

Publication Status of National Institute for Research in Tuberculosis (NIRT), Chennai during 2009 - 2018: An Analytical Study

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Abstract

The present study aims to analyze the publication pattern of National Institute for Research in Tuberculosis (NIRT) from 2009 to 2018. Five hundred ninety-one documents were published during the study period. Most of them are articles (477) and the maximum number of research publications found in the category of 'Immunology' with 225 (38.07%). PLOS One is the most preferred journal of NIRT scientists; Lancet has high impact factor (59.102) journal. Co-authorship pattern (583 records) is preferred by NIRT researchers rather than solo authorship (8 papers). H-index of NIRT output during the study period is 47. NIRT documents were cited 14700 times, and an average citation per item is 24.87; the degree of the collaboration was identified is 0.83. Swaminathan S is the most prolific author with 184 documents and the Indian Council of Medical Research (ICMR) is the effective collaborative organization.

Keywords: Tuberculosis, NIRT, Scientometric Study, Citation Analysis, Web of Science, VOS Viewer, Lotka's Law.

1. Introduction

Tuberculosis (TB) is one of the communicable diseases caused by Mycobacterium tuberculosis (MTB) bacteria which spread through the air; it is one of the top ten causes of death in the world. Worldwide, 1.5 million people died from TB during 2018. Chest pain, breathing difficulties, cough, fever, weight loss etc are the symptoms of the TB. Alcohol use disorder and tobacco smoking increase the risk factors of TB as 3.3 and 1.6 respectively. TB mostly affects adults in their most productive years and TB patients need to undergo a long course of treatment involving multiple antibiotics. Globally, TB incidence is falling at about 2% per year. This needs to increase 4 to 5% annual decline to reach the milestones of End TB Strategy on 2020. The fight against tuberculosis continues relentlessly and the last word has not been said so far.

The main goal of any research is to develop new knowledge. Research output is the wealth of any individual, organization and also a nation. The R&D institutes of State, Central and Deemed Universities play a vital role in research activities. Analysis of research output will support the higher educational institutes to understand and plan accordingly. Scientometrics or bibliometrics is one of the techniques to analyze the publication trends of the concerned

organization. The primary objective of this study is to identify the publication pattern of NIRT during 2009 – 2018. NIRT is a premier institution for Tuberculosis research in India. Data were accessed from Web of Science (WOS) and analyzed with different scientometric techniques. There is a notable increase in NIRT publications during the last decade; the authorship pattern, degrees of collaboration, citations, relative growth rate, doubling time, collaboration index, journals impact factor, and etc. will identify the publication trends of NIRT during the study period.

National Institute for Research in Tuberculosis (NIRT)

The National Institute for Research in Tuberculosis¹⁰ [Formerly known as Tuberculosis Research Centre (TRC)], was set up in Madras in 1956 as a five-year project under the joint venture of the Indian Council of Medical Research (ICMR), the Government of Tamil Nadu, the World Health Organization (WHO) and the British Medical Research Council (BMRC). In 1964, TRC declared as a permanent organization under the ICMR and institute celebrated its Golden Jubilee in 2006. The main objective of the Centre was to study the mass domiciliary application of chemotherapy during the treatment of pulmonary TB. NIRT has a Supranational Reference Laboratory and WHO Collaborated with the institute for TB Research, Training. International Centre for Excellence in Research (ICER) was established at NIRT recently with the collaboration of National Institute of Health (NIH).

The Centre is recognized to conduct post-graduate training and to offer Ph.D. degree programmes in bacteriology, biochemistry, immunology and statistics affiliated by the Madras University and Inter-University Board of India and Sri Lanka. It is a training centre for WHO fellows and medical UG and PG courses of the University of Madras and neighbouring states. The Centre functions from three campuses at Chennai, Tiruvallur, Madurai and main campus on Chetput, Chennai.

2. Related Studies

Senthil Kumar, N. et al. (2018) has studied the research output of CSIR-CECRI, Karaikudi, from 2010 to 2015. Six hundred fifty articles were published; maximum publications were noted in 2011 with 131 (20.15%) and minimum noted in 2013 as 81 (12.46%); Researchers interested in publishing their articles in 'RSC advances' journal (6.46%) followed by 'Electrochimica Acta (3.39%) journal. Jayachandran M. is the most prolific author during the study period with 48 records (7.385 % of total output). CSIR-CECRI has more collaboration with South Korea i.e. 36 (5.5%) followed by the USA with 17 (2.62%).

Thanuskodi, S. (2011) revealed the bibliometric study of the Library Herald journal from 2006 to 2010. One hundred thirty-eight articles were published during the study period; single author contributions (52.17%) are more than joint author contributions (47.83%); the maximum numbers of contributions noted from Indian researchers were 89.95% and rest of 10.15% from other countries. Highest number of articles submitted to library herald journal by university researchers were 38 followed by college researchers with 27 (19.56%). This study reveals that library herald is one of the most prestigious journals for LIS professionals to publish their research articles.

Parameshwar and Kolle (2016) analyzed the publications' status of "Annals of Library and Information Studies" (ALIS) journal between 2006 and 2015. 335 records were published; an average paper per annum is 33.5 articles. The highest number of articles contributed by Delhi authors were 88 followed by Karnataka researchers with 44 records; researchers

interested in delivering their articles as a joint-authorship pattern (65.07%). More number of articles published in 2010 as 43 (12.84%) followed by 2011 with 36 (10.75%) documents. Sen B.K. is the most prolific author (23; 6.87%); Country-wise comparison is concerned, Indian researchers published 271 articles in ALIS followed by Nigerians with 19 records. Out of the top ten highly cited articles, eight belong to bibliometric/scientometric study based records by LIS authors.

Yeung, Goto and Leung (2017) studied the research publications of neuroimaging from 2003 to 2014. Twenty-three thousand one hundred fifty-five research papers and 1155 reviews were published; Thompson, Paul M. is the most prolific author (158; 0.65%) among 56,090 researchers, and USA contributed (10,354) 42.59% an neuroimaging research and less contributions noted from Romania (1; <0.01%); Harvard University authors contributed 666 records (15.1%). 'Neuroimage' and 'Human Brain Mapping' are the most preferred research journals.

Rajgoli, Mamdapur, Ghouse and Prabahar (2017) have analyzed the Journal of the Indian Society of Remote Sensing (JISRS) during 1973-2014; 1310 articles published in 140 issues; more number of records published between 2003 and 2014 with 48 (52.14); 3952 authors contributed 1310 articles and citation count is 19044. Author productivity of JISRS according to Lotka's Law for n is 2.48; Dadhwal is the most prolific author with 36 papers and Space Applications Centre (SAC), Ahmedabad contributed more research papers to JISRS journal during the study period.

3. Objectives of the study

- a. To identify the year-wise distribution of NIRT.
- b. To know the document-wise distribution of NIRT papers.
- c. To analyze the highly cited articles of NIRT publications.
- d. To find out the individual author values of TLCS, TGCS, TPCR, TLCSb and TLCSe.
- e. To find out the Research Growth Rate (RGR) and Doubling Time of NIRT during the select period.

4. Methodology

The primary data¹³ were retrieved from the Web of Science (WOS) core collection database, developed by Clarivate Analytics on December 23, 2019. The keywords used to retrieve the data are Organization enhanced and time span as 'National Institute for Research in Tuberculosis' and '2009 to 2018' respectively. Histcite¹⁴ and Microsoft Excel spreadsheet was used for further tabulation. VOS viewer¹⁵ applied for the network charts of authorship pattern and collaborative countries.

5. Data Analysis and Discussion

Year-wise Distribution:

Year-wise distribution of NIRT researchers during 2009 to 2018 has been identified and presented. Five hundred ninety-one records were published in 10 years; more number of papers published in the year 2018 (13.88%) followed by 2016 with 79 (13.37%) articles; fewer records absorbed in the year of 2013 i.e. 42 (7.11%). The average output of NIRT publications per year is 59.1%.

Table 1: Year-wise distribution

Years	No. of Records	Percentage	Cumulative No. of Records	Cumulative Percentage
2009	52	8.80	52	8.80
2010	49	8.29	101	17.09
2011	45	7.61	146	24.70
2012	56	9.48	202	34.18
2013	42	7.11	244	41.29
2014	55	9.31	299	50.59
2015	61	10.32	360	60.91
2016	79	13.37	439	74.28
2017	70	11.84	509	86.12
2018	82	13.88	591	100.00
Total	591	100.00		

Average output per year - 59.1%

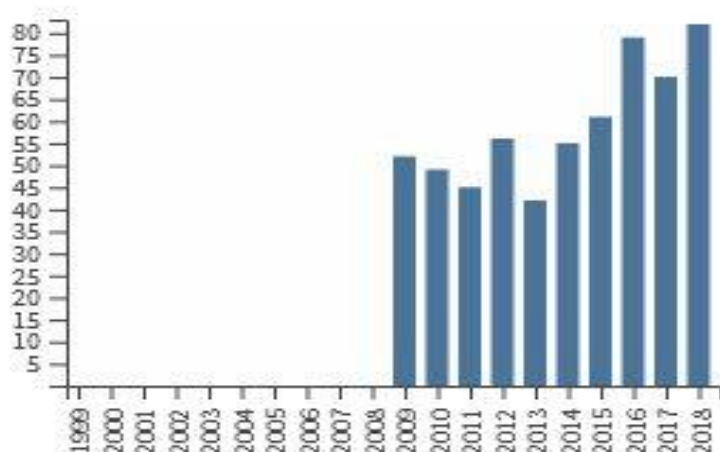


Fig 1: Total publications by year

Annual Growth Rate (AGR)

Annual Growth Rate (AGR) analysis is one of the techniques used to identify the research output of the organization. The below-mentioned formula was used to calculate the AGR of NIRT publications during the study period.

$$\text{Annual Growth Rate (AGR)} = \frac{\text{End Value} - \text{First Value}}{\text{First Value}} \times 100$$

The present research has noted the highest growth which was found in 2018 with 82 records followed by the year 2016 with 79 papers. There were negative growth rate found during 2010, 2011, 2013 and 2017 as -5.76%, -8.16%, -25.00% and -11.39% respectively; due to less number of publications when compared previous period. Average AGR of NIRT publications during study period is 6.26%.

Table 2: Annual Growth Rate (AGR)

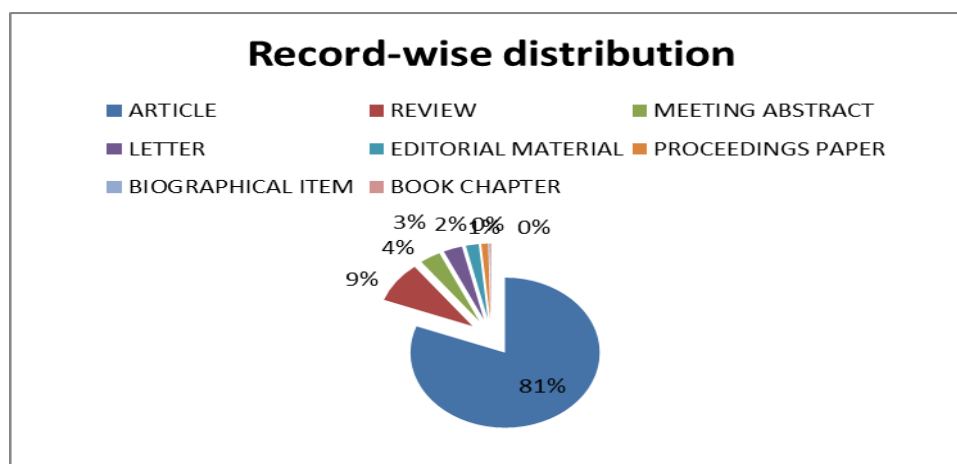
Years	No. of Records	Annual Growth Rate (AGR) Percentage
2009	52	0.00
2010	49	-5.76
2011	45	-8.16
2012	56	24.44
2013	42	-25.00
2014	55	30.95
2015	61	10.90
2016	79	29.50
2017	70	-11.39
2018	82	17.14
Total	591	62.62
Average Annual Growth Rate (AGR) - 6.26%		

Document-wise distribution

It has been discussed about the document-wise publications of NIRT during the study period. Maximum number of records was published i.e. article 477 (80.71%) followed by reviews i.e. 52 (8.80%); minimum records were noted on the bibliographical item and book chapter, single record as well.

Table 3 - Document-wise distribution

S.No.	Document type	Record count	Percentage (591)
1	Article	477	80.71
2	Review	52	8.80
3	Meeting Abstract	21	3.55
4	Letter	19	3.22
5	Editorial Material	13	2.20
6	Proceedings Paper	7	1.18
7	Biographical Item	1	0.17
8	Book Chapter	1	0.17
	Total	591	100.00

**Fig.2. Record - wise distribution**

Category-wise Distribution

The subject-wise distribution of NIRT articles has been identified between 2009 and 2018. Maximum number of articles was published on ‘Immunology’ i.e. 225 (38.07%) followed by ‘Infectious Diseases’ with 179 (30.29%); ‘Microbiology’ with 109 (18.44%) papers. Minimum number of papers was published in the area of Allergy and 23 other subfields (single article).

Table 4: Research area-wise distribution

S.No.	Category	Records	Percentage
1	Immunology	225	38.07
2	Infectious Diseases	179	30.29
3	Microbiology	109	18.44
4	Medicine General Internal	67	11.34
5	Multidisciplinary Sciences	66	11.17
6	Respiratory System	64	10.83
7	Medicine Research Experimental	52	8.80
8	Tropical Medicine	37	6.26
9	Biochemistry Molecular Biology	36	6.09
10	Public Environmental Occupational Health	32	5.42
11	Pharmacology Pharmacy	29	4.91
12	Virology	24	4.06
13	Parasitology	20	3.38
14	Cell Biology	19	3.22
15	Pediatrics	17	2.88
16	Biotechnology Applied Microbiology	13	2.20
17	Biochemical Research Methods	9	1.52
19	Biophysics	8	1.35
19	Genetics Heredity	8	1.35
20	Computer Science Interdisciplinary Applications	7	1.18
21	Endocrinology Metabolism & Pathology - each 6 records	12	2.04
22	Chemistry Analytical and 3 more subdivisions - each 5 articles	20	3.4
23	Critical Care Medicine & Crystallography - each 4 records	8	1.36
24	Biology and 7 more subdivisions - each 3 records	24	4.08
25	Chemistry Applied and 5 more subdivisions - each 2 records	12	2.04
26	Allergy and 22 more research areas - each single article	23	3.91

Most Preferred Journals

It has been observed that the most preferred journals by NIRT researchers to publish their contributions are listed in table 5. Impact Factor (IF) of the journals is accessed from SCI journals.org⁷ and 2019 journals impact factor list from Clarivate Analytics (Abuhommous, 2019). PLOS One is the most preferred journal of NIRT researchers with 58 (9.81%) records followed by the Indian Journal of Medical Research with 36 (6.09%) papers. NIRT researchers’ published 12 records in ‘Lancet’ journal which has the high impact factor

(59.102). Second high impact factored journal is ‘Clinical Infectious Diseases’ (9.055) with 19 records; National Medical Journal of India has less impact factor (0.644) journal in NIRT publications.

Table 5: Most preferred journals

S.No.	Name of the journals	No. of Articles	Percentage	IF 2019
1	PLOS One	58	9.81	2.766
2	Indian Journal of Medical Research	36	6.09	1.251
3	International Journal of Tuberculosis and Lung Disease	36	6.09	2.024
4	Tuberculosis	22	3.72	2.790
5	Clinical Infectious Diseases	19	3.22	9.055
6	Aids Research and Human Retroviruses	14	2.37	1.805
7	Journal of Infectious Diseases	13	2.20	5.045
8	PLOS Neglected Tropical Diseases	13	2.20	4.487
9	Cytokine	12	2.03	3.078
10	Lancet	12	2.03	59.102
11	American Journal of Tropical Medicine and Hygiene	10	1.69	2.315
12	Frontiers in Immunology	9	1.52	4.716
13	Indian Pediatrics	9	1.52	1.163
14	International Journal of Infectious Diseases	9	1.52	3.538
15	Clinical and Vaccine Immunology	8	1.35	3.233
16	National Medical Journal of India	8	1.35	0.644
17	Human Immunology	7	1.18	2.202
18	Infection and Immunity	7	1.18	3.160
19	Infection Genetics and Evolution	7	1.18	2.611
20	Antimicrobial Agents and Chemotherapy	6	1.02	4.715
21	Vaccine	6	1.02	4.760
22	6 Journals published 5 articles each	30	25.5	
23	8 Journals published 4 articles each	32	21.76	
24	11 Journals published 3 articles each	33	16.83	
25	28 Journals published 2 articles each	56	19.04	
26	123 Journals published 1 articles each	123	20.91	

Author Productivity

Authorship pattern of NIRT has been traced from 2009 to 2018. Within the 591 records, eight papers were published by solo authorship, which is 1.35% of total production, and the rest of 583 (98.65%) were joint authorship records. It proves that NIRT researchers prefer only a co-authorship pattern than the single authorship.

Table 6: Authorship pattern of NIRT Records

Year	Single Author - Records	Joint Author - Records	Total
2009	0	52	52
2010	1	48	49
2011	1	44	45
2012	2	54	56
2013	0	42	42
2014	2	53	55
2015	0	61	61
2016	1	78	79
2017	1	69	70
2018	0	82	82
Total	8	583	591

Research Productivity of Individual Authors

It reveals the TLCS, TGCS, TLCSb and TLCSe values of the researchers during the study period. Swaminathan, S. has got in the first position with 184, his TLCS, TGCS, TLCSb and TLCSe are 254, 8623, 209 and 62 respectively; Babu S. stood in the second position with 110 (18%) records followed by Nutman T.B. with 58 records and his TLCS, TGCS, TLCSb and TLCSe are 112, 793, 76, 44 and 10 respectively. Nutman T.B. has published notable articles than the other two top researchers. Fewer documents were noted Kumaraswami V with 28 and his TLCS, TGCS, TLCSb and TLCSe are 31, 225, 12, 10, and 8 respectively.

Table 7: Top 20 Most prolific authors

S.N.	Author	Recs	%	TLCS	TLCS/t	TLCSx	TGCS	TGCS/t	TLCSb	TLCSe	
1	Swaminathan S	188	32	254	41.32	28	8623	1716.4	209	62	
2	Babu S	110	18	145	24.12	6	1594	285.33	152	46	
3	Nutman T B	58	9.7	112	16.59	5	793	127.99	76	44	10
4	Kumar N P	53	8.9	78	13.44	4	984	177.35	67	18	
5	Hanna L E	51	8.5	27	5.7	1	342	77.42	42	3	
6	Ramachandran G	43	7.2	66	12.81	2	411	94.41	58	6	
7	Raja A	39	6.5	60	8.61	2	285	44.54	56	13	
8	Narayanan S	36	6	40	5.23	5	380	71.12	28	15	
9	Nair D	32	5.4	23	4.92	4	243	52.32	25	0	
10	Banurekha V V	31	5.2	56	9.58	3	417	79.42	41	10	
11	Kumar V	31	5.2	19	2.29	2	253	37.04	24	7	
12	Selvaraj P	31	5.2	56	7.25	6	208	36.61	50	10	7
13	Anuradha R	30	5	34	5.89	2	345	59.32	47	11	
14	Narendran G	29	4.9	69	7.79	3	310	51.52	33	22	4
15	Kumaraswami V	28	4.7	31	3.27	3	225	28.62	12	10	8

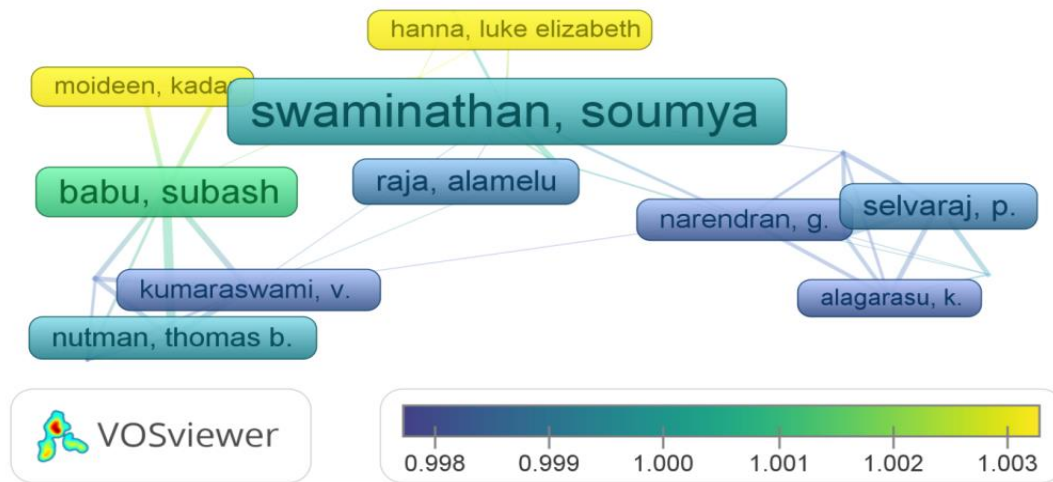


Fig 3: VOS Viewer on Co-Authorship Overlay Visualization

Testing of Lotka's Law of Scientific Productivity

Alfred J. Lotka (1926) found a law that deals with the author's publication pattern. It states that the number of authors making 'n' contributions is approximately equal to $1/n^2$ of the number of authors that produce only one contribution. i.e., in a given field, about 60% of authors out of one hundred will have one article each, 15% will have two articles each, 7% will have 3 articles each, and so on. **Lotka's Law** is mathematically expressed as:

$$Y_x = C/X^n$$

Where, Y is the number of authors credited with X (1, 2, 3, 4, 5, 6, 7, 8, 9.....) papers C is the number of authors contributing one paper and n is a rate

$$X^n * Y_x = C \text{ (Where } X = 1)$$

$$\text{i.e., } 1 * 2827 = C \text{ (C = 2827, number of authors contributing one article)}$$

When X= 2

$$2^n * 780 = C \quad (C=2827)$$

$$2^n * 780 = 2827$$

$$2^n = 2827/780 = 3.6243 \text{ (by applying log)}$$

$$n \log 2 = \log (3.6243)$$

$$n = \log (3.6243) / \log 2$$

$$n = 0.5587/0.3010$$

$$n = 1.856$$

Where, Y is the number of authors credited with X (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 20, 22, 23, 24, 25, 33, 34, 37, 38, 39, 57, 103, 149) papers, C denotes the number of authors contributing one article.

Table 8: Lotka's law of scientific productivity

No. of Articles	No. of Authors (Observed)	Observed %	No. of Authors (Expected) n=1,856	Expected %
X	5086		4859	
1	2827	55.58	2827	58.18
2	780	15.34	780	16.05
3	604	11.88	368	7.57
4	379	7.45	216	4.45
5	162	3.19	143	2.94
6	83	1.63	102	2.10
7	74	1.45	76	1.56
8	55	1.08	60	1.23
9	68	1.34	48	0.99
10	16	0.31	39	0.80
11	5	0.10	33	0.68
12	5	0.10	28	0.58
13	2	0.04	24	0.49
14	2	0.04	21	0.43
15	3	0.06	18	0.37
17	3	0.06	15	0.31
20	1	0.02	11	0.23
22	4	0.08	9	0.19
23	1	0.02	8	0.16
24	2	0.04	8	0.16
25	1	0.02	7	0.14
33	2	0.04	4	0.08
34	1	0.02	4	0.08
37	1	0.02	3	0.06
38	1	0.02	3	0.06
39	1	0.02	3	0.06
57	1	0.02	1	0.02
103	1	0.02	0	0.00
149	1	0.02	0	0.00

There were 591 articles published by 14790 authors during the period 2009-2018. It has been noted that the number of authors is 2827 (55.58%) and produced one article, 780 (15.34%) authors published two papers, 604 (11.88%) authors who produced three papers, 379 (7.45%) authors contributed for four articles and so on. According to Lotka's Law, there will be 780 (16.05%) authors who published two records, 368 (7.57%) authors contributed three articles, 216 (4.45%) authors produced four papers. Hence the present study non-confirms the Lotka's law of scientific productivity at this point.

Degree of Collaboration

The publication pattern of NIRT researchers was identified by analyzing the degree of collaboration. The mathematical formula (Subramanayam, 1983) given by Subramanyam has effectively been applied to find out the degree of collaboration which is 0.83.

Table 9: Degree of collaboration

Authorship pattern	No. of the articles
Single Authored Publications	8
Joint Authored Publications	583
Total	591

$$DC = Nm / Nm + Ns$$

Where, DC = Degree of Collaboration

Nm = Number of multiple authors

Ns = Number of single authors

$$DC = 583/583+8$$

$$DC = 583/591$$

$$DC = 0.99$$

Collaborative Organizations

Collaborative institutes have been explored and presented for understanding. Indian Council of Medical Research (ICMR) stood in the second position with 184 (31.13%) records followed by National Institutes of Health (NIH), the USA with 105 (17.77%) papers. NIRT researchers produced 56 (9.48%) records with the collaboration of World Health Organization (WHO), which is the world's premier organization, observes the global health matters, and provides support in time.

Table 10: Top 20 Collaborative organizations

S.No.	Organizations	Record count	Percentage (591)
1	National Institute for Research in Tuberculosis (NIRT)	591	100.00
2	Indian Council of Medical Research (ICMR)	184	31.13
3	National Institutes of Health (NIH), USA	105	17.77
4	NIH National Institute of Allergy Infectious Diseases (NIAID)	93	15.74
5	World Health Organization (WHO)	56	9.48
6	Johns Hopkins University	39	6.60
7	Harvard University	34	5.75
8	University of Cape Town	29	4.91
9	Government Hospital for Thorac Medicine	27	4.57
10	International Centre for Excellence in Research	24	4.06
11	University of London	23	3.89
12	All India Institute of Medical Sciences (AIIMS), New Delhi	22	3.72
13	ICMR National Jalma Institute for Leprosy other Mycobacterial Diseases, Agra	22	3.72
14	NIH National Cancer Institute NCI	22	3.72
15	Imperial College London	21	3.55
16	London School of Hygiene Tropical Medicine	19	3.22

17	Anna University, Chennai	35	5.93
18	Government Stanley Medical Hospital	18	3.05
19	Stellenbosch University	18	3.05
20	Harvard T H Chan School of Public Health	17	2.88

Citation Analysis

It has been identified the value of citation analysis for NIRT publications. 2015 papers were cited more times (5835) followed by 2009 records with 1630 times; less number of citations noted for 2018 articles (355). The average citation per item is 24.87, and an average citation per year is 1470.

Table 11: Citation Analysis

Year	Output	Total citations	Average per year
2009	52	1630	148.12
2010	49	1091	109.1
2011	45	792	87.99
2012	56	1115	139.51
2013	42	882	126.01
2014	55	1371	228.52
2015	61	5835	1167
2016	79	1156	289
2017	70	473	157.66
2018	82	355	177.5
Total	591	14700	2630.41
Average citations per item - 24.87			
Average citations per the year - 1470			

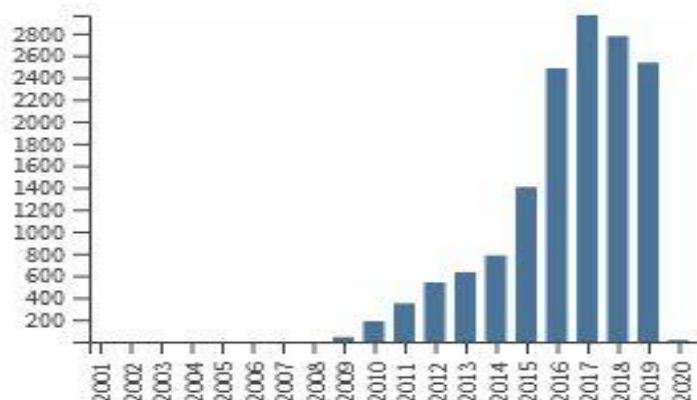


Fig 4: Sum of times cited by year

Relative Growth Rate (RGR) and Doubling Time (DT)

The concept of RGR and DT were found by Gard and Pathi in 1999 so as to identify the research output among the select R&D institutions. The mean growth rate i.e. $R(1-2)$ of total

research publications by NIRT researchers for the study period has been measured by the below mentioned formula.

$$R(1-2) = (W2-W1) / (T2-T1)$$

Where,

R (1-2) – Mean relative growth rate over the specific period of interval

W1 = log W1 (Natural log of the initial number of publications)

W2 = log W2 (Natural log of the final number of publications)

T2-T1 = Unit difference between the initial and final time

Therefore,

R(a) = Relative growth rate per unit of publications per unit of time (year)

R(p) = Relative growth rate per unit of pages per unit of time (year)

Doubling Time (DT)

There is a direct equivalence exists between the relative growth rate and doubling time. Number of research output or pages double during the select period, then the difference between the logarithms of numbers at the initial and final of the period must be logarithms of number two. Then, the difference has a value of 0.693; hence the appropriate doubling time for each specific period of interval and both the articles and pages can be measured with the formula, such as.

$$\text{Doubling Time (DT)} = 0.693 / \text{RGR}$$

Table 12: Relative Growth Rate (RGR) and Doubling Time (DT)

Year	No. of Records	Cumulative No. of Records	W1	W2	RGR	DT
2009	52	52	3.95	3.95	0	0
2010	49	101	3.89	4.62	0.73	0.95
2011	45	146	3.81	4.98	1.17	0.59
2012	56	202	4.03	5.31	1.28	0.54
2013	42	244	3.74	5.5	1.76	0.39
2014	55	299	4.01	5.7	1.69	0.41
2015	61	360	4.11	5.89	1.78	0.39
2016	79	439	4.37	6.08	1.71	0.41
2017	70	509	4.25	6.23	1.98	0.35
2018	82	591	4.41	6.38	1.97	0.35
Total	591				14.07	4.38
Average Relative Growth Rate (RGR) - 1.41						
Mean Doubling Time (DT) - 0.438						

Relative growth rate and doubling time of NIRT publications were identified and arranged. The relative growth rate in 2010 was 0.73; it has been gradually increased to 1.98 in 2017. Similarly, the doubling time in 2010 was 0.95 and it has been steadily decreased up-to 0.35 in 2017 and 2018. Average Relative Growth Rate (RGR) and the mean doubling time of NIRT publications are found to be 1.41 and 0.438 respectively.

Country-wise Distribution

There are 131 countries which contributed to NIRT publications. Indian authors contributed on all 591 (100%) records and stood in the first position followed by USA scientists with 194 (32.83%) articles; England stood in third place with 45 (7.61%) records.

Table 13: Region-wise distribution

S.No.	Country	No. of Articles	Percentage
1	India	591	100.00
2	USA	194	32.83
3	England	45	7.61
4	Switzerland	43	7.28
5	South Africa	40	6.77
6	France	24	4.06
7	Sweden	23	3.89
8	Australia	22	3.72
9	Germany	22	3.72
10	Netherlands	22	3.72
11	Brazil	21	3.55
12	Italy	18	3.05
13	Canada	17	2.88
14	Saudi Arabia	17	2.88
15	South Korea	17	2.88
16	Malaysia	16	2.71
17	Kenya	15	2.54
18	Uganda	14	2.37
19	Indonesia	13	2.20
20	Zambia	13	2.20
21	Iran and other 4 countries (12 each)	60	121.8
22	Denmark and other 6 countries (11 each)	77	143.22
23	Bangladesh and other 6 countries (10 each)	70	118.3
24	Argentina and other 19 countries (9 each)	180	273.6
25	Cameroon and other 9 countries (8 each)	80	108
26	Botswana and other 7 countries (7 each)	56	66.08
27	Algeria and other 4 countries (6 each)	30	30.6
28	Anguilla and other 10 countries (5 each)	55	46.75
29	Afghanistan and other 9 countries (4 each)	40	27.2
30	Armenia and other 11 countries (3 each)	36	18.36
31	Barbados and other 4 countries (2 each)	10	3.4
32	Azerbaijan and other 10 countries (each one)	11	1.87

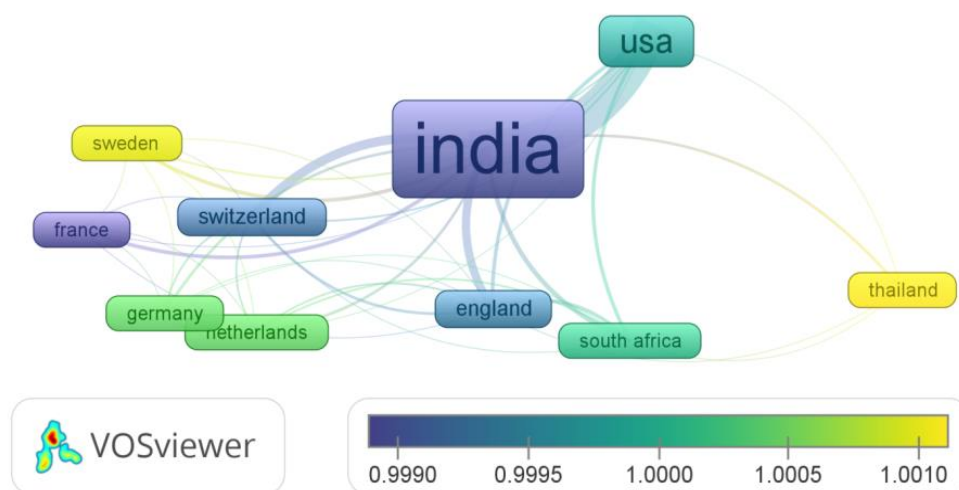


Fig 5: VOS Viewer on Country-wise Overlay Visualization

Keyword Distribution

A Comparison has been made for 15 keywords used in NIRT articles during the study period. The word ‘tuberculosis’ used in most of the records i.e. 350 (58.6%) with TLCS is 470 and TGCS is 4936 followed by ‘India’ with 127 (21.3%) documents; less number of times used keyword is ‘Antigen’ i.e. 33 (5.5%), TLCS and TGCS for this keyword is 47 and 346 respectively.

Table 14: Top 15 Keywords-wise distribution

S.No.	Keyword	No. of the Records	Percentage	TLCS	TGCS
1	Tuberculosis	350	58.6	470	4936
2	India	127	21.3	114	1078
3	HIV	122	20.4	132	1573
4	Mycobacterium	92	15.4	118	704
5	Pulmonary	76	12.7	101	692
6	Patients	74	12.4	96	702
7	Infection	57	9.5	83	457
8	Treatment	56	9.4	46	658
9	South	51	8.5	46	279
10	Associated	45	7.5	50	473
11	Infected	42	7	49	238
12	Analysis	38	6.4	48	5495
13	Children	38	6.4	66	686
14	Cell	37	6.2	52	251
15	Antigen	33	5.5	47	346

Highly Cited Articles

The impact of the highly cited articles of NIRT publications having more than 100 citations has been presented for better understanding in below table-15.

Table 15: Top 20 Highly Cited articles

S.No.	Title	Author's	Journal details	Citations
1	Global, regional, and national age-sex specific all-cause and cause-specific mortality for 240 causes of death, 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013	Naghavi, Mohsen; Wang, Haidong; Lozano, Rafael; et al.	Lancet, 2015, Volume: 385(9963) Pages: 117-171.	3,344
2	Global, regional, and national comparative risk assessment of 79 behavioral, environmental and occupational, and metabolic risks or clusters of risks in 188 countries, 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013	Forouzanfar, Mohammad H.; Alexander, Lily; Anderson, H. Ross; et al.	Lancet, 2015, Volume: 386 Issue: 10010 Pages: 2287-2323.	1,087
3	Global, regional, and national disability-adjusted life years (DALYs) for 306 diseases and injuries and healthy life expectancy (HALE) for 188 countries, 1990-2013: quantifying the epidemiological transition	Murray, Christopher J. L.; Barber, Ryan M.; Foreman, Kyle J.; et al.	Lancet, 2015, Volume: 386 Issue: 10009 Pages: 2145-2191.	767
4	Global, regional, and national incidence and mortality for HIV, tuberculosis, and malaria during 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013	Murray, Christopher J. L.; Ortblad, Katrina F.; Guinovart, Caterina; et al.	Lancet, 2014, Volume: 384 Issue: 9947 Pages:1005-1070.	476
5	Host-directed therapy of tuberculosis based on interleukin-1 and type I interferon crosstalk	Mayer-Barber, Katrin D.; Andrade, Bruno B.; Oland, Sandra D.; et al.	Nature, 2014, Volume: 511 Issue: 7507 Pages: 99-U491.	318
6	Epidemiology of antituberculosis drug resistance 2002-07: an updated analysis of the Global Project on Anti-Tuberculosis Drug Resistance Surveillance	Wright, Abigail; Zignol, Matteo; Van Deun, Armand; et al.	Lancet, 2009, Volume: 373 Issue: 9678 Pages: 1861-1873.	279
7	Estimates of global, regional, and national incidence,	Wang, Haidong; Wolock, Tim	Lancet HIV, 2016 Volume: 3(8)	245

	prevalence, and mortality of HIV, 1980-2015: the Global Burden of Disease Study 2015	M.; Carter, Austin; et al.	Pages: E361-E387.	
8	Evaluation of Tuberculosis Diagnostics in Children: 1. Proposed Clinical Case Definitions for Classification of Intrathoracic Tuberculosis Disease. Consensus From an Expert Panel	Graham, Stephen M.; Ahmed, Tahmeed; Amanullah, Farhana; et al.	Journal of Infectious Diseases, 2012, Volume: 205 Supplement: 2 Pages: S199-S208.	184
9	Pediatric Tuberculosis: Global Overview and Challenges	Swaminathan, Soumya; Rekha, Banu	Clinical Infectious Diseases, 2010, Volume: 50 Supplement: 3 Pages: S184-S194.	176
10	Nations within a nation: variations in epidemiological transition across the states of India, 1990-2016 in the Global Burden of Disease Study	Dandona, Lalit; Dandona, Rakhi; Kumar, G. Anil; et al.	Lancet, 2017, Volume: 390 Issue: 10111 Pages: 2437-2460.	136
11	Tuberculosis-advances in development of new drugs, treatment regimens, host-directed therapies, and biomarkers	Wallis, Robert S.; Maeurer, Markus; Mwaba, Peter; et al.	Lancet Infectious Diseases, 2016, Volume: 16(4) Pages: E34-E46.	133
12	Tuberculosis comorbidity with communicable and non-communicable diseases: integrating health services and control efforts	Marais, Ben J.; Loennroth, Knut; Lawn, Stephen D.; et al.	Lancet Infectious Diseases, 2013, Volume: 13(5) Pages: 436-448.	122
13	Tuberculosis Diagnostics and Biomarkers: Needs, Challenges, Recent Advances, and Opportunities	McNerney, Ruth; Maeurer, Markus; Abubakar, Ibrahim; et al.	Journal of Infectious Diseases 2012, Volume: 205 Supplement: 2 Pages: S147-S158.	108
14	Drug-Resistant Tuberculosis-Current Dilemmas, Unanswered Questions, Challenges, and Priority Needs	Zumla, Alimuddin; Abubakar, Ibrahim; Raviglione, Mario; et al.	Journal of Infectious Diseases, 2012, Volume: 205 Supplement: 2 Pages: S228-S240.	105

6. Findings of the Study

- 14790 researchers have contributed to 591 records during the study period i.e. 2009 - 2018.
- Maximum number of publications is articles (80.71%) and specialization-wise 'Immunology' research papers occupy first position with 38.07%.

- Average Output of NIRT publications per year is 59.1%.
- The Average Annual Growth Rate of NIRT publications during the study period are 6.26%.
- PLOS One is the most preferred journal of NIRT researchers (9.81%).
- Impact factor-wise, and Lancet is the high impact factored journal (59.102) of NIRT publications.
- NIRT researchers prefer to have joint authorship pattern rather than solo authorship. 583 records are co-authorship, and 8 only are single authorship papers.
- Swaminathan S is the most prolific author with 184 records during the study period.
- The degree of collaboration for NIRT publications is 0.83.
- Indian Council of Medical Research (ICMR) collaborated more with NIRT, 184 (31.13%) articles were published between 2009 and 2018.
- Total citations of NIRT records are 14700, average citations per item and average citations per year are 24.87 and 1470 respectively.
- Globally, USA researchers contributed more i.e. 194 (32.83%) documents.
- The present study non-confirms Lotka's law of distribution.

7. Conclusion

TB is one of the worst communicable diseases in the global which transmit from a human to another by coughing. Every 17 seconds once, a person dies due to TB and it reaches 1.7 million per annum; most of them are infants and kids. The maximum number of death noted in the regions of Africa and South-East Asia hence the global countries and World Health Organization (WHO) are encouraging the premier research institutes for the advance study on tuberculosis drug development. This kind of comparative study will support the researchers to identify the pioneers' publications, specialized TB research journals, list of organizations involved in TB research, funding agencies etc. The researcher can proceed to next level by analyzing the national and international TB research output as well.

India being the developing country strives hard to have established various kinds of research and development centres for the welfare of her citizens by and large. Since Tuberculosis is one of the communicable diseases, NIRT has been established to nurture the research impact on Tuberculosis. Hence academics of NIRT are supposed to involve themselves in research projects and joint ventures for curtailing the spread of Tuberculosis. The average research output may vary from one country to other due to funds, infrastructure and need. When compared with other continents, Indian researchers' contributions are noteworthy. This will enable the governments and nodal agencies to initiatives new ways to minimize life of human beings due to the spread of Tuberculosis in toto.

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