

Global Scientific Productivity of Top Four Journals of Virology Over Three Decades: A Scientometrics Study

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Abstract - Trends in Virology research have been inclined after outbreak of COVID 19 pandemic. The main objective of this study is to identifying and visualizing the scientometric indicators of top four highly productive journals publishing papers on area related to Virology research. The data collected on 5 January 2022 from Web of Science all relevant global publications of Virology research. Then, publications were restricted to top 4 highly productive journals in this field. An Exploratory and descriptive analysis of bibliographic data (number of publication/citations yearly output, growth rate, authorship and collaborative pattern, productive countries) by using Bibexcel, MS Excel and VOS viewer software packages were used. The top ranked journals of virology ranked as Journal of Virology (N= 37205, 51.50%), Virology Journal (N= 15052, 20.83%), Journal of General Virology (N= 10745, 14.87%) and Archives of Virology (N= 9238, 12.79%) respectively. Cross-country comparison reveals that the USA is currently taking the leading role, followed by the UK, Germany & Japan and China is a newcomer with potential contributions to make in this research area. The present study offers important quantitative information on top journals of Virology. In addition, researchers are increasingly investigating the intellectual structures of disciplines by using various bibliometric techniques.

Keywords: Virology, Journal of Virology, Virology journal, Journal of General Virology, Archives of Virology, Scientometrics

I. INTRODUCTION

A systematic study of research communication reveals valuable information regarding the advancement of a particular subject and its importance to the community. Scientometric analysis of literature provides a snapshot of the research trends field of concerned. Scientometrics is one of the most important measures for the assessment of scientific productions. Macias-Chapula argues that scientometric indicators have become essential to the scientific community to estimate the state-of-the-art of given topic. (Lolis, *et al.*, 2009).

Virology is a branch of microbiology that investigates a wide range of viral diseases that causes significant morbidity and mortality in human, animal, and plant populations all over the world. Clinical findings, etiology, pathogenesis, epidemiology, prevention, and treatment of viral diseases are all covered by virology science, as well as molecular therapeutics for cancer and other viral and non-viral diseases (Koopmans, 2013). In 1892, Dmitri

Ivanovsky used one of these filters to show that sap from a diseased tobacco plant remained infectious to healthy tobacco plants despite have been filtered. Martinus Beijerinck called the filtered, infectious substance a 'viruses' and this discovery is considered to be the beginning of virology. Martinus W. Beijerinck is father of Virology, who was the first to recognize that viruses are reproducing entities that are different from other organisms.

There are four most productive journals have been taken for analysis which described below. The first is *Journal of Virology* is an online bimonthly scientific journal published by the American Society for Microbiology that covers all aspects of recent research concerning areas that are related to virology. It was launched in 1967 and indexed in Agricola, Biological Abstracts, BIOSIS previews, EMBASE, MEDLINE, and Science Citation Index Expanded. It discovers the kinds of viruses, detailing the latest discoveries and focusing on the latest directions in research.

The second is *Virology journal* is an open access, peer reviewed journal that considers articles on all aspects of virology, including research on the viruses of animals, plants and microns. All articles published in Virology Journal are included in: Agricola, Biological Abstracts, BIOSIS, CABI, CAS, Citebase, Current Contents, DOAJ, Embase, EmBiology, Global Health, MEDLINE, OALster, PubMed, PubMed Central, Science Citation Index Expanded, SCImago, Scopus, Socolar and Zetoc.

The third is Journal of General Virology has been publishing peer-reviewed research for more than 50 years. It is a not-for-profit peer-reviewed scientific journal published by the Microbiology Society. The journal's diverse scope reflects the evolving nature of virology today, covering all aspects of animal, plant, insect, bacterial and fungal viruses, transmissible spongiform encephalopathies, molecular biology and immunology, virus-host interactions and antiviral compounds. It is indexed in Biological Abstracts, BIOSIS Previews, CAB Abstracts, Chemical Abstracts Service, and Current Awareness in Biological Sciences, Current Contents - Life Sciences, Current Opinion series, EMBASE, MEDLINE, and Russian Academy of Science, Science Citation Index, SciSearch, and SCOPUS.

The forth is *Archives of Virology* publishes original contributions from all branches of research on viruses, virus-like agents, and virus infections of humans, animals, plants, insects, and bacteria. The Archives of Virology is a peer-reviewed scientific journal covering research in virology. It is published by Springer science and Business Media and is the official journal of the virology Division of the International Union of Microbiological Societies.

II. REVIEW OF LITERATURE

The present study includes application of new indices that have not been used in previous studies reviewed here with regard to analysis of Virology research output. Ruiz-Sanez, J. & Martinez-Gutierrez, M., (2015) reveals a growth in virology research in Latin America. The purpose of this research was to assess Colombian articles on viruses and viral illnesses published in indexed journals between 2000 and 2013. They discovered that 34.2% of the publications were published in collaboration with international researchers, with the United States having the highest representation.

Wytamma, W., David, L., & Ellen, A., (2021) reported the findings of a decade-long scientometric analysis of the discipline of ranavirology. They analysed trends, identified leading papers and journals, and mapped the landscape of ranavirus cooperation. The Web of Science core collection has 545 ranavirus-related papers from 2010 to 2019, with more publications being published annually and a total of 6,830 citations. Together, the United States and the People's Republic of China are responsible for more than 60 percent of the ranavirus-related publications.

Dima, K., Jacob, M. G., & Michael F., (2021) explained trends in scientometrics research about the coronavirus and other developing viral illnesses. COVID-19 is the coronavirus epidemic with the most rapid spread over the previous two decades. Analysing more than 35 million publications spanning the last two decades, we compare the amount of research undertaken on earlier coronavirus epidemics, notably SARS and MERS, to other infectious illnesses.

Sivankalai, S. *et al.*, (2021) examined the scientific output of the Astroviurses research community during the last two decades in the global community. The findings of this analysis indicate that the scientific literature on astroviruses grew exponentially with an average yearly growth rate of 8.86 percent throughout the time specified. The Journal of Medical Virology was the most prolific magazine, providing 71 articles to the total.

Nirmal, S. *et al.*, 2019 utilised scientometric analysis and network visualisation of journal papers on the Nipah virus to better comprehend the subject's research patterns. Bhardwaj, R. K., (2016) discussed a scientometric examination of global Ebola virus publishing data. He disclosed that 2446 publications on the Ebola virus had been

published in 159 journals by 84 nations as of December 31, 2013. He discovered that the United States ranks first with 1,466 (46.9 %) research outcomes. The Ebola virus study was published in 157 publications, with the journal 'Virology' publishing 257 (10.5%) of the articles.

III. METHODS AND TOOLS

Research methodology is a systematic way to solve a problem. This study was conducted with a view to analysing the trend in the development of virology in scientometrics. The choice of the study duration was based on the assumption that the last three decades of publications and citations received in the virology field from 1991 to 2021. The scientific research productivity in the year 2022 was excluded because this year is still open for new journal issues. Due to enormity of the data, the study is limited to only four most productive journals, Journal of Virology, Virology journal, Journal of General Virology and Archives of Virology. The researcher has downloaded the bibliographical data in the form of text files and merged all those plain text files into one file using Bibexcel software. Microsoft Excel used for simple calculation and tabulation. The open-source software Bibexcel, developed by Olle Persson, was adopted for data analysis of the different 56 parameters of the study. SPSS package used for calculating correlation coefficient and testing hypothesis of the study. The authorship and co-authorship analysis via network visualizations and analysis were performed using VOS viewer software.

IV. OBJECTIVES OF THE STUDY

1. To identify the year-wise trend of literature in virology research.
2. To examine the Annual Growth Rate, Annual Ratio of Growth, Compound Growth Rate and Exponential Growth Rate of virology research.
3. To study the authorship pattern and to scrutinize Co-authorship index (CAI), Collaborative Coefficient (CC) and Modified Collaborative Coefficient (MCC).
4. To identify the most productive and cited countries and rank them on the basis of various indices.

V. RESULTS AND DISCUSSION

A. Year-Wise Growth Analysis in Virology Research

The data were collected from the Web of Science core collection maintained by Clarivate Analytics, a comprehensive and in-depth database containing almost all subjects of science and technology. An attempt has been made to analyse the outcome of highly contributing journals globally during 1991 to 2021.

The total number of publications contributed by Journal of Virology, Virology Journal, Journal of General Virology, and Archives of Virology together constitute almost 71.59% of all Virology research output globally. Hence, the analysis done can be claimed to represent the whole.

TABLE I YEAR-WISE PUBLICATIONS OF TOP FOUR JOURNALS OF VIROLOGY DURING 1991 TO 2021

Total Productivity			Journal of Virology		Virology Journal		Journal of General Virology		Archives of Virology	
Sl. No.	Years	Total	Records	%	Record	%	Record	%	Records	%
1	1991	2221	947	2.55	643	4.27	436	4.06	195	2.11
2	1992	2411	983	2.64	643	4.27	451	4.20	334	3.62
3	1993	2256	964	2.59	646	4.29	383	3.56	263	2.85
4	1994	2443	1023	2.75	665	4.42	462	4.30	293	3.17
5	1995	2471	1091	2.93	779	5.18	389	3.62	212	2.29
6	1996	2463	1166	3.13	648	4.31	389	3.62	260	2.81
7	1997	2510	1265	3.40	576	3.83	419	3.90	250	2.71
8	1998	2502	1327	3.57	549	3.65	379	3.53	247	2.67
9	1999	2431	1266	3.40	539	3.58	401	3.73	225	2.44
10	2000	2609	1421	3.82	597	3.97	349	3.25	242	2.62
11	2001	2426	1377	3.70	500	3.32	351	3.27	198	2.14
12	2002	2420	1406	3.78	466	3.10	349	3.25	199	2.15
13	2003	2562	1447	3.89	542	3.60	387	3.60	186	2.01
14	2004	2638	1505	4.05	508	3.37	410	3.82	215	2.33
15	2005	2684	1634	4.39	444	2.95	377	3.51	229	2.48
16	2006	2492	1320	3.55	539	3.58	416	3.87	217	2.35
17	2007	2673	1458	3.92	568	3.77	415	3.86	232	2.51
18	2008	2507	1285	3.45	565	3.75	357	3.32	300	3.25
19	2009	2463	1300	3.49	535	3.55	358	3.33	270	2.92
20	2010	2408	1297	3.49	483	3.21	350	3.26	278	3.01
21	2011	2360	1354	3.64	382	2.54	323	3.01	301	3.26
22	2012	2564	1596	4.29	357	2.37	298	2.77	313	3.39
23	2013	2371	1349	3.63	387	2.57	307	2.86	328	3.55
24	2014	2490	1311	3.52	456	3.03	292	2.72	431	4.67
25	2015	2326	1150	3.09	406	2.70	373	3.47	397	4.30
26	2016	2126	982	2.64	360	2.39	339	3.15	445	4.82
27	2017	2069	924	2.48	327	2.17	323	3.01	495	5.36
28	2018	1816	838	2.25	317	2.11	192	1.79	469	5.08
29	2019	1644	803	2.16	269	1.79	172	1.60	400	4.33
30	2020	1443	743	2.00	165	1.10	141	1.31	394	4.26
31	2021	1441	673	1.81	191	1.27	157	1.46	420	4.55
Total		72240	37205	100	15052	100	10745	100	9238	100

Table I represents the Virology research measured by the year-wise literature in the overall country's research output during the period from 1991 to 2021, there were a total of 72240 articles collected for analysis. The Journal of Virology covers 51.50% of the records, Virology Journal covers 20.83% of the records, Journal of General Virology covers 14.87% of the records, and Archives of Virology covers 12.79% of the records.

The researcher retrieved scholarly data from the top four journals, representing more than 70% of the world's total publication in the field of virology in the chosen period. The highest productivity was found in the year 2005 with 2684 publications, followed by 2007 with 2673 publications

and 2004 with 2638 publications. The lowest productivity was found in the year 2021 with 1441 articles, followed by 2020 with 1443 articles and 2019 with 1644 articles.

B. Annual Growth Rate and Annual Ratio of Growth (ARoG) In Virology Research

The annual growth rate is the change in the value of a measurement over the period of a year. The mean annual growth rate was found to be -0.143 of the Journal of Virology, 0.030 of Virology Journal, 0.033 of the Journal of General Virology, and -0.040 of the Archives of Virology. The Annual Growth Ratio (AGR) is calculated as the present number of publications divided by the previous

number of publications. The average annual ratio of growth was found to be 1: 0.893 of the Journal of Virology, 1:1.052

of Virology Journal, 1: 1.053 of the Journal of General Virology, and 1: 0.987 of the Archives of Virology.

TABLE II STATUS OF ANNUAL GROWTH RATE AND ANNUAL RATIO OF GROWTH OF VIROLOGY RESEARCH OVER LAST 31 YEARS

Years	Journal of Virology		Virology Journal		Journal of General Virology		Archives of Virology	
	AGR	ARoG	AGR	ARoG	AGR	ARoG	AGR	ARoG
1991	-	-	-	-	-	-	-	-
1992	-1.038	1:0.491	0.000	1:1	-0.034	1:0.967	-0.713	1:0.584
1993	-0.499	1:0.667	-0.005	1:0.995	0.151	1:1.178	0.213	1:1.270
1994	-0.353	1:0.739	-0.029	1:0.971	0	1:0	-0.114	1:0.898
1995	-0.279	1:0.782	-0.171	1:0.854	0.158	1:1.188	0.276	1:1.382
1996	-0.233	1:0.811	0.168	1:1.202	0.000	1:1	-0.226	1:0.815
1997	-0.205	1:0.830	0.111	1:1.125	-0.077	1:0.928	0.038	1:1.040
1998	-0.178	1:0.849	0.047	1:1.049	0.095	1:1.106	0.012	1:1.012
1999	-0.144	1:0.874	0.018	1:1.019	-0.058	1:0.945	0.089	1:1.098
2000	-0.142	1:0.876	-0.108	1:0.903	0.130	1:1.149	-0.076	1:0.930
2001	-0.120	1:0.893	0.162	1:1.194	-0.006	1:0.994	0.182	1:1.222
2002	-0.110	1:0.901	0.068	1:1.073	0.006	1:1.006	-0.005	1:0.995
2003	-0.102	1:0.908	-0.163	1:0.860	-0.109	1:0.902	0.065	1:1.070
2004	-0.096	1:0.912	0.063	1:1.067	-0.059	1:0.944	-0.156	1:0.865
2005	-0.095	1:0.913	0.126	1:1.144	0.080	1:1.088	-0.065	1:0.939
2006	-0.070	1:0.934	-0.214	1:0.824	-0.103	1:0.906	0.052	1:1.055
2007	-0.072	1:0.933	-0.054	1:0.949	0.002	1:1.002	-0.069	1:0.935
2008	-0.059	1:0.944	0.005	1:1.005	0.140	1:1.162	-0.293	1:0.773
2009	-0.057	1:0.946	0.053	1:1.056	-0.003	1:0.997	0.100	1:1.111
2010	-0.054	1:0.949	0.097	1:1.108	0.022	1:1.023	-0.030	1:0.971
2011	-0.053	1:0.950	0.209	1:1.264	0.077	1:1.084	-0.083	1:0.924
2012	-0.059	1:0.944	0.065	1:1.070	0.077	1:1.084	-0.040	1:0.962
2013	-0.047	1:0.955	-0.084	1:0.922	-0.030	1:0.971	-0.048	1:0.954
2014	-0.044	1:0.958	-0.178	1:0.849	0.049	1:1.051	-0.314	1:0.761
2015	-0.037	1:0.964	0.110	1:1.123	-0.277	1:0.783	0.079	1:1.086
2016	-0.030	1:0.970	0.113	1:1.128	0.091	1:1.100	-0.121	1:0.892
2017	-0.028	1:0.973	0.092	1:1.101	0.047	1:1.050	-0.112	1:0.899
2018	-0.025	1:0.976	0.031	1:1.032	0.406	1:1.682	0.053	1:1.055
2019	-0.023	1:0.978	0.151	1:1.178	0.104	1:1.116	0.147	1:1.173
2020	-0.021	1:0.980	0.387	1:1.630	0.180	1:1.220	0.015	1:1.015
2021	-0.018	1:0.982	-0.158	1:0.864	-0.113	1:0.898	-0.066	1:0.938
Mean	-0.143	1:0.893	0.030	1:1.052	0.033	1:1.053	-0.040	1:0.987

In Table II, it is suggested that the mean annual growth rate is -0.143 of the Journal of Virology, 0.030 of the Virology Journal, 0.033 of the Journal of General Virology, and -0.040 of the Archives of Virology. The mean annual ratio of growth was 1:0.893 of the Journal of Virology, 1:1.052 of the Virology Journal, 1:1.053 of the Journal of General Virology, and 1:0.987 of the Archives of Virology. Table II dissimilarities between current year publications and most recent year publications in the family component to the last time publications is the annual growth rate. The current year's publications were less than those of the previous

year. The uppermost Annual Growth Rate ranges in the year 2021 (-0.018) of Journal of Virology, 2020 (0.387) of Virology Journal, 2018 (0.406) of Journal of General Virology and 1995 (0.276) of Archives of Virology. Annual Growth Rate ranges from the lowly seen in the years 1992 (-1.038) of the Journal of Virology, 2006 (-0.214) of Virology Journal, 2015 (-0.277) of the Journal of General Virology and 1992 (-0.713) of Archives of Virology.

This Table II shows that the distribution of research articles published on Virology research percentage growth ratio is

one calculated using the prior years as a base for expressing percentage change from one year to the next year. The ratio of growth varies from 0 to 2, which can be seen in the table is observed from the year 1991 to 2021. The ratio of growth is very high in the years 2021 (0.982) of the Journal of Virology, 2020 (1.630) of Virology Journal, 2018 (1.682) of the Journal of General Virology, and 1995 (1.382) of the Archives of Virology. The growth ratio ranges from 1992 (0.491) in the Journal of Virology to 2006 (0.824) in the Virology Journal, 2015 (0.824) in the Journal of General Virology, and 1992 (0.584) in the Archives of Virology.

TABLE III DESCRIPTION OF COMPOUND ANNUAL GROWTH RATE OF VIROLOGY

CAGR	Journal of Virology	Virology Journal	Journal of General Virology	Archives of Virology
	-1.650952073	-0.584508102	-1.34847588	-3.084367246

Table III shows the compound annual growth rate of the main four journals of virology. The CAGR for the Journal of Virology is -1.6509, -1.5845 for the Virology Journal, and 1.3484 for the Journal of General Virology, and -3.0843 for the Archives of Virology.

C. Compound Annual Growth Rate (CAGR) of Virology Research

Compound Annual Growth Rate is calculated as the number of publications in the present year divided by the number of publications in the previous year to the power of one divided by the period length and subtracts one from the subsequent result (Murphy, 2019). The average compound annual growth rate was found to be -1.66708 in virology research.

D. Exponential Growth Rate (EGR) of Virology Research

Exponential growth is a pattern of data that shows greater increases with passing time, creating the curve of an exponential function. The exponential growth rate of Virology research during 1991 to 2021.

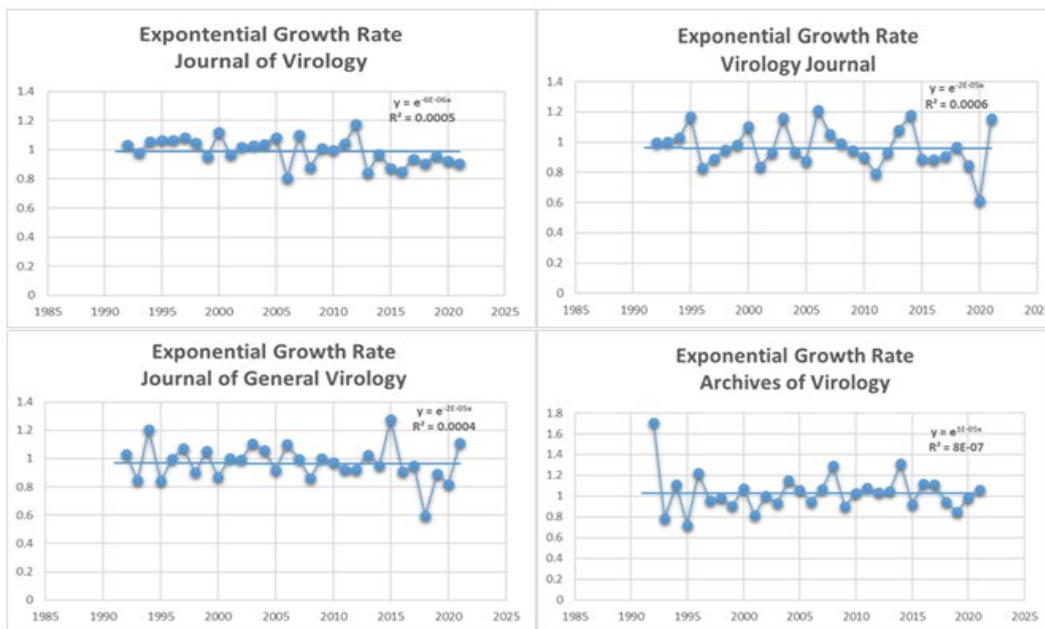


Fig. 1 Status of Exponential growth rate $b = y_t / y_{t0}$ of top four journals of Virology.

Fig. 1 shows the world literature growth for the period 1991–2021. The figure shows the exponential model $R^2=0.0005$ of the Journal of Virology, $R^2=0.0006$ of the Virology Journal, $R^2=0.0004$ of the Journal of General Virology, and $R^2= 0.0000008$ of the Archives of Virology. Hence, the value of the exponential model is low; it does not fit completely in virology research in a given period of research.

E. Author Collaboration Pattern in Virology Research

The contributions of single and multiple authors are clearly presented in global Virology research over the last 31 years in Figure below.

Fig. 2, shows a comparison between single-authored papers and multi-authored papers in virology research from 1991 to 2021.

The multi-authored papers formed the majority of papers with 36858 papers, which is 99.05 % of total publications in the Journal of Virology, 14807 papers, which is 98.37% of total publications in the Virology Journal, 10591 papers, which is 98.56% of total publications in the Journal of General Virology, and 8929 papers, which is 96.65% of total publications in the Archives of Virology journal.

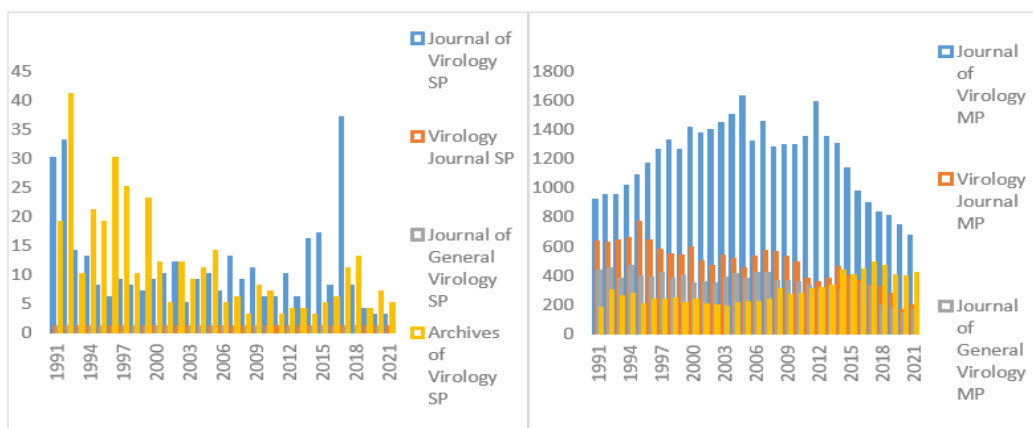


Fig. 2 Description of single authored vs Multi-authored papers of Virology research.

TABLE IV STATUS OF COLLABORATIVE CO-EFFICIENT (CC) AND MODIFIED COLLABORATIVE CO-EFFICIENT (MCC) OF VIROLOGY RESEARCH FROM 1991 TO 2021

Years	Journal of Virology		Virology Journal		Journal of General Virology		Archives of Virology	
	CC	MCC	CC	MCC	CC	MCC	CC	MCC
1991	0.68	1.47	0.68	1.48	0.71	1.41	0.65	1.54
1992	0.68	1.48	0.68	1.47	0.71	1.41	0.65	1.55
1993	0.69	1.44	0.69	1.44	0.71	1.41	0.71	1.42
1994	0.71	1.41	0.70	1.43	0.73	1.37	0.68	1.47
1995	0.71	1.41	0.70	1.43	0.72	1.39	0.67	1.51
1996	0.72	1.39	0.70	1.43	0.73	1.37	0.65	1.54
1997	0.73	1.38	0.71	1.41	0.73	1.37	0.65	1.54
1998	0.74	1.35	0.72	1.39	0.73	1.37	0.73	1.38
1999	0.74	1.35	0.73	1.37	0.74	1.36	0.65	1.54
2000	0.74	1.35	0.73	1.37	0.73	1.38	0.71	1.42
2001	0.75	1.33	0.74	1.35	0.76	1.33	0.72	1.40
2002	0.75	1.34	0.74	1.35	0.74	1.36	0.70	1.43
2003	0.76	1.32	0.74	1.35	0.75	1.34	0.73	1.38
2004	0.77	1.30	0.75	1.33	0.77	1.31	0.72	1.40
2005	0.77	1.30	0.76	1.32	0.78	1.29	0.70	1.43
2006	0.77	1.30	0.75	1.34	0.77	1.30	0.75	1.33
2007	0.78	1.29	0.76	1.31	0.77	1.30	0.77	1.31
2008	0.78	1.29	0.77	1.30	0.79	1.28	0.79	1.27
2009	0.78	1.28	0.77	1.30	0.79	1.27	0.76	1.32
2010	0.79	1.27	0.79	1.28	0.80	1.26	0.78	1.29
2011	0.80	1.26	0.77	1.31	0.81	1.25	0.79	1.28
2012	0.81	1.24	0.78	1.29	0.80	1.25	0.80	1.25
2013	0.80	1.25	0.76	1.31	0.81	1.24	0.81	1.24
2014	0.81	1.24	0.79	1.27	0.81	1.23	0.81	1.24
2015	0.81	1.24	0.72	1.38	0.79	1.27	0.82	1.22
2016	0.82	1.22	0.80	1.26	0.81	1.24	0.82	1.22
2017	0.79	1.26	0.78	1.28	0.82	1.23	0.81	1.23
2018	0.82	1.22	0.81	1.24	0.79	1.27	0.80	1.25
2019	0.83	1.21	0.81	1.24	0.81	1.24	0.83	1.21
2020	0.84	1.20	0.78	1.29	0.80	1.26	0.81	1.23
2021	0.84	1.20	0.79	1.28	0.83	1.22	0.82	1.22
Mean	0.77	1.31	0.75	1.34	0.77	1.31	0.75	1.36

In Table IV, it is suggested that CC and MCC of the top four journals of Virology are significantly different. The slope of CC showed an increment trend but MCC a decrement trend over the years. The mean of CC is calculated at 0.77 of the Journal of Virology, 0.75 of the Virology Journal, 0.77 of the Journal of General Virology,

and 0.75 of the Archives of Virology, respectively. On the other hand, the mean of MCC accounted for 1.31 of the Journal of Virology, 1.34 of the Virology Journal, 1.31 of the Journal of General Virology, and 1.36 of the Archives of Virology, respectively.

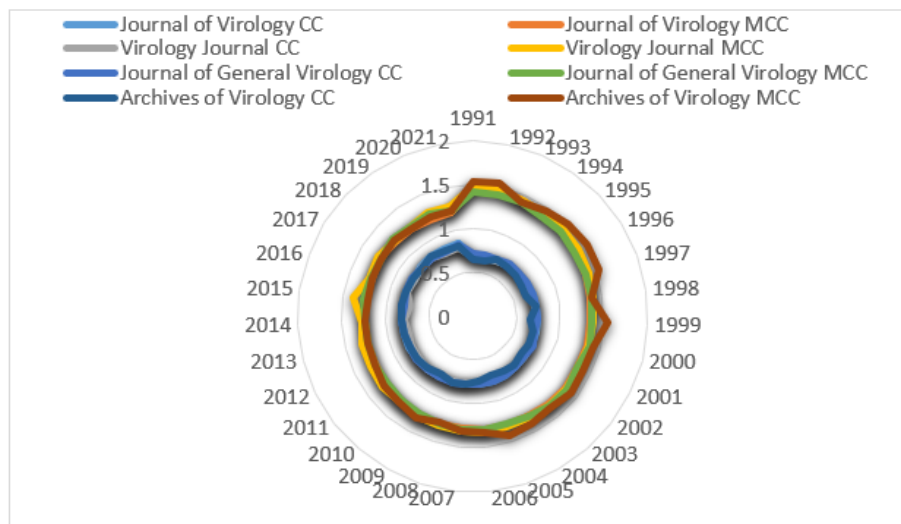


Fig. 3 Collaborative Co-efficient (CC) and Modified Collaborative Co-efficient (MCC) of Virology research

The below Table V analyses the pattern of co-authorship index. The entire information has been tabulated into block

years and author wise (i.e., 1 author, 2 authors, 3 authors, etc.).

TABLE V DESCRIPTION OF CO-AUTHORSHIP INDEX (CAI) OF VIROLOGY RESEARCH

Journal of Virology (Co-authorship Index)										
Authors	1	2	3	4	5	6	7	8	9	10
Years	CAI	CAI	CAI	CAI	CAI	CAI	CAI	CAI	CAI	CAI
1991-1995	209.81	187.80	156.16	130.70	101.12	80.86	55.61	53.37	38.17	28.41
1996-2000	64.88	138.81	132.75	115.92	111.37	96.30	87.86	78.95	67.29	57.00
2001-2005	66.93	101.19	108.12	110.62	115.45	105.46	99.93	96.51	84.80	83.21
2006-2010	74.06	81.92	88.52	100.43	104.41	107.66	113.20	101.12	113.27	99.84
2011-2015	87.23	57.63	66.70	74.18	88.51	110.13	118.76	134.24	139.87	147.35
2016-2021	136.10	41.20	49.52	67.18	70.89	91.92	117.39	131.43	155.31	188.72
Mean	106.50	101.43	100.29	99.84	98.63	98.72	98.79	99.27	99.79	100.76
Virology Journal (Co-authorship Index)										
1991-1995	136.49	153.30	132.69	115.27	98.45	87.92	69.53	48.10	33.23	34.37
1996-2000	90.81	121.03	118.18	117.54	105.77	92.24	86.02	68.99	56.50	69.52
2001-2005	64.93	88.60	98.59	106.92	107.86	106.46	109.06	100.12	91.20	91.65
2006-2010	93.64	72.08	78.78	88.44	103.36	105.56	120.83	129.55	139.65	131.88
2011-2015	135.98	74.80	73.43	82.69	89.10	101.69	116.13	128.48	167.96	161.77
2016-2021	60.34	46.09	69.38	66.79	88.80	117.90	120.35	179.20	180.96	175.03
Mean	97.03	92.65	95.18	96.28	98.89	101.96	103.65	109.07	111.58	110.70
Journal of General Virology (Co-authorship Index)										
1991-1995	136.84	155.72	140.74	128.91	106.77	91.42	66.88	59.11	42.19	32.32
1996-2000	134.86	128.14	129.52	115.93	111.15	96.86	81.82	77.98	64.05	58.98

2001-2005	89.06	102.72	101.64	112.23	105.08	100.95	115.32	90.27	78.14	92.97
2006-2010	57.41	73.74	91.09	88.75	98.32	110.96	108.14	118.70	129.80	106.95
2011-2015	95.65	51.51	53.54	73.01	89.01	116.30	122.44	136.53	150.66	161.36
2016-2021	71.57	61.49	57.70	61.49	81.18	81.60	119.40	140.96	172.84	195.03
Mean	97.56	95.55	95.70	96.72	98.59	99.68	102.33	103.92	106.28	107.94
Archives of Virology (Co-authorship Index)										
1991-1995	220.7	159.93	169.26	117.25	94.90	84.14	64.02	55.24	36.91	28.88
1996-2000	212.60	162.99	142.05	112.63	106.21	82.94	82.26	48.09	65.19	32.64
2001-2005	129.23	142.38	131.07	132.16	113.79	82.37	92.98	68.52	41.44	43.76
2006-2010	58.18	85.65	100.69	113.41	108.22	104.36	105.64	93.72	106.63	119.35
2011-2015	27.93	61.48	76.50	93.54	98.84	109.45	111.42	122.89	137.24	121.31
2016-2021	45.64	57.47	49.48	70.71	90.95	114.17	118.32	146.34	141.96	164.67
Mean	115.71	111.65	111.51	106.62	102.15	96.24	95.77	89.13	88.23	85.10

In Table V, it is suggested that the highest mean CAI was found in a 1 author paper with 106.50 and the lowest mean CAI of 5 author papers with 98.63 in the Journal of Virology. The highest mean CAI found 9 authors with 111.58 and the lowest mean CAI found two authors with 92.65 in the Virology Journal. The highest mean CAI found 10 authors with 107.94 and the lowest mean CAI found 2

authors with 95.55 in the Journal of General Virology and in the Archives of Virology. The highest mean CAI found 1 author paper with 115.71 and the lowest mean CAI found 10 authors with 85.10.

F. Country Wise Analysis with Its Indices

TABLE VI DESCRIPTION OF PRODUCTIVITY, CITATIONS, ATTRACTIVE INDEX, IMMEDIACY INDEX AND TRANSFORMATIVE ACTIVITY INDEX OF TOP 10 COUNTRIES IN REFERENCE TO JOURNAL OF VIROLOGY, VIROLOGY JOURNAL, JOURNAL OF GENERAL VIROLOGY AND ARCHIVES OF VIROLOGY

JOURNAL OF VIROLOGY											
Block Years	Countries	USA	GER	UK	France	Japan	Canada	China	NL	AUS	Spain
1991-95	Citations	244430	16156	14721	13240	14167	10564	344	9108	2118	3559
	Articles	3034	220	172	180	162	162	4	76	30	53
	Attractive Index	1.15	0.82	0.75	0.9	1.01	1.04	0.04	1.26	0.38	0.71
	Immediacy Index	80.56	73.44	85.59	73.56	87.45	65.21	86	119.84	70.6	67.15
	TAI	118.86	85.85	73.71	84.78	96.55	2.42	106.74	98.17	41.58	76.18
1996-2000	Citations	306365	29650	25186	23448	16031	14180	2719	8094	8721	8251
	Articles	3795	392	326	316	247	192	18	117	100	111
	Attractive Index	1.05	1.09	0.93	1.16	0.83	1.01	0.21	0.81	1.13	1.19
	Immediacy Index	80.73	75.64	77.26	74.2	64.9	73.85	151.06	69.18	87.21	74.33
	TAI	106.31	109.4	99.91	92.44	121.21	7.8	90.47	108.08	99.12	114.09
2001-2005	Citations	299960	31944	33726	21886	21187	13482	9112	12559	7691	7795
	articles	4258	458	460	327	345	227	73	161	100	118
	Attractive Index	0.96	1.1	1.17	1.02	1.03	0.9	0.68	1.18	0.94	1.06
	Immediacy Index	70.45	69.75	73.32	66.93	61.41	59.39	124.82	78.01	76.91	66.06
	TAI	100.98	108.2	119.34	109.3	106.18	26.76	90.55	125.9	83.91	102.67
2006-2010	Citations	229217	20032	26064	14701	17275	11275	12041	6680	7227	5785
	Articles	3889	377	392	255	280	217	152	106	118	116
	Attractive Index	0.97	0.91	1.2	0.9	1.11	1	1.18	0.83	1.17	1.04
	Immediacy Index	58.94	53.14	66.49	57.65	61.7	51.96	79.22	63.02	61.25	49.87
	TAI	102.1	98.6	112.59	98.2	91.67	61.69	95.82	91.77	109.61	111.74

2011-2015	Citations	128209	14023	11543	10463	10323	7354	19934	4525	5171	3060
	Articles	3498	363	329	289	300	254	506	93	135	101
	Attractive Index	0.87	1.02	0.85	1.03	1.06	1.04	3.12	0.9	1.34	0.88
	Immediacy Index	36.65	38.63	35.09	36.2	34.41	28.95	39.4	48.66	38.3	30.3
	TAI	90.48	93.53	93.09	103.66	102.35	202.33	110.5	79.32	123.55	95.85
2016-2021	Citations	33127	3686	3263	2127	2835	2610	9625	1289	1611	896
	Articles	2366	282	226	155	226	187	595	79	106	69
	Attractive Index	0.8	0.96	0.86	0.74	1.04	1.32	5.38	0.92	1.49	0.92
	Immediacy Index	14	13.07	14.44	13.72	12.54	13.96	16.18	16.32	15.2	12.99
	TAI	83.73	99.41	87.49	106.84	75.11	325.52	111.31	92.19	132.72	89.59
Total Citations		1241308	115491	114503	85865	81818	59465	53775	42255	32539	29346
Total Record		20840	2092	1905	1522	1560	1239	1348	632	589	568
VIROLOGY JOURNAL											
Block Years	Countries	USA	UK	GER	Japan	France	Canada	China	AUS	Spain	NL
1991-1995	Articles	1533	203	176	142	149	151	8	58	57	49
	Citations	78760	12626	9854	6955	9230	6601	430	4026	3151	4224
	Attractive Index	0.99	1.4	1.13	0.94	1.41	1.13	0.1	1.14	0.9	1.43
	Immediacy Index	51.38	62.2	55.99	48.98	61.95	43.72	53.75	69.41	55.28	86.2
	TAI	104.35	93.12	122.39	150.48	122.6	129.93	7.01	93.11	104	117.61
1996-2000	Articles	1441	157	170	152	130	111	9	62	60	53
	Citations	71008	9176	8206	6839	4889	4899	1843	3710	3465	2475
	Attractive Index	1.02	1.16	1.07	1.05	0.85	0.95	0.49	1.19	1.13	0.95
	Immediacy Index	49.28	58.45	48.27	44.99	37.61	44.14	204.78	59.84	57.75	46.7
	TAI	103.55	105.22	124.8	122.86	95.14	119.67	8.33	105.07	115.56	134.29
2001-2005	Articles	1218	109	142	147	121	101	39	54	51	36
	Citations	55689	5616	6367	6396	5151	3972	2938	2230	2420	2313
	Attractive Index	0.97	0.86	1.01	1.19	1.09	0.94	0.94	0.87	0.96	1.08
	Immediacy Index	45.72	51.52	44.84	43.51	42.57	39.33	75.33	41.3	47.45	64.25
	TAI	98.77	114.85	117.65	96.27	97.7	125.71	40.73	103.28	110.86	102.95
2006-2010	Articles	1424	90	111	141	72	111	99	50	51	30
	Citations	53447	3434	5553	4265	2714	3843	4619	1685	2574	1110
	Attractive Index	1.04	0.59	0.99	0.89	0.64	1.02	1.66	0.74	1.14	0.58
	Immediacy Index	37.53	38.16	50.03	30.25	37.69	34.62	46.66	33.7	50.47	37
	TAI	105.64	100.77	84.13	72.71	98.22	68.43	94.59	87.48	101.41	78.48
2011-2015	Articles	984	75	68	87	58	86	147	43	35	21
	Citations	27679	2235	1842	2278	1684	1853	3542	1009	1053	661
	Attractive Index	1.01	0.38	0.33	0.48	0.4	0.49	1.27	0.44	0.47	0.35
	Immediacy Index	28.13	29.8	27.09	26.18	29.03	21.55	24.1	23.47	30.09	31.48
	TAI	98.53	83.93	69.57	81.79	102.72	74.41	189.58	101.55	93.94	74.15
2016-2021	Articles	664	33	44	85	37	49	262	41	17	17
	Citations	6949	333	377	739	527	443	2574	420	237	145
	Attractive Index	0.009	0.004	0.004	0.01	0.008	0.008	0.06	0.012	0.007	0.005
	Immediacy Index	10.47	10.09	8.57	8.69	14.24	9.04	9.82	10.24	13.94	8.53
	TAI	80.64	99.44	54.59	43.64	70.98	57.56	409.79	117.43	55.34	72.8

Total Papers	7264	667	711	754	567	609	564	308	271	206	
Total Citations	293532	33420	32199	27472	24195	21611	15946	13080	12900	10928	
JOURNAL OF GENERAL VIROLOGY											
Block Years	Countries	USA	UK	Japan	GER	France	NL	AUS	China	Canada	Spain
1991-1995	Citations	16388	18245	9865	5320	5042	5798	2851	510	2692	1693
	Record	388	381	165	121	128	82	56	7	81	43
	Attractive Index	1	1.14	1.49	0.87	1	1.56	1.04	0.19	1.11	0.73
	Immediacy Index	42.24	47.89	59.79	43.97	39.39	70.71	50.91	72.86	33.23	39.37
	TAI	108.48	130.98	115.28	86.71	119.52	8.36	89.33	133.73	137.06	86.51
1996-2000	Citations	18990	18758	6608	7268	6438	4144	3343	822	2249	2029
	Record	360	348	151	166	135	70	70	13	46	48
	Attractive Index	1.04	1.06	0.9	1.07	1.15	1.01	1.1	0.28	0.83	0.78
	Immediacy Index	52.75	53.9	43.76	43.78	47.69	59.2	47.76	63.23	48.89	42.27
	TAI	97.35	115.71	102.03	115.05	121.92	15.02	108.01	110.41	75.28	93.4
2001-2005	Citations	17238	20636	7819	7943	7587	3596	2524	1793	2448	3553
	Record	341	342	169	163	159	75	49	32	52	71
	Attractive Index	0.89	1.09	1	1.1	1.28	0.82	0.78	0.56	0.85	1.29
	Immediacy Index	50.55	60.34	46.27	48.73	47.72	47.95	51.51	56.03	47.08	50.04
	TAI	89.09	109.87	110.33	109.15	138.74	35.73	73.05	114.3	82.22	133.48
2006-2010	Citations	14050	12356	5046	6254	4230	2748	2716	4249	3155	2881
	Record	383	265	133	161	107	67	69	100	80	59
	Attractive Index	0.91	0.82	0.81	1.08	0.9	0.79	1.05	1.68	1.38	1.31
	Immediacy Index	36.68	46.63	37.94	38.84	39.53	41.01	39.36	42.49	39.44	48.83
	TAI	98.79	84.05	85.73	106.44	92.18	110.23	101.55	100.81	124.89	109.51
2011-2015	Citations	9967	7059	2395	2531	1029	1366	1544	4326	1021	1059
	Record	331	206	124	106	51	41	68	164	55	49
	Attractive Index	1.19	0.87	0.71	0.81	0.4	0.73	1.11	3.17	0.83	0.9
	Immediacy Index	30.11	34.27	19.31	23.88	20.18	33.32	22.71	26.38	18.56	21.61
	TAI	101.92	77.99	95.4	83.65	52.44	215.79	119.46	73.63	102.49	108.57
2016-2021	Citations	4423	1710	818	875	403	614	545	1531	406	263
	Record	291	161	96	100	47	24	55	174	32	21
	Attractive Index	1.47	0.58	0.68	0.78	0.44	0.9	1.08	3.11	0.91	0.62
	Immediacy Index	15.2	10.62	8.52	8.75	8.57	25.58	9.91	8.8	12.69	12.52
	TAI	107.25	72.96	88.41	94.46	57.85	274.05	115.66	51.59	71.38	55.69
Total Papers	2094	1703	838	817	627	359	367	490	346	291	
Total Citations	81056	78764	32551	30191	24729	18266	13523	13231	11971	11478	
ARCHIVES OF VIROLOGY											
Block Years	Countries	China	USA	Japan	GER	UK	France	AUS	Brazil	Italy	India
1991-1995	Citations	152	7584	3779	2948	4614	1242	2171	252	1451	231
	Record	10	235	157	117	103	65	61	14	81	12
	Attractive Index	0.04	0.94	0.89	0.88	1.03	0.53	1.08	0.17	0.84	0.25
	Immediacy Index	15.2	32.27	24.07	25.2	44.8	19.11	35.59	18	17.91	19.25
	TAI	4.04	99.28	97.32	128.01	121.46	97.47	105.71	24.81	151.82	23.94

1996-2000	Citations	403	7830	5564	3589	4822	2245	1825	678	1281	553
	Record	17	250	234	125	119	70	74	14	43	20
	Attractive Index	0.09	0.84	1.13	0.93	0.93	0.83	0.78	0.39	0.64	0.51
	Immediacy Index	23.71	31.32	23.78	28.71	40.52	32.07	24.66	48.43	29.79	27.65
	TAI	7.28	111.91	153.71	144.92	148.7	111.22	135.89	26.28	85.4	42.28
2001-2005	Citations	3900	9273	4052	3520	6033	2834	1454	538	1576	956
	Record	76	234	176	76	110	72	62	18	42	41
	Attractive Index	0.96	1.08	0.9	1	1.28	1.15	0.68	0.34	0.87	0.97
	Immediacy Index	51.32	39.63	23.02	46.32	54.85	39.36	23.45	29.89	37.52	23.32
	TAI	38.8	124.84	137.78	105.01	163.82	136.35	135.69	40.28	99.42	103.31
2006-2010	Citations	5120	8728	4725	3373	4830	2293	2464	1694	1454	1064
	Record	215	249	191	93	92	82	72	51	53	57
	Attractive Index	1.26	1.02	1.05	0.95	1.02	0.93	1.15	1.06	0.8	1.08
	Immediacy Index	23.81	35.05	24.74	36.27	52.5	27.96	34.22	33.22	27.43	18.67
	TAI	86.91	105.19	118.4	101.75	108.49	122.96	124.78	90.36	99.34	113.72
2011-2015	Citations	7240	8695	4551	3706	3255	1807	2136	2315	2480	1775
	Record	512	309	169	104	67	63	50	86	74	103
	Attractive Index	1.85	1.06	1.06	1.09	0.72	0.76	1.04	1.51	1.42	1.88
	Immediacy Index	14.14	28.14	26.93	35.63	48.58	28.68	42.72	26.92	33.51	17.23
	TAI	151.66	95.65	76.77	83.38	57.9	69.22	63.49	111.65	101.64	150.58
2016-2021	Citations	5839	5596	2339	2569	2751	3307	1830	3419	1893	895
	Record	911	402	219	135	113	120	92	215	86	122
	Attractive Index	2.53	1.15	0.92	1.28	1.03	2.36	1.51	3.77	1.83	1.6
	Immediacy Index	6.41	13.92	10.68	19.03	24.35	27.56	19.89	15.9	22.01	7.34
	TAI	182.09	83.97	67.13	73.04	65.89	88.97	78.84	188.36	79.71	120.36
Total Papers		1762	1686	1149	651	604	475	411	402	380	357
Total Citations		22654	47706	25010	19705	26305	13728	11880	8896	10135	5474

In Table VI show the contributions to virology made by the world's top 10 countries over the last three decades. The USA has the major share of 56.01% papers (20240) & 58.32% citations (1241308), followed by Germany with 5.62% papers (2092) & 5.43% citations (115491) and the UK with 5.12% papers (1905) & 5.38% citations (114503) in the Journal of Virology. The USA with 48.26% papers (7264) & 50% citations (293532), followed by Japan with 5.01% papers (754) & 4.68% citations (27472) and Germany with 4.72% papers (711) & 5.48% citations (32199) in the Virology Journal.

The USA with 25.12% papers (2699) & 23.80% citations (101467), followed by the UK with 20.95% papers (2251) & 23.49% citations (100161) and Germany with 11.2 % papers (1205) 10.40% citations (44357) & in the Journal of General Virology. The China with 19.07% paper (1762) & 13.13% citations (22654), followed by the USA with 18.25% papers (1686) & 27.65% citations (47706) and Japan with 12.4% papers (1149) & 14.50% citations (25010) in the Archives of Virology.

The highest Attractive Index in block 1991-1995 was found to be Sweden with 1.44, Norway with 1.65 in block 1996-2000, Austria with 1.86 in block 2001-2005, Singapore with 1.71 in block 2006-2010, China with 3.12 in block 2011-2015, and China with 5.38 in block 2016-2021 in Journal of Virology. The highest Attractive Index in block 1991-1995 was found to be Hungary with 1.61, Russia with 1.62 in block 1996-2000, Denmark with 3.21 in block 2001-2005, Thailand with 2.32 in block 2006-2010, Belgium with 1.41 in block 2011-2015, and China with 0.060 in block 2016-2021 in Virology Journal. The highest Attractive Index in block 1991-1995 found Japan with 1.20, Israel with 1.35 in block 1996-2000, Norway with 1.92 in block 2001-2005, Thailand with 2.30 in block 2006-2010, China with 3.13 in block 2011-2015 and Brazil with 6.85 in block 2016-2021 in Journal of General Virology. The highest Attractive Index in block 1991-1995 was found to be Sweden with 1.44, Taiwan with 1.34 in block 1996-2000, the UK with 1.28 in block 2001-2005, South Korea with 1.35 in block 2006-2010, New Zealand with 2.55 in block 2011-2015, and Switzerland with 4.45 in block 2016-2021 in Archives of Virology.

The highest Immediacy Index secured by South Africa with 148.33 in 1991-1995 block, China with 155.06 in 1996-2000 block, China with 124.82, in 2001-2005 block, Denmark with 88.41 in 2006-2010, Russia with 53.10 in 2011-2016 block and Thailand with 19.75 in 2017-2021 block in Journal of Virology. The highest Immediacy Index secured by Thailand with 93 in 1991-1995 block, China with 204.78 in 1996-2000 block, China with 75.33 in 2001-2005 block, Singapore with 81.94 in 2006-2010, S Africa with 57.86, in 2011-2016 block and Hungary with 287 in 2017-2021 block in Virology Journal. The highest Immediacy Index was secured by Singapore with 162.67 in the 1991-1995 block, Thailand with 71.50 in the 1996-2000 block, Thailand with 82.43 in the 2001-2005 block, South Africa with 56.57 in the 2006-2010 block, Thailand with 51.81 in the 2011-2016 block and Denmark with 43.20, Hungary with 30.18 in the 2017-2021 block in Journal of General Virology. The highest Immediacy Index secured by UK with 44.80 in 1991-1995 block, Hungary with 61.82 in 1996-2000 block, Thailand with 96 in 2001-2005 block, Belgium with 91.89 in 2006-2010, Belgium with 76.84 in 2011-2015 block and Switzerland with 48.04 in 2016-2021 block in Archives of Virology.

The Transformative Activity Index of top 30 countries. Out of that, Thailand has the highest TAI with 136.03 in 1991-95 block, Brazil with 131.66 in 1996-2000 block, New Zealand with 171.88 in 2001-2005 block, Russia with 155.90 in 2006-2010 block, Canada with 206.59 in 2011-2015 and Canada with 330.89 in 2016-2021 in Journal of Virology. The Hungary had the highest TAI with 148.62 in the 1991-95 block, Switzerland with 207.53 in the 1996-2000 block, Denmark with 244.75 in the 2001-2005 block, Thailand with 203.47 in the 2006-2010 block, Thailand with 223.70 in 2011-2015 and China with 429.24 in 2016-2021 in Virology Journal. The Israel had the highest TAI with 114.39 in the 1991-95 block, Israel with 134.21 in the 1996-2000 block, Norway with 177.94 in the 2001-2005 block, Thailand with 1.99.12 in the 2006-2010 block, China with 226.78 in 2011-2015 and China with 285.74 in 2016-2021 in Journal of General Virology. The Sweden has the highest TAI with 171.92 in 1991-95 block, Switzerland with 172.27 in 1996-2000 block, Finland with 190.8 in 2001-2005 block, Australia with 124.78 in 2006-2010 block, New Zealand with 180.85 in 2011-2015 and Egypt with 221.29 in 2016-2021 in Archives of Virology.

VI. CONCLUSION

The scientific information gained from this study will be of immense help in assessing and promoting virology research. It would help scholars of virology and researchers to become aware of the current trends in virology research activity. The quality of virology-based research originating globally was low for some countries. More effort is needed to bridge the gap in virology-based research and to promote better evaluation of virology use or control services in the world. The foremost aim of this study was to draw attention to and to open doors for a scientific discussion among professionals and academicians about virology research.

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