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Measuring Growth and Impact of Neuroscience Researches in India: A Scientometric analysis based on Scopus

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Abstract

Present study focuses on growth of neuroscience research in India and its impact on scholarly world. Total 4812 data were collected from Scopus database for the period of 2004-2018. Analysis of the data revealed considerable increase in Annual Growth Rate in neuroscience research with 10.52% CAGR for the entire period. Relative Growth Rate (RGR) was increasing with minor fluctuations i.e. growth in Neuroscience research is not exponential ratio rather than it is arithmetic ratio and Doubling Time is similar to RGR. Trend (Least Square) of the neuroscience publications showed an increase trend during the study period. But the prediction of the trend up to the year 2023 has indicated the downward trend in the growth. Articles were the major form of publication followed by letters. Collaborative Index (CI) ranges from 4.22 to 5.02 with an average of 4.75 per joint authored papers. Degree of collaboration for total publications of the neuroscience was 0.93 i.e. team research, which is confirmed by the value of Collaboration coefficient. Mega-authored papers received highest 24657 (49.88%) citations, whereas single authored papers received lowest 861(1.74%) citations. Author Shukla, D. is the most productive author contributing 42 articles.1934 (40.19%) of total publications did not have any institutional collaboration, 1063 (22.09%) publications were co-authored with other institutes/universities/colleges of India, 764 (15.88%) were collaborated within their own organization/institute/university/college in which they are affiliated and 1051 (21.84%) publications were collaborated with foreign authors.

Keywords: Relative Growth Rate (RGR), Doubling time, Collaborative Index (CI), Degree of Collaboration, Relative Citation Index (RCI) and Least Square method.

Introduction

India has the long tradition of curing diseased people with various herbs. Atharva Veda was written in 1000 BC by Northern Indian Doctors dealt, with the various diseases and their cure. Indus valley civilization also has evidence for treating tooth cavity by drilling in, around 5000BC. Famous Ayurveda doctor Sushruta lived in 500BC and in his Sushruta Samhita, he dealt about the treatment of broken bone, blockage in the intestine or cataract operation of the eyes, Tuberculosis etc. Later in 200AD, Charaka recognized that prevention is better than cure. This can be achieved by keeping three Humors of the body (bile, phlegm and air) in right balance. Another important school of medicine Bagbhatta's Ashtanga Hridya, deals with various diseases along with neurological diseases, to be the result of vat dosa (humor) in human beings

and their cure with various herbs and spices.[1] In modern India, the first account of a neurosurgical procedure was reported from Madras, which is a trans-sphenoidal hypophysectomy, in 1935, which was performed by Lt. Col. Frederick Jasper Anderson of Madras. India offered graduate training in Neurology starting in the last quarter of the 20th century.[2] Neurological Society of India was found in 1951 by Dr. Jacob Chandy, Dr. B. Ramamurthi, Dr. S. T. Narasimhan and Dr. Baldev Singh. Dr. B Rammurthi, a neurosurgeon and co-founder of NSI, is credited with the establishment of Department of Neurosurgery in Madras. [3]

Sientometrics is the field of study concerned with the statistical analysis of the scientific publications with the help of some indicators to show the collaboration, growth pattern of literature, Co-citation and trend analysis on a given discipline or topic of a discipline. Number of scientometric studies has been carried out by different authors all across the world. In Neuroscience on the basis of BIOSIS database from 1983-1986 based on Spanish literature, scientometric study was carried to find out the issues related with funding policies, most productive institutions and their international visibility. These are the criteria, on the basis of which the institutions are funded in the field of neuroscience. [4] peer reviewed papers published in 161 neurological journals by European authors were screened by ISI in the period 1995–1998, to report the amount and quality of neurological research in the different countries of the European Union (EU), the USA and the world, on the basis of number of papers, the impact factors (IF), the population of the source country and gross domestic product (GDP).[5]A bibliometric analysis on Retrograde Amnesia was carried out on the basis of Co-citation mapping and peer review. [6]A bibliometric study of the Chinese Neuroscience literature based on MEDLINE was carried out from 1984 through 2001 with an emphasis on growth pattern. [7]Indian neuroscience research was mapped on the basis of SCOPUS citation Database from 1999 to 2008. The basis of study was citations received by the articles in the field on three year basis, to assess the impact of Indian research output, leading institutions, and authors in the field. India got 21st rank among 26 top productive countries and publication share was 0.99% during the tenure.[8] Another study was carried out to evaluate the global scientific output of acupuncture research in the Science Citation Index-Expanded and toassess the tendencies and research performances of leading countries/territories and institutes from 1991-2009. Articles referring to acupuncture were assessed by distribution of document types, languages, journals, subject categories, source countries, and source institutes. Journal of Alternative and Complementary Medicine published the most articles, followed by American Journal of Chinese Medicine and Acupuncture & Electro-Therapeutics Research which were listed in category of integrative & complementary medicine.[9] Neuroscience article which was based on mapping of NSCI and PUBMED from 1992-2005, measuring Impact Factor, Citation pattern, published literature type, collaboration pattern and author contribution was published in Current Science in 2013. Papers after 4-5 years of publication and with international collaboration get a good citation.[10] Neuroscience research landscape has been evaluated from 2006-2015, on the basis of Web of Science and Journal Citation Report. Frequently used terms and citation rate was analyzed, Bradford's Scattering Law revealed that area in neuroscience research is increasing.

China emerged as the leading country in Neuroscience research. [11] The present study is based on Scopus database from 2004-2018, to find out Literature Growth rate, Collaboration trend and Author Productivity. An attempt has been made to find out Trends in the research in Neuroscience in India.

OBJECTIVE OF THE STUDY

The following objectives have been framed for the study:

- To depict the growth of scholarly publications in neuroscience during the period of the study.
- To examine the authorship pattern, authors productivity and their impact on scholarly world as well as nature of collaborative research.
- To analyze the institutionalcollaborative publications andscattering of collaboration with other continents and countries
- To find out the most preferred publications.

SOURCE DATABASE & METHODOLOGY

Citation data related to Indian neuroscience research from 2004 to 2018 were retrieved from the Scopus database on 20th November 2018. In advance search, subject code for Neuroscience was used to find out the literature. Total 664000 neuroscience literature from abroad were shown in the display for the time span of 1858 - 20th Nov. 2018. Then data was restricted for India in Country/Territory option for the time span of 2004-2018. After that total 4812 bibliographic records on neuroscience literature published from India were retrieved from the Scopus database and subjected to further analysis. Retrieved data was analyzed for Collaborative Index (CI), Collaborative Coefficient (CC) and Relative Citation Index.

ANALYSIS AND INTERPRETATIONS

Year-Wise Growth Trend of Neuroscience Publication

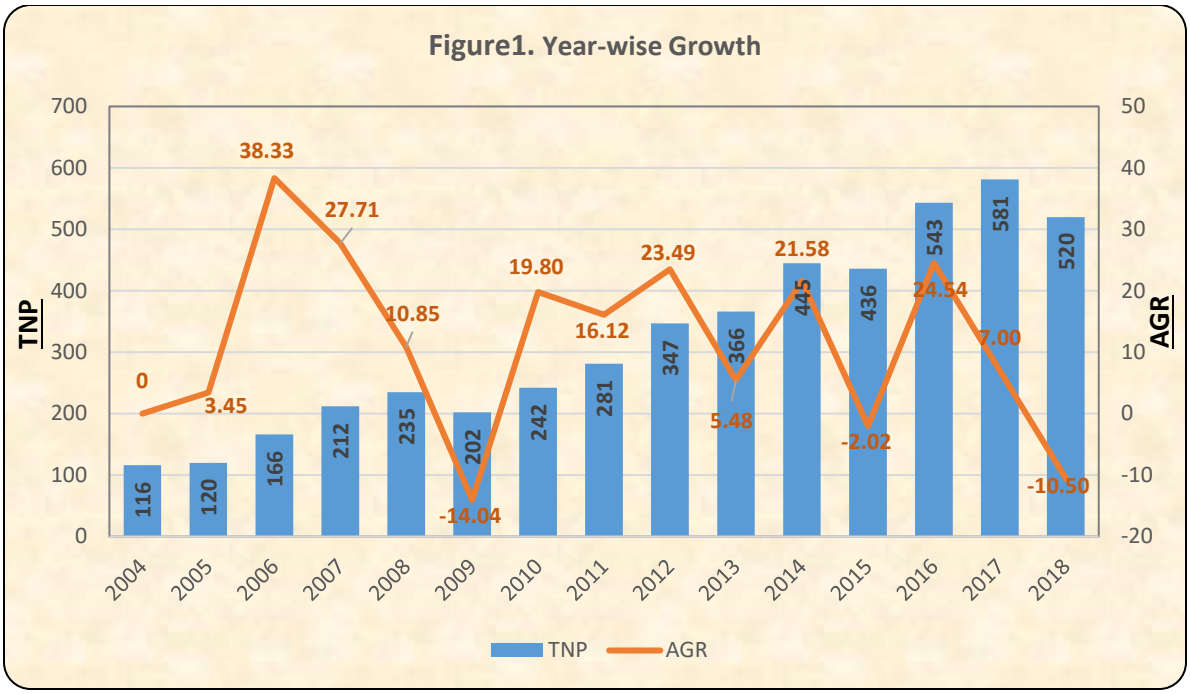
Annual Growth rate (AGR) & CAGR of Neuroscience PublicationsTable-2 and Fig.-2 reveals that during the period of 2004–2018, a total of 4812 publications were published on neuroscience research from India. The highest number of publications was 581(12.27%) published in 2017. The lowest publications 116(2.41%) were published in 2004. The average number of publications published per year was 320.8. But it is seen that first seven years in which the less than average papers (320.8) were published i.e. 2004-2010. The more productive years with more than average papers were in 2011-2018. It has also been seen that 1166 papers published in the year 2004 in the neuroscience field, which increased gradually. In the early stage the quantity of scientific publications were less but increased gradually even though there are ups and drop downs in a few years.

Table -1. AGR of Neuroscience publications 2004-2018					
Year	**TNP**	**TNP%**	**Cumulative**	**Cumulative%**	**AGR**
2004	116	2.41	116	2.41	--
2005	120	2.49	236	4.90	3.45
2006	166	3.45	402	8.35	38.33
2007	212	4.41	614	12.76	27.71
2008	235	4.88	849	17.64	10.85
2009	202	4.20	1051	21.84	-14.04
2010	242	5.03	1293	26.87	19.80
2011	281	5.84	1574	32.71	16.12
2012	347	7.21	1921	39.92	23.49
2013	366	7.61	2287	47.53	5.48
2014	445	9.25	2732	56.77	21.58
2015	436	9.06	3168	65.84	-2.02
2016	543	11.28	3711	77.12	24.54
2017	581	12.07	4292	89.19	7.00
2018	520	10.81	4812	100.00	-10.50
Total	**4812**	**100.00**	**--**	**--**	**10.52%***

Table-1provides the AGR of the number of documents for period 2004–2018 at the global level as well as continental also.

$$AGR = \frac{end\ value\ - first\ value}{first\ value} x100$$

Figure-1 presentsthe total distribution and average growth pattern of neuroscience publications. Fluctuation was seen throughout the study period. The compound annual growth rate (CAGR) (calculated using the formula available at www.investopedia.com/calculator/cagr.aspx) was found to be 10.52% during the period 2004–2018. The AGR for publications has been increasing trend during the study period. But the AGR decreased -14.04 in 2009 and it again decreased in 2015 and 2018. It has been seen that, there is major fluctuation during the whole study period as illustrated in figure-1. The reason for the fluctuation is that there was no constant growth of publication.



Relative Growth Rate and Doubling Time

The relative growth rate (RGR) is the increase in number of articles or pages per unit of time. The mean relative growth rate (R) over the specific period of interval can be calculated from the following equation:

Relative Growth Rate (RGR): $(1\text{-}2^{R} = \log_e W_2 - \log_e W_1/T_2\text{-}T_1)$

Where 1-2R: mean relative growth rate over the specific period of interval; loge W1: log of initial number of publications; logeW2: log of final number of articles after a specific period of interval; T_2-T_1: the unit difference between the initial time and the final time.

It is clear from Table and Fig.,that relative growth rate (RGR) hasdecreased continuously with minor fluctuations. This is also confirmed that the growth of the literature is not in exponential ratio rather it is in arithmetic ratio, and explosion of the neuroscience literature has not taken place during the period of study.

Table2. Relative growth rate (RGR) and doubling time (DT) of neuroscience publications

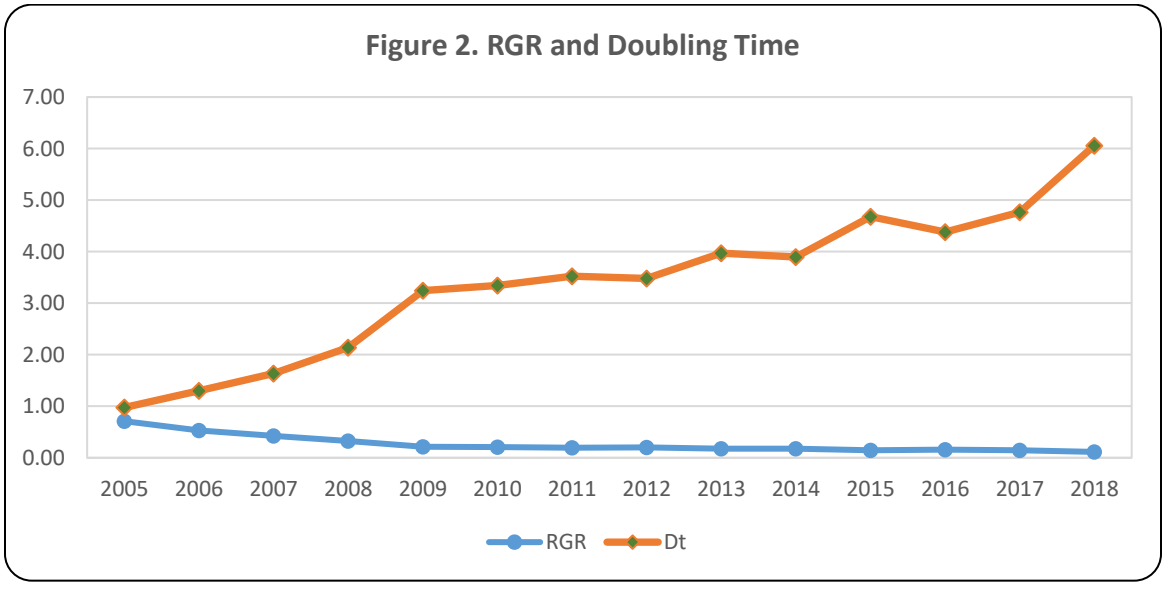
Year	Publications	Cumulative	W1	W2	RGR	DT
2004	116	116	0	4.75	-	
2005	120	236	4.75	5.46	0.71	0.98
2006	166	402	5.46	6.00	0.53	1.30
2007	212	614	6.00	6.42	0.42	1.64
2008	235	849	6.42	6.74	0.32	2.14

2009	202	1051	6.74	6.96	0.21	3.25
2010	242	1293	6.96	7.16	0.21	3.34
2011	281	1574	7.16	7.36	0.20	3.52
2012	347	1921	7.36	7.56	0.20	3.48
2013	366	2287	7.56	7.73	0.17	3.97
2014	445	2732	7.73	7.91	0.18	3.90
2015	436	3168	7.91	8.06	0.15	4.68
2016	543	3711	8.06	8.22	0.16	4.38
2017	581	4292	8.22	8.36	0.15	4.76
2018	520	4812	8.36	8.48	0.11	6.06

There exists a direct equivalence between the relative growth rate and the doubling time. Ifthe number of articles or pages of a subject doubles during a given period then thedifference between the logarithms of numbers at the beginning and end of this period mustbe logarithm of the number 2. If natural logarithm is used this difference has a value of0.693. Thus the corresponding doubling time for each specific period of interval and forboth articles and pages can be calculated by the formula-

Doubling time DT = 0.693/R

Therefore, doubling time for articles DT (a) = $0.693/1\text{-}2^{R}$ ($aa^{-1}year^{-1}$)
The Doubling Time (DT) has increased when calculated year wise. The Doubling Time increases from 0.89 in 2000 to 4.40 in 2011. In 2012, it slight decreased into 4.22 and again increased into 4.57 in 2013 (Fig. 6). Though the doubling time is increasing but it is not showing the exponential growth rate as seen in the Annual Growth Rate analysis presented above.



Trend Analysis (Least Square Method)

Trend analysis is one of the best tools to analyze the trend values in any field of research. It provides a convenient basis for obtaining the line of best fit in a series. Line of the best fit is a line from which the sum of the deviations of various points on its either side is zero. Further the sum of the squares of these deviations would be the least as compared to the sum of squares of the deviations obtained by using other lines.

The equation of straight line trend is: Y = a+bX, Where, Y = indicates that the estimated values of the trend and X = represents the deviations in time period and 'a' and 'b' are constants.

The values of two constants 'a' and 'b' are estimated by solving the following two normal equations.

$$\sum Y = Na + b\sum X$$

$$\sum XY = a\sum X + b\sum X^2$$

Where N represents number of years for which data is given. The variable X can be measured from any point of time as origin. To make calculation simpler, it is better to take the mid-point of time as the origin because the negative values of first half of the time series will equalize the positive values in the second half of the series which symbolically gives $\sum X = 0$.

When $\sum X = 0$, the two normal equations for finding the constants 'a' and 'b' will be

$$\sum Y = Na \propto a = \frac{\sum Y}{N} = Y$$

$$\sum XY = b\sum X^2 \propto b = \frac{\sum XY}{\sum X2}$$

This provides that the constant 'a' is simply equal to the mean of Y values and the constant 'b' gives the rate of change. The constant 'a' refers to the Y intercept, i.e. the difference between the point of origin and the point where the trend line touches the Y axis. The constant 'b' refers to the slope of the line which indicates the change in Y for each unit change in X.

The equation of the straight line trend is Y = a + bX since $\sum X = 0$, therefore

$$a = \sum Y/N = 4812/15 = 320.8$$

$$b = \frac{\sum XY}{\sum X2} = 9438/790 = 11.94$$

Thus substituting the value of 'a' and 'b' in the straight line of the trend, we get,

$$Y = a+bX,\ Y= 320.8+ (11.94)xX$$

Estimate of 2023 will be calculated on the basis of X=12

$$Y^{2023}= 320.8+ (11.94) \times 12$$

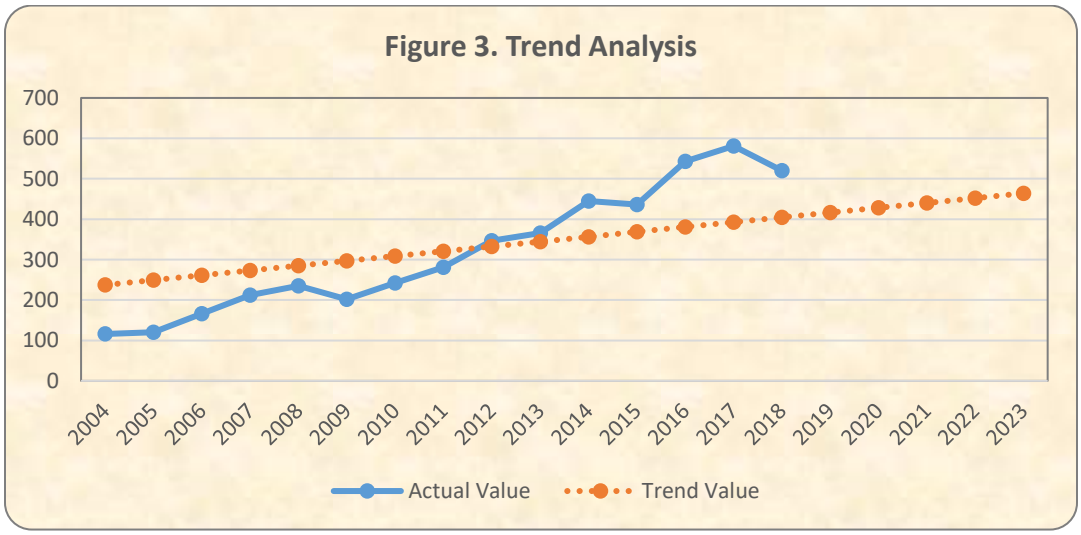
$$Y^{2023}= 464.2$$

Table 3. Computation of straight line trend by the least squares method

Year	No. of Pub. Actual (Y)	X	XY	X^2	No. of Pub. Trend Value (Yt.)
2004	116	-7	-812	49	237.15
2005	120	-6	-720	36	249.1
2006	166	-5	-830	25	261.05
2007	212	-4	-848	16	273
2008	235	-3	-705	9	284.95
2009	202	-2	-404	4	296.9

2010	242	-1	-242	1	308.85
2011	281	0	0	0	320.8
2012	347	1	347	1	332.75
2013	366	2	732	4	344.7
2014	445	3	1335	9	356.65
2015	436	4	1744	16	368.6
2016	543	5	2715	25	380.55
2017	581	6	3486	36	392.5
2018	520	7	3640	49	404.45
2019		8		64	416.4
2020		9		81	428.35
2021		10		100	440.3
2022		11		121	452.25
2023		12		144	464.2
Total	**4812**		**9438**	**790**	**7013.5**

Table-3 and Fig.-3 show that the Trend of the neuroscience publications, calculated year wise,isincreasing during the study period. But the prediction of the trend made up to the year 2023 indicates the downward trend in the growth of neuroscience publications. This has been illustrated with the trend line and actual line presented in the Fig.-3.



Form of Publications

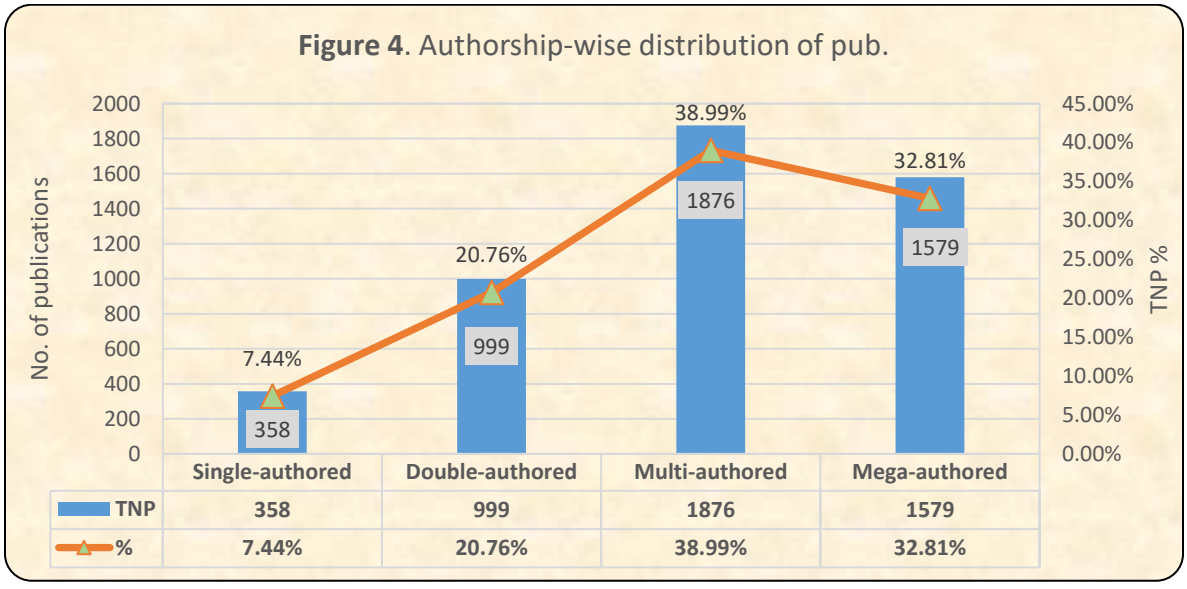
Table-4 reveals that the major publications covered by Scopus database on neuroscience research in India, is Journal articles with 3420 (71.07%) publications followed by letter with 419 (8.71%) publications. Review ranks the third position with 374 (7.77%), book chapter in the fourth place with 266 (5.53%), Note with 130 (2.70%), editorial and conference paper stood in the last category respectively. The results indicate that the research output in the subject (Neuroscience) during the period of study are mostly published in the form of journal articles.

Table 4. Form of Publications

S. No.	Document Type	TNP	TNP%
1	Article	3420	71.07
2	Letter	419	8.71
3	Review	374	7.77
4	Book Chapter	266	5.53
5	Note	130	2.70
6	Editorial	70	1.45
7	Conference Paper	57	1.18
8	Article in Press	38	0.79
9	Short Survey	18	0.37
10	Book	12	0.25
11	Erratum	7	0.15
12	Retracted	1	0.02
	Total	**4812**	**100.00**

Author-wise growth of neuroscience publications

To gauge more effective authorship trend the whole publications were divided into the four categories (single, double, multi and mega-authored). Figure 5.5.3 presents that out of 4812 neuroscience publications, 358(7.44%) were single authored papers, 999(20.76%) two authored papers, 1876(38.99%) multi-authored papers and 1579(32.81%) mega-authored papers. The authorship pattern clearly shows that 71.80% publications were contributed by multi and mega-authors while 28.20% of total publications were published by single and double-authors.



Measures of Authorship pattern

The Collaborative Index (CI), Degree of Collaboration (DC) of publications, and Collaboration Co-efficient parameters were used to measure authorship pattern. For Collaborative Index analysis, as given by Lawani[12] in 1980, following formula has been used,

$$CI = \frac{\sum_{j=1}^{A} jf_j}{N}$$

Where, fj is the number of J authored papers published in a discipline during a certain period N is the total number of research papers published in a discipline during a certain period of time. We have omitted the single authored publication which is equal to 1 always. To determine the number of authors per joint authored paper, the following formula has been used.

$$\textbf{Collaborative Index} = \frac{\textbf{Total Authors}}{\textbf{Total Joint Papers}}$$

It was seen from the table-4, Collaborative Index (CI) ranges from4.22to 5.02with an average of 4.75 per joint authored papers which implied that research team falls between 3 and 5 authors in neuroscience research in India.

To determine the Degree of Collaboration (DC) of publications, the numbers of single authored and multi-authored publications are calculated using the formula:[13]

$$DC = \frac{Nm}{Ns + Nm}$$

Whereas,

DC= Degree of Collaboration of scientists, Nm = Number of multiple authored Papers and Ns = Number of single-authored papers

DC gives 0 weight to single-authored paper and 1 for maximal.

$$\textbf{DC} = \frac{4454}{4454+358} = \textbf{0.93}$$

As per Subramanyam DC of a discipline, must be between 0 and 1, hence the degree of collaboration of total publications of the neuroscience is 0.93. The value of DC brings out clearly the prevalence of team research in neuroscience field. Out of the total publications, 92.56 % publications were collaborated by multi authors and 7.44 % of total contributions by single authors.

To measure the collaborative research pattern a simple indicator called Collaboration Co-efficient given by Ajiferuke [14] and further used by Karki and Garg [15] to measure the extent and strength of collaboration among the researchers in India in the Bibliometric discipline. It can be expressed mathematically as:

$$CC = 1 - \frac{\sum_{j=1}^{k} \left(\frac{1}{j}\right) f_j}{N}$$

Where, fj is the number of J authored papers published in a discipline during a certain period of time N is the total number of research papers published in a discipline during a certain period of time and k is the greatest number of authors per paper in a discipline. According to Ajiferuke, CC tends to zero as single authored papers dominate and to 1-1/j as j-authored papers dominate. This implies that higher the value of CC, higher the probability of multi or mega authored papers.Table-5 shows the average value of CC was 0.63 for the study period. The Collaborative Coefficient (CC) ranges more than average value during the study period except years 2004, 2005, 2006, 2007, 2011, 2013, 2014 and 2016. This implies that during these years, research is less focused on either multi or mega-authored papers. While in rest of the years focus was more on two, three or more than three authored papers i.e. mixed collaborative coefficient.

Table 5.Measures of authorship pattern

Year	Single-authored	Double-authored	Multi-authored	Mega-authored	TNP	TNA	CI	DC	CC
2004	11	32	47	26	116	443	4.22	0.91	0.59
2005	15	24	47	34	120	438	4.17	0.88	0.59
2006	12	45	58	51	166	654	4.25	0.93	0.61
2007	20	54	78	60	212	796	4.15	0.91	0.60
2008	10	67	80	78	235	936	4.16	0.96	0.64
2009	10	43	83	66	202	837	4.36	0.95	0.64
2010	9	56	99	78	242	976	4.19	0.96	0.65
2011	23	66	110	82	281	1072	4.16	0.92	0.61
2012	25	60	141	121	347	1488	4.62	0.93	0.64
2013	33	62	165	106	366	1457	4.38	0.91	0.62
2014	50	91	167	137	445	1816	4.60	0.89	0.60
2015	25	82	176	153	436	1988	4.84	0.94	0.64
2016	42	125	190	186	543	3133	6.25	0.92	0.62
2017	48	94	225	214	581	2625	4.92	0.92	0.63
2018	25	98	210	187	520	2484	5.02	0.95	0.65
Total	**358**	**999**	**1876**	**1579**	**4812**	**21143**	**4.75**	**0.93**	**0.63**

Note: * average value, TNP=total no. of pub., TNA=total no. of authors

Citation impact of authorship pattern

Table -6 reveals that among the four types of authorship patterns, mega-authored papers received highest 24657 (49.88%) citations, whereas single authored papers received lowest 861(1.74%) citations. In terms of citedness, total citedness was 71.40% during study period. Mega, multi and double-authored papers have more than 50% citedness while single-authored have less than 50%.

Relative Citation Impact [16]can be defined as the average citations of a country's papers in the field divided by the world average in the corresponding field during the same period. Table-6 indicates that RCI value of mega-authored papers was more than total average value, double and multi-authored papers' RCI value was near to average value while single authored papers had less RCI value. The result indicates that collaborative authored works were in high quality.

Table 6. Volume of Publication and Citation measures

Authorship Type	TNP	TNP%	TPC	Citation	Citation %	Citedness%	CPP	RCI
Single-authored	358	7.44	154	861	1.74	43.02	2.41	0.23
Double-authored	999	20.76	697	8179	16.55	69.77	8.19	0.80
Multi-authored	1876	38.99	1340	15732	31.83	71.43	8.39	0.82
Mega-authored	1579	32.81	1245	24657	49.88	78.85	15.62	1.52
TOTAL	4812	100.00	3436	49429	100.00	71.40	10.27	1.00

TPC= total publication cited, CPP= citation per paper and RCI= relative citation index

IDENTIFICATION OF MOST PROLIFIC AUTHOR

Table-7 presents the rank list of authors who have contributed 25 or more than 25 articles are taken into account. The list contains top10 authors with more than 25 articles each. It reveals that Shukla, D. is the most productive author contributing 42 articles followed by Anand A. with 41 articles and Prabhakar H. with 36 articles respectively.

In the area of author wise RCI, out of the top ten authors listed below only five authors had higher than average RCI. Among these authors, highest RCI were for Misra U.K. (1.437) of SPGI Lucknow, Manivasagam A. (1.396) of Annamalai University Tamilnadu, Kalita J. (1.395) of SGPGI Lucknow and so on…

Table 7. Most prolific authors

S.N.	Authors	Affiliation	TNP	Citation	RCI
1.	Shukla, D.	Department of Neurosurgery, National Institute of Mental Health and Neurosciences, Bengaluru, Karnataka	42	135	0.313
2.	Anand, A.	Neuroscience Research Lab, Department of Neurology, PGI Medical Education and Research, Chandigarh	41	190	0.451
3.	Prabhakar, H.	Department of Neuroanaesthesiology, AllMS, New Delhi	36	3	0.008
4.	Mahapatra, A.K.	Department of Neurosurgery, AllMS, New Delhi	35	170	0.473
5.	Satyarthee, G.D.	Department of Neurosurgery, Neurosciences Centre, AIIMS, New Delhi, India	35	42	0.117
6.	Kalita, J.	Department of Neurology, SGPGI Lucknow, Uttar Pradesh	34	487	1.395
7.	Misra, U.K.	Department of Neurology, SGPGI Lucknow, Uttar Pradesh	33	487	1.437

8.	Mahadevan, A.	Department of Neuropathology, National Institute of Mental Health and Neurosciences, Bangalore ,Karnataka	26	279	1.045
9.	Mallick, B.N.	School of Life Sciences, Jawaharlal Nehru University, New Delhi	25	280	1.091
10.	Manivasagam, T.	Department of Biochemistry and Biotechnology, Annamalai University, Annamalainagar, Tamil Nadu	25	344	1.396

COLLABORATION WITH NATIONAL AND INTERNATIONAL INSTITUTES

Table-8 presents Volume of Publication and Citation measures, it reveals that 1934 (40.19%) of total publications did not have any institutional collaboration,1063 (22.09%) publications were co-authored with other institutes/universities/colleges of India, 764 (15.88%) werecollaborated within their own organization/institute/university/college in which they are affiliated and 1051 (21.84%) publications were collaborated with other foreign institutions.

Table-8 Volume of Publication and Citation measures

Collaboration type	TNP	Percentage	TPC	Citedness	Citation	Citation%	CPP	RCI
Intra-institute	764	15.88	538	70.42	4366	8.83	5.71	0.56
Inter-institute	1063	22.09	758	71.31	8054	16.29	7.58	0.74
International	1051	21.84	862	82.02	22502	45.52	21.41	2.08
Without collaboration	1934	40.19	1278	66.08	14507	29.35	7.50	0.73
Total	**4812**	**100.00**	**3436**	**71.40**	**49429**	**100.00**	**10.27**	**1.00**

TPC= total publication cited, CPP= citation per paper and RCI= relative citation index

Top 10 Most Productive Journals

Table-9 represents top ten journals in which Indian Neuroscience literature were published. Journal of Neurosciences in Rural Practice tops the list with 813 (1690%) of total neuroscience literature published followed by Journal of Pediatric Neurosciences with 712 (14.98%), Annals of Neurosciences with 197 (4.09%) publications.

Table 9. Prolific Journals in Neuroscience

SOURCE TITLE	TNP	%	TPC	TNC	CPP	RCI
Journal of Neurosciences in Rural Practice	813	16.90	482	808	0.99	0.10
Journal of Pediatric Neurosciences	721	14.98	449	1679	2.33	0.23
Annals of Neurosciences	197	4.09	122	505	2.56	0.25
International Journal of Integrative Biology	171	3.55	137	1200	7.02	0.68

Neuroscience Letters	159	3.30	141	2158	13.57	1.32
Brain Research	123	2.56	118	3382	27.50	2.68
Neuroscience	123	2.56	115	3011	24.48	2.38
CNS And Neurological Disorders Drug Targets	102	2.12	91	1065	10.44	1.02
Peerj	84	1.75	55	421	5.01	0.49
Journal Of Neuroscience	78	1.62	73	3240	41.54	4.04

Table-10 shows the result of various continents collaborating with India in neuroscience domain. It is observed that total 1051 (21.84%) of total 4812 publications collaborated with other countries in which some papers were collaborated by more than one countries in that case each countries given full credit for that. Highest 695(14.44%) of Indian publications have collaborated with North American continents followed by 651(13.53%) with Europe, 423(8.79%) with Asia, 83(1.72%) and so on…. USA was the highest collaborative country, followed by United Kingdom and Australia.

Table 10. Continent-wise collaboration of neuroscience publications											
Europe		**Asia**		**Africa**		**North America**		**S. America**		**Australia**	
Country	**Pub.**	**Country**	**Pub.**	**Country**	**Pub.**	**Country**	**Pub.**	**Country**	**Pub.**	**Country**	**Pub.**
United Kingdom	140	Saudi Arabia	66	South Africa	16	United States	578	Brazil	20	Australia	74
Germany	87	Japan	59	Egypt	8	Canada	84	Colombia	15	New Zealand	6
Italy	55	China	43	Nigeria	6	Mexico	15	Argentina	10	Fiji	1
France	54	Malaysia	35	Ethiopia	4	Panama	9	Chile	10	Papua New Guinea	1
Sweden	39	South Korea	31	Kenya	3	Puerto Rico	2	Venezuela	5	Samoa	1
Switzerland	36	Singapore	26	Uganda	3	Barbados	1	Ecuador	4		
Spain	34	Oman	23	Algeria	2	Belize	1	Peru	3		
Netherlands	27	Taiwan	18	Morocco	2	Cuba	1	Paraguay	1		
Belgium	21	Israel	14	Benin	1	Greenland	1	Suriname	1		
Ireland	19	Russian Federation	14	Cameroon	1	Grenada	1	Uruguay	1		
Portugal	15	Turkey	11	Cote d'Ivoire	1	Jamaica	1				
Denmark	14	United Arab Emirates	10	Gambia	1	Nicaragua	1				
Poland	14	Bangladesh	8	Ghana	1						
Finland	13	Nepal	8	Libyan Arab Jamahiriya	1						
Hungary	11	Pakistan	8	Malawi	1						
Norway	11	Thailand	7	Mauritius	1						
Czech Republic	10	Philippines	5	Mozambique	1						
Romania	10	Sri Lanka	5	Namibia	1						
Austria	7	Viet Nam	5	Seychelles	1						
Greece	7	Hong Kong	4	Sudan	1						

Serbia	3	Iran	4	Tanzania	1						
Slovakia	3	Kuwait	4	Tunisia	1						
Slovenia	3	Indonesia	2								
Croatia	2	Iraq	2								
Estonia	2	Jordan	2								
Georgia	2	Lebanon	2								
Latvia	2	Myanmar	2								
Bosnia and Herzegovina	1	Armenia	1								
Bulgaria	1	Cambodia	1								
Cyprus	1	Macao	1								
Iceland	1	Palestine	1								
Lithuania	1	Qatar	1								
Luxembourg	1										
Macedonia	1										
Malta	1										
Tonga	1										
Ukraine	1										
Total 651(13.57)		**423(8.79%)**		**58(1.21%)**		**695(14.44%)**		**70(1.45%)**		**83(1.72%)**	

Conclusion

Indian Neuroscience though of modest origin in 20th Century has seen considerable increase in the Annual publication growth from 2004-2018. Cumulative Annual Growth rate is found to be 10.52% for the entire period. Relative growth rate for the publications (RGR) has been decreasing continuously, also the growth of the literature is in arithmetic ratio and the explosion of the neuroscience literature has not taken place during the period of study. Doubling time has found to be 4.58 points. Trend value of the neuroscience publications shows increasing trend during the study period. But the prediction of the trend made up to the year 2023 has indicated the downward trend in the growth of neuroscience publications. Articles are the major form of publication (70.71%) followed by letters. Collaborative Index (CI) ranges from 4.22 to 5.02 with an average of 4.75 per joint authored papers which indicates collaborative research and research team comprises of 3 to 5 authors. Degree of collaboration for total publications of the neuroscience was 0.93. The value of DC brings out clearly the prevalence of team research in neuroscience field which is evident, out of total publications, 92.56 % were collaborated with multi authorship and 7.44 % by single authors. In the field of authorship patterns, mega-authored papers received highest 24657 (49.88%) citations, whereas single authored papers received lowest 861(1.74%) citations. In author ranking area, Shukla, D. is the most productive author contributing 42 articles. 1934 (40.19%) of total publications did not have any institutional collaboration, 1063 (22.09%) publications were co-authored with other institutes/universities/colleges of India, 764 (15.88%) were collaborated within their own organization/institute/university/college in which they are affiliated and 1051 (21.84%) publications were collaborated with foreign authors. In a nutshell, Indian neuroscience research trend shows collaborative research with multi-authors prevalence, which is proved by citation study.

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