



Studies on Relative Growth Rate and Doubling Time of Publications Productivity of Nuclear Medicine Research

N. Rathika¹ and S. Thanuskodi^{1*}

¹*Department of Library and Information Science, Alagappa University, India.*

Authors' contributions

This work was carried out in collaboration between both authors. Author NR designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author ST supervised of the study. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JPRI/2021/v33i32A31732

Editor(s):

(1) Dr. Rafik Karaman, Al-Quds University, Palestine.

Reviewers:

(1) Abdolreza Noroozi Chakoli, Shahed University, Iran.

(2) Bexy Rojas-Moreno, Universidad Central de Venezuela, Venezuela.

(3) Thiago Magela Rodrigues Dias, Centro Federal de Educação Tecnológica de Minas Gerais, Brazil.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/67475>

Original Research Article

Received 10 February 2021

Accepted 15 April 2021

Published 19 June 2021

ABSTRACT

Scientometrics is a branch of the library and information science. Scientometric tools can be used to quantify and compare the scientific activities at various levels of collection including institutions, sectors, provinces, and countries. They can also be used to measure research collaborations, map scientific networks, and monitor the evolution of scientific fields. Scientometric indicators give policy-makers objective, reproducible, and therefore verifiable information that goes away from the unreliable. Scientometrics is anxious about the quantitative features and characteristics of science and scientific research. Scientometrics is a restraint, which uses statistical and computational techniques to realize the structure and changing aspects of science. The study shows that the Authorship Pattern in Nuclear Medicine literature fluctuates from single-authored publications to 78 authored publications during the study period 1991-2020. As per the analysis of the table, the highest number of research output by single-authored was 14.06% with 1776 contributions followed by double authored contributions was 13.07% (1651) and three authored contributions were 12.59% (1590).

*Corresponding author: E-mail: thanuskodi_s@yahoo.com;

Keywords: *Scientometrics; relative growth rate; doubling time; nuclear medicine; citations; authorship pattern and time series analysis.*

1. INTRODUCTION

Scientometrics is a new branch of knowledge, which uses bibliometric measurements for the evaluation of scientific progress, level of scientific developments, social relevance, and impact of the applications of science and technology. Many of these studies border on the science of science, science policy, etc. The term scientometrics was derived from the Russian term and is defined as the study of the measurements of scientific and technological progress [1]. Scientometrics is the study of the quantitative aspects of science as a discipline or economic activity". It is part of the sociology of science and has application to science policy-making. It involves quantitative studies of scientific activities including, among others, publication and so overlaps bibliometrics to some extent [2]. Measuring results and developments of science are called scientometrics and more, in particular, measuring these developments by analyzing articles, books, and journals is called bibliometrics [3]. Application of quantitative techniques (systems analysis, mathematical and statistical techniques, etc) to scientific communications (science output, science policy) Science administration, etc. [4].

1.1 Nuclear Medicine

Nuclear medicine is a field of medicine that develops its name from the utilization of radioactive rays emitted from the atomic nuclei of non-sealed radionuclide for the diagnosis and treatment of diseases. The field is separated into diagnosis and therapy. Diagnostic Nuclear medicine is generally divided into diagnostic imaging, in which biological functions are estimated built on images obtained by external counting of radionuclide-labeled agents, and in vitro testing, in which trace elements in biological samples such as blood and urine collected from living subjects are measured by radioimmunoassay techniques.

Intervention using radionuclide is called "radionuclide therapy". For instance, Na 131I is used for the treatment of hyperthyroidism and thyroid cancer, $^{90}\text{SrCl}_2$ is used for firing pain in patients with bone metastasis from malignant tumors, and ^{90}Y is used for labeling monoclonal antibodies focused against cancer antigens. The origin of nuclear medicine can be found back in

the discovery of X-rays and radionuclide. Three months after the discovery of the X-ray, Becquerel discovered that radioactive rays were produced from uranium. After that natural radionuclides such as polonium and radium were found successively by Pierre and Marie Curie. By 1902, it started that the radioactive rays emitted from radionuclides were α rays, β rays (electrons), and γ rays (electromagnetic waves). Also, in 1932, positrons were detected from cosmic rays.

1.2 Statement of the Research Problem

The present study is to analyze the scholarly publications of research in the area of Nuclear Medicine for a period of 30 years from 1991 to 2020. This study intends to identify the list of core journal publications, growth rate, research productivity of authors and institutions, the contribution of each country, continent, and various similar aspects at national and international levels in the field of Nuclear Medicine. The present research is entitled "Mapping of Research productivity on Nuclear Medicine: A Scientometric Analysis".

1.3 Need of the Study

The present study is of much significance, Nuclear Medicine can treat a wide variety of diseases and disorders at the same time it has some controversies. At this juncture, it is necessary to eradicate the misconceptions on Nuclear Medicine and to analyze the quantitative and qualitative research output of literature in Nuclear Medicine by applying Scientometric methods.

1.4 Review of Literature

Vijayakumar, Sivasubramaniyan, and Rao [5] carried out to investigate the "Bibliometrics analysis of the Indian Journal of Nuclear medicine during the period 2014-2018". The data obtained from the Scopus bibliographic database for the study. The main objectives of the study authorship pattern, the most prolific authors, most productive countries. They reported a total of 513 papers published in the study period. 2017 was the most productive year with 114(22.22%) publications. The highest citation was received in the year 2014 with 195(36.25%). The high frequented keywords are "Human" which is the topper with 434 (84.60%)

publications. The most productive journal in India with publications of 388 (75.63%).

McKellar and Currie [6] evaluated "Publication productivity in Nuclear Medicine from 2009 to 2013". They obtained the data from the PubMed database; they retrieved 165 documents from the database. The most prolific Radiotherapy author is the highest number of articles 42 has the 2nd position. Brennan is the most prolific Radiographer with 58 articles overall in the 1st position.

Rathika and Thanuskodi [7] analyzed "Research output on Encephalitis Literature during the year 2008-2017". The data were retrieved from the Web of Science database. The adopts various methods like relative growth rate, exponential growth rate, doubling time, etc. The study revealed that Encephalitis published 6,405 articles. The highest number of articles published in the year 2017 followed by 2016. The USA has the highest number of publications with 2,331 (36.39%). The study exposes is clear that the relative growth rate of total research output decreased gradually. The growth rate is 0.29 in 2008 which decreased up to 0.07 in 2017. The mean relative growth rate for the study period from 2007 to 2017 is 0.11. The study that the Vincente. Occupied first position followed by Weaver SC., occupied the second rank in the list.

Garg & Kumar [8] carried out a study on "Bibliometrics of the global Drug Abuse Research Output as Reflected by Coverage in Web of Science Core Collection during 2001-2018" and the data required for the study was retrieved from the Web of Science database. A total of 18, 431 records were retrieved published in the drug cancer. The study revealed that SUA is the most productive country in research related to drug abuse and produced far more scientific papers than European countries. They have been published in 20 different languages. The highest number of papers 16,180 (96.6%) were published in the English language. The University of California System is the most prolific institution of 1002 (5.31%). The top 12 authors published more than 35 papers; the average number of papers is 4.7. Of the top 12 prolific authors, 10 authors were from the USA and two from Sweden. The study concluded that the mechanism is needed that support research in developing and marginalized economies as drug abuse is also prevalent in these countries.

Sadik Batcha [9] carried out "Research contributions on oral cancer in India during the

period 2010-2017". The data retrieved from the Web of Science database for the study. The study reported that the USA produced 31.34% of global publications on oral cancer. All India Institute of Medical Science has a TLCS of 490 and TGCS 3980. The most productive journals colloids and surface B-Bio interfaces 1180 articles and impact factor 3.887. According to statistics, the number of deaths in 2012 due to oral cancer is 36463 in males and 15361 in females. The study concluded that Indian oral cancer research is continuously increasing. This study may have found that a hospital and a university have very active research activities as compared to other specialized research Institutes.

Gupta and Ahmed [10] carried out "Pancreatitis cancer research in India during 2007-2016" to retrieve the data using the Scopus database. They examined 1168 articles obtained from the database. The international collaborative publications in pancreatic research were 26.71% during 2007-2016. The USA is the largest publications share with 65.06%, followed by Japan (16.35%). The total journal output of 1148 papers. Published in the journal of pancreas 32 during 2007-2011.

1.5 Objectives of the Study

- To assess the evolution of research productivity on Nuclear Medicine.
- Research output at national levels during the period 1991-2020.
- To evaluate the development of research productivity on Nuclear Medicine Research output at a national and international levels during the study period 1991-2020.
- To study relative growth Rate (RGR) and Doubling Time (DT) of Nuclear Medicine.
- To identify the authorship pattern to find the top-level authors along with their institutions in the field of Nuclear Medicine.
- To find out the year-wise distribution of pages and references in Nuclear Medicine.
- To spot and list out the core journals in the field of Nuclear Medicine during the period 1991-2020.

2. METHODOLOGY

The study aims to recognize the growth of scientific output in the field of Nuclear Medicine for a period of 30 years (from 1991 to 2020). The data required for the present study were retrieved from the Web of Science database. A total of 12,632 records were retrieved using the

keyword search term (TOPIC (“Nuclear Medicine”)) AND Timespan: 1991-2020 from the database. The retrieved data were analyzed by using Microsoft-Excel package, HistCite software, Bib Excel, and VOS viewer Software as per the objectives of the study, and the data has been presented as tables and graphs. The study was designed to evaluate and know the growth rate of output, authorship productivity, collaborative tendency, citation metrics, top journal’s list, and geographical distribution of publications at national and international levels in Nuclear Medicine.

2.1 Data Analysis

2.1.1 Growth rate of publications

The growth rate is a measurement which necessary in any field. In meaning the growth of the number of publications in a specific discipline, this is frequently a measure of

the annual increase or decrease. Table 1 shows that the growth of Nuclear Medicine totally 12,632 records the maximum number of publications in the year 2020 with 771 (6.10%) publications followed by the year 2019 with 677 (5.63%) publications and the least number of publications in the year 1992 with 170 (1.35%) publications respectively.

$$AGR = \frac{\text{End Value} - \text{First Value}}{\text{First Value}} \times 100$$

The annual growth rate of publications during the year 1991-2020 between -2.30 and 13.88. The highest annual growth rate was (40.00) in 1993 followed by (27.73) in 1995 and (21.29) growth in 2010. This specifies that the attentiveness and importance of nuclear medicine have been in the study period (1991-2020).

Table 1. Growth of nuclear medicine literature

Sl. No.	Year	No. of records	% of 12632	Cumulative growth	Cumulative %	Annual growth rate (AGR)
1	1991	174	1.38	174	1.38	
2	1992	170	1.35	344	2.72	-2.30
3	1993	238	1.88	582	4.61	40.00
4	1994	220	1.74	802	6.35	-7.56
5	1995	281	2.22	1083	8.57	27.73
6	1996	271	2.15	1354	10.72	-3.56
7	1997	313	2.48	1667	13.20	15.50
8	1998	300	2.37	1967	15.57	-4.15
9	1999	331	2.62	2298	18.19	10.33
10	2000	314	2.49	2612	20.68	-5.14
11	2001	322	2.55	2934	23.23	2.55
12	2002	312	2.47	3246	25.70	-3.11
13	2003	341	2.70	3587	28.40	9.29
14	2004	346	2.74	3933	31.14	1.47
15	2005	341	2.70	4274	33.83	-1.45
16	2006	364	2.88	4638	36.72	6.74
17	2007	401	3.17	5039	39.89	10.16
18	2008	473	3.74	5512	43.64	17.96
19	2009	451	3.57	5963	47.21	-4.65
20	2010	547	4.33	6510	51.54	21.29
21	2011	593	4.69	7103	56.23	8.41
22	2012	549	4.35	7652	60.58	-7.42
23	2013	559	4.43	8211	65.00	1.82
24	2014	575	4.55	8786	69.55	2.86
25	2015	547	4.33	9333	73.88	-4.87
26	2016	599	4.74	9932	78.63	9.51
27	2017	596	4.72	10528	83.34	-0.50
28	2018	656	5.19	11184	88.54	10.07
29	2019	677	5.36	11861	93.90	3.20
30	2020	771	6.10	12632	100	13.88
Total		12632	100			

The years 1992, 1994, 1996, 1998, 2000, 2002, 2005, 2009, 2012, 2015 and 2017 have a negative growth rate. The goal for the fluctuation is that there is no continuous growth of publications every year.

Citation exploration is a top indicator in calculating individuals. Citation analysis forms link between various disciplines, study workers, periodicals, authors and countries. Citations are assumed to reflect the quality of research. Table 2 illustrated Year-wise Local Citation Score of Nuclear Medicine Literature. It was found that the highest local citation score is 1198 in the year 2008 and the lowest number of citations 158 was found in the year 2020. During the study period a total of 19323 citations were received. The

overall citation per paper was 1.53 and average citation per year was 644.

The Relative Growth Rate (RGR) is increase in the number of articles or pages per unit of time. The mean RGR is over the specific period of interval can be calculated from the following formula.

$$RGR = \frac{W_2 - W_1}{T_2 - T_1}$$

W_1 is log of initial number of articles;
 W_2 is log of final number of articles after a specific period of interval
 $T_2 - T_1$ is unit difference between the initial time and the final time.

Table 2. Year-wise local citation score of nuclear medicine literature

Year	No. of records	Local citation score	% of 19323	Citation per publication
1991	174	256	1.32	1.47
1992	170	325	1.68	1.91
1993	238	422	2.18	1.77
1994	220	434	2.25	1.97
1995	281	425	2.20	1.51
1996	271	694	3.59	2.56
1997	313	672	3.48	2.15
1998	300	637	3.30	2.12
1999	331	876	4.53	2.65
2000	314	656	3.39	2.09
2001	322	675	3.49	2.10
2002	312	683	3.53	2.19
2003	341	764	3.95	2.25
2004	346	769	3.98	2.22
2005	341	821	4.25	2.41
2006	364	804	4.16	2.21
2007	401	866	4.48	2.16
2008	473	1198	6.20	2.53
2009	451	938	4.85	2.08
2010	547	1026	5.31	1.88
2011	593	1065	5.51	1.80
2012	549	684	3.54	1.25
2013	559	787	4.07	1.43
2014	575	670	3.47	1.18
2015	547	500	2.59	0.91
2016	599	449	2.32	0.75
2017	596	476	2.46	0.80
2018	656	376	1.95	0.57
2019	677	217	1.12	0.33
2020	771	158	0.82	0.22
Total	12632	19323	100	1.53

Average citation per year=644

Table 3. Relative growth rate and doubling time

Sl. No.	Year	No. of records	Cumulative growth	W1	W2	Relative growth rate (RGR)	Doubling time (DT)
1	1991	174	174		5.16		
2	1992	170	344	5.16	5.84	0.68	1.02
3	1993	238	582	5.84	6.37	0.53	1.32
4	1994	220	802	6.37	6.69	0.32	2.16
5	1995	281	1083	6.69	6.99	0.30	2.31
6	1996	271	1354	6.99	7.21	0.22	3.10
7	1997	313	1667	7.21	7.42	0.21	3.33
8	1998	300	1967	7.42	7.58	0.17	4.19
9	1999	331	2298	7.58	7.74	0.16	4.46
10	2000	314	2612	7.74	7.87	0.13	5.41
11	2001	322	2934	7.87	7.98	0.12	5.96
12	2002	312	3246	7.98	8.09	0.10	6.86
13	2003	341	3587	8.09	8.19	0.10	6.94
14	2004	346	3933	8.19	8.28	0.09	7.53
15	2005	341	4274	8.28	8.36	0.08	8.33
16	2006	364	4638	8.36	8.44	0.08	8.48
17	2007	401	5039	8.44	8.52	0.08	8.36
18	2008	473	5512	8.52	8.61	0.09	7.72
19	2009	451	5963	8.61	8.69	0.08	8.81
20	2010	547	6510	8.69	8.78	0.09	7.90
21	2011	593	7103	8.78	8.87	0.09	7.95
22	2012	549	7652	8.87	8.94	0.07	9.31
23	2013	559	8211	8.94	9.01	0.07	9.83
24	2014	575	8786	9.01	9.08	0.07	10.24
25	2015	547	9333	9.08	9.14	0.06	11.47
26	2016	599	9932	9.14	9.20	0.06	11.14
27	2017	596	10528	9.20	9.26	0.06	11.89
28	2018	656	11184	9.26	9.32	0.06	11.46
29	2019	677	11861	9.32	9.38	0.06	11.79
30	2020	771	12632	9.38	9.44	0.06	11.00
Total		12632					

Table 3 denoted the Relative Growth Rate (RGR) of Nuclear medicine for the study period. The maximum RGR value was 0.68 in the year 1992 and followed by the year 1993 with the value of 0.53. Similarly, the lowest value showed in the years 2015, 2016, 2017, 2018, 2019, and 2020 with the same value of 0.06. The Doubling time is the time required of publications to double size. As observed by Braford "Between Relative growth rate and doubling time there is a direct equivalence". For the study doubling time of publications was calculated by the formula is given.

$$DT = \frac{0.693}{RGR}$$

Table 3 disturbed with the Doubling Time (DT). It was recognized that the maximum DT in the year 2017 with the value of 11.89 and followed by the year 11.79. Similarly, the lowest DT was reported

in the year 1992 with a value of 1.02. On the whole, it was known to there was also variation in both Relative Growth Rate and Doubling Time during the study period.

Times Series Analysis deals with the Future Growth of publications. Each Year the publication production is rising massively and the growth of publication are analyzed with the getting worse analysis. Hence, the technique is used to calculate the number of publications for the near future. In this study 2025, 2030, 2040, and 2050 are studied. Since the calculations, it is found that the valued future growth in Nuclear Medicine literature increased from 2020 with 771 publications to 2025 with 777 publications to 2030 with 867 publications to 2040 with 1045 publications and 2050 with 1223 publications. Hence, it was assumed that the growth of

Table 4. Time series analysis of nuclear medicine literature

Sl. No.	Year	Publications (Y)	X	X ²	XY
1	1991	174	-14.5	210.25	-2523
2	1992	170	-13.5	182.25	-2295
3	1993	238	-12.5	156.25	-2975
4	1994	220	-11.5	132.25	-2530
5	1995	281	-10.5	110.25	-2950.5
6	1996	271	-9.5	90.25	-2574.5
7	1997	313	-8.5	72.25	-2660.5
8	1998	300	-7.5	56.25	-2250
9	1999	331	-6.5	42.25	-2151.5
10	2000	314	-5.5	30.25	-1727
11	2001	322	-4.5	20.25	-1449
12	2002	312	-3.5	12.25	-1092
13	2003	341	-2.5	6.25	-852.5
14	2004	346	-1.5	2.25	-519
15	2005	341	-0.5	0.25	-170.5
16	2006	364	0.5	0.25	182
17	2007	401	1.5	2.25	601.5
18	2008	473	2.5	6.25	1182.5
19	2009	451	3.5	12.25	1578.5
20	2010	547	4.5	20.25	2461.5
21	2011	593	5.5	30.25	3261.5
22	2012	549	6.5	42.25	3568.5
23	2013	559	7.5	56.25	4192.5
24	2014	575	8.5	72.25	4887.5
25	2015	547	9.5	90.25	5196.5
26	2016	599	10.5	110.25	6289.5
27	2017	596	11.5	132.25	6854
28	2018	656	12.5	156.25	8200
29	2019	677	13.5	182.25	9139.5
30	2020	771	14.5	210.25	11179.5
Total		12632	0	2247.5	40055

publications in the Nuclear Medicine literature may be definitely improved as per the projected future years.

Straight Line equation $Y_c = a + bX$

Since $\Sigma X = 0$

$a = \Sigma Y/N = 12632/30 = 421.07$

$b = \Sigma XY/\Sigma X^2 = 40055/2247.5 = 17.82$

Estimated literature in 2025 = $421.07 + (17.82 \times (2025 - 2005)) = 777.47$

Estimated literature in 2030 = $421.07 + (17.82 \times (2030 - 2005)) = 866.57$

Estimated literature in 2040 = $421.07 + (17.82 \times (2040 - 2005)) = 1044.77$

Estimated literature in 2050 = $421.07 + (17.82 \times (2050 - 2005)) = 1222.97$

Table 5 represented the number of pages in Nuclear Medicine Literature during the period 1991-2020 of the study. It was found that 99952 pages are found to contain 12632 publications during the period. The highest number of pages

of 6982 (6.99%) is found to be 771 publications in 2020, followed by 6089 (6.09%) of the pages found out to be in 677 publications in 2019. It concludes that the overall pages of the publications between 1103(1.10%) appearing in 174 publications in 1991 and 3021(3.02%) of papers appearing in 364 publications in 2006. It is found that in general, when there is an increase in the publication the growth is also found to be increased. It is noted that the same did not appear in the fluctuating trend during the study.

The above Table 6 shows the year wise distribution of references in Nuclear Medicine during 1991-2020. It is observed from the data that there is a decreasing and increasing trend in the quantum references from 1991-2020. It was obvious from the table that a maximum number of references (7.32%) were published in the year

Table 5. Year-wise Distribution of Pages Output

Sl. No.	Year	No. of publications	No. of pages	% of 99952	Average no. of pages per publications
1	1991	174	1103	1.10	6.34
2	1992	170	1092	1.09	6.42
3	1993	238	1669	1.67	7.01
4	1994	220	1763	1.76	8.01
5	1995	281	2360	2.36	8.40
6	1996	271	2228	2.23	8.22
7	1997	313	2437	2.44	7.79
8	1998	300	2651	2.65	8.84
9	1999	331	2691	2.69	8.13
10	2000	314	2847	2.85	9.07
11	2001	322	2257	2.26	7.01
12	2002	312	2325	2.33	7.45
13	2003	341	2423	2.42	7.11
14	2004	346	2742	2.74	7.92
15	2005	341	2454	2.46	7.20
16	2006	364	3021	3.02	8.30
17	2007	401	3038	3.04	7.58
18	2008	473	3500	3.50	7.40
19	2009	451	3285	3.29	7.28
20	2010	547	4004	4.01	7.32
21	2011	593	4356	4.36	7.35
22	2012	549	4175	4.18	7.60
23	2013	559	4247	4.25	7.60
24	2014	575	4629	4.63	8.05
25	2015	547	4319	4.32	7.90
26	2016	599	4593	4.60	7.67
27	2017	596	5092	5.09	8.54
28	2018	656	5580	5.58	8.51
29	2019	677	6089	6.09	8.99
30	2020	771	6982	6.99	9.06
Total		12632	99952	100	7.91

2020 and minimum number of references (0.73%) of 2817 was published in the year 1992 respectively.

The intellectual communication is well executed by referring to publications to earlier research in the more number of references, the additional quality of the reference paper. Table 7 shows that there are 387952 references covered range from 0 references to 580 references. None of the references covered 17.29% of total publications in the study. The research publication with 11-20 range reference is the highest number in the study. When the number of references increases above 40 the number of publications decreases. Therefore, it is assumed that the optimum number of references in research publications in the nuclear medicine research.

2.2 Author Productivity

Table 8 concerned with Authorship Pattern Vs Number of Publications revealed that the Authorship Pattern in Nuclear Medicine literature fluctuates from single-authored publications to 78

authored publications during the study period 1991-2020. As per the analysis of the table, the highest number of research output by single-authored was 14.06% with 1776 contributions followed by double authored contributions was 13.07% (1651) and three authored contributions were 12.59% (1590). At this point, the largest collection had been designed by publications with single-authored to six authored. It was also concluded that only on publication contributed by 78 authors. It displays that collaborative research ruled than specific research in the field of study. There were some anonymous contributions found with 314 publications (2.46%) in the authorship pattern of Nuclear Medicine literature.

Table 9 show that the contributions made as single vs. multiple authors' publications fluctuated in the study period. The highest percentage of single-authored contributions was identified in the year 1995 with 87 publications and the highest percentage of multi-authored contributions identified in the year 2020 with 706 publications. It was visibly specified that the multi-authorship pattern with 10542 (83.45%)

Table 6. Year wise distribution of references

Sl. No.	Year	No. of references	% of 387952	Cumulative references	Cumulative percentage
1	1991	2978	0.77	2978	0.77
2	1992	2817	0.73	5795	1.49
3	1993	3670	0.95	9465	2.44
4	1994	4919	1.27	14384	3.71
5	1995	5967	1.54	20351	5.25
6	1996	6648	1.71	26999	6.96
7	1997	8086	2.08	35085	9.04
8	1998	7590	1.96	42675	11.00
9	1999	10286	2.65	52961	13.65
10	2000	8733	2.25	61694	15.90
11	2001	8953	2.31	70647	18.21
12	2002	9666	2.49	80313	20.70
13	2003	8699	2.24	89012	22.94
14	2004	10927	2.82	99939	25.76
15	2005	9434	2.43	109373	28.19
16	2006	12610	3.25	121983	31.44
17	2007	11855	3.06	133838	34.50
18	2008	14847	3.83	148685	38.33
19	2009	13472	3.47	162157	41.80
20	2010	16425	4.23	178582	46.03
21	2011	18858	4.86	197440	50.89
22	2012	17367	4.48	214807	55.37
23	2013	16957	4.37	231764	59.74
24	2014	19597	5.05	251361	64.79
25	2015	17254	4.45	268615	69.24
26	2016	18724	4.83	287339	74.07
27	2017	21180	5.46	308519	79.53
28	2018	24073	6.21	332592	85.73
29	2019	26965	6.95	359557	92.68
30	2020	28395	7.32	387952	100
Total		387952	100		

publications was biggest than the single authorship pattern with 1776 (14.06%) publications. It was known that collaborative authorship was the major kind of authorship pattern in the field of Nuclear medicine literature.

Table 10 illustrate the Degree of Collaboration, Collaboration Index, and Collaboration Co-efficient. Using Subramanyam's formula using the Degree of Collaboration in Nuclear Medicine Literature.

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

Nm=Number of Multi authors during a period in a field

Ns=Number of Single authors during a period in a field

The Degree of Collaboration ranged from 0.60 to 0.92 during the period (1991 to 2020). The Degree of Collaboration was on the increasing

trend throughout the study period. The minimum value (0.60) in the year 1991 and 0.92 in the year 2013, 2015, and 2020 which was the maximum. When two or more two authors contribute their knowledge to publish a paper with joint or collaborative work is called collaboration. The CI can obtain by the total number of authors divided by the number of published articles. The following results were observed CI values between 4.04 and 6.76. The CI was valued for the year 1991 to 2020 such that; the minimum number of values 3.97 in the year 1993 followed by 3.98 in the year 1992. The maximum number of values 6.86 in the year 2019.

Collaborative Coefficient that reflects both the mean number of authors per paper as well as the proportion of multi-authored papers. The value of the Collaborative Coefficient range between 0 and 1. The following results were observed that the cc value is between 0.41 and 0.71. The CC was valued for the year 1991 to 2020. The

Table 7. Reference pattern vs publications in nuclear medicine literature

Reference pattern	No. of records	% of 12632	No. of references	% of 387952
0	2184	17.29	0	0
1-10	1551	12.28	9602	2.48
11-20	2369	18.75	37046	9.55
21-30	2264	17.92	57284	14.77
31-40	1447	11.46	50903	13.12
41-50	773	6.12	35016	9.03
51-60	437	3.46	24134	6.22
61-70	329	2.60	21487	5.54
71-80	279	2.21	21079	5.43
81-90	179	1.42	15294	3.94
91-100	185	1.46	17706	4.56
101-110	123	0.97	12953	3.34
111-120	105	0.83	12154	3.13
121-130	62	0.49	7750	2.00
131-140	60	0.47	8137	2.10
141-150	41	0.32	5975	1.54
151-160	50	0.40	7781	2.01
161-170	32	0.25	5275	1.36
171-180	22	0.17	3849	0.99
181-190	18	0.14	3342	0.86
191-200	17	0.13	3296	0.85
201-210	16	0.13	3303	0.85
211-220	10	0.08	2160	0.56
221-230	16	0.13	3611	0.93
231-240	10	0.08	2360	0.61
241-250	12	0.09	2935	0.76
251-300	17	0.13	4610	1.19
301-400	17	0.13	5555	1.43
401-500	5	0.04	2207	0.57
501-580	2	0.02	1148	0.30
Total	12632	100	387952	100

maximum number of values 0.71 in the year 2020 followed by 0.70 in the year 2015, 2017, and 2018.

From Table 11 document type-wise distribution of publications of Nuclear Medicine literature was detected. As per the analysis, there were 18 types of document categorized. The document type "Article" was the highly preferred document type by the researchers which received 7544 (59.72%) publications with 138460 citations among all types of documents. The document type "Review" received 1642 (13.00%) publications with 47016 citations and the document type "Meeting Abstract" received 1065 (8.43%) publications with 103 citations. Then again, the document type "Review" had received the highest CPP value of 28.63, followed by document type "Article" with the value of 18.35 and "Proceedings Paper" with the value 18.04 respectively. Then again the document type

"Article" had received the highest h-index value of 134, followed by document type "Review" with an h-index value is 100 respectively.

Table 12 showed the Language-wise distribution of Nuclear Medicine Research. It was recognized that contributions were made in 19 languages at the global level. It was noted that the English language was the leading language of interaction which received 11651 (92.23%) publications with 204449 citations. After that the German language received 448 (3.55%) publications with 1486 citations and the French language received 303 (2.40%) publications with 382 citations. Also, the language English had received with highest CPP value of 17.55, Followed by Polish with the value 3.89 and Korean with the value of 3.50 respectively. The English language has the highest h-index value 156 followed by German with a value of 16.

Table 8. Authorship pattern of nuclear medicine literature

Authorship pattern	No. of contribution	% of 12632	No. of authors	% of 61819
1	1776	14.06	1776	2.87
2	1651	13.07	3302	5.34
3	1590	12.59	4770	7.72
4	1515	11.99	6060	9.80
5	1317	10.43	6585	10.65
6	1183	9.37	7098	11.48
7	874	6.92	6118	9.90
8	713	5.64	5704	9.23
9	461	3.65	4149	6.71
10	381	3.02	3810	6.16
11	245	1.94	2695	4.36
12	153	1.21	1836	2.97
13	112	0.89	1456	2.36
14	75	0.59	1050	1.70
15	65	0.51	975	1.58
16	44	0.35	704	1.14
17	30	0.24	510	0.82
18	19	0.15	342	0.55
19	23	0.18	437	0.71
20	16	0.13	320	0.52
21	17	0.13	357	0.58
22	8	0.06	176	0.28
23	4	0.03	92	0.15
24	5	0.04	120	0.19
25	5	0.04	125	0.20
26	8	0.06	208	0.34
27	4	0.03	108	0.17
28	3	0.02	84	0.14
29	2	0.02	58	0.09
30	2	0.02	60	0.10
31	4	0.03	124	0.20
32	2	0.02	64	0.10
33	3	0.02	99	0.16
36	1	0.01	36	0.06
43	1	0.01	43	0.07
46	1	0.01	46	0.07
53	1	0.01	53	0.09
58	1	0.01	58	0.09
64	1	0.01	64	0.10
69	1	0.01	69	0.11
78	1	0.01	78	0.13
Anonymous	314	2.49	-	-
Total	12632	100	61819	100

Table 9. Single author vs multiple authors of nuclear medicine literature

Sl. No.	Year	Single author	Multiple authors	Anonymous	Total
1	1991	68	101	5	174
2	1992	45	124	1	170
3	1993	82	146	10	238
4	1994	55	148	17	220
5	1995	87	175	19	281
6	1996	75	178	18	271
7	1997	74	224	15	313
8	1998	84	195	21	300
9	1999	63	256	12	331
10	2000	60	233	21	314
11	2001	52	251	19	322
12	2002	59	241	12	312
13	2003	58	267	16	341

Sl. No.	Year	Single author	Multiple authors	Anonymous	Total
14	2004	58	281	7	346
15	2005	42	286	13	341
16	2006	48	302	14	364
17	2007	45	348	8	401
18	2008	56	407	10	473
19	2009	67	379	5	451
20	2010	72	467	8	547
21	2011	57	533	3	593
22	2012	61	483	5	549
23	2013	42	510	7	559
24	2014	55	512	8	575
25	2015	43	500	4	547
26	2016	55	537	7	599
27	2017	44	545	7	596
28	2018	48	600	8	656
29	2019	62	607	8	677
30	2020	59	706	6	771
Total		1776	10542	314	12632
%		14.06	83.45	2.49	

Table 10. Degree of collaboration, collaboration index and collaboration co-efficient of nuclear medicine literature

Sl. No.	Year	Degree of collaboration (DC)	Collaboration index (CI)	Collaboration co-efficient (CC)
1	1991	0.60	4.04	0.41
2	1992	0.73	3.98	0.49
3	1993	0.64	3.97	0.43
4	1994	0.73	4.18	0.51
5	1995	0.67	4.35	0.47
6	1996	0.70	4.55	0.50
7	1997	0.75	4.54	0.53
8	1998	0.70	4.87	0.50
9	1999	0.80	5.13	0.58
10	2000	0.80	5.25	0.58
11	2001	0.83	5.19	0.60
12	2002	0.80	5.05	0.58
13	2003	0.82	5.49	0.60
14	2004	0.83	5.88	0.61
15	2005	0.87	5.27	0.64
16	2006	0.86	5.57	0.63
17	2007	0.89	5.34	0.64
18	2008	0.88	5.58	0.66
19	2009	0.85	5.79	0.64
20	2010	0.87	5.39	0.65
21	2011	0.90	5.65	0.67
22	2012	0.89	5.56	0.66
23	2013	0.92	5.76	0.69
24	2014	0.90	5.91	0.67
25	2015	0.92	6.01	0.70
26	2016	0.91	6.00	0.68
27	2017	0.93	6.33	0.70
28	2018	0.93	6.53	0.70
29	2019	0.91	6.86	0.69
30	2020	0.92	6.76	0.71

Table 11. Document type wise distribution

SI. No.	Document type	No. of contributions	% of 12632	Total citations	% of 206951	CPP	h-index
1	Article	7544	59.72	138460	66.90	18.35	134
2	Review	1642	13.00	47016	22.72	28.63	100
3	Meeting Abstract	1065	8.43	103	0.05	0.10	4
4	Editorial Material	1011	8.00	3855	1.86	3.81	26
5	Proceedings Paper	907	7.18	16361	7.91	18.04	58
6	News Item	192	1.52	137	0.07	0.71	6
7	Letter	159	1.26	667	0.32	4.19	10
8	Correction	33	0.26	18	0.01	0.55	3
9	Note	31	0.25	267	0.13	8.61	9
10	Biographical-Item	15	0.12	5	0.00	0.33	1
11	Reprint	10	0.08	22	0.01	2.20	2
12	Book Review	8	0.06	0	0.00	0.00	0
13	Bibliography	6	0.05	0	0.00	0.00	0
14	Item About an Individual	3	0.02	0	0.00	0.00	0
15	Book Chapter	2	0.02	40	0.02	20.00	1
16	Poetry	2	0.02	0	0.00	0.00	0
17	Discussion	1	0.01	0	0.00	0.00	0
18	Software Review	1	0.01	0	0.00	0.00	0
Total		12632	100	206951	100	16.38	

Table 12. Language wise distributions

SI. No.	Language	No. of contributions	% of 12632	Total citations	% of 206951	CPP	h-index
1	English	11651	92.23	204449	98.79	17.55	156
2	German	448	3.55	1486	0.72	3.32	16
3	French	303	2.40	382	0.18	1.26	8
4	Spanish	149	1.18	493	0.24	3.31	11
5	Portuguese	10	0.08	29	0.01	2.90	4
6	Greek	10	0.08	20	0.01	2.00	3
7	Polish	9	0.07	35	0.02	3.89	3
8	Russian	8	0.06	13	0.01	1.63	2
9	Japanese	7	0.06	11	0.01	1.57	2
10	Italian	7	0.06	2	0.00	0.29	1
11	Czech	6	0.05	15	0.01	2.50	2
12	Hungarian	6	0.05	2	0.00	0.33	1
13	Serbian	5	0.04	2	0.00	0.40	1
14	Chinese	5	0.04	1	0.00	0.20	1
15	Korean	2	0.02	7	0.00	3.50	1
16	Croatian	2	0.02	2	0.00	1.00	1
17	Turkish	2	0.02	0	0.00	0.00	0
18	Slovene	1	0.01	1	0.00	1.00	1
19	Unspecified	1	0.01	1	0.00	1.00	1
Total		12632	100	206951	100	16.38	

3. RECOMMENDATIONS

Based on the findings of the research study two sets of recommendations have been made one for research organisations and another for researchers.

- Sign more MOUs with leading research institutions and universities to encourage collaborative research.
- Motivate the researchers to publish more by providing incentives and awards.
- Train the young researchers in Research methodology and preparation of papers for publications in journals.
- Researchers have to do more collaborative work.
- Researchers have to publish more in journals which have high Impact factor.
- Researchers can perform similar research in a new context, location and culture

4. CONCLUSIONS

Scientometric assessment becomes a key element of research in the Library and Information. Productivity indicators can be measured through several publications by scientists, Science institutions, and countries. Such kinds of studies provide an insight into the dynamics of research activities and facilitate the researchers/scientists, policymakers to provide adequate facilities and proper guidance. Hence, it is the indispensable technique used to the quality and quantity of literature published from various disciplines within a particular geographical area. This research is the pioneering scientometric study on nuclear medicine research. The study has evaluated a total of 12,632 documents published during a period of 30 years i.e. from 1991 to 2020, using specific scientific indicators. All the seven objectives of the research study have been fully accomplished.

CONSENT

It's not applicable.

ETHICAL APPROVAL

It's not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
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