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Scientific Productivity of the Nuclear Medicine Literature: A Scientometric Analysis

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Abstract: ***The present study is to analyze the scholar publications of nuclear medicine research for 30 years from 1991 to 2020. These study objectives to discover the list of most important journal publications, the growth rate, and the research productivity and contribution of authors and institutions. Every country, continent and a number of similar aspects nationally and internationally in nuclear medicine. The extracted data was in text format, analyzed according to the objectives of the study the use of Histcite , Microsoft-Excel suite and VOS viewer software, and presented as data tables and graphs. Scientific measurement techniques are involved in evaluating the publication of nuclear medicine, the growth rate of research publications, author productivity, collaborations, citations, high-quality journal lists, and the geographical distribution of publications nationally and internationally in nuclear medicine. This study published that the development of nuclear medicine used to be unstable till 2017. Then, gradually increasing from 2018 to 2020, 12,632 publications had been covered in the Web of Science Database on Nuclear Medicine. The outcomes show that the highest quantity of publications published in 2020 used to be 771.***

Keywords: Nuclear Medicine, Scientometric, Citation Analysis, Author Productivity, Bradford's distribution and Geographical distribution

1. Introduction

Scientometrics is one of the quantitative studies of the literature of scientific disciplines and their research relevance. It identifies emerging areas of scientific research and explores the development of research over a significant period. Besides, Scientometrics is gaining more importance in libraries and other types of research in information science. This includes quantitative studies of scientific activities, research communications, publications, and bibliometrics measurements. The quality of research depends on quality library service. Good research emphasizes the development of generation, policies, or theories. In the age of information explosion in science and technology, bibliometrics / Scientometrics are becoming a common research tool to explore the impact of a particular research field or organization or country. This study examines research performance in the literature published from the Web Science Database in Nuclear medicine research over the past 30 years from 1991 to 2020.

2. Nuclear Medicine Research

Nuclear medicine is a branch of medical science that uses radioisotopes to diagnose and treat quite number disorders. At diagnosis, nuclear imaging is unique due to the fact it provides accurate functional data that is no longer reachable from other conventional imaging methods. Gamma cameras, SPECT-CT, PET-CT, and PET-MRI are advanced nuclear imaging equipment. It is also the major molecular imaging approach to depict glycolytic activity, amino-acid turnover, protein synthesis, receptor distribution, and many other molecular and biochemical phenomena. Nuclear imaging is one of the essential imaging techniques for most cancers and many benign non-cancerous diseases. Radio-isotope treatment is indicated for thyroid cancers, neuroendocrine cancers, hepatocellular carcinomas, and painful bone metastases; in vitro and in vivo radiotherapy techniques are important equipment in superior medical research. Modern medicine and oncology can't be practiced barring nuclear medicine.

Nuclear medicine has long history and has been contributed for decades through scientists in a variety of fields such as physics, medical chemistry and engineering. This versatile involvement makes it difficult for historians to trace the origins of nuclear medicine. However, researchers accept as true with that the birth of this radiological phenomenon might also have happened between 1934 when synthetic radionuclides have been first discovered, and cloned with radionuclides for medical use by using the Oak Ridge National Laboratory in 1946.

Nuclear medicine was first diagnosed as a potential medical specialty in 1946 when it used to be described through Sam Seidlin in the Journal of the American Medical Association. Seidlin reports on the success of radioactive iodine (I-131) in the treatment of sufferers with advanced thyroid cancer. Subsequently, the use of I-131 was once extended to applications such as thyroid gland imaging, therapy of hyperthyroidism, and thyroid function. India has a significant lack of nuclear medical technicians. Many nuclear medicine units -diagnostic and treatment systems are being established across the country; however there is a lack of skilled manpower. Such human resources additionally play a key role in medical research, drug development laboratories, cyclotron units, imaging equipment, and the pharmaceutical industry.

3. Review of Literature

Vijayakumar, Sivasubramaniyan, and Rao (2019) carried out the "Bibliometrics analysis of the Indian Journal of Nuclear medicine during the duration 2014-2018".

The data retrieved from the Scopus bibliographic database for the study. The main objectives of the study are authorship patterns, the most prolific authors, most productive countries. They reported 513 papers published in the study period. 2017 used to be the most productive year, with 114(22.22%) publications. The highest citation was once acquired in the year 2014 with 195(36.25%). The excessive frequented key phrases are "Human" which is the topper with 434 (84.60%) publications. The most productive journal in India with 388 (75.63%) publications.

Esmaeilpour-Bandboni et al., (2018) The study was conducted in the "Scientometric analysis of Radiology, Nuclear Medicine and Medical Imaging publications of Iran in the Web of Science and Scopus Database". In this study, a total of 3335 data were retrieved from the Web of Science and Scopus database between 2001 and 2016. The h-index of Iranian scientific documents is ranked 28th and 99.8% of the documents were published in English. 221032 documents are listed in the 2016 Scopus on Radiology. The annual publication compares the top 10 types of research conducted in collaboration with countries, journals, institutions and universities and selected two databases. The study concludes that Iranian researchers in the field of radiology were increasing the volume and quality of their scientific articles.

Mini Devi (2015) a study had been done entitled "Scientometrics analysis of the growth of literature in Nuclear Medicine". The data was retrieved from the Web of Science database core collection provided by Thomson Reuters from 1999 to 2014. Some aim was used in this study, such as relative growth rate, doubling time, growth of output, and rapid growth of productivity. This study has been found to facilitate medical policymakers with optimal infrastructure and other essential ancillary facilities for the researcher.

McKellar and Currie (2015) "Publication productivity in nuclear medicine from 2009 to 2013" was evaluated. They received data from the PubMed database; they procured 165 documents from the database. The most prolific Radiotherapy author Therapist 2nd place with 42 articles. This study found that Brennan was the best radiographer in the 1st place with 58 articles.

Zeraatkar (2013) studied radiology, nuclear medicine, and medical imaging: A Bibliometrics study. This paper indexed in the Thomson Reuters Web of Science database in the field mentioned above with at least one affiliation corresponding to "Iran" was included in the study. VOS viewer software was used to analyze the data for generating density maps and density cluster maps of organizations, authors, and journals based on bibliographic coupling and co-citation similarity measures. Tehran University of Medical Sciences has proven to be the dominant institution in the country in all fields of radiology, nuclear medicine and medical imaging. The study concluded that more detailed studies could be done to obtain more mature scientific maps. The study noted that it would be useful for decision makers to make similar analyzes for other countries and then compare them with internal scientific maps.

4. Objectives of the Study

1) To study the research productivity development of nuclear medicine research production nationally and internationally from 1991 to 2020.
2) To find the year-wise distribution of pages and references in Nuclear Medicine.
3) To find the most effective authors of Nuclear Medicine research.
4) To study Language-wise distribution and document-wise distribution in nuclear medicine
5) The implication of the Lotka's law is related to author productivity in nuclear medical research.
6) To suggest the rational measures to enhance to yield high research productivity in Nuclear medicine.

5. Methodology

The study purposes 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 extracted 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 extracted data were in a textual format and the same were analyzed by using the Microsoft-Excel package, and VOS viewer Software as per the objectives of the study, and the data has been presented as tables and graphs. Scientometrics techniques evaluate the publication of Nuclear Medicine, the growth rate of research output, authorship productivity, collaborative tendency, citation metrics, top journal list, and geographical distribution of publications at national and international levels in Nuclear Medicine.

6. Data analysis and Interpretation

6.1 Year-wise publication of Nuclear Medicine Literature

Figure 1: Growth of Nuclear Medicine Literature

Figure 1 reveals that 12,632 publications were published in Nuclear Medicine research from 1991 to 2020. The highest number of publications released in 2020 was 771. The lowest publications were 170 published in 1992. But the table shows the increasing trend of growth literature during the study period.

6.2 Year-wise distribution of Pages in Nuclear Medicine Literature

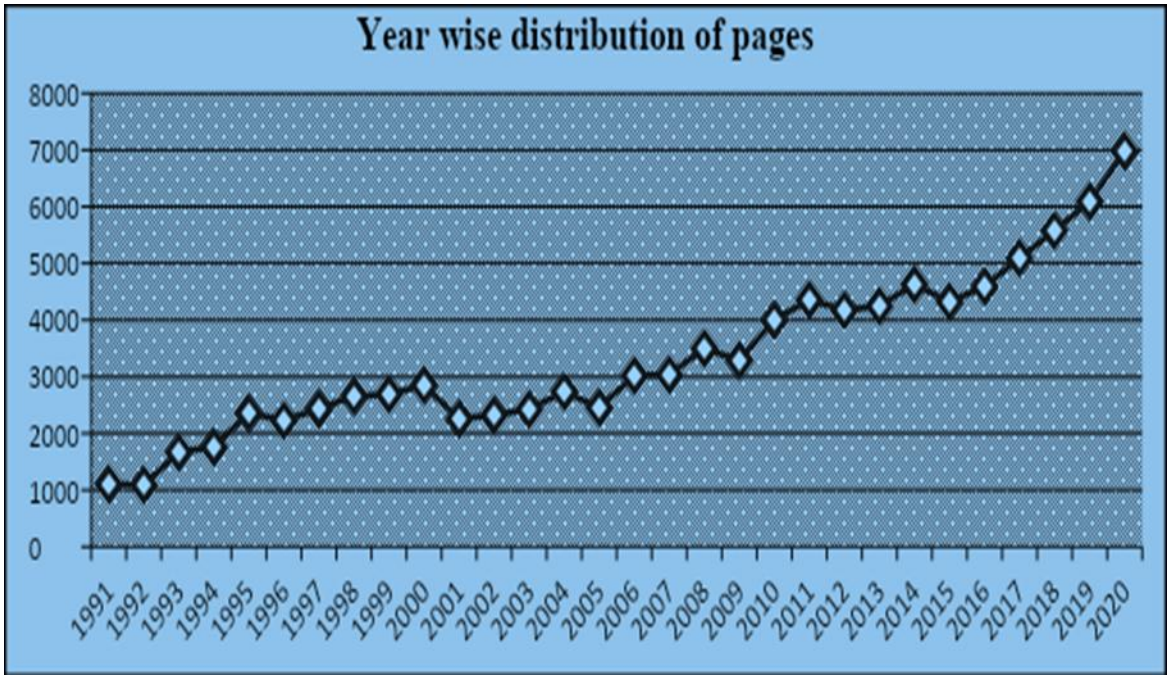

Figure 2: Year-wise distributions of pages in Nuclear Medicine

Figure 2 shows the number of pages in the Nuclear medicine literature for the period 1991-2020. It was found that there were 12632 publications on 99952 pages during this period. The maximum number of 6982 (6.99%) pages in 2020 was 771 publications, followed by 6089 (6.09%) pages with 677 publications in 2019. The average number of pages per publication in 2020 was 9.06%, followed by the average number of pages per publication in 2019 at 8.99 and the average number of pages per publication in 2017 was 8.54, respectively.

6.3 Language-wise distribution of Nuclear Medicine Literature

It has been identified in a language-wise research publication in nuclear medicine for the present research.

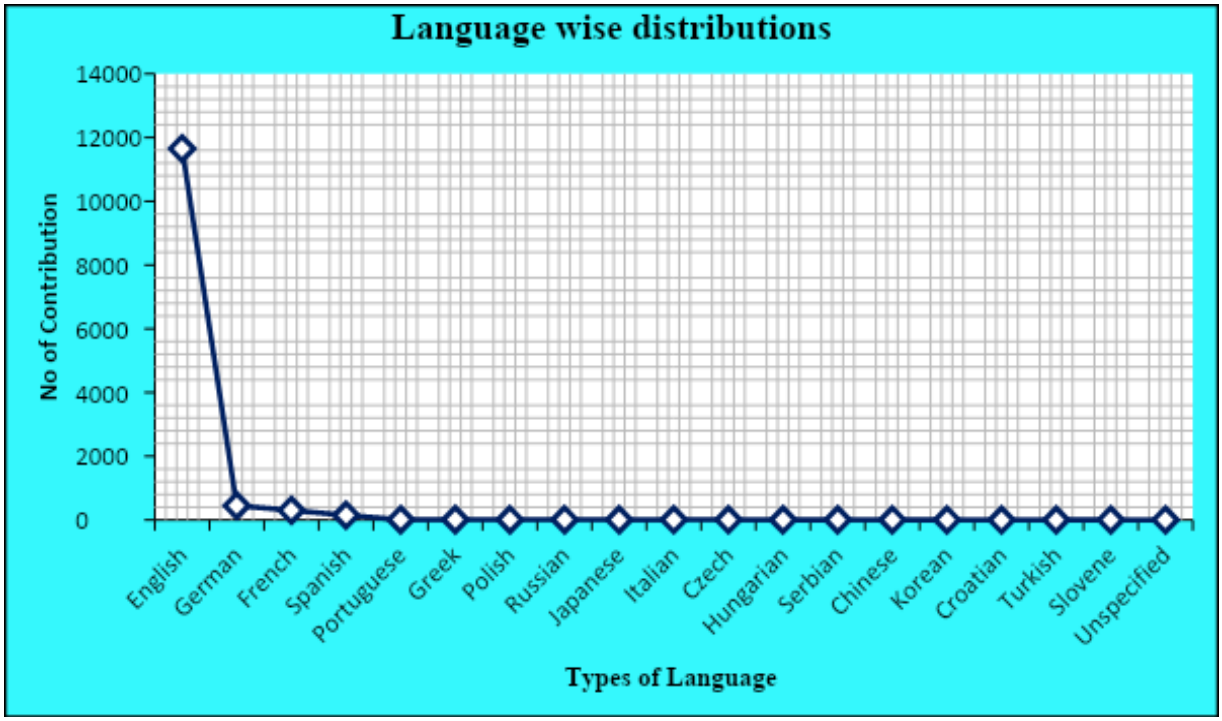

Figure 3: Language- Wise distributions

Figure 3 illustrate the language-wise distribution of the nuclear medical literature. Of the total 12632 records, 11651 (92.23%) were published in English, followed by 448 (3.55%) in German, 303 papers in French (2.40%), 149 papers in Spanish (1.18%), 10 papers in Portuguese and Greek (0.08). In remain languages, 9 documents in Polish (0.07%), 8 documents in Russian (0.06%), 7 papers in Japanese and Italian (0.06%), 6 documents in Czech and Hungarian (0.05%), 5 Documents in Serbian and Chinese (0.04%), 2 in Korean, Croatian and Turkish (0.02%), and 1 paper in Slovene (0.01%) and in unspecified languages. Therefore, English dominates worldwide publications in nuclear medicine research.

6.4 Document type-wise distribution of Nuclear Medicine Literature

This shows that there were different literary publications in nuclear medicine literature, such as research papers; research Articles, reviews, Editorial Material, Meeting Abstracts, etc.

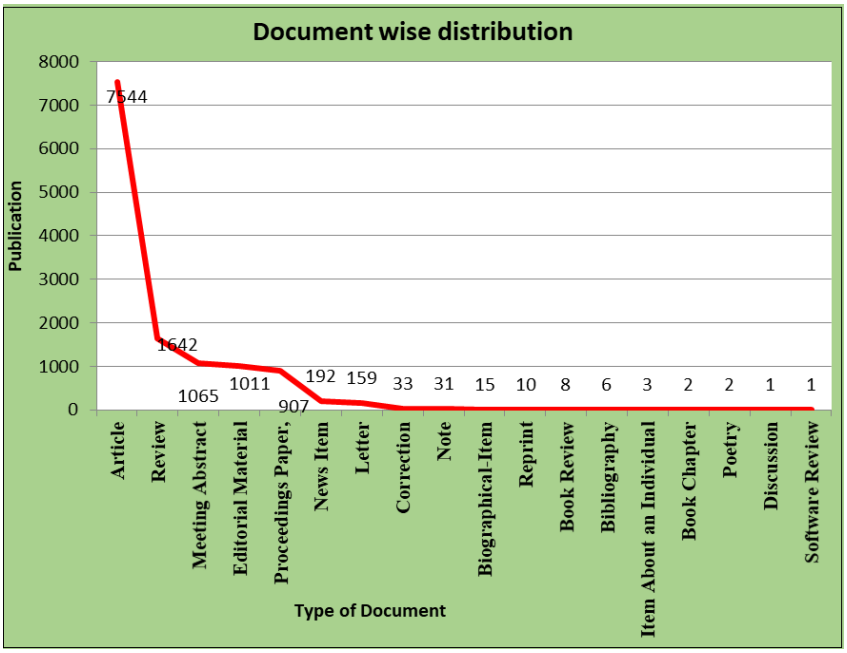

Figure 4: Document Type Wise Distribution

Distribution of Nuclear medicine literature Identified from Figure 4 documents. According to the analysis, 18 types of documents were classified. "Article" is the most preferred document type by researchers with 7544 (59.72%) publications with 138460 Citations in many documents. The document type "Review" received 1642 (13.00%) releases with 47016 Citations, and the "Meeting Summary" document type received 1065 (8.43%) records with 103

Citations. Again, the maximum CPP value of the document value "review" is 28.63, followed by the document type "article" value 18.35. The document type "article" received a maximum H-index value of 134, followed by the document type "Review" H-index value of 100.

6.5 Research area-wise distribution of Nuclear Medicine Literature

This shows that there were different research area publications in nuclear medicine literature, such as Chemistry; Oncology, General Internal Medicine, Environmental Sciences Ecology, Public Environmental Occupational Health, Engineering, Physics and Pharmacology Pharmacy.

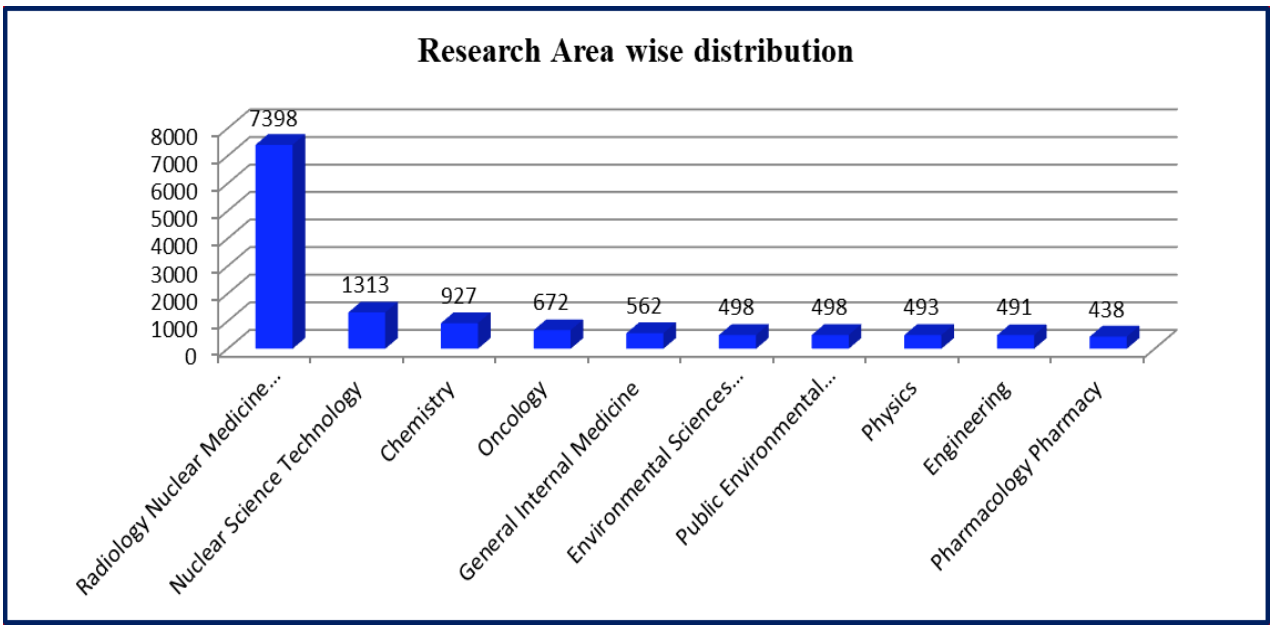

Figure 5: Top 10 Research area wise distributions of publications

Figure 5 show the research area-wise distributions of the publications. Analysis of the data can reveal that 107 research areas have been conducted in Nuclear Medicine research worldwide.

The research area contains a maximum of 7398 (58.56%) outputs of radiological nuclear imaging and the total citations were 112228. Nuclear Science Technology 1313 (10.390) publications with 13881 total citations. Followed by Chemistry has published 927 (7.33%) publications with a total citation is 15963, Oncology 672 (5.32%) publications with the total citations of 16622, General Internal Medicine 562 (4.44%) with the total citations of 5539, Environmental Sciences Ecology 498 (3.94%) with the total citation of 3916, Public Environmental Occupational Health 498 (3.94%) with the total citations of 3737, Physics 493 (3.90%) with the total citations of 6003, Engineering 491 (3.88%) publications with the total citations of 10068 and Pharmacology Pharmacy 438 (3.46%) publications with the total citations of 6470.

6.6 Keywords plus Occurrence of Nuclear Medicine Literature

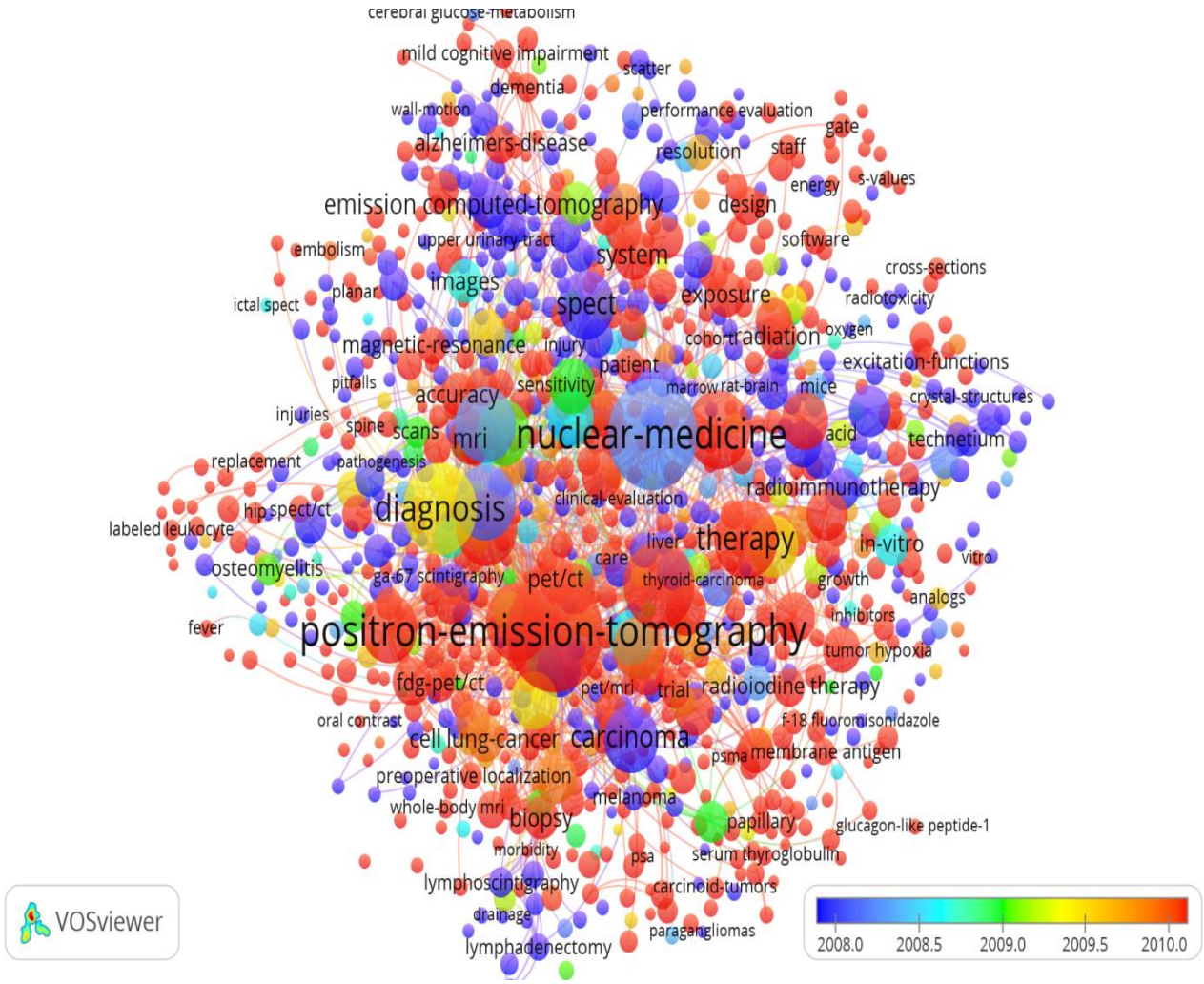

Figure 6: Top 50 Keywords plus of Nuclear Medicine Literature

Figure 6 indicates the keywords of the plus occurrence in the selected field of study. A total of 61308 keywords were used in this research. The keyword "Positron-Emission-Tomography" tops the position with 1088 (1.77%) records. "Nuclear-Medicine" in 2nd position with 964 (1.57%) records. "Diagnosis" 3rd position with 617 (1.01%) records. "Cancer" is in the 4th position with 556 (0.91%) records. "Therapy" is in the 5th position with 445 (0.73%) records. "Management" is in the 6th position with 440 (0.72%) records. The top 50 keywords were only mentioned in the table above.

6.7 Single Author Vs Multi - Authors of Nuclear Medicine Literature

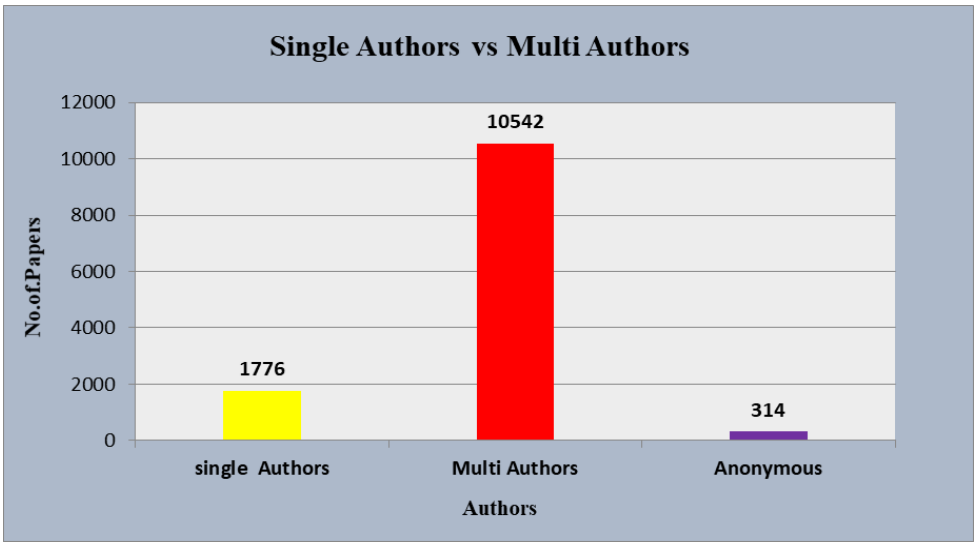

Figure 7: Single Author Vs Multiple Authors Contributions

Figure 7 shows that the contributions made by single authors and multi- author during the study period were inconsistent. The highest percentage of single author contributions was found in 1995 with 87 publications and the maximum percentage of multi-author contributions was found in 2020 with 706 publications. The multi- authorship pattern was the largest, with 10542 (83.45%) publications was much larger than the single authorship pattern with 1776 (14.06%) publications. In the nuclear medical literature, collective creativity is known as an important form of authorship pattern.

6.8 Source Title Distributions of Publications

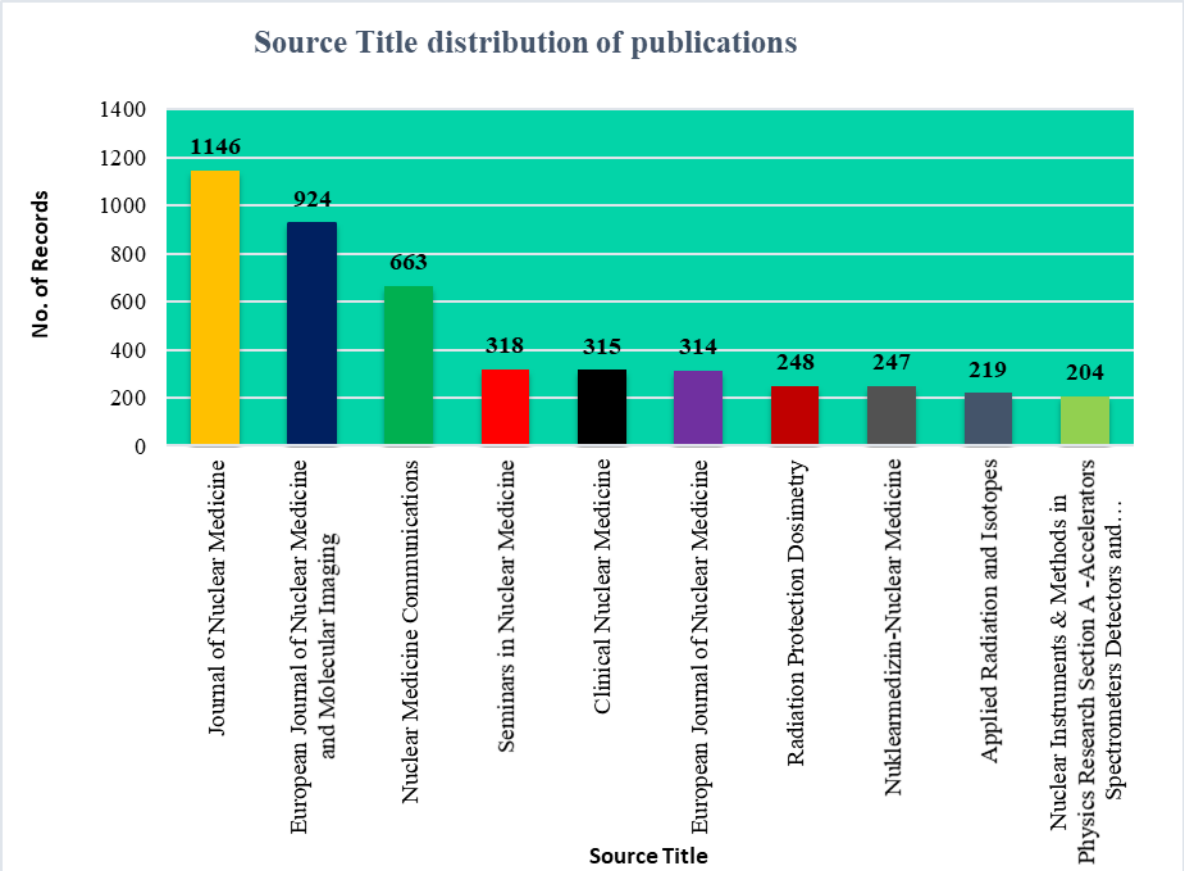

Figure 8: Top 10 Source Title Vs Number of Publications

Figure 8 illustrate the source title-wise distribution of the publication in the selected research field. 1845 source titles contributed to nuclear medicine research. The Journal of Nuclear Medicine, published by the Society of Nuclear Medicine and Molecular Imaging of the United States, tops the list with 1146 (9.07%) publications and is identified as H-Index 85. It is followed by European Nuclear Medicine and Molecular Imaging and H-Index 63 with Springer 924 (7.31%) publication from the United States, Atomic Communications from the United States with 663 (5.25%) publications and H-Index value of 33, seminars on nuclear medicine from the United States 318 (2.52%) with publications, and the H-Index value is 49, Medical Nuclear Medicine from the United States with 315 (2.49%) publications and 314 (2.49%) publications from the European Atomic Energy Journal and H-Index value with 43. The remaining 44 original titles were given in the table above.

6.9 Bradford's Distribution of Sources

Bradford's law of scattering is a law for reducing returns and scatter. Bradford enacted the law in 1948 and claimed the given subject area that "there are a few very productive periodicals, a large number of moderate producers, and a large number of declining productivity." Many major journals provide the core of articles on a given topic, which make up a substantial percentage (1/3) of the articles, followed by the second largest group of journals with one-third. A large group of journals picked up the last third.

Table 1: Bradford's Distribution of Sources in Zones

Zone	No. of Journals	% of 1490	No. of Articles	% of 7544	Bradford Multiplier
1	13	0.87	2532	33.56	-
2	128	8.59	2516	33.35	9.85
3	1349	90.54	2496	33.09	10.54
	1490	100	7544	100	20.39 (10.20)

According to Bradford's Journal distribution, the relationship between zones is 1: n: n^2. According to Bradford, three zones were created for the distribution of journal and the number of articles published in each journal. The distribution of these three zones is given in the table. In the context of the current literature on Nuclear Medicine, 13 journals constitute 2532 articles in the first zone, 2516 articles in the next zone of 128 journals, and the largest group of 1349 journals with 2496 articles. Bradford proposed dividing each zone into three equal zones with one-third of the articles. According to Bradford's law, each zone must follow a linear geometric expression in the form 1: n: n^2.

Bradford's journal distribution was able to see the differences in the relationship between the zones were found to be 13: 128: 1349. The Bradford multiplier factor between the first and second zones was 9.85, the second and third zones were 10.54, and the average multiplier value was 10.20.

Bradford's distribution= $13:13\times10.20:13\times(10.20)^2 = 1: n: n^2$
i.e.13:132.60:1352.52=1498.12
Percentage of error $= \frac{1498.12-1490}{1490} \times 100 = 0.54\%$

Based on this calculation, it was found that the percentage error was low and that the data in the Nuclear Medicine literature were fit the Bradford's Law.

6.10 Country wise Distribution in Nuclear Medicine Literature

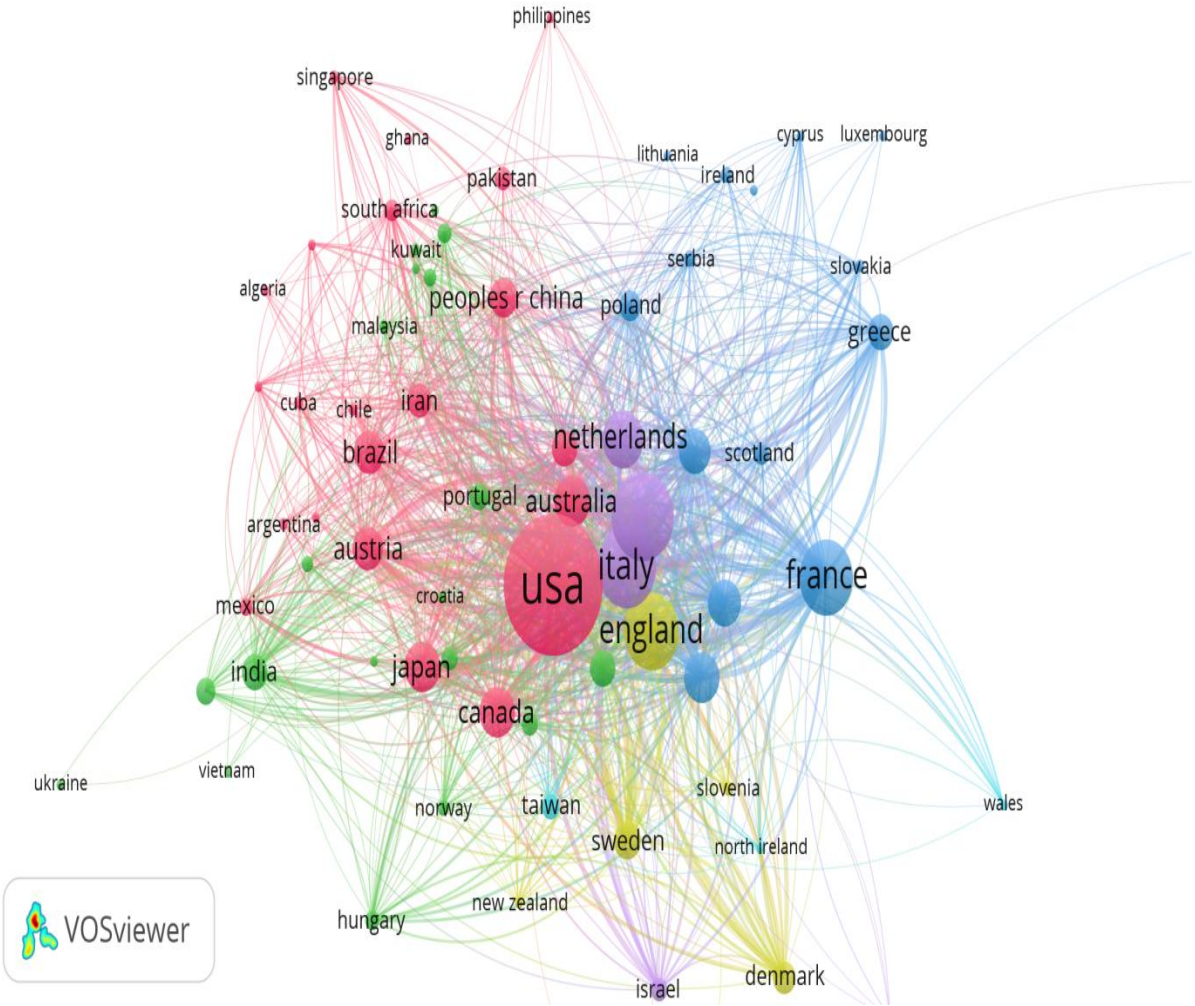

Figure 9: Country wise Distribution in Nuclear Medicine Literature

Figure 9 show the contribution country-wise publications to the Nuclear Medicine literature for the period 1991 to 2020. There were 108 countries involved in the Nuclear Medicine Literature. Of those, the United States topped the list with a maximum share of 3480 (27.55%) publications, with 89795 citations and 124 with h-index. Germany got in second position with 1330 (10.53%) publications with 31297 citations; the h-index was 84. Italy became third position with a share of 1145 (9.06%) publications and 21810 citations with the h-index were 68. India has the 211(1.67%) publications with 2741 times cited, all database citations and the h-index is 25 and listed in the 20th position.

6.11 Continent –wise distribution of Nuclear Medicine Literature

Table 2: Continent wise Distribution of Nuclear Medicine Literature

S. No.	Continent Name	No. of Contributions	% of 12632	Times Cited, All Databases	% of 206951	Citation Per Paper (CPP)	Relative Citation Impact (RCI)	Rank
1	Europe	8507	67.34	180855	87.39	21.26	1.30	1
2	North America	4011	31.75	102511	49.53	25.56	1.56	2
3	Asia	1984	15.71	24073	11.63	12.13	0.74	3
4	Oceania	461	3.65	8528	4.12	18.50	1.13	4
5	South America	414	3.28	4972	2.40	12.01	0.73	5
6	Africa	228	1.80	1416	0.68	6.21	0.38	6
Undefined		763	6.04	1186	0.57	1.55	0.09	

This analysis covers the research publication of the nuclear medicine research literature at the continental level. There were seven continents, but here the researcher has taken only six continents because the last continent of Antarctica has no contribution to the publications of this region. So for this part of the analysis, the researcher has selected the continents of Asia, Europe, Africa, North America, South America, Europe and Oceania.

Table 2 illustrates the continental-wise distribution of the total research publication of the nuclear medicine literature. During the cited period, the European continent ranked first with the highest publications of the 8507 (67.34%) records of the nuclear medical literature, followed by the 180855 (87.39%) value of all databases and the second-largest publications in the North American continent with 4011 publications. (31.75%) and time cited, all database citations were 102511 (49.53%). From this analysis, it can be seen that the Asian continents contributed in 1984 (15.71%).

7. Recommendations

- The government and other private International Organization may establish separate research institution with adequate financial support to carry out nuclear medicine research and it will helps to produced more publication.
- Nuclear scientists need to be provided with proper protection is essential to understand the impact of a virus such as COVID-19.
- A research consortium may be formed by the top producing countries in Nuclear medicine research. It will help the lower producing countries to strengthen and deepen the research in nuclear medicine.
- The Indian scientist should be encouraged to produce good quality Nuclear medicine research output, which should be published in the highly impacted international journals.
- The study suggest that, in order to improve the nuclear research publications with modern methods, tools, equipment, quality of research laboratories, improved internet connectivity, access to information, course content and teaching quality to improve the quality of research methods, research and development centers and colleges are to be established.
- There is a need to establish more interdisciplinary research institutes to uncover the positive aspects of nuclear research for the benefit of society. This study will help determine the extent and direction of nuclear medicine research we need in our country.

8. Conclusion

The study was conducted quantitatively on the contributions made by the nuclear medicine research publications based on a scientometric analysis of 12632 records published in various forms and the data retrieved from the WoS database from 1991-2020. The researcher highlighted an in-depth analysis on the scientific outputs, citations analysis, time series analysis, authorship pattern and Lotka's law of author productivity, Relative Growth Rate, Doubling Time, major journals, Bradford's distribution of journals, author Geographical distribution of publications, types of sources, Language, keywords, Activity Index, the degree of collaboration, and co-authorship index. About country-wise productivity; there were 108 countries involved in nuclear medicine research is produced scientific publications and United States contributed the highest scientific output with 3480 (27.55%) publications followed by Germany with 1330 (10.53%) publications, Italy with 1145 (9.06%) publications, the UK with 1105 (8.75%) publications, France with 968 (7.66%) publications. India contributed 211 (1.67%) of the world output placed in the 20th position.

The results of the study shown that the growth of Nuclear medicine fluctuated till 2017. Afterward, there was a gradual increase from 2018 to 2020. This forecast an increase in the number of publication growth in the future. The Growth of literature had shown no definite form. Bradford's scattering law is used to identify major journals and determines 'Scientometrics' as major journals in this field. Lotka's law was used to identify the production methods of authors. It can be seen that the distribution of the authors did not follow the law of Lotka's Law. Mapping the research publication was done using VOS viewer software. It helps to clearly understand the output and distribution of data. The researcher says that the main purpose of measurement activities is to provide information that leads to quality judgment, which will make scientists a prospective part of the general "scientific science" and a powerful tool for research and innovation.

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