Int J Med. Public Health. 2022; 12(4):156-164
A Multifaceted Peer Reviewed Journal in the field of Medicine and Public Health
www.ijmedph.org

Review Article

"Respiratory Syncytial Viruses (RSV) Infection in Children": A Scientometric Analysis of Global Publications during 2002-21

BM Gupta[1,*], Manish Mohan Gore[2], Atul Gupta[3], Avadhesh Kumar Patel[4]

ABSTRACT

The study reviewed the publication growth and identified key players and traced the evolution of research themes on "RSV Infection in Children". Using Scopus database, a keyword search was undertaken, which yielded 917 research records during 2002 to 2021. The retrieved research data was analyzed using a bibliometric analysis techniques and MS-Excel software. The co-authorship network visualization of authors, organizations and countries and co-occurrence network visualization of all keywords are visualized using VOSviewer software. The 917 papers were written by 4902 authors employed at 710 organizations based in 104 countries/territories and were published in 273 journals in the field. The top journals ranked by publication productivity were *Pediatric Infectious Disease Journal, Journal of Infectious Diseases* and *PLOS One* and by citation impact per paper were *American Journal of Respiratory and Critical Care Medicine, Infectious Diseases and Therapy* and *Journal of Pediatrics*. Authors from countries contributed the most publications were USA, U.K. and China, and those contributing the most impactful publications were France, Japan and Spain. Center for Disease Control and Prevention, USA, University Medical Center Utrecht, Netherlands, and MedImmune LLC Inc. USA are the three organizations with the most productive publications and Kenya Medical Research Institute, South African Medical Research Council, South Africa and University of Witwatersrand, Johannesburg, South Africa are the organizations with most impactful organizations. Authors contributing the most were O. Ramilo (USA), E.A.F. Simoes (USA) and R.A. Karron (USA) and the most impactful papers were D.J. Nokes (U.K.), K.M. Edwards (USA) and C.B. Hall (USA). Based on collaboration network maps, there were significant collaborations based on common interests. According to the keyword co-occurrence diagram, the most frequent keywords are "Respiratory Synctial Virus", "Respiratory Syncytial Pneumovirus", "Human Respiratory Syncytial Virus", "Hospitalization", "Respiratory Tract Infection" and "Brochiolitis". Analysis of 44 significant keywords showed that the research was distributed into 4 clusters, which indicates the most significant areas of current research. With the acceleration of the child diseases, the number of articles on "RSV in Children" is increasing rapidly. Bibliometric analysis of global research in this area for the last 20 years can provide useful information and meaningful reference to funding agencies and researchers, enabling them to explore current research status and identify the future areas and hotspots.

Keywords: Respiratory Syncytial Viruses Infection, RSV Infection, Respiratory Virus, Children, Global Publications, Scientometrics, Bibliometrics.

BM Gupta[1,*], Manish Mohan Gore[2], Atul Gupta[3], Avadhesh Kumar Patel[4]

[1]Formerly with CSIR-NISTADS, New Delhi, INDIA.
[2]National Institute of Science Communication & Policy Research, New Delhi, INDIA.
[3]Dr. Rajendra Prasad Government Medical College, Kangra at Tanda, Himachal Pradesh, INDIA.
[4]Banaras Hindu University, Department of Library and Information Science, Varanasi, Uttar Pradesh, INDIA.

Correspondence
Dr. BM Gupta
Formerly with CSIR-NISTADS,
New Delhi 110012, INDIA.
Email id: bmgupta1@gmail.com

History
- Submission Date: 14-09-2022;
- Revised Date: 30-10-2022;
- Accepted Date: 12-11-2022.

DOI : 10.5530/ijmedph.2022.4.29

Article Available online
http://www.ijmedph.org/v12/i4

INTRODUCTION

RSV was isolated and reported first in 1956 from nasal samples of chimpanzee,[1] which later reported from infants with severe respiratory tract infection in 1957.[2] Children across the world are most commonly infected by Respiratory Syncytial Virus (RSV). It is increasingly recognized as an important pathogen in adults, especially the elderly. An upper respiratory infection is the most common clinical scenario encountered in RSV infection, but RSV commonly presents as bronchiolitis (a lower respiratory tract illness) in young children with small airway obstruction, and can rarely progress to pneumonia, respiratory failure, apnea, and death. RSV is a single-stranded, negative-strand, RNA virus belonging to the *Paramyxoviridae* family, and is in the genus Pneumovirus.[3] RSV has biennial peaks of occurrence but seasonal incidence of RSV is more evident in rainy season in tropical countries and winter months in temperate regions.[4-5] Immunity after RSV infection is partial and reinfection is common in childhood.[6] RSV causes substantially to morbidity and mortality burden globally among children of age ranged 0–60 months and particularly during the first 6 months of child-birth and in LMICs. According to 2019 Global Survey, there were 33·0 million RSV-associated acute lower respiratory infection episodes, 3·6 million RSV-associated acute lower respiratory infection hospital admissions, 26300 RSV-associated acute lower respiratory infection in-hospital deaths and 101 400 RSV-attributable overall deaths in children aged 0–60 months.[7] Treatment for RSV falls into

Cite this article : Gupta BM, Gore MM, Gupta A, Patel AK. "Respiratory Syncytial Viruses (RSV) Infection in Children": A Scientometric Analysis of Global Publications during 2002-21. 2022;12(4):156-64.

three categories: supportive care, immune prophylaxis, and antiviral medication.[3]

Literature Review

Despite the public health importance of the disease, few studies have evaluated research in the area using bibliometric methods. Among the specific studies on this topic, Bruggmann *et al.*[8] assessed scientific publication output of Respiratory syncytial virus by geographical, chronological and socioeconomic criteria and analyzed the authors publishing in the field by gender. 15 most cited articles and the most prolific journals were also identified on RSV research. Kirolos, Christides, Xian, Reeves, Nair and Campbell[9] explored the types of study and geographical spread of RSV-related publications from Europe and North/Central America. It also identified productive research institutions and funding bodies, who contributed to RSV research. It explored the existing status and explored future research areas on this topic. Among related research, the bibliometric assessment were made in areas of bronchitis research[10] and pneumonia.[11-13]

The bibliometrics methods studies publication patterns using descriptive approach or using citation analysis on aggregated publication data of major players. The two approaches indicate how many articles your organization has published, or evaluated, such as using citation analysis to look at how those articles influenced subsequent research by others. While doing comparisons, counting the publications may be useful. But citation analysis allows us to look at the impact of those articles have had on others by determining how often they are cited. Citation analysis can also show what journals, organizations and even countries have high impact in different fields of research.[14] Bibliographic data is also used for obtaining the network maps showing keyword co-occurrences, country co-authorship, institutional-co-authorship and author co-authorships using VOSviewer software and the clustering techniques

Due to burden of disease and associated morbidity and mortality there has been renewed interest in research on "RSV Infection in Children". Only few studies have evaluated research using scientometric methods. We therefore planned to undertake this scientometric study to understand global research on RSV and its various ramifications. The aim of this study was to utilize the bibliographic features of publications on "RSV Infection in Children": (i) To study the growth rate and growth pattern in literature during 2002-21, (ii) To identify the most prolific countries, organizations and authors, (iii) To analyze the co-authorship patterns of countries, organizations and authors on the basis of clustering technique (iv) to identify the important sources and their productivity and citation impact, (v) To identify the important keywords and their co-occurrence to understand the significant research areas, (5) To analyze the bibliometric characteristics of high-cited papers. The study uses VOSviewer to prepare the network map of organizational, country and author co-authorship analysis with clustering technique and MS-Excel for graphical and statistical analysis.

METHODOLOGY

All relevant studies on "RSV Infection in Children" indexed and retrieved from the Scopus database (http://www.scopus.com) till June 1, 2022. Scopus is one of the largest abstract and citation databases of peer-reviewed literature and provides overview of the world's research output in the fields of science, technology, medicine, social sciences, and arts and humanities.[1] It is a an international interdisciplinary database that indexes much more number of journals in comparison to PubMed or Web of Science, particularly in medical sciences field.[15]

The literature on this theme was searched on two set of keywords related to "Respiratory Syncytial virus" and Child (child* or kid* or newborn* or pediatric* or paediatric* or juvi*). These two set of keywords joined by boolen operator "and" were searched in 'Title" tag of the Scopus database. In all 917 global records were obtained. The search strategy used is given below. For each of the retrieved documents, data on the following bibliographic characteristics were extracted: year of publication, journal of publication and subject category, document type, authorship, citations, institutional affiliation(s), and keywords. The data was downloaded as a csv file from Scopus and then was exported to MS-Excel. Microsoft Excel 2016 (Microsoft, Redmond, WA) was used to perform statistical analyses of countries, institutions, articles, source publications, and authors. Bibliographic data is also used for obtaining the network maps showing keyword co-occurrences, country co-authorship, institutional-co-authorship and author co-authorships using VOSviewer software and the clustering techniques.[16] A number of quantitative and qualitative indicators are used for analyzing the performance of global RSV for Children's.

TITLE ("Respiratory Syncytial virus" AND (child* OR kid* OR newborn* OR pediatric* OR paediatric* OR juvi*) AND PUBYEAR > 2001 AND PUBYEAR < 2022 AND PUBYEAR > 2001 AND PUBYEAR < 2022.

RESULTS AND ANALYSES

Overall Trends

The cumulative and yearly global publications trend in "RSV Infection in Children" is presented in Table 1. The number of publications increased from 26 in year 2002 to 89 in year 2021, growing at the rate of 45.85 per year and registering 8.33% annual average growth rate. As shown in Figure 1, the growth line of publications slightly fluctuates with increasing trends. The trend line is generated by an exponential with equation $Y = 2.7E\text{-}49e^{0.0575X}$ and $R^2 = 0.853$ and linear $R^2 = 0.796$, which shows that $R^2_{exponential} > R^2_{Linear}$ for publications, which means the growth of publications is exponential. The cumulative publication output in the last 10 years was 577, significantly higher than the 340 in the first 10 years and experienced 69.71% absolute growth. This indicates the growing interest in RSV virus.

The 917 global publications on "RSV Infection in Children" received 25303 citations, averaging 27.59 citations per year. Of the 917 global publications, 30.32% (278) publications received extra-mural funding support and received 10299 citations, averaging 37.05 citations per paper. The funded papers increased from 45 during 2002-11 to 233

Table 1: Cumulative and Yearly Publications Output in "RSV Infection in Children".

Year	TP	TC	CPP	Year	NP	NC	CPP
2002	26	1391	53.50	2014	39	1235	31.67
2003	26	1618	62.23	2015	44	1002	22.77
2004	30	1806	60.20	2016	47	1112	23.66
2005	34	996	29.29	2017	60	2132	35.53
2006	31	1110	35.81	2018	65	798	12.28
2007	40	1157	28.93	2019	59	271	4.59
2008	34	1134	33.35	2020	76	443	5.83
2009	35	2237	63.91	2021	89	376	4.22
2010	36	2672	74.22	2002-11	340	15379	45.23
2011	48	1258	26.22	2012-21	577	9924	17.20
2012	41	1203	29.34	2002-21	917	25303	27.59
2013	57	1352	23.72				

TP: Total publications; TC: Total citations; CPP: Citations per paper.

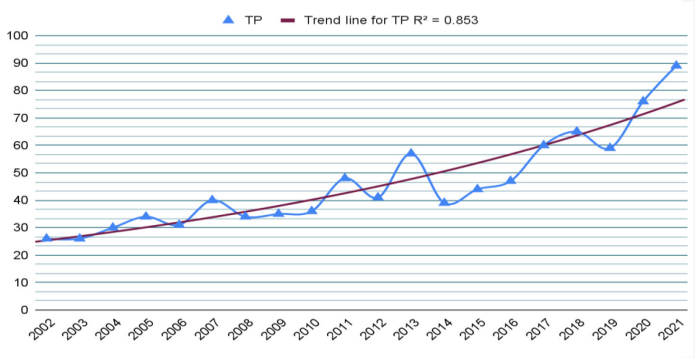

Figure 1: Growth line of publications.

during 2012-21. The largest funding support in terms of research output (42 papers) came from National Institute of Health, USA, followed by National Institute of Allergy and Infectious Diseases, USA (33 papers), Bill and Melinda Gates Foundation, USA (31 papers), U.S. Department of Health and Human Service, USA (29 papers), MedImmune (26 papers), European Commission (19 papers), AbbVie (18 papers), Center for Disease Control and Prevention, USA, Japan Society for Promotion of Science and National Center for Advancing Translational Sciences (16 papers each), etc. Among publication types, articles constitute the largest publication share (80.81% and 741 papers), followed by reviews (8.40% share and 77 papers), letters (3.71% share and 34 papers), erratum (2.18% share and 20 papers), notes (2.07% share and 19 papers), conference papers (1.96% share and 18 papers), book chapters (0.55% share and 5 papers) and editorials (0.33% share and 3 papers).

Geographical Distribution

The 104 countries participated in global research on "RSV Infection in Children", of which 78 countries contributed 1-10 papers each, 12 countries 11-20 papers each, 7 countries 21-50 papers each, 5 countries 12351-100 papers each and 2 countries 109-315 papers each. The top 10 countries published 40 to 315 papers and together contributed 817 papers and 41168 citations, accounting for 89.09% and more than 100.0% share of global papers and citations. Only one country, namely USA contributed 117 papers, more than average per paper (81.70) of top 10 countries. In contrast five countries have registered more than the average citations per paper and relative citation index (50.39 and 1.83) of top 10 countries: France (87.65 and 3.18), Japan (82.55 and 2.99), Spain (78.21 and 2.833), U.K. (56.55 and 2.05) and Netherlands (51.81 and 1.88). The collaborative share of top 10 countries varied from 13.43% to 67.80%, with an average of 46.88% (Table 2).

Collaborative Linkages among Top 10 Countries

The total collaborative linkages (TCL) of top 10 countries varied from 51 to 398. The top 5 countries with highest TCL are USA (398), U.K. (250), Netherlands (198), France (175) and Spain (158). The TCL among top 10 countries however varied from to 13 to 132. The country to country collaborative linkages varied from 1 to 26, with highest collaborative linkages (26) was between USA-U.K., followed by USA-Spain (24 linkages), U.K.-Netherlands (23 linkages), USA-Canada and USA-Netherlands (19 linkages each), USA-Spain (16 linkages),Netherland-France (15 linkages), U.K.-France (13 linkages), U.K.-Australia (12 linkages), USA-Australia (11 linkages), USA-Italy, Netherland-Italy, Spain-France and France-Italy (10 linkages each), Canada-Spain and Spain-Netherlands (9 linkages each), etc.

Table 2: Top 10 Countries in "RSV Infection in Children".

Sl. No	Name of the country	TP	TC	CPP	HI	ICP	%ICP	RCI	TCL	%TP
1	USA	315	15523	49.28	59	121	38.41	1.79	398	34.35
2	U.K.	109	6164	56.55	34	71	65.14	2.05	250	11.89
3	China	67	1547	23.09	14	9	13.43	0.84	51	7.31
4	Canada	62	2226	35.90	21	35	56.45	1.30	101	6.76
5	Netherlands	59	3057	51.81	26	40	67.80	1.88	198	6.43
6	Spain	56	4380	78.21	21	33	58.93	2.83	158	6.11
7	Japan	22	1816	82.55	16	12	54.55	2.99	76	2.40
8	Italy	44	850	19.32	15	17	38.64	0.70	66	4.80
9	France	43	3769	87.65	19	26	60.47	3.18	175	4.69
10	Australia	40	1836	45.90	17	19	47.50	1.66	120	4.36
	Total of top 10 countries	817	41168	50.39		383	46.88	1.83		
	Global total	917	25303	27.59				1.00		
	Share of top 10 countries in global total	89.09								

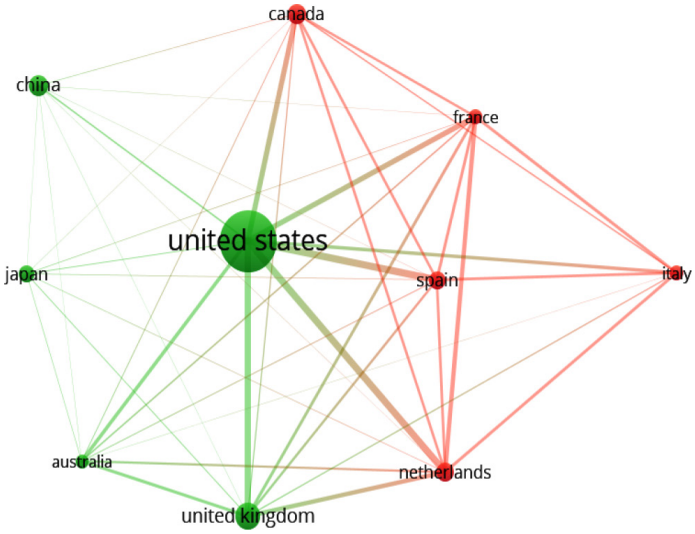

Figure 2: Country Co-Authorship Network of Top 10 Most Productive countries.

The collaborative country network of top 10 countries presented in Figure 2, constructed using VOSviewer software. These countries are grouped into two clusters, each with a different color. Cluster 1 (Red color, 5 Countries) includes, *Canada, Netherlands, Spain, France* and *Italy.* Cluster 2 (Green, 5 Countries) includes the *United States, United Kingdom, China, Japan* and *Australia*.

Significant Keywords

Keywords define the field, subfield, topic, research issue, etc. that are covered by the articles. It also offers a simple way to capture words and short phrases that appear most frequently and can also represent its main content, and the frequency of occurrence and co-occurrence can reflect themes that focus on a special field to some extent. Connecting keywords

Table 3: List of 44 Most Prominent Keywords on "RSV Infection in Children".

Sl. No	Name of the Keyword	Frequency	TCL	Sl. No	Name of the Keyword	Frequency	TCL
1	Respiratory Syncytial Virus (RSV)	823	26019	23	Genotype	63	2511
2	Human Respiratory Syncytial Virus	407	13248	24	Respiratory Syncytial Virus Vaccine	62	2615
3	Hospitalization	404	12761	25	Rice Stripe Virus	52	1868
4	Respiratory Syncytial Pneumovirus	342	11712	26	Oxygen Therapy	49	2045
5	Respiratory Tract Infection	266	7135	27	Phylogeny	47	1949
6	Bronchiolitis	204	6269	28	Antibody Agents	46	2097
7	Virus Infection	158	5474	29	Human Metapneumovirus	46	1676
8	Lower Respiratory Tract Infection	154	5694	30	Immunoprophylaxis	46	1631
9	Polymerase Chain Reaction	149	3116	31	Metapreumovirus	44	1814
10	Wheezing	116	4516	32	Chronic Lung Disease	44	1893
11	Reverse Transcription Polymerase Chain Reaction	108	3837	33	Nasopharyngeal Aspiration	43	1779
12	Antiviral Agents	95	3431	34	Nose Smear	41	1853
13	Pneumonia	94	3323	35	Pneumovirus	39	1588
14	Asthma	91	3594	36	Paramyxoviridae Infection	38	1553
15	Artificial Ventilation	87	3556	37	Rhinovirus	38	1654
16	Viral Bronchiolitis	77	2414	38	Co-infection	37	1588
17	Influenza	77	2632	39	Respiratory Sounds	37	1496
18	Real Time Polymerase Chain Reaction	77	3376	40	Intensive Care	36	1391
19	Congenital Heart Disease	75	2840	41	Virus RNA	36	1542
20	Nasopharynx	73	3003	42	Genetic Variability	34	1486
21	Monoclonal Antibody	69	2177	43	Ribavirin	34	1353
22	Coughing	67	3194	44	Prophylaxis	33	598
24	RSV Vaccine	62					
25	Rice Stripe Virus	52					

into a network of those that appear in the same publication gives insight into the landscape of knowledge in the field.

The top 44 keywords which are having at least 33 occurrences are shown in Table 3. The table shows that "Respiratory Syncytial Virus" author keyword is largely studied concept (with 823 occurrences and 26019 TLS), followed by Respiratory Syncytial Pneumovirus (342 occurrences and and 11712 TLS), Human Respiratory Syncytial Virus (407 occurrences and 13248 TLS), Hospitalization (404 occurrences and 12761 TLS), Respiratory Tract Infection (366 occurrences and 7135 TLS), Brochiolitis (204 occurrences and 6269 TLS), etc.

We used VOSviewer to generate keyword co-occurrence network. Initially, a total of 40965 keywords from the list of 917 papers (with minimum of 1 occurrence) were extracted. In order to generate the co-occurrence network of most frequently used author keywords, the keywords were limited to at least 33 occurrences which resulted in a total of 769 keywords. Of 769 keywords, only 44 keywords were selected for keyword co-occurrence network. Figure 3 depicts the frequently used 44 author keywords co-occurrence network, which are presented under 4 clusters, each cluster being represented by different color and indicating a different theme. Cluster 1 (Red, 19 Keywords) includes to *human respiratory syncytial virus, polymerase chain reaction, co-infection, phylogeny, genotype, nasopharynx, paramyxoviridae infections, metapneumovirus,* and others; Cluster 2 (Green, 16 keywords) includes *respiratory syncytial virus, hospitalization, respiratory syncytial pneumovirus, congenital heart disease, lower respiratory tract infection, artificial ventilation, ribavirin, respiratory syncytial virus vaccine,* and others; Cluster 3 (Blue, 9 Keywords) includes *asthma, bronchiolitis,*

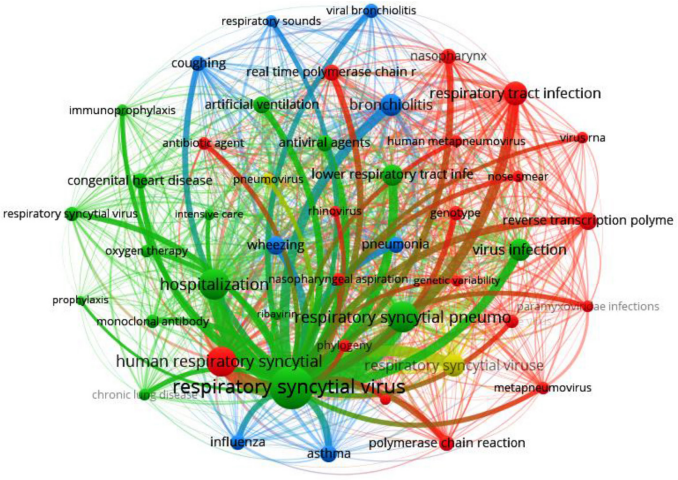

Figure 3: Keyword Co-occurrence Network.

coughing, pneumonia, wheezing, influenza, viral bronchiolitis, and respiratory sounds; and Cluster 4 (Yellow, 2 Keywords) includes *pneumovirus and respiratory syncytial viruses.*

Most Productive and Impactful Organizations

The 710 global organizations participated in global research on "RSV Infection in Children", with top 25 organizations together contributing

Table 4: Bibliometric Profile of Top 7 Most Productive and 7 Most Impactful Organizations in "RSV Infection in Children" during 2002-21.

Sl. No	Name of the organization	TP	TC	CPP	HI	ICP	%ICP	RCI	TCL
Top 7 Most Productive Organizations									
1	Center for Disease Control and Prevention, USA	40	4921	123.03	22	20	50.00	4.46	290
2	University Medical Center Utrecht, Netherlands	30	2050	68.33	16	18	60.00	2.48	276
3	MedImmune LLC Inc. USA	26	1410	54.23	20	7	26.92	1.97	136
4	Baylor College of Medicine, USA	23	923	40.13	17	8	34.78	1.45	187
5	John Hopkins Bloomberg School of Public Health, USA	21	3367	160.33	11	10	47.62	5.81	286
6	University of Colorado, School of Medicine, USA	21	894	42.57	15	14	66.67	1.54	139
7	Nationalwide Children's Hospital, USA	21	1263	60.14	12	14	66.67	2.18	147
Top 7 Most Impactful Organizations									
1	Kenya Medical Research Institute	14	3410	243.57	12	14	100	8.83	138
2	South African Medical Research Council, South Africa	15	3329	221.93	12	14	93.33	8.04	232
3	University of Witwatersrand, Johannesburg, South Africa	17	3492	205.41	13	15	88.24	7.45	267
4	Hospital Clinic Barcelona, Spain	20	3783	189.15	13	17	85	6.86	238
5	University of Edinburg, U.K.	20	3307	165.35	11	19	95	5.99	235
6	John Hopkins Bloomberg School of Public Health, USA	21	3367	160.33	11	10	47.62	5.81	286
7	Wilhelmina Kinderziekenhuis, Netherland	11	1610	146.36	10	8	72.73	5.3	181

467 papers and 46932 citations, constituting 50.93% and more than 100.0% share of global papers and citations. Among the top 25 organizations, 13 were from USA, 4 from U.K., 3 from Netherlands, 2 from South Africa, and 1 each from Canada, Kenya and Spain. On further analysis, it was observed the organizations that have published at least 13 papers and maximum 40 are in the list under consideration for analysis. The publication profile of these 7 top most productive and 7 most impactful organizations, on the basis of publications and citation impact per paper are listed in Table 4.

The top 25 organizations have together contributed 467 papers (50.93% share) in the cumulative publication output with an average of 18.68 papers per organization. Only 11 organizations have produced greater number of publications than the group average. The total citations received by the papers of these 25 organizations are 46392 and accordingly, the citations per paper (CPP) and relative citation index (RCI) received by 467 papers are 100.50 and 3.64. The 11 organizations registered more than the average citations per paper and relative citation index of top 25 organizations.

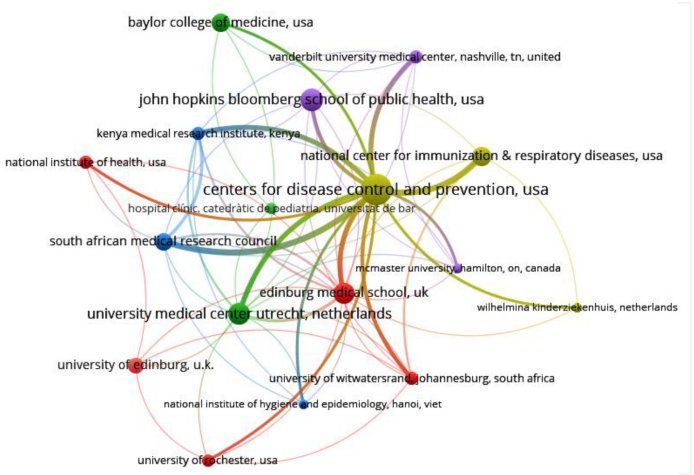

Figure 3: Top Organizations Collaborative Network Map.

Collaborative Linkages among Top 25 Organizations

The total collaborative linkages (TCL) of top 25 organizations varied from 59 to 290, with the top 4 organizations with highest TCL (290, 286, 276 and 267) were Center for Disease Control and Prevention, USA, John Hopkins Bloomberg School of Public Health, USA, University Medical Center Utrecht, Netherlands and University of Witwatersrand, Johannesburg, South Africa. The organization to organization collaborative linkages varied from 1 to 17, with highest collaborative linkages (17 each) was between Center for Disease Control and Prevention, USA and National Center for Immunization and Respiratory Diseases, USA and University Medical Center, Utrecht, Netherlands and Wilhelmina Kinderziekenhuis, Netherlands, followed by University of Edinburg, U. and Edinburg Medical School, U.K (14 linkages), Colorado School of Public Health, USA and University of Colorado, School of Medicine, USA (13 linkages), etc.

The top 25 organizations collaborative network map generated using VOSviewer is presented in Figure 3. The most highly connected and related items are chosen to be 17 items with at least 6 links between them, and a network map of these connected organizations is created, with the remaining organizations having fewer or no connections with other organizations. There are five clusters made up of these 17 highly connected organizations, each with its own color. The five clusters are: Cluster 1 (Red, 5 Organizations) consists of *Edinburgh Medical School, UK; University of Edinburgh, UK; University of Witwatersrand, Johannesburg, South Africa;* and others. Cluster 2 (Green, 3 Organizations) consists of *University Medical Center Utrecht, Netherlands; Baylor College of Medicine, USA; and Hospital Clinic Barcelona, Spain*. Cluster 3 (Blue, 3 Organizations) consists *Kenya Medical Research Institute, Kenya; South African Medical Research Council, South Africa;* and *National Institute of Hygiene and Epidemiology, Vietnam*. Cluster 4 (Yellow, 3 Organizations) includes *Center for Disease Control and Prevention, USA; National Center for Immunization and Respiratory Diseases, USA;* and *Wilhelmina Kinderziekenhuis, Netherlands.* Cluster 5 (Violet, 3 Organizations) includes *John Hopkins Bloomberg School of Public Health, USA; Vanderbilt University Medical Center, USA*; and *McMaster University, Canada*. The remaining organizations have fewer or no network relations with each other, so they were presented separately [Figure 3].

Table 5: Bibliometric Profile of Top 7 Most Productive and 7 Most Impactful Authors in "RSV Infection in Children" during 2002-21.

Sl. No	Name of the author	Affiliation	TP	TC	CPP	HI	ICP	%ICP	RCI	TCL
		Top 7 Most Productive Authors								
1	O. Ramilo	Nationwide Children's Hospital, USA	21	1029	49.00	13	11	52.38	1.78	173
2	E.A.F. Simoes	Colorado School of Public Health, USA	19	911	47.95	13	15	78.95	1.74	149
3	R.A. Karron	John Hopkins Bloomberg School of Public Health, USA	16	467	29.19	10	7	43.75	1.06	180
4	H. Nair	University of Edinburg, U.K.	16	3289	205.56	10	15	93.75	7.45	176
5	L. Bont	University Medical Center Utrecht, Netherlands	15	1556	103.73	12	10	66.67	3.76	271
6	S.A. Madhi	University of Wittwatersrand, Johanessburg, South Africa	15	3407	227.13	12	13	86.67	8.23	251
7	A. Mejias	The Ohio State University, USA	15	693	46.20	9	8	53.33	1.67	135
		Top 7 Most Impactful Authors								
1	D.J.Nokes	University of Warwick, U.K.	9	3255	361.67	8	9	100.00	13.11	85
2	K.M. Edwards	Center for Disease Control and Prevention, USA	9	2723	302.56	8	4	44.44	10.97	246
3	C.B.Hall	University of Rochester School of Medicine, USA	9	2444	271.56	8	2	22.22	9.84	73
4	S.A.Madhi	University of Wittwatersrand, Johanessburg, South Africa	15	3407	227.13	12	13	86.67	8.23	251
5	H. Nair	University of Edinburg, U.K.	16	3289	205.56	10	15	93.75	7.45	176
6	M.Venter	National Health Laboratory Sevices, South Africa	9	1227	136.33	27	6	66.67	4.94	202
7	F.P.Polack	Fundacion INFANT, Argentina	9	1224	136.00	7	7	77.78	4.93	192

Most Productive and Impactful Authors

The 4902 global authors participated in global "RSV Infection in Children", with 4846 authors contributing 1-5 papers each, followed by 46 authors 6-10 papers each, 9 authors 11-20 papers each and 1 author 21 papers. The publication profile of these 7 top most productive and 7 most impactful authors, on the basis of publications and citation impact per paper are listed in Table 5. The 25 prolific authors with at least 8 or more publications are included in the present analysis. With an average of 11.52 papers per author, these authors produced a total of 288 papers 28014 citations, accounting for 31.41% and more than 100% share in cumulative publications and citations. Among the top 25 authors, 11 were from USA, 4 from U.K., 2 each from China and South Africa, and 1 each from Argentina, China, Italy, Japan, Netherlands, Spain and South Africa. Only 9 authors have produced greater number of publications than the group average. The total citations received by the papers of these 25 organizations are 428014 and accordingly, the citations per paper (CPP) and relative citation index (RCI) received by 288 papers are 97.27 and 3.53. The 9 organizations registered more than the average citations per paper and relative citation index of top 25 organizations.

Collaborative Linkages among Top 25 Authors

Co-authorship analysis is an important measure and considered as one of the influential parameters in evaluating the research output of any discipline. The top 25 most productive authors' network visualization, with at least three mutual links of publications, is shown in Figure 4, which is divided into six clusters represented with various colors. Cluster 1 (Red, 6 Authors) include *H. Nair, H. Campbell, S.A. Madhi*, and others; Cluster 2 (Green, 4 Authors) includes *E.A.F. Simoes, L. Bont, B. Paes, and X. Carbonell-Estrany*; Cluster 3, 4, and 5 (Blue, Yellow, and Violet) includes 3 authors each. Cluster 6 contains 1 author

According to the thickness of the line, *O. Ramilo - A. Mejias* have the 15 highest number of publications in collaboration with each other, and *E.A.F. Simoes - X. Carbonell-Estrany* have the second pair of authors with 10 collaborative publications with each other. The third pair of authors is *H. Nair - H. Campbell,* with 7 mutual publications, while the fourth is *E.A.F. Simoes - L. Bont,* with 5 mutual publications. There are many authors' collaborations having 3 minimum links obtained such as

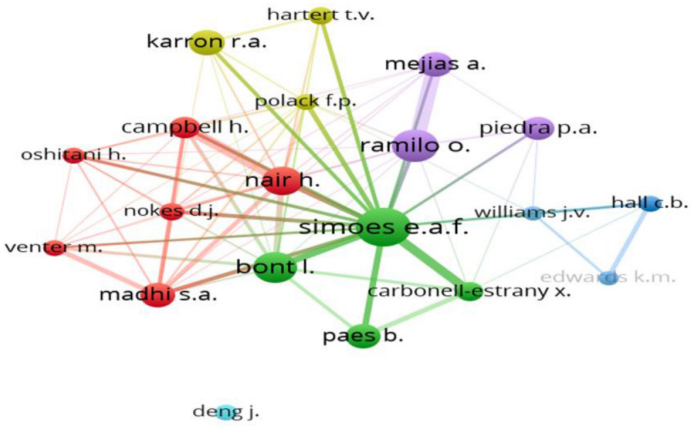

Figure 4: Collaborative Linkages Map of Top 25 Authors.

H. Campbell - L. Bont; C.B. Hall - J.V. Williams; F.P. Polack - H. Nair; and others.

Important Sources

Of the 917 global publications on "RSV Infection in Children", 906 are published in journals, 6 in book series, 3 in conference proceedings and 1 each as book and undefined. The 906 papers are published in 273 journals, of which 239 journals published in 1 journal each, 61 journals 21-75 journals 2 papers each, 25 journals 3 paper each, 14 journals 4 papers each, 7 journals 5 papers each, 16 journals 6-10 papers each, 6 journals 11-20 papers each and 5 journals 21-74 papers each. These 25 journals together contributed 311 papers, constituted 33.91% share of journal global output.

More than one-fifth (22.25%) of these global journals were published in 6 journals publishing 19-74 papers each and contributed more than 2.0% each. They include *Pediatric Infectious Disease Journal* (8.07% share), *Journal of Infectious Diseases* (4.80% share), *PLOS One* (2.62% share), *Journal of Medical Virology* (2.40% share), *Clinical Infectious Diseases* (2.29% share) and Pediatrics (2.07% share). Another 8 journal

(14 papers), that published 1-5 papers, which together contributed 10.69% global share includes *Pediatrics Pulmonology* (15 papers), Journal of Clinical Virology (14 papers), *BMC Infectious Diseases* and Journal of *Pediatrics* (13 papers each), *Influenza and other Respiratory* Versus (12 papers), *Journal of Clinical Microbiology* (11 papers), *Acta Paediatrics International Journal of Paediatrics* and Journal of Allergy and Clinical Immunology (10 papers each).

American Journal of Respiratory and Critical Care Medicine is the frontier journal with the highest level of impact on the body of knowledge on the RSV (with CPP of 73.67). Interestingly, it published only six relevant articles, followed by *Infectious Diseases and Therapy* (with CPP of 54.71), *Journal of Pediatrics* (CPP of 53.85), *Journal of Allergy and Clinical Immunology* (CPP of 46.10), *Journal of Allergy and Clinical Immunology* (CPP od 41.55), *Pediatric Infectious Disease Journal* (CPP of 41.23) etc.

The top 25 sources are selected with a minimum of 6 publications, at least more than 50 citations and more than 400 total link strengths (TLS). The network visualizations of 25 journals drawn by VOS viewer software is shown in Figure 5. There are three clusters with different colours. Cluster 1 contains 11 items, red colour, including *Pediatric Infectious Disease Journal, Pediatrics, Journal of Pediatrics*, and others; Cluster 2, green colour, contains 9 items, including *Journal of Infectious Diseases, PLOS One, Journal of Medical Virology,* and others; and Cluster 3, blue colour, contains 5 items, including *Epidemiology and Infection, Clinical Microbiology and Infection, European Journal of Pediatrics*, and others. The size of the circles defines the number of publications and the thickness of connecting lines shows the links between them. *Pediatric Infectious Disease Journal* (TLS=9529), *Journal of Infectious Diseases* (TLS=3926), *PLOS One* (TLS=4010), *Journal of Medical Virology* (TLS=2962), *Clinical Infectious Diseases* (TLS=1862), and *Pediatrics* (TLS=2841) have larger size of circles, whereas *Pediatric Infectious Disease Journal-Pediatrics, Pediatric Infectious Disease Journal-Journal of Infectious Diseases,* and *Pediatric Infectious Disease Journal-Pediatrics* have thicker connecting lines between them.

Most Influential Works

Only 42 (4.58%) out of 917 global publications received on "RSV Infection in Children" received 100 to 1839 citations per paper and are assumed here as high-cited. Together these 42 high-cited papers received 11008 citations since their publications till 28.5.2022, averaging 262.09 citations per paper. These 42 high-cited papers show a skewed distribution, with 30 and 5 papers falling in citation range 100-200 and 201-300, as against 3, 2 and 2 papers in citation range 301-500, 501-999 and 1356-1839. Among document type, the 42 high-cited papers consist of 32 articles, 7 reviews and 3 conference papers. By type of collaborations, 7 papers report zero collaboration (with participation of one organization) and 35 involve participation of 2 or more organizations (19 national collaborative and 16 international collaborative).

Among 52 countries participating in 42 high-cited papers, the USA depicted the largest participation in 29 papers, followed by U.K. (11 papers), Spain (7 papers), Netherlands (6 papers), Canada (5 papers), France and South Africa (4 papers each), Australia, Croatia, Germany, India, Japan, Kenya and Mozambique (3 papers each), Argentina, Cambodia, Chile, Indonesia, Israel, Italy, Jordan, Norway, Pakistan, Philippines and Thailand (2 papers each) and 27 other countries with 1 paper each.

The 551 authors from 305 organizations participated in 42 high-cited papers. The most (9) high- cited papers are contributed by Centers of Disease Control and Prevention, USA, followed by Hospital Clinic Barcelona, Spain (7 papers), National Institute of Health, USA and Kenya Medical Research Institute 5 papers each), University Medical Center Utrecht, Netherlands, John Hopkins Bloomberg School of Public Health, USA, University of Edinburg, U.K., University of Witwatersrand, Johannesburg, South Africa and South African Medical Research Council, South Africa (4 papers each), MedImmune LLC Inc. USA, University of Colorado, School of Medicine, USA, Nationalwide Children's Hospital, USA, University of Colorado Anschutz Medical Campus, USA, Wilhelmina Kinderziekenhuis, Netherland and Edinburg Medical School, USA (3 papers each), etc.

The most (5 each) high-cited papers among top 42 are contributed by K.M. Edwards (Center for Disease Control and Prevention, USA) and D.J. Nokes (University of Warwick, U.K.), followed by E.A.F. Simoes (Colorado School of Public Health, USA), H. Nair (University of Edinburg, U.K.), S.A. Madhi (University of Wittwatersrand, Johanessburg, South Africa), X. Carbonell-Estrany (Hospital Clinic Barcelona, Spain), and C.B.Hall (University of Rochester School of Medicine, USA)(4 papers each), O.Ramilo (Nationwide Children's Hospital, USA), etc.

The 22 journals published these 42 high cited papers. *Pediatric Infectious Diseases* reported the most papers (8), followed by *Pediatrics* (7 papers), *Journal of Infectious Diseases* (4 papers), The *Lancet, Clinical Infectious Diseases, American Journal of Respiratory and Critical* and *Cochrane Database of Systematic Reviews* (2 papers each), and 15 journals with 1 paper each.

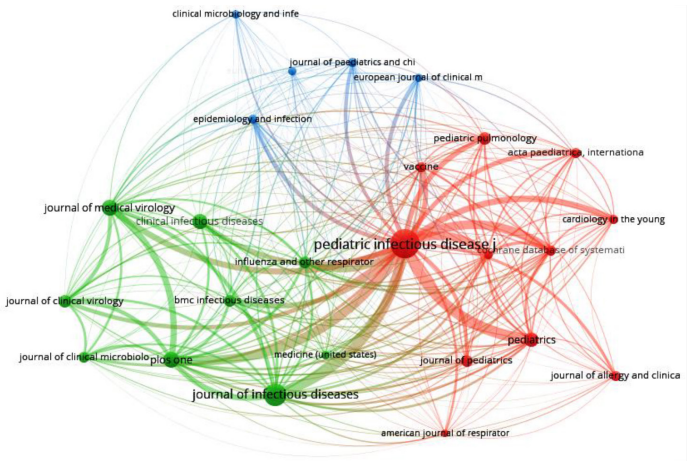

Figure 5: Top Journals.

DISCUSSION AND CONCLUSION

The findings of this study have several implications for the scholars and practitioners interested in "RSV Infection in Children", as it provides a comprehensive overview of the research domain that introduce readers with the key studies using bibliometric methods. We collected bibliography data on 917 studies from the Scopus database, authored by 4902, 4800 scholars belonging to 710 organizations from 104 countries and published in 213 academic journals. The 917 global publications on "RSV Infection in Children" received 25303 citations, averaging 27.59 citations per paper. Around 30.32% (278 papers) out of 917 papers received extra-mural funding support from 150+ funding agencies and these funded papers received 3705 citations, averaging 37.05 citations per paper (higher than 27.59 for overall papers). The top 6 funding organizations with contribution in funded papers were from USA and they together provided funding for 109 funded papers out of 278 global funded publications identified in this study. The three major funding agencies in Europe were responsible for 27 funded publications. Only three

Japanese funding agencies together contributed 19 funded publications. Similarly funding agencies from China and Canada together contributed 15 and 7 funded papers respectively. Pharmaceutical companies (with 8 to 26 funded papers) such as Medimmune/AstraZeneca, AbbVie, Pfizer, AstraZeneca, GlaxoSmithKline, Merck and Abbott Laboratories are prominent funders of considerable number of RSV-related publications and together contributed for 59 funded publications. The amount of funding provided for research is directly reflected in the research output of these countries. The non-availability of extramural research funding may be a contributing factor for the aforementioned lack of research output in some countries, particularly developing.

Among 104 countries, USA and U.K. played the most dominant role with 34.35% and 11.89% share in global output, followed by China, Canada, Netherlands and Spain contributing each between 6.1% to 7.31% and other four countries, namely Italy, France, Australia and Japan (from 2.40% to 4.80%). As against research output, the countries depicting comparatively higher CPP and RCI were France (87.65 and 3.18), Japan (82.55 and 2.99), Spain (78.21 and 2.833), U.K. (56.55 and 2.05) and Netherlands (51.81 and 1.88). All Top 10 countries depict collaborative linkages among themselves, however comparative stronger linkages were depicted by USA (TCL=398), U.K. (TCL=250), Netherlands (TCL=198), France (TCL=175) and Spain (TCL=158). In country-to-country collaborative linkages, the highest collaborative linkages (26) was between USA-U.K., followed by USA-Spain (24 linkages), U.K.-Netherlands (23 linkages), USA-Canada and USA-Netherlands (19 linkages each), USA-Spain (16 linkages), Netherland-France (15 linkages), U.K.-France (13 linkages), U.K.-Australia (12 linkages), etc.

Among the top 25 organizations, 13 were from USA, 4 from U.K. and 3 from Netherland and 2 from South Africa most actively participated in global research. However, in terms of CPP and RCI, organizations from Kenya, South Africa and U.K. dominated. The top 4 organizations with strongest total collaborative linkages (290, 286, 276 and 267) were Center for Disease Control and Prevention, USA, John Hopkins Bloomberg School of Public Health, USA, University Medical Center Utrecht, Netherlands and University of Witwatersrand, Johannesburg, South Africa. The inter-collaborative linkages map of the top 25 organizations indicate 17 out of 25 top organizations are strongly connected and these 17 organizations are depicted in 5 clusters and organizations within each cluster have the strongest collaborative linkages among themselves.

Among the top 25 authors, as the major participation 11 authors came from USA, 4 authors from U.K., 2 authors each from China and South Africa and the rest from 7 other countries with 1 paper each. The most productive authors were from USA, U.K., Netherlands and South Africa. Unlike organizations, the most impactful authors, measured by CPP and RCI came from USA, South Africa and U.K. Top 5 organizations with strongest total collaborative linkages (290, 286, 276 and 267) were Center for Disease Control and Prevention, USA, John Hopkins Bloomberg School of Public Health, USA, University Medical Center Utrecht, Netherlands and University of Witwatersrand, Johannesburg, South Africa. There is a strong international collaboration among authors across countries and also within countries. Top 5 authors with strongest total collaborative linkages (484, 397, 346 and 338) were *S.A. Madhi, H. Nair, E.A.F. Simoes and L. Bont* (338 TLS). Top 25 most productive authors' network visualization depicts the author collaboration across six clusters with strongest linkages among themselves.

Above bibliometric description gives a snapshot of strong research areas in this field as well as possible gaps requiring additional focus at global level. For this purpose, 44 significant keywords were identified in the study that appear most frequently represent its main content, and the frequency of occurrence and co-occurrence may reflect themes that focus in research and insight into the landscape of knowledge. 44 significant keywords were selected for keyword co-occurrence network and grouped under 4 clusters, each cluster being represented by different colour and indicating a different theme.

The study observed that while developed countries continue to be playing leading roles in this field, research trends in lower and lower-middle income countries in this field is weak. Since developing countries are the most affected from RSV virus and account for major share in global morbidity and mortality burden among children; therefore it is need of the hour to undertake more stronger and meaningful research in these countries. These countries must prioritize research in this area and should also receive funding support from international and developed countries. Besides active collaboration, research should be promoted between developed and developing countries, so that quantitative and qualitative research can come out and benefits of such research should reach the concerned population groups in developing countries.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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Cite this article : Gupta BM, Gore MM, Gupta A, Patel AK. "Respiratory Syncytial Viruses (RSV) Infection in Children": A Scientometric Analysis of Global Publications during 2002-21. 2022;12(4):156-64.