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A Bibliometric Analysis of Nanomedicine Research from 2009-2018

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Abstract: *This paper is based on the bibliometric analysis of Nanomedicine research published from 2009 to 2018. Total 6415 records were retrieved for analysis from the Web of Science database. The study covers year wise distribution of publications, identification of most prolific authors, identification of most contributing countries, application of Bradford's law and identification of core journals in the field of nanomedicine. The study reveals that China has contributed highest publications followed by USA and India. The authorship pattern of the publications was studied. The publications are highly collaborative (DC=0.98).*

Keywords:

Bibliometric Analysis, Bradford's Law, Authorship pattern, Degree of collaboration, Citation, Web of Science

Introduction:

Nanomedicine is a very young and rapidly growing field of medical science (Chang, 2015). Nanomedicine is the application of nanotechnology to medicine. Application and use of nanomedicine have been successfully utilized for the betterment of our life (Chang, 2015). Using nanomedicine, drugs can be delivered directly to the affected cells, which reduce the chances of damaging the other healthy tissue or organs (Kargozar and Mozafari, 2018). This nanomedicine field is still emerging and the research has been increasing globally day by day (Sandhiya et al., 2009).

As the research productivity in every discipline is increasing rapidly, especially in the field of science & technology, it has been creating a lot of problems for the library and information center. It is not possible for a library to provide all the documents to the users in this information era. Due to exponential rise in the growth of literature as well as the price value, it has become very much important for the libraries and also for the researchers to identify core literature and save time, space and resource as well. Bibliometrics, a young science, involves different tools and techniques to critically analyse and evaluate the scientific literature. In this paper, a bibliometric study is carried out to analyze the research productivity in the field of Nanomedicine.

Objectives:

1. To analyse year wise publication and calculate Annual growth Rate, Annual Average Growth Rate, Relative Growth Rate and Doubling Time of the literature.
2. To identify the most prolific authors.
3. To identify the core journals.
4. To analyse the language wise distribution.
5. To analyse the region wise distribution of papers.
6. To analyse the authorship pattern.

Methodology:

The data used for this study was based on the SCI-Expanded (Science Citation Index Expanded) and SSCI (Social Science Citation Expanded) of Web of Science (WoS) of the Institute for Scientific Information. The following search expression was used to gather the data:

TOPIC: (Nanomedicine) AND DOCUMENT TYPES: (Article) Timespan=2009-2018. Indexes=SCI-EXPANDED, SSCI, A&HCI, ESCI.

Total number of 6415 articles within that window period is retrieved. The records were downloaded in both .txt and .xls format. Further the data data analysis was done through MS Excel and BibExcel software.

Year wise analysis:

Table 1: Year wise analysis

Year	No. of Publications
2009	139
2010	238
2011	359
2012	383
2013	526
2014	681
2015	859
2016	950
2017	1051
2018	1229

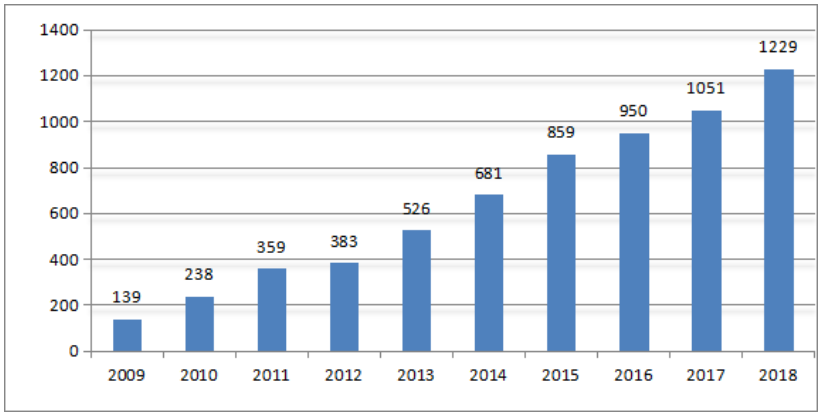


Fig 1: Year wise distribution of paper

Table 1 shows the year wise distribution of paper. From the diagram we have found that 2018 was the most productive year whereas the less productive year was 2009.

Annual Growth rate and Annual Average Growth Rate

Table 2: Year wise AGR and AAGR

Year	No. of Publications	AGR (%)	No. of Citations
2009	139		9050
2010	238	71.223	15695
2011	359	50.840	19568
2012	383	6.685	14122
2013	526	37.337	18351
2014	681	29.468	19238
2015	859	26.138	18275
2016	950	10.594	15250
2017	1051	10.632	9708
2018	1229	16.936	3287

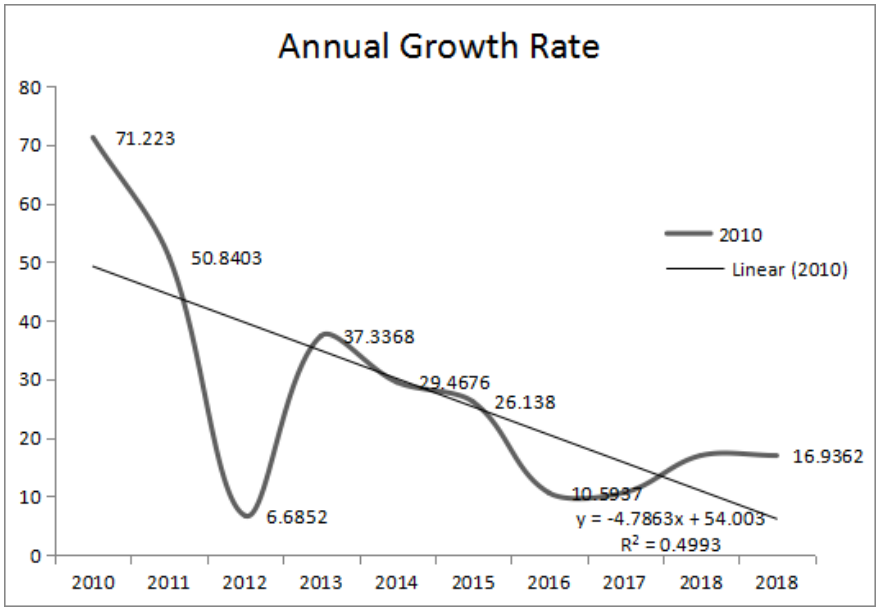


Fig 2: AGR

The table 2 shows the Annual Growth rate of the literature for each year. The figure 2 shows the Year vs. AGR graph along with its trend line. The AGR is highest in the year 2010 (71.223) and lowest in the year 2012 (6.6852). The value of R^2 is also calculated and it is found to be 0.4993.

The average annual growth rate,

AAGR = (71.223+50.8403+6.6852+37.3368+29.4676+26.138+10.5937+10.6315+16.9362)/9

= 28.87%

Relative Growth Rate and Doubling Time of publications

Table 3 Relative Growth Rate and Doubling Time of publications

Year	No. of Publications	Cumulative total	W1	W2	RGR	DT
2009	139	139	---	4.93	---	---
2010	238	377	4.93	5.93	1	0.693
2011	359	736	5.93	6.6	0.67	1.03
\2012	383	1119	6.6	7.02	0.42	1.65
2013	526	1645	7.02	7.4	0.38	1.82
2014	681	2326	7.4	7.75	0.35	1.98
2015	859	3185	7.75	8.06	0.31	2.23
2016	950	4135	8.06	8.32	0.26	2.66
2017	1051	5186	8.32	8.55	0.23	3.01
2018	1229	6415	8.55	8.76	0.21	3.3

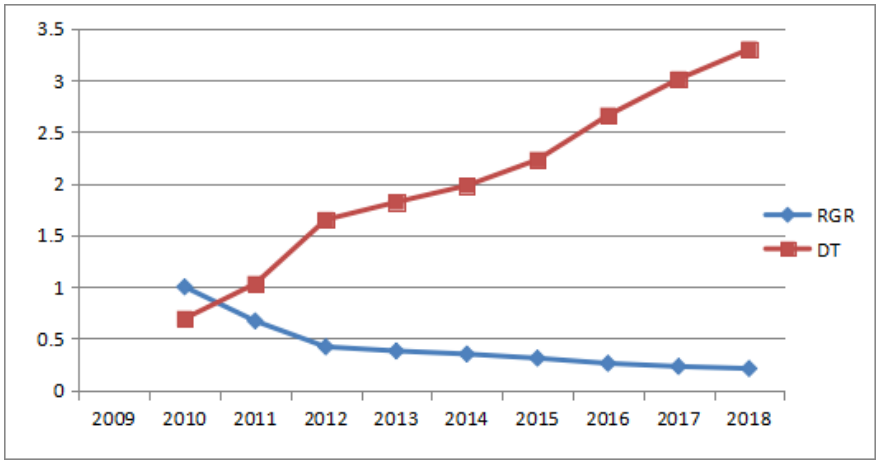


Fig 3 RGR and DT

The year wise RGR is found to be in the range of 1 to 0.09. Year wise calculation of RGR reveals that it has decreased from 2010. The graph has shown that the trend is decreasing in the fig 3. The DT has shown a year wise increase from 0.693 to 3.3.

Language wise distribution of papers:

Table 4: Language wise distribution of paper

Languages	Records	% of 6415
ENGLISH	6373	99.345
CHINESE	11	0.171
FRENCH	7	0.109
GERMAN	7	0.109
RUSSIAN	5	0.078
PORTUGUESE	4	0.062
SPANISH	4	0.062

The table 4 shows that English language has the highest contribution with 6373 records (99.345%).

Top 15 most productive authors:

Table 5: Most productive author

Authors	Records	% of 6415	Average citations per items	h-index
WANG J	68	1.06	25.56	23
ZHANG Y	68	1.06	29.12	19
WANG Y	66	1.029	20.32	19
CHEN Y	65	1.013	24.15	19
LIU Y	59	0.92	40.86	23
CHEN XY	43	0.67	35.88	19
FENG SS	41	0.639	65.73	29
LI J	41	0.639	37.61	18
LI L	41	0.639	24.9	18
LIU Z	41	0.639	54.29	23
LI Y	40	0.624	13.1	13
LIU J	40	0.624	23.95	17
ZHANG L	37	0.577	13.32	12

STORM G	36	0.561	39.58	20
COUVREUR P	35	0.546	28.06	17

Table 5 shows the Top 15 contributed author, their total number of publications, average citations per items and h-index. Thus, we have found that Wang J has contributed highest number of article (68) with 25.56 average citations per item and h-index 23. Couvreur P has contributed the lowest number of article (35) with 28.06 average citations per item and h-index 17. So the table shows that h-index does not depend on number of contributions.

Record wise Journal List with its Citation:

Table 6: Top 15 most productive journals

Journal	Record	Citation	CPP
Journal of Nanoparticle Research	362	4159	11.49
Nanoscale	339	3632	10.71
ACS Nano	246	17173	69.81
International Journal of Nanomedicine	232	4016	17.31
Biomaterial S	207	10262	49.47
IET Nanobiotechnology	190	693	3.65
ACS Applied Materials & Interfaces	162	2664	16.44
Nanomedicine-Nanotechnology Biology And Medicine	149	5191	34.84
Nanomedicine	123	2356	19.15
RSC Advances	105	808	7.70
Colloides & Surfaces B-Biointerfaces	97	1959	20.20
International Journal of Pharmaceutics	97	2309	23.80

Molecular Pharmaceutics	95	2380	25.05
Small	81	1894	23.38
Advanced Materials	76	3436	45.21

Table 6 shows the list of the top 15 most productive journal list with the citation they received and their CPP. It shows that Journal of Nanoparticle Research occupies the first place with 362 articles and 4159 citations and the Advanced Materials occupies the last place with 76 articles and 3436 citations.

Core Journals:

Bradford's Law (1948) stated that if journals of a specific subjects are arranged in decreasing number of publications, then then there will be a core group of journals which have significantly contributed to the growth of the subject and there will be another group of journals which have contributed same number of article but higher in number of journals in comparison to that of the core. Again, a third group having same number of articles that of the core but the number of journals is higher than that of the second group. If we denote the journals in the core as zone 1 and journals in second and third group as zone 2 and zone 3 respectively then the number of journals in zone 1, zone 2 and zone 3 will depict a relationship of 1: n: n^2 where n is the 'Bradford's multiplier'.

Table 7: Bradford's law for core journals

No. Of Journal	No. of Article	Journal Rank	Cum. No. of Article
1	362	1	362
1	339	2	701
1	246	3	947
1	232	4	1179
1	207	5	1386
1	190	6	1576
1	162	7	1738

1	149	8	1887
1	123	9	2010
1	105	10	2115
2	97	12	2309
1	95	13	2404
1	81	14	2485
1	76	15	2561
1	75	16	2636
2	67	18	2770
1	65	19	2835
1	62	20	2897
1	58	21	2955
2	57	23	3069
1	56	24	3125
2	53	26	3231
1	49	27	3280
1	47	28	3327
2	43	30	3413
2	42	32	3497
2	41	34	3579
1	39	35	3618
1	38	36	3656
2	36	38	3728
2	35	40	3798
1	34	41	3832
1	30	42	3862
1	29	43	3891
1	28	44	3919
1	27	45	3946
2	25	47	3996
2	23	49	4042
1	22	50	4064
2	21	52	4106
3	20	55	4166
3	18	58	4220
2	17	60	4254
4	15	64	4314
4	14	68	4370
3	13	71	4441

2	12	73	4465
8	11	81	4553
9	10	90	4643
6	9	96	4697
9	8	105	4769
18	7	123	4896
18	6	141	5003
27	5	168	5138
50	4	218	5338
75	3	293	5563
135	2	428	5833
551	1	979	6384

In the table 7, the journals are arranged in decreasing order of their productivity. The total numbers of 979 journals are found from the study. According to the Bradford's law, the total number of journals can be divided into three zones in such a way that each zone contains almost same number of articles. So, here each zone should contain approximately 2128 articles.

Table 8: Bradford zone

Zone	No. of journals	No. of article	Bradford Multiplier
zone 1	10	2115	
zone 2	49	2122	4.9
zone 3	920	2137	18.77

From the table 8, it is clear that Zone 1 (core journals) contained 10 journals with 2115 articles, Zone 2 contained 49 journals with 2122 articles and zone 3 contained 920 journals with 2137 articles. According to Bradford's law (1948), the ratio should be in $1:n:n^2$. Here, the ratio is 10:49:920::1:4.9:92. So the value in the zone 3 is far away from n^2 ($4.9^2=24$). Therefore, it is proved from the study that Bradford's law doesn't fit to the above data.

Top 8 leading countries in Nanomedicine

Table 9: Leading countries

Country	Record
China	1736
USA	1683
India	495
Italy	441
Germany	359
France	357
England	285
Spain	277

In table 9, top 8 productive countries are arranged according to their total number of publications. China has contributed highest number (1736) of publications, whereas Spain has the least number (277) within the window period of 10 years.

World share of Publications, citations, RCI and ACI:

If RCI=1, citation rate of a country is equal to world citation rate

If RCI<1, citation rate of a country is less than world citation rate

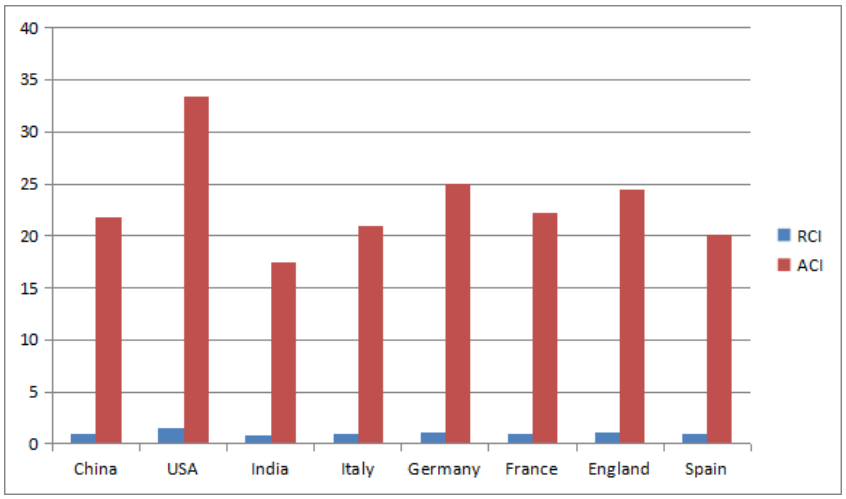
If RCI>1, citation rate of a country is higher than world citation rate. It shows that the country has high impact on research.

Table 10: World share publications, citations, RCI, ACI and h-index

Country	Records	World Share publication	Total citation	World share citation	RCI	ACI	h-index
China	1736	27.06	37721	26.46	0.98	21.73	84
USA	1683	26.23	56221	39.44	1.5	33.4	107
India	495	7.71	8675	6.08	0.79	17.52	47
Italy	441	6.87	9212	6.46	0.94	20.89	47
Germany	359	5.59	8965	6.29	1.12	24.97	51
France	357	5.55	7917	5.55	1	22.18	46

England	285	4.44	6851	4.78	1.08	24.38	42
Spain	277	4.31	5581	3.91	0.91	20.14	38

Fig 4.4 ACI and RCI of top 8 country



From the table 10, it is clear that china has the highest world share publications. Out of 6415 publications, China has contributed 1736 publications with 27.06 % world share publication. USA has the highest RCI (1.5) and ACI (33.4). Among the countries, USA, Germany, France and England have RCI greater than 1. That means these 4 countries share of citation rate is higher than the world citation rate.

Degree of collaboration:

Table 11: Authorship pattern

Authorship	No. of Articles
Total article	6415
Single authored article	127
Multiple authored article	6288

Fig 5 Authorship pattern

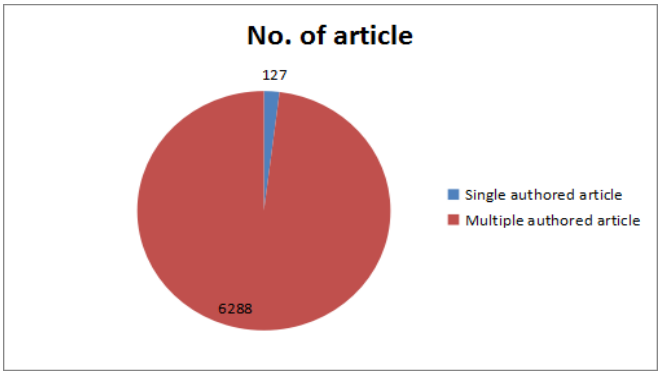


Table 11 shows that the number of single authored article is very less in comparison to the number of multiple authored article.

For degree of collaboration, the formula given by Subramanyam (Subramanyam, 1983) is used.

The degree of collaboration,

DC = Nm / (Nm+Ns)

Where,

Nm = number of multi authored papers

Ns = number of single authored papers

DC = 6288/6415

= 0.98

The value of DC is 0.98, which brings out that there exists a very high level of collaboration among the author.

Conclusion: The analysis shows increase in the number of publications in the field of nanomedicine. In addition, China, USA and India are the leading nations. The Bradford's law of scattering is studied to find out the core journals but failed to prove the law. The study shows that the degree of collaboration among the authors is very high (DC=0.98). This bibliometric study may help the researchers as well as librarians in finding the core research materials on nanomedicine.

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