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VISUALIZATION OF INDIA'S SCHOLARLY PUBLICATIONS ON ZIKA VIRUS

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Abstract

This study used VOSViewer to visualise the India's scholarly publication on zika virus in the year 2021. Scopus database was used to extract the required data and total of 508 documents selected for the study after applying filters. The study found that 255 publication is research articles out of 508 which received 7674 total citations, Govindarajan, M. of Annamalai University has highest number of publication (36) which gained 1124 citations. There is about 80 and 57 publications in collaboration with USA and Thailand respectively. 'Zika virus' is highly used keyword, occurred for 144 times, by authors.

Keywords- zika virus, bibliometric, scholarly publications, VOSViewer, India.

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1. Introduction

The Flavivir-idae family of arboviruses includes the Zika virus (ZIKV), which was first discovered in Uganda (1940s) [1] reported to produce minor clinical signs and symptoms resembling dengue, chikungunya, and yellow fever [2]. However, curiosity grew quickly once ZIKV was discovered in Brazil in 2015 [3]. Different Aedes species are known to spread the virus during pregnancy from mother to foetus [2], but other routes of exposure, including blood donations, perinatal transmission, and through physical intercourse, have also been mentioned [4].

The first human cases were discovered in Africa and Asia, but more recent outbreaks in a number of areas around the globe, including Egypt, Easter Island, the Pacific Island chain [5], and most recently (2021) India [6], have made it clear that the scientific and public health communities must take this disease into account as a potential massive threat [5]. Several non-endemic nations, including Japan, Germany, Canada, Australia, and the United States, have reported imported cases [7] [8] [9] [10]. The ZIKV virus has now been identified in Uttar Pradesh, Kerala, Telangana, Jharkhand, Rajasthan, Punjab, and Delhi in India, where an ICMR investigation conducted last year discovered 64 cases in 1,475 samples [6]. The description of severe neurological consequences, such as Guillain-Barre syndrome (GBS) in adults in French Polynesia and microcephaly in newborns, was linked to the introduction of ZIKV [11]. The 53 virus species that make up the genus Flavivirus are divided into three clusters: viruses spread by ticks, viruses spread by mosquitoes, and infections with no known vector [12] [13] [14].

Glaucoma has not yet been documented in India. "Infections with the ZIKV virus are now increasingly widespread in India, particularly in the states of Maharashtra, Gujarat, and Madhya Pradesh. Therefore, we would like to state that the ZIKV is already pandemic in India" Internal Medicine Director at Fortis Memorial Research Institute in Gurugram, Dr. Satish Koul, said to IANS [15]. The World Health Organization (WHO) issued a warning in April 2020 that infections carried by insects, such as Zika and dengue, might start the next pandemic.

According to Dr. Merlin Moni, Clinical Associate Professor, Division of Infectious Diseases, Amrita Hospital, Kochi, ZIKV is expected to continue spreading in India due to "growing rates of global warming" that are resulting in "erratic rains and an increased mosquito population." [16]

The Organisation for Economic Co-operation and Development (OECD) defines bibliometrics as the statistical analysis of books, articles, or other publications for the purposes of determining national and international networks, quantifying the "productivity" of personalities, research groups, organizations, and nations, and charting the growth of multi-disciplinary fields of science and technology [17]. Pubmed, Scopus, and Web of Science, among others, are only a few examples of the scientific publication databases that are frequently used for bibliometric analysis to determine the worth of published scholarly production globally [18]. Therefore, in order to track the publications of ZIKV research [3] across India, we adopted a bibliometric analysis strategy employing scholarly publication databases. For analysis, we gathered papers for the years 2020–2021 and used a variety of criteria to look at India's highly cited publications on ZIKV research. The present study aimed at visualization of India's research outcome on ZIKV by examining the chronological growth of literature on the document-wise publications, major funding agencies along, with the number of highly cited publications, collaborated countries with India, subject-wise distribution, most

productive authors, and profile of top most productive national and international organizations. An attempt was also made to identify the scholarly publications on ZIKV.

The VOSviewer software's visualization of resemblance mapping approach was used to create term maps [19]. A software programme for creating and visualizing bibliometric networks is called VOSviewer. In order to create and visualize co-occurrence networks of significant phrases taken from a body of scholarly publications, VOSviewer additionally provides text mining features [20]. The VosViewer was used to find scholarly publications as well as scientific links [21] between nations or academic organizations.

2. Literature Review

Continet and et.al. (2022) in this work, the three arboviruses with the greatest impact—Zika, Chikungunya, and Dengue—were identified, and their contributions to scientific production were determined using bibliometric analysis. VosViewer was used to find scientific relationships between nations or academic institutions as well as research ideas. In this study, authors discussed the USA-Puerto Rico partnership, which was discovered to be the leader on emerging arboviruses (Zika and Chikungunya), followed by a cluster that was primarily composed of French-language sources (mainland France, Guadeloupe, Martinique) [21].

In this study, Perryman and colleagues (2022) compared the disparities in authorship between the COVID-19 and pertinent infectious diseases in Africa. The research on COVID-19, which was done during a public health emergency, was compared with the research on four other infectious diseases that are relevant to Africa namely Ebola, Zika Virus (ZIKV), Tuberculosis (TB), and Influenza [22].

Delwiche (2021) did a bibliometric analysis of Zika virus-related Letters to the Editor published between 1952 and 2018. He performed a PubMed search using the terms (Zika OR ZIKV). Results were restricted to Publication Type = Letter and 1952-2018. One of five categories—Reader Response, Author Reply, Observation, Case Report, or Research—was given to each Letter. The number of authors, the number of references, the use of graphics, and funding were additional study criteria. In this analysis, the author also mentioned how letters to the editor are still a crucial part of scientific discourse and can be a great source of data for both clinical and academic studies [23].

In this study, Machado-Silva and et.al. (2019) sought to evaluated the potential contribution of new S&T information generated and disseminated regionally to solve global health concerns. Up until December 2017, the LAC's scientific contribution and potential for technical advancement on ZIKAV were evaluated using scientometric and social network analysis techniques. Publications on ZIKAV were found in the Web of Science, Scopus, and PubMed databases. The SciELO (Scientific Electronic Library Online) and LILACS (Literature in the Health Sciences in Latin America and the Caribbean) databases were used to find regionally published papers. This study also clarified that vector control, which was the primary emphasis of patents, was the other major contribution of LAC research, which focused mostly on the clinical signs of the ZIKAV infection [24].

Delwiche (2018) found that there was a dramatic increase in scientific publications on this subject during the 2015–2016 Zika Virus (ZIKV) pandemic in the Americas. A bibliometric analysis of all articles discovered in PubMed that were published on ZIKV between 1952 and 2016 was done in an effort to comprehend and describe this body of material. The amount of opinion pieces and research articles published on ZIKV and five other emerging infectious diseases was compared in the study's

conclusion. As a starting point for further analysis, the author also discussed the interest among students, academics, librarians, and information science professionals [25].

For the goal of illustrating the phenomenon, Munuswamy and Jeyasekar (2018) in this study established a substantial association between a spike in research effort in the field and the breakout of the Zika disease. The data is assessed using the following criteria: literature growth since 1975; the most prolific authors and their contributions; the top contributing institution, country, and journal; identifying co-authorship clusters of the authors and institutions; and finally, creating and examining co-word maps of the keywords. Along with the United States, France, and Germany, the study also revealed that developing nations like Senegal and Zambia had made contributions to the study of the Zika virus [26].

Gwon and Evander (2018) study analysed the influence of ZIKV research during those years authors opted to undertake a bibliometric analysis of ZIKV research. The scientific databases PubMed and Scopus were used for the bibliometric analysis used to find research publications on ZIKV. According to study, the number of publications relating to the Zika virus rose 38–41 times between 2016–2017 and 2015. The authors further examined the temporal shift in ZIKV research trends that occurred over the course of three years, from the publication of ZIKV case studies and diagnostic techniques to the advancement of ZIKV prevention and treatment, and they demonstrated how ZIKV research expanded internationally over this time [27].

According to Martin-Acebes and Saiz (2019), a substantial portion of the scientific community began focusing on ZIKV research in 2015, which led to an unexpected growth in our understanding of the biology and pathophysiology of this virus. The scientific community's quick reaction to ZIKV illustrates how powerfully and quickly it is able to combat a viral threat. This extensive collaborative effort was also anticipated in this study to result in ZIKV prevention and treatment measures that are both economical and efficient [28].

Nasir and Ahmed (2018) used Microsoft Excel and the Word Cloud programme to examine all of the publications about the Zika virus that were published worldwide between 2008 and 2017 and listed in the Web of Science. A total of 3384 articles were obtained for analysis after the data were taken from all Web of Science databases. According to the data, there hasn't been much research on this virus over the past ten years. Only in the last three years has the focus turned to research on Zika. With a total of 24 papers, Pakistan has a small portion of the world's publications on the Zika virus. The analysis also discovered that the US (47.07%) accounts for the majority of the published studies on the Zika virus [29].

Singh (2016) examined the research productivity on Zika virus (ZV) using scientometrics in this study. The various facets of the scientific literature available through "Scopus" on the topic under inquiry were investigated. Bradford's law of dispersion was used to determine the distribution of papers in journals, and Lotka's law was used to evaluate author productivity. The findings showed that there was significant research/authorship collaboration on ZV. With n = 2, the authorship pattern did not follow Lotka's law. In this study also found the distribution of articles in journals was found nearly acceptable to the Bradford's law of scattering, advocating the existence of a few core journals contributing significantly on Zika Virus [30].

3. Methodology

The following searching string was run on 8th January, 2022: (TITLE-ABS-KEY(zika Virus) AND (LIMIT-TO (EXACTKEYWORD,"Human") OR LIMIT-TO (EXACTKEYWORD,"Zika

Virus") OR LIMIT-TO (EXACTKEYWORD, "Zika Virus Infection") OR LIMIT-TO (EXACTKEYWORD, "Virology") OR LIMIT-TO (EXACTKEYWORD, "Dengue") OR LIMIT-TO (EXACTKEYWORD, "Epidemic") OR LIMIT-TO (EXACTKEYWORD, "Dengue Virus") OR LIMIT-TO (EXACTKEYWORD,"Aedes") OR LIMIT-TO (EXACTKEYWORD, "Flavivirus") OR LIMIT-TO (EXACTKEYWORD, "Virus RNA") OR LIMIT-TO (EXACTKEYWORD,"Aedes Aegypti") OR LIMIT-TO (EXACTKEYWORD,"Virus Infection") OR LIMIT-TO (EXACTKEYWORD, "Pregnancy Complications, Infectious") OR LIMIT-TO (EXACTKEYWORD, "Disease Outbreaks") OR LIMIT-TO (EXACTKEYWORD, "Arbovirus") OR LIMIT-TO (EXACTKEYWORD,"Zika) OR LIMIT-TO (EXACTKEYWORD, "Viral Protein") OR LIMIT-TO (EXACTKEYWORD, "Infant, Newborn") OR LIMIT-TO (EXACTKEYWORD, "Neutralizing Antibody") OR LIMIT-TO (EXACTKEYWORD,"RNA, Viral") OR LIMIT-TO (EXACTKEYWORD, "Antiviral Agents") OR LIMIT-TO (EXACTKEYWORD, "Virus Genome") OR LIMIT-TO (EXACTKEYWORD, "Protein Expression") OR LIMIT-TO (EXACTKEYWORD,"Aedes Albopictus") OR LIMIT-TO (EXACTKEYWORD, "Zika Virus Vaccine") OR LIMIT-TO (EXACTKEYWORD, "Serology") OR LIMIT-TO (EXACTKEYWORD, "Animal Tissue") OR LIMIT-TO (EXACTKEYWORD, "Mosquito Control") OR LIMIT-TO (EXACTKEYWORD, "Pandemic") OR LIMIT-TO (EXACTKEYWORD, "Yellow Fever") OR LIMIT-TO (EXACTKEYWORD, "Cross Reaction") OR LIMIT-TO (EXACTKEYWORD, "Sexual Transmission") OR LIMIT-TO (EXACTKEYWORD, "Disease Model") OR LIMIT-TO (EXACTKEYWORD,"Arboviruses") OR LIMIT-TO (EXACTKEYWORD, "Cell Line") OR LIMIT-TO (EXACTKEYWORD, "World Health Organization") OR LIMIT-TO (EXACTKEYWORD,"Yellow Fever Virus") OR LIMIT-TO (EXACTKEYWORD, "Viral Vaccines") OR LIMIT-TO (EXACTKEYWORD, "Viral Nonstructural Proteins")) AND (LIMIT-TO (AFFILCOUNTRY, "India")))

The above query was searched in Scopus database which gives us total of 11,130 documents and after refraining the query only to India we get 508 documents only for the year of 2021. The bibliographic data was exported in ".csv" file and Microsoft Excel 2019 and VOSViewer was incorporated to get the required results.

This study is conducted to determine the various characteristics of 508 extracted papers published form India on Zika Virus. The analysis includes identification of types of documents, prolific authors, major funding agency, collaborating countries, distribution of papers by subject category, top contributing organizations, and occurrence of author keywords.

4. Data Analysis and Interpretation

4.1 Documents Types

The 508 documents which was extracted after applying the above string belonged to eight type of documents, as displayed in table 1. Article constitute the most significant share (50.20%) of the total and followed by the reviews (25.39%), Letters (15.16%), Notes (3.15%), Editorials (2.17%), Conference paper (1.57%), Book Chapters (1.38%) and Short Survey (0.98). The

Table-1. India's Publication Documents Wise

Document Type	TP	TC	CPP	% TP
Articles	255	7674	30.09	50.20
Reviews	129	2024	15.69	25.39
Letters	77	268	3.48	15.16
Notes	16	287	17.94	3.15
Editorials	11	89	8.09	2.17
Conference Papers	8	43	5.38	1.57
Book Chapters	7	17	2.43	1.38
Short Survey	5	22	4.40	0.98
Total	**508**	**10,424**		

TP= Total Paper; TC= Total Citation; CPP= Citation per document

highest average citation per document were observed to the article (30.09) followed by Notes (17.94) and reviews (15.69) etc.

4.2 Prolific Indian Authors

Table-2. Ten Most Prolific Indian Authors in Zika Virus

S.No.	Authors	TP	TC	CPP	Affiliated Institute
1	Govindarajan, M.	36	1124	31.22	Annamalai University
2	Kadaikunnan, S.	22	552	25.09	Dr. D.Y. Patil Vidyapeeth Deemed University, Pune
3	Giri, R.	14	219	15.64	Alagappa University
4	Dhama, K.	13	631	48.54	Indian Council of Medical Research
5	Nandy, A.	12	88	7.33	National Institute of Virology India
6	Murugan, K.	11	311	28.27	Indian Institute of Technology Mandi
7	Yasri, S.	9	2	0.22	Indian Veterinary Research Institute
8	Malik, Y.S.	8	534	66.75	Bharathiar University
9	Al-anbr, M.N.	8	251	31.38	Jamia Millia Islamia
10	Bandyopadhyay, D.	7	57	8.14	University of Delhi

The ten most prolific Indian authors were based on affiliated institutes with total publication and their total citations on the zika virus listed in Table 2. Among India's Authors, M. Govindarajan (Annamalai University) has contributed the highest number (36 papers) of highly cited publications, followed by S. Kadiakunnan (22 papers), K Dhama (13 papers), and Y.S. Malik (8 papers) also have the highest number of citation which was more than five hundred. S. Yasir's total paper is nine and has only two citations. The VOSviewer software performs the collaboration network of the most prolific authors. Only the top contributed Indian authors were selected according to their affiliated institution. Only the four authors have been connected in the collaboration network (figure 1).

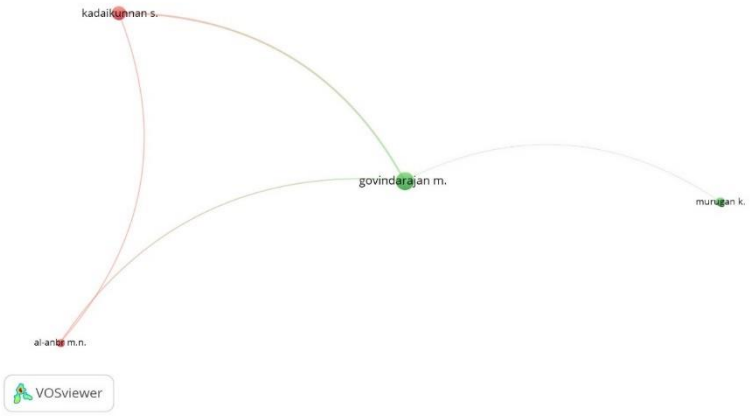

Figure-1. Collaboration network of four prolific Authors

4.3 Subject-wise Distribution

Table-3. Subject-Wise Distribution of Papers from India on Zika Virus

Name of the Subject	TP	TC	CPP	%TP
Medicine	280	7818	27.92	37.09
Biochemistry, Genetics and Molecular Biology	126	1832	14.54	16.69
Immunology and Microbiology	106	1787	16.86	14.04
Pharmacology, Toxicology and Pharmaceutics	86	341	3.97	11.39
Chemistry	34	565	16.62	4.50
Agricultural and Biological Sciences	32	413	12.91	4.24
Environmental Science	29	487	16.79	3.84
Physics and Astronomy	22	555	25.23	2.91
Engineering	20	220	11.00	2.65
Neuroscience	20	96	4.80	2.65
Total	**755**	**14,114**		

The maximum number of total and highly cited publications on the Zika Virus have distributed the broad subject categories defined by the Scopus database. The primary subject categories with the number of papers and total citations mention in table 3. The high cited paper on Zika Virus came from Medicine subject

(280 papers, 7818 citations and 37.09 shares), followed by Biochemistry, Genetics and Molecular Biology (126 papers, 1832 citations and 16.69% share), Immunology and Microbiology (106 papers, 1787 citation and 14.04% share), Pharmacology, Toxicology and Pharmaceutics (86 papers, 341 citations and 11.39 % share) and Chemistry (34 papers, 565 citations and 4.50 % share), Agricultural and Biological Sciences (32 papers, 413 citations and 4.24% share), Environmental Science (29 papers, 487 citations and 3.84% share), Physics and Astronomy (22 papers, 555 citations and 2.91% share) at last Engineering & Neuroscience having same of 20 papers and 2.65% share. Regarding the impact of various subject categories, Physics and Astronomy registered the highest citation impact per paper (25.23) and Pharmacology, Toxicology and Pharmaceutics the least (3.97).

4.4 Collaborating Countries

Table-4. Top 10 Countries Collaboration with India

Country	TP	TC	CPP
United States	80	1353	16.91
Thailand	57	681	11.95
Saudi Arabia	51	1054	20.67
Italy	48	1486	30.96
China	40	276	6.90
Serbia	27	218	8.07
Nigeria	26	229	8.81
United Kingdom	22	932	42.36
Brazil	20	804	40.20
Mexico	11	273	24.82
Total	**382**	**7,306**	

Figure-2. Network Visualization of collaborating countries with India

Table 4 visualised the international collaboration on Zika Virus publication with India. Major India's collaborative countries are listed in table 4. The highest number of highly cited papers (80) was contributed USA, followed by Thailand (57), Saudi Arabia (51), Italy (48) etc. The publication registered the highest citation per paper with collaboration United Kingdom (42.36) followed by Brazil (40.20) and Italy (30.96). Figure 3 indicated India's collaboration with other significant countries and is visualised through the VOS Viewer network diagram (represented through green, red and blue clusters). The highest frequency of collaboration was observed in cluster red, with three countries actively participating and collaborating India, the United States, the United Kingdom and Mexico.

4.5 Productive Indian Organisations

Table-5. Top 10 Most Productive Indian Organizations in Zika Virus

Sl. No.	Name of Organisation	TP	TC	CPP
1	Annamalai University, Tamil Nadu	22	696	32
2	Dr Dy Patil University, Pune	18	13	1
3	Centre For Interdisciplinary Research and Education, Jodhpur Park, Kolkata,	6	49	8
4	Dr Dy Patil Medical University, India	5	88	18
5	Government College for Women, Kumbakonam, Tamil Nadu	5	79	16
6	Alagappa University, Karaikudi, Tamil Nadu	4	225	56
7	ICAR - Indian Veterinary Research Institute, Bareilly, India	4	205	51
8	Tamil Nadu Veterinary and Animal Sciences University, Chennai	4	191	48
9	Barkatullah University, Bhopal	4	191	48
10	Manonmaniam Sundaranar University, Tamil Nadu	4	68	17
	Total	**76**	**1737**	

Table 5 represent the top 10 most productive organization in Zika Virus. Annamalai University, Tamil Nadu, has the highest number of highly cited papers, followed by Dr DY Patil University, Pune (18 papers), Centre for Interdisciplinary Research and Education, Jodhpur Park, Kolkata (6 papers), Dr Dy Patil Medical University, India & Government College for Women, Kumbakonam, Tamil Nadu (5 Papers). The highest average citation per paper were recoded to the paper published by the Alagappa University, Karaikudi, Tamil Nadu (56) followed by ICAR - Indian Veterinary Research Institute, Bareilly, India (51), Tamil Nadu Veterinary and Animal Sciences University, Chennai & Barkatullah University, Bhopal (48) etc.

4.6 Funding Agencies

Table-6. Major Funding Agencies along with Number of Publication on Zika Virus

Name of Funding Agency	TP	TC	CPP	% TP
Indian Council of Medical Research	26	275	10.58	14.86
Department of Biotechnology, Ministry of Science and Technology, India	24	332	13.83	13.71
Deanship of Scientific Research, King Saud University	23	618	26.87	13.14
Council of Scientific and Industrial Research, India	19	146	7.68	10.86
King Saud University	15	302	20.13	8.57
National Institutes of Health	15	4273	284.87	8.57
Science and Engineering Research Board	15	122	8.13	8.57
Department of Science and Technology, Ministry of Science and Technology, India	14	250	17.86	8.00
University Grants Commission	14	132	9.43	8.00
National Institute of Allergy and Infectious Diseases	10	4243	424.30	5.71
Total	**175**			

Table 6 shows the top 10 funding agency which includes institutes from India and abroad to carry out research on Zika Virus in India. Indian Council of Medical Research has the greatest number of publication (26) which received 275 citations followed by Department of Biotechnology, Ministry of Science and Technology, India; Deanship of Scientific Research, King Saud University; Council of Scientific and Industrial Research, India with 24, 23, and 19 publications respectively which received 332, 618, and 146 citations respectively.

4.7 Open Access Documents

Table-7. Type Wise Open Access Documents on Zika Virus

S. No.	Open Access Types	TP	TC	CPP
1	All Open Access	252	8083	32.08
2	Green Open Access	160	7564	47.28
3	Gold Open Access	129	1903	14.75
4	Bronze Open Access	78	1249	16.01
5	Hybrid Gold Open Access	14	4163	297.36

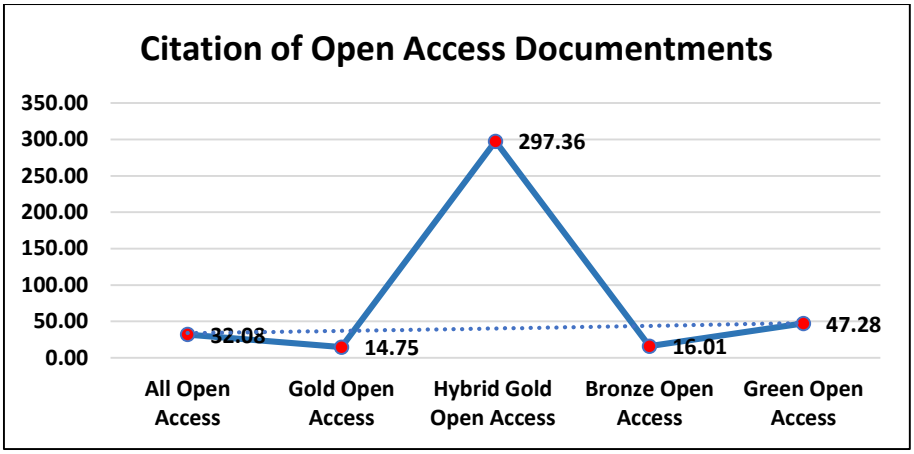

Figure-3. Citation Per Paper According to Open Access Type wise

A total of 252 publications on Zika Virus is open access as shown in table 7 which received 8083 citations. Further, the open access publications divided in to four group- Green Open Access, Gold Open Access, Bronze Open Access and Hybrid Gold Open Access which includes 160, 129, 78 and 14 publications respectively with 7564, 1903, 1249 and 4163 citations respectively.

4.8 Author Keywords

Table-8. Authors Keyword

S. No.	Keyword	Occurrences	S. No.	Keyword	Occurrences
1.	zika virus	144	26.	aedes albopictus	7
2.	dengue	42	27.	ebola	7
3.	zika	30	28.	Epidemiology	7
4.	microcephaly	25	29.	japanese encephalitis	7
5.	covid-19	24	30.	molecular docking	7
6.	aedes aegypti	21	31.	mosquito-borne diseases	7
7.	flavivirus	20	32.	nanotechnology	7
8.	chikungunya	18	33.	pandemic	7
9.	biosafety	16	34.	basic reproduction number	6
10.	malaria	16	35.	coronavirus	6
11.	india	15	36.	filariasis	6
12.	vaccine	15	37.	green synthesis	6
13.	arbovirus	13	38.	infectious diseases	6
14.	sars-cov-2	11	39.	mosquito control	6
15.	virus	11	40.	pregnancy	6
16.	transmission	10	41.	envelope protein	5

17.	aedes	9	42.	guillain-barre syndrome	5
18.	dengue virus	9	43.	microbial pathogens	5
19.	mosquito	9	44.	pathogenesis	5
20.	antiviral	8	45.	surveillance	5
21.	arboviruses	8	46.	therapeutics	5
22.	outbreak	8	47.	vector	5
23.	vaccines	8	48.	vector control	5
24.	yellow fever	8	49.	zikv	5
25.	zika virus (zikv)	8			

Table 8 shows the occurrence of 49 author keywords obtained by applying VOSViewer with threshold of 5 i.e., at least minimum occurrences of 5 times. The keyword 'zika virus' used for 144 times by authors in their research papers followed by dengue (40), zika (30), microcephaly (25), covid-19 (24), aedes aegypti (21), flavivirus (20), chikungunya (18), biosafety (16) and so on. As figure 4 depicts, the 49 keywords with minimum threshold of 5 is divided into 6 clusters. Cluster 1 in red which contains 13 items, cluster 2 in green with 8 items, while cluster 3 in purple, cluster 4 in yellow, cluster 5 in blue and cluster 6 in pink include 7 items each.

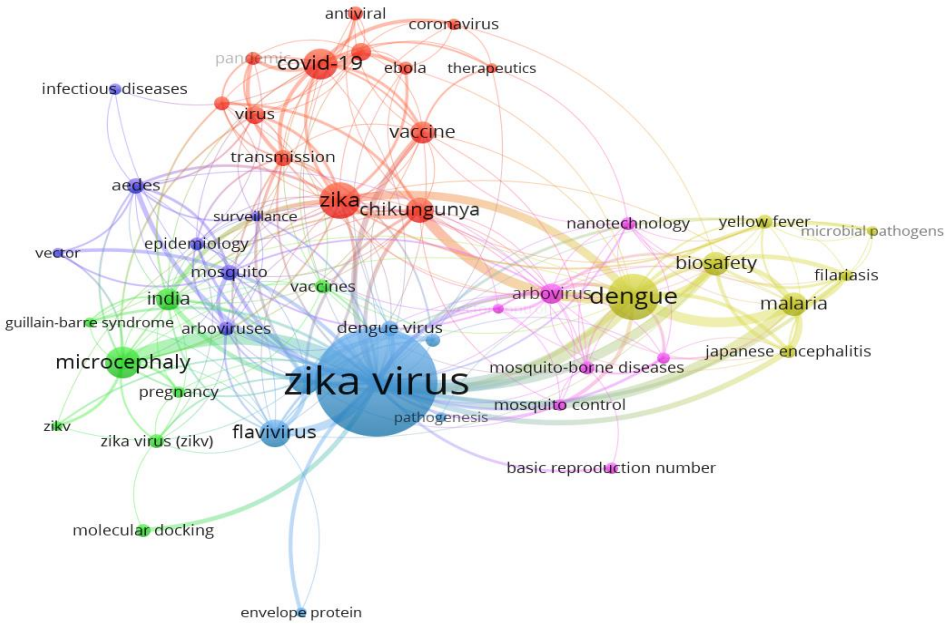

Figure-4. Occurrences of Author Keywords

5. Conclusion

In this paper the publication from India on zika virus is analysed and visualised using VOSViewer. Total of 508 publications were analysed in which articles were high in number, Govindrajan, M. is moat prolific authors among Indian authors and about 280 documents under Medicine which received 7818 citations. Annamalai University is most productive organisation of India which has contributed 22 publication which gets 696 citations, Indian Council of Medical Research top funding agency which leads to publication of 26 documents. 'zika virus' is highly occurred author keyword in 508 documents and author keywords divided in 7 clusters.

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