

Impact of COVID-19 on Stroke: A Scientometric Assessment of Global Publications during 2020-21

Yogendra Singh^{1,*}, BM Gupta², KK Mueen Ahmed³, Madhu Bansal⁴

ABSTRACT

Background and Aim: The COVID-19, as a global epidemic, has led to public health problems including its impact on stroke. There has been a significant increase in the research on the impact of COVID-19 on stroke. Little attention, however, has been focused on the overall trend in this field based on bibliometric analysis. This study aimed to assess the characteristics and trends of research on "Impact of COVID-19 on Stroke." **Methods:** Using Scopus database, a search query was formulated involving keywords related to "COVID-19" and "Stroke" for identifying relevant literature on this topic, resulting in 956 publications during 2020-21. **Results:** The 956 global publications on this topic registered an average 11.75 citations impact per paper. About one-fifth (19.56%) share of global publications was supported by extramural funding support. USA ($n=341$; 35.67%) contributed the largest number of papers, followed by the Italy ($n=106$; 11.09%) and U.K. ($n=77$; 8.05%). China (24.42 and 2.52) had registered the highest citation impact per paper and relative citation index, followed by France (22.02 and 1.87) and the USA (18.96 and 1.61). Harvard Medical School, USA ($n=27$) ranked first in publication productivity, followed by the University of Toronto, Canada ($n=23$) and The University of Thessaly, Greece ($n=23$). NTU Langone Health, USA (54.27 and 4.62) University of Pennsylvania, USA (35.55 and 3.03) and Hospital Universitario La Paz, Spain (28.0 and 2.38) ranked top in citation impact. S. Yagi (USA) ($n=16$) ranked first in publication productivity, followed by G. Tsvigoulis (Greece) ($n=15$) and H.S. Markus (U.K.) ($n=11$) and J.T. Fifi (USA) (171.88 and 14.63), J. Mocco (USA) (128.45 and 10.93) and P. Jabbour (USA) (45.86 and 3.90) ranked on top in citation impact. *Stroke* ($n=95$) ranked first in productivity, followed by *Journal of Stroke and Cerebrovascular Disease* ($n=81$) and *Frontiers in Neurology* ($n=34$). **Conclusion:** This study suggests that a large amount of literature has accumulated on "Impact of Covid-19 on Stroke," both from developed and developing countries.

Key words: COVID-19, Stroke, Global Publications, Scientometrics, Bibliometric analysis.

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INTRODUCTION

COVID-19 (Coronavirus disease 2019) is primarily a severe acute respiratory syndrome, but it has many non-pulmonary manifestations also that can range from asymptomatic to renal, cardiac, or even neurological. Initial neurological symptoms that occur alone or along with respiratory ones may include headache, dizziness, crania nerve damage, etc. Coagulopathy, disrupted epithelial function, and promoted hyper-coagulated state are some of the conditions induced by SARS-COV-2 infection and are well evidenced by increased D-dimer, fibrinogen, factor VIII and Willebrand factor. All these factors may cause cardiovascular damage in the patient leading to stroke. The health care system is already overburdened due to unprecedented strain; stroke may not get priority and hence sometimes neglected.^[1] Stephenia *et al.*^[2] conducted a meta-analysis of 2277 papers. They found that out of 108571 patients, the percentage of Cardiovascular Disease (CVD) patients was 1.4 (95% CI: 1.0-1.9). Ischemic Stroke was the most common manifestation with 87.4%

occurrence while intracerebral hemorrhage was the least occurred with 11.6% of patients. It was also found that older people with other comorbid conditions such as hypertension, diabetes mellitus, coronary artery disease, and severe infection were more susceptible to CVD compared to those who were not having the above-mentioned comorbidities. In-hospital mortality data deaths of younger people with higher NIHSS (National Institute of Health Stroke Scale) were due to stroke compared to Non-COVID people.

Several bibliometric studies have been conducted in the past on Stroke^[3-5] and COVID-19,^[6,7] including a few on neurological implications of COVID-19.^[8-10] There were several reviews and meta-studies available covering different dimensions of research on this topic. There is, however, no bibliometric study focusing on the implications of COVID-19 on stroke. We, therefore, decided to undertake a bibliometric study focusing on the assessment of global output on "Impact of COVID-19 on

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Stroke". The study specifically aims to analyze the global output and its citation impact, contribution and impact of the top 12 countries, distribution of global output by broad subjects, keywords, and type of stroke, contribution and impact of top organizations and authors, and their collaborative linkages, identification of core journals and broad characteristics of high-cited papers.

MATERIALS AND METHODS

The authors performed a bibliometric search on the theme "Impact of COVID-19 on Stroke" in Scopus database using a search strategy, which identified, retrieved, and downloaded all relevant publications records on this theme. The search strategy used two sets of keywords related to "COVID-19" and "Stroke" in field tags, "Keyword" or "Title" (Article Title). The search was limited till 17.3.2022 covering the 2020-2021 periods. The search yielded 956 records, which were further analyzed using additional analytical provisions in the Scopus database.

TITLE ("covid 19" OR "2019 novel coronavirus" OR "coronavirus 2019" OR "coronavirus disease 2019" OR "2019-novel CoV" OR "2019 nov" OR covid 2019 OR "corona virus 2019" OR ncov-2019 OR ncov2019 OR "nov 2019" OR 2019-ncov OR covid-19 OR "Severe acute respiratory syndrome coronavirus 2" OR "SARS-CoV-2") OR KEY ("covid 19" OR "2019 novel coronavirus" OR "coronavirus 2019" OR "coronavirus disease 2019" OR "2019-novel CoV" OR "2019 nov" OR covid 2019 OR "corona virus 2019" OR ncov-2019 OR ncov2019 OR "nov 2019" OR 2019-ncov OR covid-19 OR "Severe acute respiratory syndrome coronavirus 2" OR "SARS-CoV-2") and Title (stroke*).

RESULTS

Overall Output

The global research on "Impact of COVID-19 on Stroke" resulted in 956 published papers (2020=375; 2021=502 and 2022=79), as indexed in the Scopus database. These 956 publications registered 11234 citations, averaging 11.75 citations per publication (CPP). Amongst 956 publications, 187 (19.56%) publications received external funding support from 100+ global funding agencies and they together registered 2256 citations, averaging 12.06 citations per paper. Document type

analysis revealed that articles constituted the largest global share (63.39%), followed by letters and reviews (14.85% and 12.45%), notes and editorials (3.97% and 3.56%), and others less than 1.0% (erratum, conference papers, short surveys, book chapters and retracted) (from 0.10% to 0.94%).

Top 12 Most Productive Countries

These 956 published papers were represented by 91 countries with authors from 61 countries contributing 1-10 papers each, 13 countries publishing 11-20 papers each, 10 countries 21-50 papers each, and 7 countries 51-341 papers each. There were 12 countries which produced more than 30 papers (31-341). We include these countries in our further geopolitical analysis

Researchers from the top 10 countries published 31-77 papers each and researchers from 2 countries published more than 100 papers. The researchers from the top 12 countries contributed 31 to 341 papers each and together contributed 971 papers, which were cited 15135 times, constituting more than 100% share respectively in global publications and citations. The largest number of publications emerged from the USA (341 papers, 35.67% share), followed by Italy (106 papers, 11.09% share), the U.K. (77 papers, 8.05% share), China (71 papers, 7.43% share), and Spain (64 papers, 6.69% share). Overall, the research output from 3 out of the top 12 countries registered CPP and relative citation index (RCI) higher than their group average (15.59 and 1.33) and these countries were France (22.02 and 1.87), the USA (18.96 and 1.61), and U.K. (16.53 and 1.41). The share of international collaborative papers from the top 12 countries varied from 32.08% to 82.54%, with an average of 43.56% (Table 1).

Collaborative Linkages among Top 12 Countries

The total collaborative linkages of top 12 countries on "Impact of COVID-19 on Stroke" varied from 60 to 194 each and individual country-to-country linkages varied from 1 to 34. The top 3 countries having the largest number of collaborative linkages (194, 118, and 101) were from authors from the USA, Italy, and Canada. The largest country-to-country

Table 1: Profile of top 12 countries in global output on "Impact of COVID-19 on stroke".

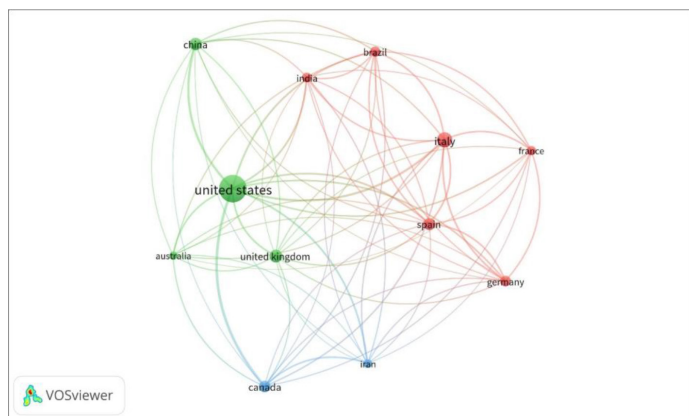
S. No.	Country	TP	TC	CPP	H-Index	ICP	%ICP	RCI	%TP	TCL (NOC)
1	USA	341	6467	18.96	37	119	34.90	1.61	35.67	194 (11)
2	Italy	106	1485	14.01	18	34	32.08	1.19	11.09	118 (11)
3	U.K.	77	1273	16.53	14	32	41.56	1.41	8.05	66(11)
4	China	71	908	12.79	14	29	40.85	1.09	7.43	73(11)
5	Spain	64	971	15.17	15	22	34.38	1.29	6.69	98(11)
6	Canada	63	947	15.03	16	52	82.54	1.28	6.59	101(11)
7	Germany	53	548	10.34	11	27	50.94	0.88	5.54	83(11)
8	Brazil	45	555	12.33	9	26	57.78	1.05	4.71	90(11)
9	India	45	377	8.38	11	19	42.22	0.71	4.71	72(11)
10	France	41	903	22.02	16	19	46.34	1.87	4.29	71(11)
11	Iran	34	478	14.06	9	23	67.65	1.20	3.56	75(11)
12	Australia	31	223	7.19	9	21	67.74	0.61	3.24	60(11)
	Total	971	15135	15.59	179	423	43.56	1.33	101.57	
	Global total	956	11234	11.75				1.00	100.00	

Share of top 12 countries in global total

TP: Total papers; TC: Total citations; CPP: Citations per paper; ICP: International collaborative paper; RCI: Relative citation index' TCL (NOC): Total collaborative linkages among top 12 countries (Number of countries)

Table 2: Country-wise productivity and centralities measures of top 12 countries.

Sl.No.	Country	Total Papers	Total Citations	Degree of Centrality	Closeness Centrality	Betweenness Centrality	Eigen Centrality
1	USA	344	3094	49	0.945455	0.01834	0.994555
2	Italy	108	1082	50	0.962963	0.022835	1.00000
3	U.K.	78	1123	47	0.912281	0.010244	0.983805
4	China	73	859	45	0.881356	0.008354	0.960722
5	Spain	66	844	47	0.912281	0.012218	0.980240
6	Canada	63	876	46	0.896552	0.043916	0.964830
7	Germany	53	491	48	0.928571	0.018149	0.980230
8	Brazil	47	516	48	0.928571	0.01378	0.989512
9	India	45	302	45	0.881356	0.008937	0.958488
10	France	41	817	46	0.896552	0.043785	0.964842
11	Iran	34	458	42	0.83871	0.003671	0.928842
12	Australia	31	171	43	0.852459	0.004599	0.940817

**Figure 1:** Collaborative Network of Top 12 Countries (Source: VOSviewer; Frequency: > 30).

collaborative linkages (34) were between the authors from USA-Canada, followed by USA-China (25 linkages), USA-Italy (22 linkages), etc.

Figure 1 presents the collaborative network map of the top 12 countries for “Impact of COVID-19 on Stroke”. Table 2 presents the data about total papers, total citations, degree of centrality, closeness centrality, betweenness centrality, and Eigen centralities for the top 12 countries.

Subject-Wise Distribution of Publications

According to Scopus database classification, the largest share (85.99%) of publications were listed under the category of Medicine, followed by Psychology (10.03%), Pharmacology, Toxicology and Pharmaceutics (9.79%), Neurosciences (5.95%), Biochemistry, Genetics and Molecular Biology (5.86%), etc. In terms of citation impact per paper (CPP), the publications listed under the category of Environment Science registered the highest CPP (11.02) and the publications listed under the category of Pharmacology, Toxicology and Pharmaceutics had the least CPP (5.70) (Table 3).

Types of Strokes

By type of stroke, the largest number of publications on this topic were focused on Ischemic Stroke (35.46%), followed by Hemorrhagic Stroke (16.95%), Transient Ischemic Attack (7.74%), Brain Stem Stroke (0.84%), and Cryptogenic Stroke (0.31%). In terms of citation impact per paper,

Table 3: Subject-wise distribution of papers on “Impact of COVID-19 on stroke”.

Sl.No	Name of the Subject	TP	TC	CPP	%TP
1	Medicine	860	10034	11.67	89.96
2	Neuroscience	191	1769	9.26	19.98
3	Nursing	111	2559	23.05	11.61
4	Biochemistry, Genetics and Molecular Biology	27	185	6.85	2.82
5	Immunology and Microbiology	15	397	26.47	1.57
6	Pharmacology, Toxicology and Pharmaceutics	13	65	5.00	1.36
7	Global total	956	11234	11.75	100.00

TP: Total papers; TC: Total citations; CPP: Citations per paper

Table 4: Publication distribution by type of stroke impacted by COVID-19.

Sl.No	Type of Stroke	TP	TC	CPP	%TP
1	Ischemic Stroke	339	1803	5.32	35.46
2	Hemorrhagic Stroke	162	1746	10.78	16.95
3	Transient Ischemic Attack	74	1213	16.39	7.74
4	Brain Stem Stroke	8	22	2.75	0.84
5	Cryptogenic Stroke	3	6	2.00	0.31
	Global total	956	11234	11.75	100.00

TP: Total papers; TC: Total citations; CPP: Citations per paper

papers on Transient Ischemic Attack registered the highest (16.39 CPP), followed by Hemorrhagic Stroke (10.78 CPP), Ischemic Stroke (5.32 CPP), Brain Stem Stroke (2.75 CPP), and Cryptogenic Stroke (2.0 CPP) (Table 4).

Significant Keywords

The 51 important keywords have been identified from the global literature on “Impact of COVID-19 on Stroke”, which have a frequency of occurrences ranging from 36 to 727 (Table 5). These keywords either independently, or in combination with other keywords throw some light on emerging concepts or indicate the trends of research in this field.

Table 5: List of top 51 significant keywords along with frequency of their occurrence.

Sl.No	Name of the keyword	Frequency	S.No	Name of the keyword	Frequency
1	Stroke	727	27	Atrial Fibrillation	72
2	Cerebrovascular Accident	692	28	Thrombosis ATPase	65
3	Covid-19	685	29	Anticoagulant Agents	62
4	Coronavirus Disease 2019	682	30	Thorax Radiography	58
5	Brain Ischemia	388	31	Telemedicine	64
6	SARC-CoV-2	345	32	Fibrinogen	58
7	Ischemia Stroke	297	33	Endovascular Surgery	55
8	Virus Pneumonia	241	34	Dyspnea	53
9	Thrombectomy	169	35	Brain Infarction	49
10	Brain Hemorrhage	143	36	Hydroxychloroquine	47
11	Computer-Assisted Tomography	138	37	Stroke Rehabilitation	46
12	D Dimer	131	38	Dysarthria	44
13	Severe Acute Respiratory Syndrome Coronavirus 2	131	39	Percutaneous Thrombectomy	44
14	Hypertension	127	40	Aphasia	43
15	Fibrinolysis Therapy	120	41	Heparin	43
16	Mechanical Thrombectomy	119	42	Ferritin	41
17	Diagnostic Imaging	115	43	Enoxaparinase	40
18	NMR Imaging	112	44	Middle Cerebral Artery	39
19	C. Reactive Protein	103	45	Heart Infarction	38
20	Computed Tomography Angiography	101	46	Blood Vessel Occlusion	37
21	Acute Ischemic Stroke	99	47	Hemiparesis	37
22	Blood Clot Mysis	83	48	Lactate Dehydrogenase	36
23	Neuroimaging	80	49	Lung Embolism	36
24	Diabetes Mellitus	77	50	Subarachnoid Hemorrhage	36
25	Transient Ischemic Stroke	74	51	Thrombolysis	36
26	X-Ray Computed Tomography	74			

Figure 2 depicts the keyword co-occurrence network using both author keywords with the help of VOSviewer (<https://www.vosviewer.com>) software. The keywords fall into three clusters:

- (i) Cluster 1 (Red with 29 keywords) includes Computer-Assisted Tomography (138), D. Dimer (131), Severe Acute Respiratory Syndrome Coronavirus 2 (131), Hypertension (127), Diagnostic Imaging (115), NMR Imaging (112), C. Reactive Protein (103), Computed Tomography Angiography (101), Neuroimaging (80), Diabetes Mellitus (77), etc.
- (ii) Cluster 2 (Green with 18 keywords) includes Stroke (727), Cerebrovascular Accident (692), COVID-19 (685), Coronavirus Disease 2019 (682), Brain Ischemia (388), SARC-CoV-2 (345), Virus Pneumonia (241), Thrombectomy (169), Brain Hemorrhage (143), Fibrinolysis Therapy (120), *et al.*
- (iii) Cluster 3 (Blue with 3 keywords) include Ischemia Stroke (297), Acute Ischemic Stroke (99) and Anticoagulant Agents (62).

Profile of Top 30 Organizations

Overall, the publications emerged from 499 organizations on “Impact of COVID-19 on Stroke” with authors from 364 organizations publishing 1-5 papers each, authors from another 112 organizations publishing 6-10 papers each, authors from 26 organizations publishing 11-20 papers each and authors from 3 organizations publishing 21-27 papers each. The authors from the top 30 organizations contributed 10 to 27 papers and

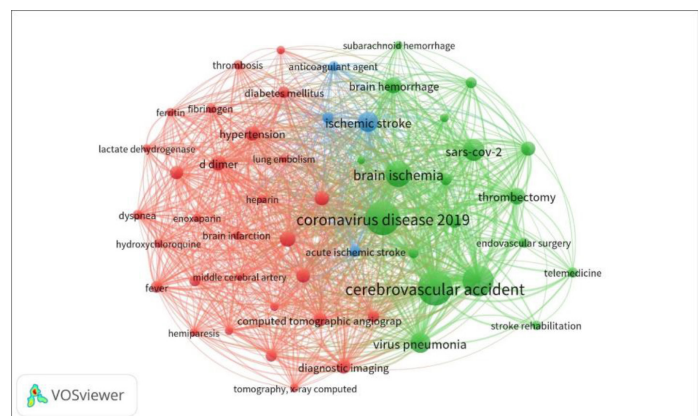


Figure 2: Keyword Co-occurrence Network (Source: VOSviewer; Frequency: > 35).

together contributed 414 papers and 6869 citations, constituting 43.31% and 61.14% share of global publications and citations.

On further analysis, it was seen that authors from ten organizations contributed papers higher than their group average (13.8) and these were: Harvard Medical School, USA (27 papers), University of Toronto, Canada (23 papers), University of Thessaly, Greece (21 papers), University of Calgary, Canada and Massachusetts General Hospital, USA

Table 6: Profile of top 8 most productive and most impactful organizations on “COVID-19 and stroke”.

Sl.No	Name of the Organization	TP	TC	CPP	HI	ICP	%ICP	RCI
Top 8 Most Productive Organizations								
1	Harvard Medical School, USA	27	508	18.81	11	16	59.26	1.60
2	University of Toronto, Canada	23	382	16.61	9	11	47.83	1.41
3	University of Thessaly, Larissa, Greece	21	332	15.81	8	10	47.62	1.35
4	University of Calgary, Canada	18	321	17.83	7	6	33.33	1.52
5	Massachusetts General Hospital, USA	18	79	4.39	6	5	27.78	0.37
6	University of California, Los Angeles, USA	17	294	17.29	9	7	41.18	1.47
7	David Geffen School of Medicine at UCLA, USA	16	130	8.13	6	8	50.00	0.69
8	Icahn School of Medicine at Mount Sinai, USA	16	395	24.69	9	6	37.50	2.10
Top 8 Most Impactful Organizations								
1	NTU Langone Health, USA	11	597	54.27	7	4	36.36	4.62
2	University of Pennsylvania, USA	11	391	35.55	6	9	81.82	3.03
3	Hospital Universitario La Paz, Spain	12	336	28.00	6	5	41.67	2.38
4	McMaster University, Canada	11	285	25.91	7	4	36.36	2.21
5	University of Cambridge, U.K.	12	302	25.17	3	5	41.67	2.14
6	Hospital Clinic Barcelona, Spain	11	272	24.73	6	6	54.55	2.10
7	Icahn School of Medicine at Mount Sinai, USA	16	395	24.69	9	6	37.50	2.10
8	University of Washington, USA	11	242	22.00	7	7	63.64	1.87

TP: Total papers; TC: Total citations; CPP: Citations per paper; ICP: International collaborative paper; RCI: Relative citation index.

(18 papers each), University of California, Los Angeles, USA (17 papers), David Geffen School of Medicine at UCLA, USA and Icahn School of Medicine at Mount Sinai, USA (16 papers each), Emory University School of Medicine, USA and Atkinson University Hospital, Greece (14 papers each). Research from fourteen organizations registered CPP and RCI above their group average (16.59 and 1.41): NTU Langone Health, USA (54.27 and 4.62), University of Pennsylvania, USA (35.55 and 3.03), Hospital Universitario La Paz, Spain (28.0 and 2.38), McMaster University, Canada (25.91 and 2.21), University of Cambridge, U.K. (25.17 and 2.14), Hospital Clinic Barcelona, Spain (24.73 and 2.10), Icahn School of Medicine at Mount Sinai, USA (24.69 and 2.10), University of Washington, USA (22.0 and 1.87), University of Tennessee Health Science Center, USA (20.50 and 1.74), Harvard Medical School, USA (18.81 and 1.60), Beijing Tiatah Hospital, Capital Medical University, China (18.55 and 1.58), University of Calgary, Canada (17.83 and 1.52), University of California, Los Angeles, USA (17.29 and 1.47) and Capital Medical University, China (17.0 and 1.45) (Table 6).

Out of 499 participating organizations, 47 were isolated which produced 6 or more papers. A collaboration network of these 47 organizations using VOSviewer software was presented in Figure 3, which depicted the various organizations in seven clusters, represented by different colors.

Figure 3: Institutional Collaboration Network (Source: VOSviewer; Frequency: > 5).

Profile of Top 30 Authors

Overall, 1148 authors contributed to the research on the topic “Impact of COVID-19 on Stroke”, with 559 authors publishing 1 paper each, 310 authors publishing 2 papers each, 89 authors publishing 3 papers each, 126 authors publishing 4-5 papers each and 65 authors published 6-16 papers each. The top 30 authors individually contributed 7 to 16 papers each and together they contributed to 259 papers and 7105 citations, constituting 27.09% and 63.25% share of global papers and citations. On further analysis, it was seen that authors from ten authors contributed papers higher than their group average (8.63) and these authors were:

S.Yagi (USA)(16 papers), G. Tsvigoulis (Greece)(15 papers), H.S. Markus (U.K.)(11 papers), J. Mocco(USA)(11 papers), M.S.V. Elkind (USA) and D.S. Liebeskind (10 papers each), T.N. Nguyen (USA), R.G. Nogueira (USA), A.L. Qureshi (USA) and J.E. Siegler (9 papers each). Research from five authors registered CPP and RCI above their group average (27.43 and 2.33): J.T.Fifi (USA) (171.88 and 14.63), J. Mocco (USA) (128.45 and 10.93), P. Jabbour (USA) (45.86 and 3.90), S. Yagi (USA) (36.56 and 3.11) and H.S. Markus (U.K.) (27.45 and 2.34) (Table 7).

A network collaboration map of top 30 authors is presented in Figure 4, which divides them into different clusters representative by different colors.

Profile of Top 30 Journals

Of the total 958 global publications on “Impact of COVID-19 on Stroke”, 950 publications were published in 179 journals, 3 in conference proceedings, 2 in book series, and 1 in a trade journal. In terms of various journals, 153 journals published 1-5 papers each, 15 journals published 6-10 papers each, 9 journals published 11-34 papers each, and 2 journals published 81-95 papers each. The top 30 journals that published the most papers are shown in Table 8, and these 15 journals contributed 507 papers, constituting 53.37% share of total journal publications in this research field.

On further analysis, it was found that (I) the top 8 most productive journals include Stroke (95 papers), *Journal of Stroke and Cerebrovascular Disease* (81 papers), *Frontiers in Neurology* (34 papers), *European Journal of Neurology* (26 papers), *Neurological Sciences* (25 papers), *International Journal of Stroke* (24 papers), *Cerebrovascular Diseases* (22 papers) and *American Journal of Neuroradiology*. The top 8 journals in terms of CPP were *Journal of Neurology*, *Neurosurgery and Psychiatry* (54.82), *Stroke* (26.73), *International Journal of Stroke* (23.71), *Neurology* (19.83), *Canadian Journal of Neurological Sciences* (16.29), *Journal of Neurointerventional Surgery* (16.07), *PLOS One* (14.13) and *Journal of Neurology* (13.0). The top 8 journals in terms of total citations were *Stroke* (2539 citations), *Journal of Stroke and Cerebrovascular Disease*

Table 7: Profile of top 15 most productive authors on “impact of COVID-19 on stroke”.

Sl.No	Name of the author	Affiliation of the author	TP	TC	CPP	HI	ICP	%ICP	RCI
Top 8 Most Productive Authors									
1	S. Yagi	NYU Langone Health, USA	16	585	36.56	9	5	31.25	3.11
2	G. Tsvigoulis	University of Thessaly, Larissa, Greece	15	206	13.73	8	12	80.00	1.17
3	H.S. Markus	University of Cambridge, U.K.	11	302	27.45	3	4	36.36	2.34
4	J. Mocco	Icahn School of Medicine at Mount Sinai, USA	11	1413	128.45	8	1	9.09	10.93
5	M. S. V. Elkind	Columbia University, USA	10	165	16.50	6	6	60.00	1.40
6	D.S. Liebeskind	University of California, Los Angeles, USA	10	204	20.40	6	5	50.00	1.74
7	T.N. Nguyen	Boston Medical Center Nogueira USA	9	68	7.56	5	5	55.56	0.64
8	R.G. Nogueira	Grady M8e183morial Hospital Atlanta, USA	9	83	9.22	4	3	33.33	0.78
Top 8 Most Impactful Authors									
1	J.T. Fifi	Icahn School of Medicine at Mounr Sinai, USA	8	1375	171.88	6	1	12.50	14.63
2	J. Mocco	Icahn School of Medicine at Mount Sinai, USA	11	1413	128.45	8	1	9.09	10.93
3	P. Jabbour	Thomas Jefferson University Hospital, USA	7	321	45.86	5	4	57.14	3.90
4	S. Yagi	NYU Langone Health, USA	16	585	36.56	9	5	31.25	3.11
5	H.S. Markus	University of Cambridge, U.K.	11	302	27.45	3	4	36.36	2.34
6	T.G. Jovin	Cooper University Hospital, USA	7	188	26.86	5	1	14.29	2.29
7	A. Borhani-Haghighi	Shiraz University of Medical Sciences, Iran	7	179	25.57	5	7	100.00	2.18
8	J.E. Siegler	Cooper University Hospital, USA	9	218	24.22	7	3	33.33	2.06

TP: Total papers; TC: Total citations; CPP: Citations per paper; ICP: International collaborative paper; RCI: Relative citation index

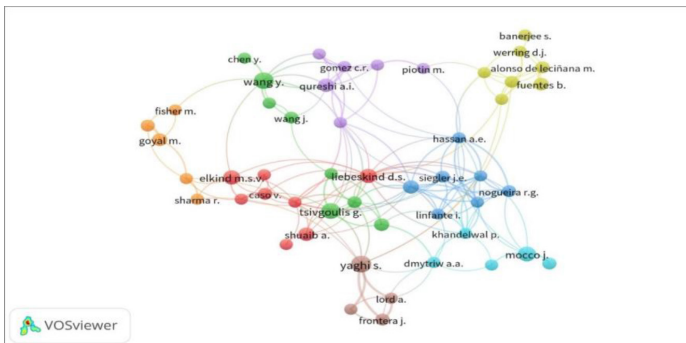


Figure 4: Author Collaboration Network (Source: VOSviewer; Frequency: > 5).

(762 citations), *Journal of Neurology, Neurosurgery and Psychiatry* (603 citations), *International Journal of Stroke* (569 citations), *European Journal of Neurology* (318 citations), *Neurological Sciences* (275 citations), *Journal of Neurointerventional Surgery* (241 citations) and *Frontiers in Neurology* (235 citations) (Table 8).

High Cited Papers

Out of 956 publications on “Impact of COVID-19 on Stroke”, only 25 (1.37%) were cited more than 100 times, with the highest number of citations being 1152 since the publication and together these 25 papers (assumed as high-cited) were cited 2515 times, averaging 303.4 CPP. Amongst 25 high-cited publications (HCP), 18 papers received 100-196 citations, 6 papers 211-382 citations, and 1 paper 1152 citations. Among these 25 high cited papers, 30 countries, 147 organizations and 340 authors participated and they were published in 12 journals.

Among 25 HCPs, the largest number of publications (13 papers) was published by authors from the USA, followed by Italy (6 papers), the U.K. (5 papers), China (4 papers), France (3 papers), Brazil, Denmark, Canada, Iran, Mexico, Romania and Spain (2 papers each), Austria,

Columbia, Egypt, Finland Hong Kong, India, Japan, Norway, Pakistan, Poland, Singapore, Saudi Arabia, South Korea, Spain, Sweden, Switzerland, Taiwan and Turkey (1 paper each).

The 25 HCPs (comprises of 15 articles, 4 each as letters and reviews, and 1 each as editorial and notes) involve only 1 organization in 5 papers (zero collaborative) and the remaining 20 papers involve 2 or more organizations (14 national collaborative and 6 international collaborative).

Among 12 participative journals in 25 HCP, the largest number of publications (10) was contributed by *Stroke*, followed by *International Journal of Stroke*, *Journal of Stroke and Cerebrovascular Disease*, *Journal of Neurology, Neurosurgery and Psychiatry*, and *New England Journal of Medicine* (2 papers each), *Brain, Behavior and Immunity*, *European Neurology*, *JAMA Neurology*, *Journal of Neurology*, *Neurological Sciences*, *Journal of Thrombosis and Thrombolysis* and *Transnational Stroke Research* (1 paper each).

DISCUSSION AND SUMMARY

The present study showed that over the last 2.3 years a large amount of literature has accumulated on the topic “Impact of COVID-19 on Stroke”. A total number of 956 publications were published on the topic during 2020-2021 till 17.3.2022. These publications were cited 11234 times, registering a CPP of 11.75. Only one-fifth proportion (19.56%) of these papers was supported by global extramural funding sources. However, the papers that were supported by the global funding agencies had an overall CPP slightly above (12.06) than the average CPP (11.75) on the topic.

Research on the area of “Impact of COVID-19 on Stroke” emerged from 91 countries, with strong participation mainly from the developed and also some participation from developing countries. Of the top 12 countries, 8 are developed and have contributed 81.16% share of global output and registered 16.52 CPP. In contrast, the four developing countries (China, Iran, India, and Brazil) together contributed an

Table 8: Profile of top 8 most productive and 8 most impactful authors on “impact of COVID-19 on stroke”.

Sl.No	Name of the journal	TP	TC	CPP
Top 8 Most Productive Journals				
1	Stroke	95	2539	26.73
2	Journal of Stroke and Cerebrovascular Disease	81	762	9.41
3	Frontiers in Neurology	34	235	6.91
4	European Journal of Neurology	26	318	12.23
5	Neurological Sciences	25	275	11.00
6	International Journal of Stroke	24	569	23.71
7	Cerebrovascular Diseases	22	140	6.36
8	American Journal of Neuroradiology	20	190	9.50
Top 8 Most Impactful Journals				
1	Journal of Neurology, Neurosurgery and Psychiatry	11	603	54.82
2	Stroke	95	2539	26.73
3	International Journal of Stroke	24	569	23.71
4	Neurology	6	119	19.83
5	Canadian Journal of Neurological Sciences	7	114	16.29
6	Journal of Neurointerventional Surgery	15	241	16.07
7	PLOS One	8	113	14.13
8	Journal of Neurology	17	221	13.00

TP: Total papers; TC: Total citations; CPP: Citations per paper

18.84% global share and registered 11.89 CPP. There is a need for more active international collaboration between developed and developing countries.

In terms of specific strokes, Ischemic Stroke contributed the largest share (35.46%) of papers in global output, followed by Hemorrhagic Stroke (16.95%), Transient Ischemic Attack (7.74), Brain Stem Stroke (0.84%), and Cryptogenic Stroke (0.31%).

By specific institution, it was evident that the maximum number of publications emerged from Harvard Medical School, USA (27 papers), followed by the University of Toronto, Canada (23 papers), University of Thessaly, Greece (21 papers), University of Calgary, Canada and Massachusetts General Hospital, USA (18 papers each) and the University of California, Los Angeles, USA (17 papers). When the citation impact of the organizations was evaluated by considering CPP and RCI, publications emerging from NTU Langone Health, USA (54.27 and 4.62) had maximum citation impact and this was followed by the University of Pennsylvania, USA (35.55 and 3.03), Hospital Universitario La Paz, Spain (28.0 and 2.38), McMaster University, Canada (25.91 and 2.21), University of Cambridge, U.K. (25.17 and 2.14), Hospital Clinic Barcelona, Spain (24.73 and 2.10), Icahn School of Medicine at Mount Sinai, USA (24.69 and 2.10) and University of Washington, USA (22.0 and 1.87).

When the publication data were evaluated for the productivity of various authors, S. Yagi (USA) and G. Tsivgoulis (Greece) were observed to be the most productive authors with 15-16 publications each. Five other authors, i.e., H.S. Markus (U.K.), J. Mocco (USA), M.S.V. Elkind (USA), and D.S. Liebeskind published 10-11 papers each. When the citation

impact of the authors was evaluated in terms of CPP and RCI, J.T.Fifi (USA) (171.88 and 14.63), J. Mocco (USA) (128.45 and 10.93), P. Jabbour (USA) (45.86 and 3.90), S. Yagi (USA) (36.56 AND 3.11) and H.S. Markus (U.K.) (27.45 and 2.34) emerged at the top of the list.

The maximum number of publications were published in Stroke (95 papers), followed by *Journal of Stroke and Cerebrovascular Disease* (81 papers), *Frontiers in Neurology* (34 papers), *European Journal of Neurology* (26 papers), *Neurological Sciences* (25 papers), *International Journal of Stroke* (24 papers), *Cerebrovascular Diseases* (22 papers) and *American Journal of Neuroradiology*. Considering the citation impact of the journal per paper, the *Journal of Neurology, Neurosurgery and Psychiatry* (54.82) was the most impactful journal in terms of CPP, followed by *Stroke* (26.73), *International Journal of Stroke* (23.71), *Neurology* (19.83), *Canadian Journal of Neurological Sciences* (16.29), *Journal of Neurointerventional Surgery* (16.07), *PLOS One* (14.13) and *Journal of Neurology* (13.0).

To conclude, this bibliometric study showed that a significant amount of literature has emerged on the topic of “Impact of COVID-19 on Stroke” during the last 2 years. However, it is important to note that the research output is unevenly distributed across different countries, organizations, authors, and journals. An important finding is that the research on the topic was not limited to developed countries and in fact, around 20.0% of the publications were published by researchers in developing countries.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ABBREVIATIONS

CVD: Cardiovascular Disease; **NIHSS:** National Institute of Health Stroke Scale; **CPP:** Citations Per Publication; **TP:** Total Papers; **TC:** Total Citations; **ICP:** International Collaborative Paper; **RCI:** Relative Citation Index; **TCL:** Total Collaborative Linkages.

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