Republic : 1949-	29	0.03
61.	Saudi Arabia	28	0.03
62.	Malaysia	27	0.03
63.	Croatia	25	0.03
64.	Uganda	23	0.03
65.	Costa Rica	22	0.02
66.	Georgia (Republic	22	0.02
67.	Papua New Guine	22	0.02
68.	Slovakia	18	0.02
69.	Unknown	17	0.02
70.	Ethiopia	17	0.02
71.	Bangladesh	17	0.02
72.	Chile	16	0.02
73.	Cuba	15	0.02
74.	Puerto Rico	15	0.02
75.	China (Republic: 1949-)	15	0.02
76.	Philippines	13	0.01
77.	Nepal	12	0.01
78.	Lebanon	11	0.01
79.	Portugal	11	0.01
80.	Madagascar	9	0.01
81.	Sri Lanka	9	0.01
82.	Peru	8	0.01
83.	Colombia	7	0.01
84.	Kyrgyzstan	7	0.01
85.	Tanzania	6	0.01
86.	Panama	6	0.01
87.	Bosnia And Herce	5	0.01
88.	Northern Ireland	5	0.01
89.	Uzbekistan	5	0.01
90.	Indonesia	5	0.01
91.	Tunisia	4	0
92.	Mali	3	0
93.	Luxembourg	3	0
94.	Belorussia	2	0
95.	Zambia	2	0
96.	Serbia	2	0
97.	Morocco	2	0
98.	Bosnia-Herzegovi	1	0
99.	Serbia And Monte	1	0
100	Guatemala	1	0
101	New Guinea	1	0
102	Hong Kong	1	0
103	Cameroon	1	0
	Total	91758	100

Table 9: List of countries along with their optimum value in authorship pattern:

Sl.No	Country	% of Anon	% of Single	% of two Authors	% of three Authors	% of four Authors	% of five Authors	% of more than five Authors	Total
1	China	0.43	12.65	13.21	27.35	14.98	12.94	18.44	20929
2	United States	2.4	16.94	15.49	15.38	13.62	11.13	25.03	19175
3	England	0.74	12.77	14.35	15.88	15.49	13.25	27.51	12143
4	Germany	1.44	9.57	10.5	14.07	14.84	15.27	34.31	6260
5	Netherlands	0.35	7.11	16.33	18.43	17.51	14.08	26.19	5094
6	Japan	0.11	7.36	9.08	16	18.12	17.74	31.6	4526
7	Ireland	0.08	3.47	10.84	15.2	15.68	13.55	41.17	3947
8	GERMANY, WEST	0.49	32.07	29.2	20.22	9.29	4.77	3.96	2853
9	Switzerland	2.43	19.34	18.66	17.16	13.96	9.69	18.74	2342
10	USSR	0.41	34.32	29.86	17.91	9.2	7.34	0.96	1457
11	India	0.24	10.79	26.01	27.36	18.32	9.75	7.53	1261
12	France	1.98	21.61	21.11	21.01	13.48	11.1	9.71	1009
13	Italy	0.62	26.61	20.3	16.09	13	8.54	14.85	808
14	Poland	0	25.62	28.73	20.96	10.25	6.83	7.61	644
15	Denmark	1.26	13.19	20.41	15.23	16.8	14.13	19	637
16	GERMANY, EAST	0.35	28.62	31.94	20.07	13.09	2.97	2.97	573
17	Not Available	0.19	52.8	28.54	12.87	3.92	0.93	0.75	536
18	Australia	2.14	26.85	19.84	13.62	12.84	8.37	16.34	514
19	Canada	5.65	33.89	17.78	14.44	8.79	5.86	13.6	478
20	Singapore	0	5.19	7.67	13.32	14	16.48	43.34	443
21	Spain	0	23.37	22.01	12.5	13.32	10.6	18.21	368
22	Brazil	0.27	15.03	15.57	11.75	14.75	11.75	30.87	366
23	Greece	0	1.14	10.29	9.71	13.14	12	53.71	350
24	Scotland	0	33.14	15.84	12.02	12.61	10.26	16.13	341
25	Korea (South)	0.29	5.9	10.91	12.09	13.86	13.57	43.36	339
26	Russia	0.68	12.29	22.53	17.75	18.77	9.22	18.77	293
27	Austria	0.43	33.05	24.89	16.74	10.73	6.44	7.73	233
28	Sweden	2.28	39.73	26.94	15.07	9.13	3.65	3.2	219
29	Hungary	0	33.17	15.87	17.79	13.94	8.65	10.58	208
30	Nigeria	0	12.25	19.61	25.49	14.22	12.75	15.69	204
31	Thailand	0	5.42	15.76	22.66	20.2	11.33	24.63	203
32	Belgium	0.52	34.2	21.76	18.65	9.84	6.74	8.29	193
33	Pakistan	0	14.97	11.23	21.39	18.18	12.3	21.93	187
34	Venezuela	1.08	12.97	20	32.43	20.54	9.73	3.24	185
35	CZECHOSLOVAKIA	0	28.99	28.4	23.08	13.02	2.96	3.55	169
36	New Zealand	3.07	39.88	20.25	11.04	4.29	5.52	15.95	163
37	Czech Republic	0.7	19.72	28.87	20.42	9.15	8.45	12.68	142
38	Russia (Federation)	0	12.95	15.83	15.83	22.3	14.39	18.71	139
39	Norway	0.76	40.15	15.15	15.91	9.09	6.82	12.12	132
40	Romania	0	9.68	22.58	12.9	17.74	17.74	19.35	124
41	Mexico	0	22.88	14.41	11.02	14.41	20.34	16.95	118
42	Bulgaria	0.94	18.87	28.3	17.92	16.98	12.26	4.72	106
43	Ukraine	0	35.58	17.31	16.35	9.62	9.62	11.54	104
44	South Africa	4.17	42.71	29.17	12.5	8.33	3.13	0	96
45	TAIWAN	0	17.95	17.95	25.64	19.23	8.97	10.26	78
46	United Arab Emirates	0	15.07	13.7	24.66	12.33	12.33	21.92	73
47	Egypt	0	10.14	21.74	31.88	24.64	8.7	2.9	69
48	Yugoslavia	0	39.62	41.51	9.43	1.89	3.77	3.77	53
49	Senegal	0	26	16	6	12	18	22	50
50	Israel	0	26.67	24.44	15.56	13.33	8.89	11.11	45
51	KOREA	0	2.33	4.65	25.58	25.58	13.95	27.91	43
52	Argentina	0	27.5	17.5	22.5	12.5	7.5	12.5	40
53	Kenya	0	33.33	25	19.44	2.78	5.56	13.89	36
54	Lithuania	0	2.94	11.76	26.47	29.41	17.65	11.76	34
55	Iran	3.03	12.12	3.03	18.18	30.3	15.15	18.18	33

Sl.No	Country	% of Anon	% of Single	% of two Authors	% of three Authors	% of four Authors	% of five Authors	% of more than five Authors	Total
56	Jamaica	0	6.06	24.24	15.15	18.18	15.15	21.21	33
57	Turkey	0	36.67	23.33	16.67	3.33	10	10	30
58	Zimbabwe	0	26.67	26.67	16.67	16.67	6.67	6.67	30
59	China (Republic : 1949-)	0	17.24	3.45	6.9	20.69	13.79	37.93	29
60	Finland	0	68.97	20.69	10.34	0	0	0	29
61	Saudi Arabia	0	21.43	21.43	10.71	17.86	3.57	25	28
62	Malaysia	0	11.11	37.04	7.41	14.81	7.41	22.22	27
63	Croatia	0	32	16	4	12	16	20	25
64	Uganda	0	21.74	17.39	26.09	13.04	8.7	13.04	23
65	Costa Rica	0	13.64	22.73	18.18	27.27	9.09	9.09	22
66	Georgia (Republic)	0	18.18	13.64	18.18	0	45.45	4.55	22
67	Papua New Guinea	0	54.55	9.09	18.18	18.18	0	0	22
68	Slovakia	0	5.56	11.11	33.33	27.78	5.56	16.67	18
69	Bangladesh	0	0	23.53	29.41	23.53	17.65	5.88	17
70	Ethiopia	5.88	35.29	11.76	11.76	0	23.53	11.76	17
71	Unknown	0	88.24	5.88	0	5.88	0	0	17
72	Chile	0	31.25	18.75	12.5	12.5	6.25	18.75	16
73	China (Republic: 1949-)	0	13.33	13.33	26.67	20	6.67	20	15
74	Cuba	0	0	6.67	53.33	13.33	13.33	13.33	15
75	Puerto Rico	0	40	13.33	13.33	13.33	6.67	13.33	15
76	PHILIPPINES	0	61.54	15.38	0	15.38	7.69	0	13
77	Nepal	8.33	0	16.67	8.33	41.67	8.33	16.67	12
78	Lebanon	0	54.55	9.09	9.09	18.18	0	9.09	11
79	Portugal	0	81.82	9.09	9.09	0	0	0	11
80	MADAGASCAR	0	0	0	0	22.22	11.11	66.67	9
81	Sri Lanka	0	66.67	22.22	0	0	11.11	0	9
82	Peru	0	25	0	50	0	0	25	8
83	Colombia	0	28.57	0	14.29	14.29	42.86	0	7
84	KYRGYZSTAN	0	28.57	42.86	28.57	0	0	0	7
85	PANAMA	0	0	0	33.33	0	50	16.67	6
86	Tanzania	0	0	0	0	0	16.67	83.33	6
87	Bosnia and Hercegovina	0	0	0	40	20	20	20	5
88	Indonesia	0	40	0	0	20	20	20	5
89	Northern Ireland	0	40	20	20	0	0	20	5
90	UZBEKISTAN	0	60	20	0	0	20	0	5
91	Tunisia	0	25	0	0	25	25	25	4
92	LUXEMBOURG	0	100	0	0	0	0	0	3
93	Mali	0	0	0	0	0	33.33	66.67	3
94	BELORUSSIA	0	100	0	0	0	0	0	2
95	MOROCCO	0	50	0	50	0	0	0	2
96	Serbia	0	0	50	0	0	0	50	2
97	ZAMBIA	0	50	0	50	0	0	0	2
98	BOSNIA-HERZEGOVINA	0	100	0	0	0	0	0	1
99	CAMEROON	0	0	100	0	0	0	0	1
100	GUATEMALA	0	100	0	0	0	0	0	1
101	HONG KONG	0	100	0	0	0	0	0	1
102	NEW GUINEA	0	100	0	0	0	0	0	1
103	Serbia and Montenegro	0	0	0	0	0	0	100	1

Table 10: Top 25 countries in solo research:

S.No	Country	Optimum Value(in %)	Total Publication Count
1	U.S.	16.94	19175
2	Germany(West)	32.07	2853
3	Switzerland	19.34	2342
4	USSR	34.32	1457
5	France	21.61	1009
6	Italy	26.61	808
7	Australia	26.85	514
8	Canada	33.89	478
9	Spain	23.37	368
10	Scotland	33.14	341
11	Austria	33.05	233
12	Sweden	39.73	219
13	Hungary	33.17	208
14	Belgium	34.2	193
15	Czechoslovakia	28.99	169
16	Newzeland	39.88	163
17	Norway	40.15	132
18	Mexico	22.88	118
19	Ukarine	35.58	104
20	South Africa	42.71	96
21	Senegal	26	50
22	Israel	26.67	45
23	Argentina	27.5	40
24	Kenya	33.33	36
25	Finland	68.97	29

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