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Original Article

Post-Covid-19 Impact on Cognitive Impairment: A Bibliometric Assessment of Global Literature during 2020-23

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ABSTRACT

Objectives: The characteristic symptom of coronavirus disease 2019 (COVID-19) is respiratory distress, but neurological symptoms are the most frequent extra-pulmonary symptoms. This study aims to explore the current status and hot topics of "Post Covid-19 Impact on Cognitive Impairment", using bibliometric analysis. The aim was to identify, explore the current trends and present status and hot topics related to this topic, using quantitative and qualitative methods and indicators. **Methodology:** Publications "Post Covid-19 Impact on Cognitive Impairment" were retrieved from the Scopus database on 4 July 2023. The Advanced search was conducted using the following pre-defined search strategy involving keywords related to "Covid-19" and "Cognitive Impairment". Microsoft Excel 2010 and VOSviewer were used to characterize the largest contributors, including the authors, journals, institutions, and countries. The hot topics and knowledge network were analyzed by VOSviewer. **Results:** A total of 467 publications between 2020 and 2023 were identified and retrieved, with a steady increase in annual publications. The USA (*n*=131), Italy (*n*=62), and the U.K (*n*=41) were three key contributors to this field. The U.K. (58.87 and 2.73), Canada (28.38 and 1.32) and USA (27.80 and 1.29) were the countries with highest citation influence, in terms of CPP and RCI. The University of Toronto, Canada (*n*=17), INSERM, France and AP-HP Assistance Publique - Hopitaux de Paris, France (*n*=13 each) were the major institutions with the largest publications. The Instituto de Salud Carlos III, Spain (82.67 and 3.84), University of Toronto, Canada (45.35 and 2.11) and King's College London, U.K. (42.83 and 1.99) were the institutions with highest citation influence (CPP and RCI). The C. Franke (Germany), F. Landi (Italy) and I. Margalit (Israel) (*n*=4 each) were the most prolific authors. The H.E. Davis (USA) (284.0 and 13.18), P. Dudouet (France) (66.33 and 3.08) and C. Eldin (France) (66.33 and 3.08) were the authors with highest citation influence. *International Journal of Environmental Research and Public Health* (*n*=17), *Journal of the American Medical Directors Association* (*n*=9) and *Frontiers in Immunology* (*n*=8) were the most productive journals, while *Alzheimers and Dementia* (341.2), *EClinical Medicine* (236.75) and *Brain Behavior and Immunity* (68.5) were on top journals in citation impact (CPP and RCI). Covid-19 (*n*=450), Cognitive defect (*n*=438), Long Covid (*n*=346), Fatigue (*n*=227), Depression (*n*=169), Dyspnea (*n*=146) and Headache (*n*=117) were the central and significant keywords regarding the "Post Covid-19 Impact on Cognitive Impairment" topic. **Conclusion:** This bibliometric analysis mapped the overall research structure of "Post Covid-19 Impact on Cognitive Impairment" theme and analyzed the current research trends and hotspots for future studies orientation.

Key words: ??

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INTRODUCTION

The coronavirus disease 19 (COVID-19), first appeared in Wuhan, Hubei, China, and then shown global spread within a short period, becoming a pandemic as reported by the World Health Organization.[1] Since the beginning of the COVID-19 pandemic, the global confirmed case count has reached 769,774,646, including 6,955,141 deaths, as reported to WHO on 16 August 2023.[2] It is believed that COVID-19 is mostly known

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for its dramatic respiratory manifestation, but it is often referred as multisystem conditions, with effects on cardiovascular, osteoarticular, hematopoietic and nervous systems.[3]

Furthermore, in addition to the symptoms occurring during the acute stage, many patients also complain of long-term sequelae, even after recovery from the infection. This clinical picture is called "long-term COVID-19 syndrome", and it indicate new symptoms 3 months after the initial SARS-CoV-2 infection, with these symptoms lasting for at least 2 months. The long COVID common symptoms include fatigue, shortness of breath and cognitive dysfunction; although over 200 different symptoms have been reported that can have an impact on everyday functioning. According to WHO, around 10–20% of people infected by SARS-CoV-2 may go on to develop symptoms that can be diagnosed as long COVID.[4]

Although most COVID-19 patients have initially complained of respiratory insufficiency, the presence of neuropsychiatric manifestations is also reported frequently, ranging from headache, hyposmia/anosmia, and neuromuscular dysfunction to stroke, seizure, encephalopathy, altered mental status, and psychiatric disorders, both in the acute phase and in the long term. These neuropsychiatric complications have emerged as a potential indicator of worsened clinical outcomes and poor prognosis, thus contributing to mortality in COVID-19 patient.[5]

Emerging reports suggest a the high frequency of neuropsychiatric symptoms after infection with COVID-19 emphasize fatigue, cognitive dysfunction and sleep disorders, with increased rates of newly diagnosed mood or anxiety disorders, and dementia were some of the most persistent, debilitating and concerning alterations in the lives of COVID-19 survivors that can develop even after the resolution of the infection.[6-8]

Amongst the different neuropsychiatric symptoms associated with COVID-19, deficits in cognitive functions play a prominent role in hindering a full recovery of patients. Physiologically, these functions comprise different abilities, such as working memory, attention/vigilance, verbal/visual learning, reasoning/problem solving and executive functioning.[9-11]

The cognitive deficits presence may lead to substantial detriments to the quality of life and daily functioning of individuals, as also observed in elderly people and other neurological or psychiatric conditions.[9,12,13]

As a matter of fact, people with cognitive impairment might present difficulties in instrumental activities of daily living, in making decisions that affect their everyday activities (medical decisions and managing their finances) and in learning new things and completing tasks that rely heavily on memory and complex reasoning.[14-16]

Bibliometric methods are widely accepted quantitative techniques for analyzing publication data in a given field,[17] involving application of bibliometric tools (e.g., Bibliometrix R, Gephi, Pajek, CiteSpace, and VOSviewer) to analyze publication trends, major contributors, central themes, and frontier topics in a given field.[18]

Bibliometric studies do exist on different disciplines of cognitive impairment related research, such as on vascular cognitive impairment,[19] brain imaging of mild cognitive impairment,[20] virtual reality for mild cognitive impairment,[21] Post-stroke cognitive impairment,[22] electroencephalogram research in mild cognitive impairment,[23] Atrial Fibrillation and Cognitive Dysfunction[24] and cerebral microbleeds and cognitive impairment.[25] These publications provide an overview of cognitive impairment related research in neurosciences and psychiatry disciplines. Given the high incidence of COVID-19 globally and the concern associated with long-term consequences of the infection, data on the cognitive impairment linked to SARS-CoV-2 infection has been widely published. Therefore, there is a need to undertake the present bibliometric study which aims to provide an extensive overview on the published studies on the topic, "Post Covid-19 Impact on Cognitive Impairment" with a focus on: (1) the characteristics and publishing trends; (2) the identification of most influential papers and to study their characteristics; (3) the main contributing countries, organizations, authors and journals; (4) the study of collaborative profile of countries, organizations, authors and keywords; (5) identification of core journals publishing in this field; (6) the important subject topics and frontier themes of research.

METHODOLOGY

This research involved the search in the Scopus database. Advance retrieval of subject records was adopted. The retrieval formula is given at the end of this section. To prevent bias incurred by routine database updates, literature search was conducted on a particular date (4.7.2023). A total of 467 publications of all types were retrieved. Full records, including titles, authors, keywords, country, institution, and references of each publication were collected on 4.7.2023. The data downloaded was screened by authors to confirm the relationship on the topic. All data were converted to plain text format and imported in M.S. Excel and VOSviewer software for further bibliometric analysis. Nodes in the VOS viewer map corresponds to distinct parameters, such as countries, institutions, authors or keywords. Weighting attributes, including the number of publications or quantity of citations was used to determine node size. The colors of nodes and lines represent different clusters. To evaluate the strength of the connections, the Total Link Strength (TLS) index was used, representing the overall co-authorship and co-citation link strength among countries, institutions, or keywords.[26]

The search terms included TITLE-ABS-KEY ("COVID 19" OR "2019 novel coronavirus" OR "coronavirus 2019" OR "SARS-CoV-2" OR "SARS-CoV 2" OR "coronavirus disease 2019"

OR "2019-novel CoV" OR "2019 ncov" OR "COVID 2019" OR "corona virus 2019" OR "nCoV-2019" OR ncov2019 OR "nCoV 2019" OR 2019-ncov OR covid-19 OR "Severe acute respiratory syndrome coronavirus 2" OR "Novel Coronavirus") AND KEY ("brain fog" OR cognitive*) AND KEY (long AND covid* OR post AND covid*) AND (LIMIT-TO (EXACTKEYWORD, "Cognitive Defect") OR LIMIT-TO (EXACTKEYWORD, "Dementia") OR LIMIT-TO (EXACTKEYWORD, "Cognitive Dysfunction") OR LIMIT-TO (EXACT KEYWORD, "Mild Cognitive Impairment") OR LIMIT-TO (EXACTKEYWORD, "Cognitive Impairment").

ANALYSES AND RESULTS

Overall Picture

The number of publications visually reflects the development trend in a certain field within a period. A total of 467 publications were identified, which registered 10060 citations, averaging 21.54 CPP. The number of publications related to "Post Covid-19 Impact on Cognitive Impairment" increased yearly from 15 in 2020 to 90 in 2021 and to 261 in 2022 and then decreased to 101 in 2023 (due to incomplete coverage in 2023).

Of the 467 papers on this topic, 30.71% (153) received external funding from international agencies. Together these 153 papers received 4699 citations, averaging 32.76 CPP. Among the international funding agencies supporting research in this area, National Institute of Health (NIH), USA contributed the largest number of papers (*n*=22), followed by European Regional Development Fund, Instituto des Salud Carlos III, National Institute of Neurological Disorders and Stroke and National Institute of Aging (*n*=9 each), European Commission, National Heart, Lung and Blood Institute and National Natural Science Foundation of China (*n*=7 each), etc.

Among the population age groups, the maximum focus was adult's publications (*n*=215 and 46.04% share), followed by aged (*n*=128 and 27.41%), middle-aged (*n*=96 and 20.56%), children (*n*=30 and 6.42%) and adolescents (*n*=29 and 6.21%).

Clinical studies (*n*=244 and 52.25% share) constituted the largest group among study types in 467 publications, followed by complications (*n*=167 and 35.76%), epidemiology (*n*=153, 32.76%), quality of life (*n*=91 and 19.49%), risk factors (*n*=69 and 14.78%) and pathophysiology (*n*=41 and 8.78%).

Original articles (*n*=383 and 60.6% share) constituted the largest share among 467 papers, followed by reviews (*n*=107 and 22.91%), letters (*n*=31 and 6.64% share), editorials (*n*=29 and 6.21% share), notes (*n*=13 and 2.78% share), short surveys (*n*=3 and 0.21% share) and book chapters (*n*=1 and 0.21% share).

Analysis of countries and regions

"Post Covid-19 Impact on Cognitive Impairment" related articles were published from 71 countries and showed uneven distribution, with 55 countries contributing 1-10 papers each, followed by 14 countries contributing 11-50 papers each and the rest 2 countries 62-131 papers each. The top 10 countries individually published 17 to 131 papers and together contributed 434 papers and 10667 citations, accounting for 92.93% and more than 100.0% share in global publications and citations. Table 1

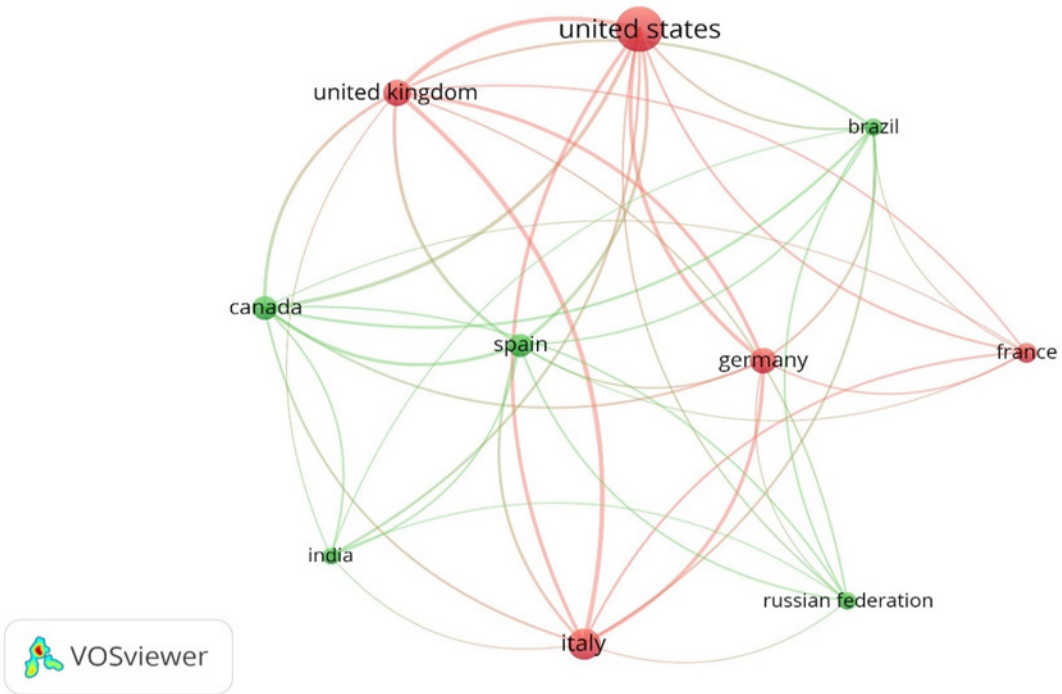

Figure 1: Co-authorship analysis and cluster map of top 10 countries/regions.

shows the contribution of top 10 countries. Only four countries contributed more than the average publication productivity (43.4) of all 10 countries and these were USA (USA)(131 papers and 28.05% share), Italy (62 papers and 13.28% share), U.K (47 papers and 10.06% share) and Germany (41 papers and 8.78% share). The top 4 countries together accounted for more than 60.0% share of global output. Only three countries registered citation impact (CPP and RCI) more than the average values (24.58 and 1.14) of all top 10 countries and these were UK (58.87 and 2.73), Canada (28.38 and 1.32) and USA (27.8 and 1.29).

A map of country and region cooperation through VOSviewer is shown in Figure 1. When the number of publications was limited to 17, only 10 nations were involved in the analysis of global cooperation using the VOSviewer. The network generated indicates 10 nodes, 42 links and 725 total link strength, with network density of 0.467. The clustering of 10 country analysis conducted using VOSViewer produced two distinct clusters with five members each. USA, Italy, UK, Germany and France were in cluster one while Canada, Brazil, Spain, Brazil and India formed cluster two.

The total link strength of top countries 10 varied from 21 to 112. The top 5 countries with the highest Total Link Strength (TLS) were the UK (TLS=159), USA (TLS=12), Italy (TLS=94), Germany (TLS=81) and Canada (TLS=76), according to the co-authorship visualization map. However, the TLS within the top countries network varied from 7 to 52, with the highest link strength (n=52 with 9 countries) depicted by USA, followed by UK (n=50 with 9 countries), Italy (n=40 with 9 countries), Canada (n=35 with 9 countries), Germany and Spain (n=31 each with 9 countrien). The country-to-country collaborative linkages across top 10 countries varied from 1 to 11, with highest collaborative linkages (n=11) depicted by country pair "USA-UK", followed by "USA-Germany" and "USA-Canada" (n= 8 each), "USA-Italy", "Italy-Germany" and "UK-Germany" (n=7 each), etc.

In terms of Degree Centrality (DC) values, the lead countries were USA (0.6667), followed by UK (0.5733), Brazil (0.5733), Italy (0.56), Canada (0.52), and Germany (0.5067). In terms of Closeness Centrality (CC), the lead organizations were USA (0.766), UK (0.7129), Brazil (0.7129), Italy (0.7059), Canada (0.6857), and Germany (0.6729). In terms of Betweenness Centrality (BC) values, the lead countries were USA (0.1368), France (0.0771), Italy (0.0698), UK (0.0665), and Brazil (0.602). The assessment of centrality reflects the influence and importance of the nodes in the network.

Analysis by broad subjects and significant Keywords

Broad Subject Areas

The research output on "Post Covid-19 Impact on Cognitive Impairment" covered seven broad subject areas according to subject categories defined by Scopus database. Medicine,

Table 1: Top 10 countries terms of publications and centrality values for "Post Covid-19 Impact on Cognitive Impairment".

Sl. No.	Name of the country	TP	TC	CPP	RCI	ICP	%ICP	TLS	%TP	DC	CC	BC	EC
1	United States of America	131	3642	27.80	1.29	45	34.35	112	28.05	0.0478(1)	0.766(1)	0.1368(1)	1.0(1)
2	Italy	62	840	13.55	0.63	20	32.26	94	13.28	0.0402	0.7059	0.0698(3)	0.9587
3	United Kingdom	47	2767	58.87	2.73	29	61.70	159	10.06	0.0411(2)	0.7129(2)	0.0665	0.9764(3)
4	Germany	41	678	16.54	0.77	17	41.46	81	8.78	0.0363	0.6729	0.0282	0.9337
5	Canada	37	1050	28.38	1.32	13	35.14	76	7.92	0.0373	0.6857	0.0287	0.9502
6	Spain	34	792	23.29	1.08	18	52.94	59	7.28	0.0277	0.6261	0.027	0.7993
7	France	26	437	16.81	0.78	9	34.62	30	5.57	0.0229	0.576	0.0771(2)	0.5955
8	Russia Federation	20	158	7.90	0.37	6	30.00	30	4.28	0.0411(3)	0.7129(3)	0.0602	0.9778(2)
9	Brazil	19	173	9.11	0.42	9	47.37	63	4.07	0.0249	0.5902	0.0418	0.716
10	India	17	130	7.65	0.36	9	52.94	21	3.64	0.0143	0.5333	0.0252	0.3522
	Total of top 10 countries	434	10667	24.58	1.14	175	40.32	725	92.93				
	Global total	467	10060	21.54	1.00								
	Share of top 10 countries in global total	92.93											

TP=Total papers; TC=Total citations; CPP=Citations per paper; ICP=International collaborative papers; TLS=Total link strength; DC=Degree Centrality; CC=Closeness Centrality; BC: Betweenness Centrality; EC: Eigenvector Centrality.

Neuroscience, Biochemistry, Genetics and Molecular Biology", and "Immunology and Microbiology" were the four subject areas that made up the most articles (with 81.8%, 23.77%, 11.35% and 7.71% share in global output), followed by Psychology, Environmental Science and Pharmacology, Toxicology and Pharmaceutics. In terms of Citation impact Per Paper (CPP), Neuroscience and Immunology and Microbiology registered the highest citation impact (30.03 CPP and 28.61 CPP) and Psychology and Environmental Science the least (6.95 CPP and 6.65 CPP) (Table 2).

Analysis of Keywords

Keyword analysis can classify high-frequency keywords and determine the strong relationship between them. It can identify the internal structure of an academic field and reveal the research frontiers of the discipline. The main hotpots and prospective study directions in this discipline were assessed in this study through keyword co-occurrence analysis. Closer and larger labels indicated more frequent co-occurrence of different keywords, whereas related keywords were represented by the same color.

The key co-occurrence network was obtained by combining author and indexed keywords using VOSviewer software. A total of 5128 keywords were identified in 467 articles published from 2020-2023, having 75 nodes, with 2980 total link strength. The graph density of this network was 0.473 showing that all keywords are not densely connected with each other. The present study however, investigated only 75 significant keywords that were appeared for 20 to 450 times (Table 3). The term "Covid-19" appeared most frequently (450 times), followed by "Cognitive Defect" (437 times), "Long COVID" (353 times), "Fatigue" (227 times), "Depression" (169 times), "Headache" (117 times), "Anosmia" (110 times), "Anxiety" and "Cognition" (106 times each). The co-occurrence analysis produced 4 clusters. Table 3 gives the cluster details frequency and number of links to other keywords of these 75 keywords. A cluster network is presented in the Figure 2.

Cluster 1, included 27 keywords (with frequency and number of occurrences) include Fatique (227)(2776); Dyspnea (146)(1955); Headache (117)(1805); Anosmia (110)(1676); Myalgia (87)(1404); Sleep Disorder (86)(1237); Coughing (60)(990); Dizzines (54)(915); Fever (54)(875); Clouding of Consciousness (56)(797); Ageusia (46)(761); Arthralgia (46)(826); Diabetes Mellitus (46)(647); posttraumatic stress disorder (46)(684); Anxiety Disorder (43)(567); Heart Palpitation (40)(748); insomnia (40)(671); dysgeusia (32)(541); smelling disorder (31)(464); Diarrhea (30)(590); Paresthesia (30)(516); Hyposmia (26)(378); Tachycardia (26)(414); Amnesia (25)(432); Muscle Weakness (24)(392); Taste Disorder (24)(371); Malaise (22)(361); Hair Loss (21)(433); and Rash (21)(439).

Cluster 2 had 19 keywords (with frequency and number of occurrences) include Neurological Disease(76)(971); Inflammation (42)(480); Vaccination (42)(440); Cerebrovascular Accident (39)(547); Delirium (38)(461); chronic fatigue syndrome (35)(454); nervous system inflammation (35)(420); angiotensin converting enzyme 2 (34)(460); immune response (34)(425); Alzheimer disease (29)(307); interleukin 6 (28)(398); Obesity (28)(412); dysautonomia (25)(384); C-reactive protein (23)(337); tumor necrosis factor (22)(290); autoimmunity (21)(293); hypoxia (20)(326) and Oxidative Stress (20)(256).

Cluster 3 had 16 keywords (with frequency and number of occurrences) include COVID-19 (450)(4350), followed by Cognitive Defect (438)(3562); Long Covid-19 9346)(3562); Anxiety (107)(1397); Cognition (106)(1038); Mental Disease (81)(1035); Cognitive Dysfunction (75)(604); Memory Disorder (57)(758); Executive Function (42)(371); Cognitive Impairment (33)(250); Brain (32)(355); Memory (32)(323); SARS-COV-2 Vaccine (22)(228).

Cluster four had 13 keywords (with frequency and number of occurrences) include Hospitalization (87)(994); Intensive Care Unit (60)(737); Dementia (53)(458); Hypertension(52)(703); Comorbidity (51)(583); Mental Health (42)(463); Cardiovascular Disease (38)(538); Daily Life Activity (32)(332); artificial ventilation (30)(372); Physical Activity (30)(360); Exercise (28)(301); and respiratory tract disease (28)(373).

Table 2: Subject-Wise Distribution of Papers.

Sl. No.	Name of the subject	TP	TC	CPP	%TP
1	Medicine	382	8510	22.28	81.80
2	Neuroscience	111	3333	30.03	23.77
3	Biochemistry, Genetics and Molecular Biology	53	989	18.66	11.35
4	Immunology and Microbiology	36	1030	28.61	7.71
5	Psychology	20	139	6.95	4.28
6	Environmental Science	17	113	6.65	3.64
7	Pharmacology, Toxicology and Pharmaceutics	17	161	9.47	3.64
	Global Total	467	10060	21.54	100.00

TP=Total papers; TC=Total citations; CPP=Citations per paper.

Table 3: List of Top 75 Significant Keywords with Frequency of Appearance and TLS.

Sl. No.	Keyword	Frequency	TLS	Sl. No.	Keyword	Frequency	TLS	Sl. No.	Keyword	Frequency	TLS
1	COVID-19	450	4350	26	Comorbidity	51	583	51	Artificial ventilation	30	372
2	Cognitive defect	438	4283	27	Ageusia	46	761	52	Diarrhea	30	590
3	Long COVID	346	3562	28	Arthralgia	46	826	53	Paresthesia	30	516
4	Fatigue	227	2776	29	Diabetes mellitus	46	647	54	physical activity	30	360
5	Depression	169	2170	30	Posttraumatic stress disorder	46	684	55	Alzheimer disease	29	307
6	Dyspnea	146	1955	31	Anxiety disorder	43	567	56	Exercise	28	301
7	Headache	117	1805	32	Executive function	42	371	57	Interleukin 6	28	398
8	Anosmia	110	1676	33	Inflammation	42	480	58	Obesity	28	412
9	Anxiety	107	1397	34	Mental health	42	463	59	Respiratory tract disease	28	373
10	Cognition	106	1038	35	Vaccination	42	440	60	Hyposmia	26	378
11	Hospitalization	87	994	36	Heart palpitation	40	748	61	Tachycardia	26	414
12	Myalgia	87	1404	37	Insomnia	40	671	62	Amnesia	25	432
13	Sleep disorder	86	1237	38	Cerebrovascular accident	39	547	63	Dysautonomia	25	384
14	Mental disease	81	1035	39	Cardiovascular disease	38	538	64	Muscle weakness	24	392
15	Neurologic disease	76	971	40	Delirium	38	461	65	taste disorder	24	371
16	Cognitive dysfunction	75	604	41	Chronic fatigue syndrome	35	454	66	C-reactive protein	23	337
17	Post-acute covid-19 syndrome	65	739	42	Nervous system inflammation	35	420	67	Malaise	22	361
18	Coughing	60	990	43	Angiotensin converting enzyme 2	34	460	68	SARS-COV-2 Vaccine	22	228
19	Intensive care unit	60	737	44	Immune response	34	425	69	Tumor necrosis factor	22	290
20	Memory disorder	57	758	45	Cognitive impairment	33	250	70	Autoimmunity	21	293
21	Clouding of consciousness	56	797	46	Brain	32	355	71	Hair loss	21	433
22	Dizziness	54	915	47	Daily life activity	32	332	72	Rash	21	439
23	Fever	54	875	48	Dysgeusia	32	541	73	Adult respiratory distress syndrome	20	325
24	Dementia	53	458	49	Memory	32	323	74	Hypoxia	20	326
25	Hypertension	52	703	50	Smelling disorder	31	464	75	Oxidative stress	20	256

TLS=Total link strength.

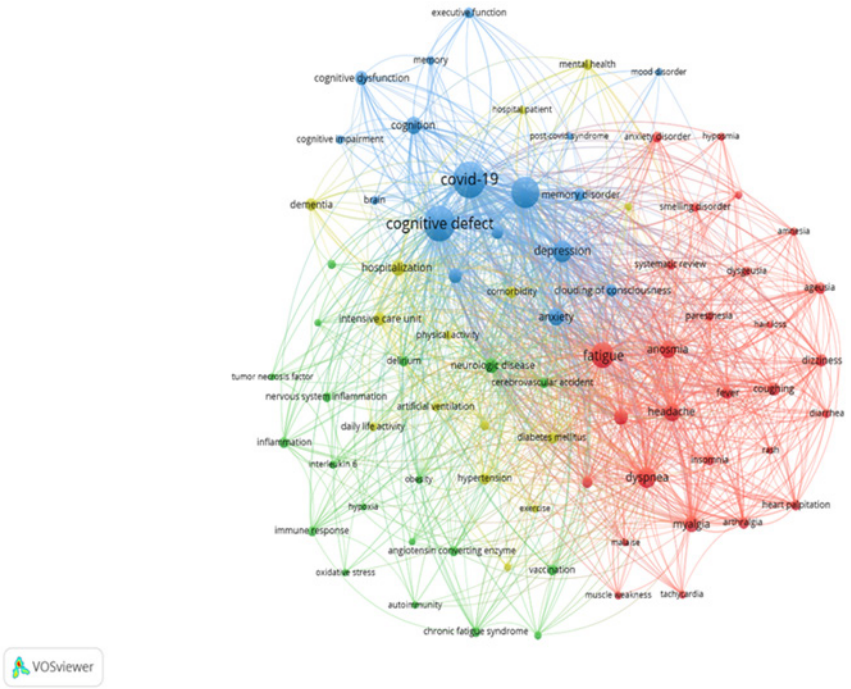

Figure 2: Network visualization of keywords based on VOSviewer.

Analysis of institutions

A total of 363 organizations published articles on "Post Covid-19 Impact on Cognitive Impairment". Of the 363 organizations, 238 published 1-5 papers each, 19 published 6-10 papers each and 7 published 11-17 papers each. Table 4 lists the top 20 organizations, which individually published 6 to 17 publications and together contributed 185 papers and 5041 citations, accounting for 39.61% and 50.11% share in global publications and citations. Among the top 20 organizations, 6 were from USA, 2 each from Canada, France, Italy, Spain and UK and 1 each from Brazil, Germany, Israel and Russia. Table 4 shows the contribution of top 20 organizations. Only seven organizations contributed more than the average publication productivity (9.25) of all 20 organizations and these included University of Toronto, Canada (*n*=17), INSERM, France and AP-HP Assistance Publique - Hopitaux de Paris, France (*n*=13 each), King's College London, UK and Imperial College London, UK (*n*=12 each), Harvard Medical School, USA and Charite - Universitsmedizin Berlin, Germany (*n*=11 each). The top 7 organizations together accounted for 16.7% share of global output. Only 8 organizations registered citation impact (CPP and RCI) more than the average values (227.25 and 1.27) of all top 20 organizations: Instituto de Salud Carlos III, Spain (82.67 and 3.84), University of Toronto, Canada (45.35 and 2.11), King's College London, UK (42.83 and 1.99), Imperial College London, UK (42.58 and 1.98), NYU Grossman School of Medicine, USA (40.29 and 1.87), Icahn School of Medicine at Mount Sinai, USA (38.11 and 1.77), Mayo Clinic, USA (35.5 and 1.65) and Yale School of Medicine, USA (34.0 and 1.58). The International Collaborative Papers (ICP) share of top 20 organizations varied from 0.0% to 75%, with an average of 44.86%.

Understanding leading institutions can help us better track academic frontiers and seize opportunities for collaboration and exchange. The top 5 most prominent institutions with the highest TLS were INSERM, France (TLS = 169), Imperial College London, U.K. (TLS = 135), King's College London, UK (TLS=130), University of Toronto, Canada (TLS=124) and AP-HP Assistance Publique-Hopitaux de Paris, France (TLS =108).

Figure 3 shows the network visualization map created by VOSviewer to investigate institutional collaboration of 20 institutes that contributed 6 or more documents. The network indicates 20 nodes, 51 links and 1613 TLS, with a network density of 0.121 and produced five clusters.

The cluster 1 (Red) included Imperial College London, Harvard Medical School, USA, Charite Universitats- medizin Berlin, Germany, Fondazione Policlinico Universitario A. Gemelli IRCCS, Italy, Ministry of Health, Russia Federation and Johns Hopkins School of Medicine, USA.

The cluster 2 (Green) includes University of Toronto, Canada, King's College London, Universita degli Studi di Padova, Italy, University of Sao Paulo and McMaster University Canada.

Cluster 3 includes (Blue) INSERM, France, AP-HP Assistance Publique-Hopitaux de Paris, France and Mayo Clinic, USA.

Table 4: Profile of Top 20 prolific organizations.

Sl. No.	Name of the organization	TP	TC	CPP	RCI	ICP	TLS	DC*	CC*	BC*	EC*
1	University of Toronto, Canada	17	771	45.35	2.11	9	124	0.0424	0.3866	0.0468	0.107
2	INSERM, France	13	291	22.38	1.04	4	169	0.08	0.3843	0.0453(3)	0.256
3	AP-HP Assistance Publique-Hopitaux de Paris, France	13	174	13.38	0.62	5	108	0.0178	0.2794	0.0017	0.015
4	King's College London, U.K.	12	514	42.83	1.99	8	130	0.0889	0.4343	0.0602	0.769)
5	Imperial College London, U.K.	12	511	42.58	1.98	9	135	0.0451	0.3817	0.0245	0.128
6	Harvard Medical School, USA	11	177	16.09	0.75	4	78	0.0787	0.4167)	0.0398	0.83
7	Charite-Universitsmedizin Berlin, Germany	11	260	23.64	1.10	4	145	0.065	0.4069	0.02340	0.741
8	Universita degli Studi di Padova, Italy	9	84	9.33	0.43	5	75	0.0301	0.3037	0.0067	0.028
9	Icahn School of Medicine at Mount Sinai, USA	9	343	38.11	1.77	2	49	0.0246	0.3112	0.0056	0.031
10	Mayo Clinic, USA	8	284	35.50	1.65	3	92	0.0814			
11	Ministry of Health, Russia Federation	8	91	11.38	0.53	3	78		0.3714	0.0388	0.434
12	Fondazione Policlinico Universitario Agostino Gemelli IRCCS, Italy	8	158	19.75	0.92	5	89	0.067	0.4107	0.0376	0.738
13	Johns Hopkins School of Medicine, USA	7	157	22.43	1.04	5	85	0.0684	0.3991	0.0195	0.735
14	Tel Aviv University, Israel	7	142	20.29	0.94	4	32	0.0951			
15	University of Sao Paulo, Brazil	7	29	4.14	0.19	3	39		0.4401	0.0385	1.0
16	Yale School of Medicine, USA	7	238	34.00	1.58	0	30	0.0595			
17	NYU Grossman School of Medicine, USA	7	282	40.29	1.87	1	35		0.4118	0.0266	0.736
18	McMaster University, Canada	7	11	1.57	0.07	3	21	0.0233			
19	Universitat de Barcelona, Spain	6	28	4.67	0.22	3	64		0.3488	0.0116	0.053
20	Instituto de Salud Carlos III, Spain	6	496	82.67	3.84	3	75	0.0212			
	Total of top 20 organizations	185	5041	27.25	1.27	83	1653				
	Global total	467	10060	21.54	1.00						
	Share of top 20 organizations in global total	39.61	50.11	1.26							

TP=Total papers; TC=Total citations; CPP=Citations per paper; ICP=International collaborative papers; TLS=Total link strength; DC=Degree Centrality; CC=Closeness Centrality; BC: Betweenness Centrality; EC: Eigenvector Centrality.

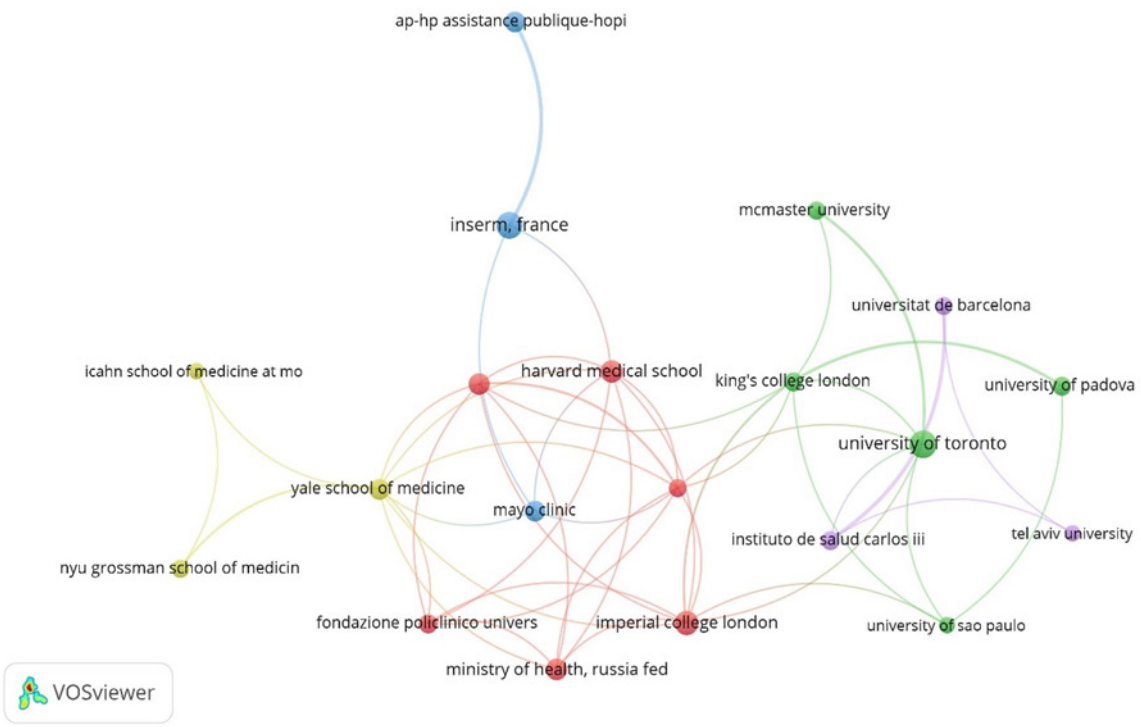

Figure 3: The top 20 institutions' collaboration network visualization map generated by VOSviewer software.

Cluster 4 (Yellowl) includes Icahn School of Medicine, USA Yale School of Medicine, USA and NYU Grossman School of Medicine and Tel Aviv University; and Cluster 5 (Purple)includes Tel Aviv University, Israel, Instituto de Salud Carlos III, Spain and Universitat de Barcelona, Spain.

In terms of Degree Centrality (DC), the lead organizations were Johns Hopkins School of Medicine, USA (0.0951), followed by Imperial College London, UK (0.0889), Mayo Clinic, USA (0.0814), INSERM, France (0.08), Harvard Medical School, USA (0.0787), etc. In terms of Closeness Centrality (CC), the lead organizations were again Johns Hopkins School of Medicine, USA (0.4401), Imperial College London, UK (0.4343), Harvard Medical School, USA (0.4167), Yale School of Medicine, USA (0.4118), Fondazione Policlinico Universitario A. Gemelli IRCCS, Italy (0.4107). In terms of Betweenness Centrality (BC), the lead organizations were Imperial College London, UK (0.0602), University of Toronto, Canada (0.0468), INSERM, France (0.0453), and Harvard Medical School, USA (0.0398).

Analysis of authors

A total of 692 authors published articles on "Post Covid-19 Impact on Cognitive Impairment". Of the 692 authors, 410 published 1 paper each, 241 published 2 papers each, 36 published 3 papers each and 5 published 4 papers each. The top 20 authors individually published 3 to 4 publications and together contributed 65 papers and 2393 citations, accounting for 13.92% and 23.79% share in global publications and citations. Among the top 20 authors, 3 each were from France and Italy, 2 each from Canada, Israel and Spain, and 1 each from Argentina, Brazil, Denmark, Germany, South Korea, U.K and USA. Table 5 shows the contribution of top 20 authors. Only five authors contributed more than the average publication productivity (3.25) of all 20 authors: C. Franke (Germany), F.Landi (Italy), I.Margalit (Israel), K.W. Miskowiak (Denmark) and D. Yelin (Israel) (4 papers each). The top 5 author's together account for 4.28% share of global output. Only 5 authors registered citation impact (CPP and RCI) more than the average values (36.82 and 1.71) of all top 20 authors: H.E. Davis (USA) (284.0 and 13.18), P. Dudouet (France) (66.33 and 3.08), C. Eldin (France) (66.33 and 3.08), K.W. Miskowiak (Denmark) (63.75 and 2.96) and S.Cammilleri (France) (58.67 and 2.72). The international collaborative papers (ICP) share of top 20 authors varied from 0% to 100.0%, with an average of 43.08%.

Authors play a critical role in promoting scientific development, especially in defining the past, present, and future disciplines in this field. We built a collaborative network based on authors whose number of published papers was more than or equal to 3; of the 692 authors, 20 met the thresholds. The author collaboration analysis identified 12 nodes, 12 links and 730 TLS, with a network density of 0.032. The low density suggests that the authors in this area are relatively scattered. Only 7 of the 20 authors in the network were connected; the result finally showed that a total of 20 authors were divided into seven clusters (Figure 4). The authors in each column belonged to the same collaborative group, and the lines between them indicated their cooperation

Table 5: Top 20 authors who published research on "Post Covid-19 Impact on Cognitive Impairment".

Sl. No.	Name of the author	Affiliation of the author	TP	TC	CPP	RCI	ICP	%ICP	TLS	%TP	DC	CC	BC
1	C. Franke	Charite-Universitsmedizin Berlin, Germany	4	32	8.00	0.37	0	0.00	37	0.86	0.0068	0.7736	0.00001
2	F. Landi	Fondazione Policlinico Universitario Agostino Gemelli IRCCS, Italy	4	41	10.25	0.48	2	50.00	55	0.86	0.0124	0.5299	0.00056
3	I. Margalit	Tel Aviv University, Israel.	4	88	22.00	1.02	3	75.00	28	0.86	0.0054	0.5167	0.00014(3)
4	K.W. Miskowiak	Kopenhagen University Hospital, Denmark.	4	255	63.75	2.96	2	50.00	23	0.86	0.0063	1(1)	0.00002
5	D. Yelin	Tel Aviv University, Israel.	4	88	22.00	1.02	3	75.00	28	0.86	0.0054	0.5167	0.00014(3)
6	A. Antonini	Universita degli Studi di Padova, Italy.	3	51	17.00	0.79	3	100.00	31	0.64	0.0065	1(1)	0.00001
7	J.C.Arango-Lasprilla	Universidad del Pais Vasco, Spain.	3	7	2.33	0.11	3	100.00	26	0.64	0.0042	1(1)	0.00001
8	S.Bae	Kyungpook Natonal University School of Medicine, South Korea.	3	69	23.00	1.07	0	0.00	16	0.64	0.0014	1(1)	0
9	A. Banerjee	University of Liverpool, U.K.	3	99	33.00	1.53	1	33.33	161	0.64	0.2393(1)	0.5653	0.0019 (2)
10	S.Baumann	McMaster University, Canada.	3	9	3.00	0.14	1	33.33	10	0.64	0.0016	1 (1)	0
11	S.Cammilleri	AP-HM Assistance Publique-Hopitaux de Marseille, France.	3	176	58.67	2.72	0	0.00	23	0.64	0.0037	0.8333	0.00001
12	E.Guedj	McMaster University, Canada.	3	9	3.00	0.14	1	33.33	10	0.64	0.0037	0.8333	0.00001
13	H.E. Davis	Oregon Health and Science University, USA.	3	852	284.00	13.18	2	66.67	63	0.64	0.0143(2)	0.3509	0.0036(1)
14	C. Delgado-Alonso	Universidad Complutense de Madrid, Spain.	3	37	12.33	0.57	1	33.33	29	0.64	0.0054	0.8966 (3)	0.00001
15	P. Dudouet	AP-HM Assistance Publique-Hopitaux de Marseille, France.	3	199	66.33	3.08	1	33.33	23	0.64	0.0042	0.9091 (2)	0.00001
16	C. Eldin	AP-HM Assistance Publique-Hopitaux de Marseille, France.	3	199	66.33	3.08	1	33.33	23	0.64	0.0042	0.9091 (2)	0.00001
17	R. Ferucci	IRCCS Instituto Auxologico Italiano, Italy.	3	88	29.33	1.36	0	0.00	37	0.64	0.0044	1(1)	0

Sl. No.	Name of the author	Affiliation of the author	TP	TC	CPP	RCI	ICP	%ICP	TLS	%TP	DC	CC	BC
18	M.Gllegos	Consejo Nacional de Investigaciones Cientificas y Technicas, Argentina.	3	3	1.00	0.05	3	100.00	7	0.64	0.0009	1(1)	0
19	E.Groppo	IRCCS Instituto Auxologico Italiano, Italy.	3	86	28.67	1.33	0	0.00	37	0.64	0.0044	1(1)	0
20	B.F. Guedes	University of Sao Paulo, Brazil.	3	5	1.67	0.08	1	33.33	63	0.64	0.0129(3)	1(1)	0.00001
		Total of top 20 authors.	65	2393	36.82	1.71	28	43.08	730	13.92			
		Global total.	467	10060	21.54	1.00							
		Share of top 20 authors in global total.	13.92	23.79									

TP=Total papers; TC=Total citations; CPP=Citations per paper; ICP=International collaborative papers; TLS=Total link strength; DC=Degree Centrality; CC=Closeness Centrality; BC: Betweenness Centrality; EC: Eigenvector Centrality.

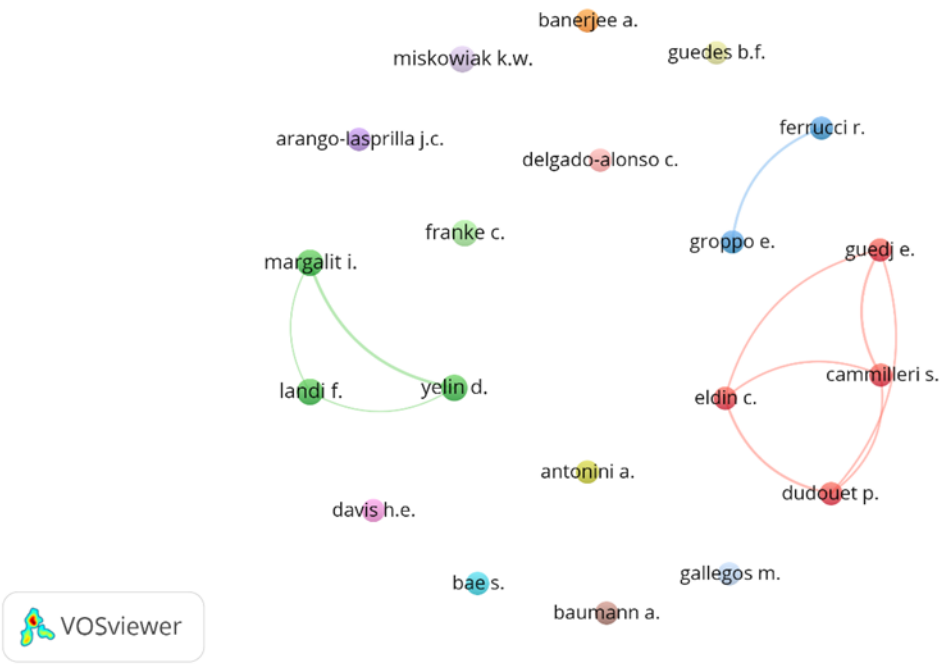

Figure 4: The TOP 20 author's collaboration network visualization map generated by VOSviewer software.

relationships. The size of nodes is proportional to the number of authors' publications. The more yellow the node color is, the more closely the corresponding author has paid attention to this field in recent years.

As seen in the centrality values, disparities same was reflected in the clustering also as only nine others were collected to at least one other authors and rest were single entity in their cluster in this group. In the first cluster there are four authors one from Canada and three from France namely E.Guedj (Canada), S.Cammilleri (France), P. Dudouet (France) and C. Eldin (France). Second group had three members first from Italy and rests from Israel namely F. Landi, I. Margalit and D. Yelin. Third group had only two members R. Ferucci and E.Groppo from IRCCS Instituto A. Italiano, Italy. Rest was the single members in their clusters. Collaboration among these authors seems to be sparse while this may not be true for the complete data set. Details of clustering and centrality value are presented in Table and network graph in Figure.

Table 6: Top 20 journals with most publications in the field of "Post Covid-19 Impact on Cognitive Impairment".

Sl. No.	Name of the journal	TP	TC	CPP	%TP
1	International Journal of Environmental Research and Public Health	17	113	6.65	3.66
2	Journal of the American Medical Directors Association	9	63	7.00	1.94
3	Frontiers in Immunology	8	113	14.13	1.72
4	Journal of Clinical Medicine	7	79	11.29	1.51
5	Journal of Neurology	7	123	17.57	1.51
6	PLOS One	7	181	25.86	1.51
7	Brain Behavior and Immunity	6	411	68.50	1.29
8	Alzheimer S and Dementia	5	1706	341.20	1.08
9	Brain Sciences	5	63	12.60	1.08
10	Clinical Microbiology and Infection	5	211	42.20	1.08
11	European Journal of Neurology	5	61	12.20	1.08
12	Frontiers in Aging Neuroscience	5	44	8.80	1.08
13	Frontiers in Medicine	5	163	32.60	1.08
14	Open Forum Infectious Diseases	5	189	37.80	1.08
15	Asian Journal of Psychiatry	4	3	0.75	0.86
16	Biomolecules	4	10	2.50	0.86
17	Brain Behavior and Immunity Health	4	38	9.50	0.86
18	EClinical Medicine	4	947	236.75	0.86
19	European Geriatric Medicine	4	79	19.75	0.86
20	Frontiers in Neurology	4	24	6.00	0.86
	Total of top 20 journals	120	4621	38.51	25.81
	Global journal papers total	465			
	Share of top 20 journals in global journal papers	25.81			

Analysis of active journals

A total of 272 journals participated in the publication of articles on "Post Covid-19 Impact on Cognitive Impairment". Table 6 lists the top 20 journals in the field. The top 20 journals published 4 to 17 papers and together published 120 papers and 4621 citations, accounting for 25.81% share in global publications. The journal with the most significant number of relevant publications was *International Journal of Environmental Research and Public Health* (*n*=17 and 3.66% share), followed by the *Journal of the American Medical Directors Association* (*n*=9 and 1.94% share), *Frontiers in Immunology* (*n*=8 and 1.72% share), *Journal of Clinical Medicine* and *Journal of Neurology* (*n*=7, 1.51% share each). The most impactful journals among top 20 in terms of CPP were: *Alzheimer's Dementia* (341.2), *EClinical Medicine* (236.75), *Brain Behavior and Immunity* (68.5), *Open Forum Infectious Diseases* (37.8), and *Frontiers in Medicine* (32.6).

High-Cited Papers

Of the 467 publications, only 22 publications assumed as high-cited papers (HCPs)(i.e., ≥ 100 citations) registered 104 to 1161 citations, which together received 5833 citations, averaging 265.14 CPP. Of the 22 HCPs, 11 were in citation range 104-168, 6 in citation range 200-273, 2 each in citation range 304-392 and 471-724, and 1 received 1161 citations. Top 10 publications are listed in Table 7.

Of the 22 HCPs (comprised of 11 each as articles and reviews), 6 publications involved the participation of single organization (no collaboration), while 14 involved the participation of 2 or more organizations with 9 national collaborative and 5 international collaboratives. In 2 publications, address was not available.

The 20 countries participated in these 22 HCPs, of which 10 papers were contributed by USA, followed by U.K. (*n*=9), Canada, Denmark and Italy (*n*=3 each), Australia, Spain and Switzerland (*n*=2 each), Brazil, China, France, Germany, India, Japan, Netherlands, Norway, Russia Federation, Singapore, Saudi Arabia and South Korea (*n*=1 each). The 22 HCPs involved the

Table 7: Profile of Top 10 HCPs.

Sl. No.	Author names	Title	Source	Number of citations
1	[No author name available]	2021 Alzheimer's disease facts and figures.	Alzheimer's and Dementia 2021, 17(3), pp. 327-406.	1205
2	Davis, H.E., Assaf, G.S., McCorkell, L., (...), Austin, J.P., Akrami, A.	Characterizing long COVID in an international cohort: 7 months of symptoms and their impact.	EClinical Medicine 2021, 38,101019.	772
3	[No author name available]	2022 Alzheimer's disease facts and figures.	Alzheimer's and Dementia 2022, 18(4), pp. 700-789.	529
4	Soriano, J.B., Murthy, S., Marshall, J.C., Relan, P., Diaz, J.V.	A clinical case definition of post-COVID-19 condition by a Delphi consensus.	The Lancet Infectious Diseases, 2022, 22(4), pp. e102-e107.	438
5	Taquet, M., Dercon, Q., Luciano, S., (...), Husain, M., Harrison, P.J.	Incidence, co-occurrence, and evolution of long-COVID features: A 6-month retrospective cohort study of 273,618 survivors of COVID-19.	PLoS Medicine, 2021, 18(9),e1003773.	323
6	Ceban, F., Ling, S., Lui, L.M.W., (...), Maletic, V., McIntyre, R.S.	Fatigue and cognitive impairment in Post-COVID-19 Syndrome: A systematic review and meta-analysis.	Brain, Behavior, and Immunity, 2022, 101, pp. 93-135.	282
7	Blomberg, B., Mohn, K.G.-I., Brokstad, K.A., (...), Cox, R.J., Langeland, N.	Long COVID in a prospective cohort of home-isolated patients.	Nature Medicine, 2021, 27(9), pp. 1607-1613.	282
8	Aiyegbusi, O.L., Hughes, S.E., Turner, G., (...), Sapey, E., Calvert, M.J.	Symptoms, complications and management of long COVID: a review.	Journal of the Royal Society of Medicine, 2021, 114(9), pp. 428-442.	258
9	Sykes, D.L., Holdsworth, L., Jawad, N., (...), Morice, A.H., Crooks, M.G.	Post-COVID-19 Symptom Burden: What is Long-COVID and How Should We Manage It?	Lung, 2021, 199(2), pp. 113-119.	216
10	Mehandru, S., Merad, M.	Pathological sequelae of long-haul COVID.	Nature Immunology, 2022 23(2), pp. 194-202.	213

participation of 74 authors and 103 organizations. Among the participating organizations, Imperial College London, U.K. contributed 3 papers, followed by University of Toronto and King's College London, U.K. (*n*=2 each). The 22 HCPs were published in 19 journals with 2 papers each in *Alzheimer's and Dementia, Brain, Behavior, and Immunity,* and *eClinicalMedicine* and 1 paper each in *BJGP Open, Clinical Microbiology and Infection, European Journal of Nuclear Medicine and Molecular Imaging, Frontiers in Medicine, Journal of the Royal Society of Medicine, The Lancet Infectious Diseases, The Lancet Respiratory Medicine, Lung, Nature Immunology, Nature Medicine, Nature Reviews Microbiology, Physiological Reports, PLoS Medicine, PLoS ONE, Psychiatry Research and Science.*

DISCUSSION

This study performed a comprehensive bibliometric analysis of global research on "Post Covid-19 Impact on Cognitive Impairment". The 467 publications were analyzed using bibliometric methods and indicators in this study, to understand the trends and characteristics of research, subject areas contributing and their distribution by type of research and population age groups, key participating countries, organizations and authors and leading medium of communications were identified. The study also presented an analysis of HCPs, examining the bibliometric characteristics of research papers in this area.

Clinical studies, complications and epidemiology (52.25%, 35.76% and 32.76%) were observed to be most researched areas in "Post Covid-19 Impact on Cognitive Impairment" research. By research priorities through their distribution by population age groups, the most studied population age groups were: adults, aged and middle aged (46.04%, 27.41% and 23.0%).

At the country level, USA (*n*=131), Italy (*n*=62), UK (*n*=47) and Germany (*n*=41) were the most productive countries, while U.K. (58.87 and 2.73), Canada (28.38 and 1.32), USA (27.80 and 1.29) and Spain (23.29 and 1.08) were the most impactful in terms of CPP and RCI.

At the institution level, University of Toronto, Canada (*n*=17), INSERM, France, AP-HP Assistance Publique - Hopitaux de Paris, France (*n*=13 each) and King's College London, U.K (*n*=12) were the most productive and active organizations and Instituto de Salud Carlos III, Spain (82.67 and 3.84), University of Toronto, Canada (45.35 and 2.11), King's College London, U.K. (42.83 and 1.99) and Imperial College London, U.K. (42.58 and 1.98) were the most impactful (CPP and RCI).

At the author level, C. Franke (Germany), F. Landi (Italy), I. Margalit (Israel) were the most productive authors and H.E. Davis (USA) (284.0 and 13.18), P. Dudouet (France) (66.33 and 3.08), C. Eldin (France) (66.33 and 3.08) and K.W. Miskowiak (Denmark) (63.75 and 2.96) were the most impactful (CPP and RCI).

At the journal level, *International Journal of Environmental Research and Public Health* (*n*=17), *Journal of the American Medical Directors Association* (*n*=9), *Frontiers in Immunology* (*n*=8) and *Journal of Clinical Medicine* and *Journal of Neurology* (*n*=7 each) were the most productive journals, while *Alzheimers and Dementia* (341.2), *EClinical Medicine* (236.75), *Brain Behavior and Immunity* (68.5) and *Open Forum Infectious Diseases* (37.8) were the most impactful in terms of CPP.

The study has few limitations, including the use of one database (Scopus), which may lead to missing of potentially valuable information. At the same time, use of multiple databases may lead to other difficulties of merging existing data in different databases, which pose significant problems.

CONCLUSION

The present study attempted to undertake a bibliometric analysis of a specialized field namely "Post Covid-19 Impact on Cognitive Impairment". This analysis contributes to the evaluation of the progress of the research knowledge and to the evaluation of the research interest in this area. The present research study allowed the identification of the various actors who contributed to the conceptualization of knowledge in this field, but also led to the identification and analyses of the most significant cited works in the field. A bibliometric examination of the research topic on 'Post Covid-19 Impact on Cognitive Impairment" was undertaken, based on 467 papers that were published between 2020 and 2023 and covered and indexed in Scopus database. The authors witnessed uneven distribution of research across organizations and authors contributing to this topic. Most of the funding (30.71%) received came from a large number of external funding agencies and these funding papers have registered much higher 32.76 CPP, than the global average 21.54 CPP. The present study generated significant statistical data (some of which are available in the tables and figures), which will help the practicing scholars to identify the important countries, organizations, authors, journals, keywords, and references. Through the data and analyses presented, the current study completes the body of existing research by identifying the current state of the art and identifying trends and research possibilities through the selection and analysis of the most pertinent publications published in the subject.

Through an extensive field mapping using keyword co-occurrences, the study increases the added value for the study as it identified the significant sub-fields of current interest in the area. The identification of top contributors' points to possible collaborators for additional research projects for practicing scholars. Finding the most pertinent sources indicates publishing prospects for "Post Covid-19 Impact on Cognitive Impairment" related articles. Leading thematic areas through significant keywords and developing research areas can be found to help practicing scholars to identify research gaps in this field.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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