Journal of Scientometric Res. 2021; 10(2):195-211
http://www.jscires.org

Research Article

Current Trend of Hydroxychloroquine Research Publications: A Scientometric Analysis

Jisha Antony[1], Raja Selvaraju[2,*], Mercy Clarance M[1]

[1]Department of Library and Information Science, DLIS, Alagappa University, Karaikudi, Tamil Nadu, INDIA.
[2]Central Library, Alagappa University, Karaikudi, Tamil Nadu, INDIA.

ABSTRACT
Hydroxychloroquine (HCQ) is one of the extensively used preventive drug in the world. In order to filter out the research strength and weaknesses of research areas of HCQ publications of selective countries, the present study analyses the thematic or subject specialization index, relative priority index, and relative specialization index of hydroxychloroquine research publications from 1989 to 10th June 2020. The top thirty-five productive research areas and fifteen leading countries have been taken for this analysis. The analysis identifies the 209 significant active sub-specialized research areas of the HCQ research of the highest productive countries. India was found to be the most specialized country in Hydroxychloroquine research. Public Environmental Occupational Health is the most specialized research area of HCQ publication. The most significant number of HCQ research publications output is coming under the research areas Rheumatology. The most significant number of research growth was observed in the year 2019. The implications of the study are discussed.

Keywords: Scientometrics, Hydroxychloroquine, Relative Priority Index, Thematic or Subject Specialization Index, Relative Specialization Index, Publication Efficiency Index.

Correspondence
Raja Selvaraju
Central Library Alagappa University
Karaikudi-630003, Tamil Nadu, INDIA.
Email id: lisraja1979@gmail.com
ORCID ID: 0000-0002-2388-8263;
0000-0002-7074-2056

Received: 07-09-2020
Revised: 01-04-2021
Accepted: 27-08-2021
DOI: 10.5530/jscires.10.2.34

INTRODUCTION

Hydroxychloroquine (HCQ) is one of the most secure and beneficial medicine included in the WHO's essential list of medicines. Plaquenil is the brand name of Hydroxychloroquine medicines. It is one of the most popular preventive medicines to prevent and treat malaria, and it is also known as an antimalarial drug. It is also utilized for the healing of rheumatoid arthritis, porphyria cutanea tarda, and lupus. The chemical formula of Hydroxychloroquine is $C_{18}H_{26}ClN_3O$. In this epidemic period of COVID 19, the study of this type of preventive medicine acquired great importance. Nowadays, numerous researches on HCQ are conducting in connection with COVID 19 treatment. In their investigations regarding hydroxychloroquine, Li, X. *et al*.[1] found it helpful for COVID-19 patients. Their study recommends HCQ as preventive medicine for healthy persons who are not showing COVID 19 symptoms. This study also points out that this medicine has minor side effects. But while prescribing HCQ for COVID 19 patients, it is essential to evaluate their immune profile thoroughly. Sarah, M. L. *et al*.,[2] in their research about the Safeness of HCQ use in COVID-19 patients, reported no severe side effects and no death experience associated with hydroxychloroquine. Skipper, C. P. *et al*. (2020),[3] in their examination on the application of HCQ on early and mild corona symptoms showing patients, reveals no significant reduction of disease intensity in such patients. Mehra, M. R. *et al*. (2020),[4] in their survey about HCQ for the treatment of COVID-19 patients, discloses that no measurable benefit found HCQ with or without the combination of macrolide some harmfulness of the use of this medicine. Derwand, R., and Scholz, M. (2020)[5] suggested that zinc supplements will strengthen the efficiency of hydroxychloroquine medicine in aged COVID 19 patients. And it is also beneficial for coronavirus patients having heart disease, lung disease, or diabetes. Geleris, J. *et al*. (2020),[6] in their study on Hydroxychloroquine in Covid-19 inpatients, exposed no benefit or danger in using this medicine; their findings did not support its use in such patients. They also recommend more clinical trials in this regard. Gautret, P. *et al*. (2020)[7] conducted a clinical study in eighty COVID-19 patients about the benefit of the combinational use of hydroxychloroquine with azithromycin. Their observational studies identified that out of two aged patients, and others recovered immediately with the help of this medicine. The review of literature manifests that scientists throughout the globe are performing numerous researches on hydroxychloroquine. But still, there is no scientometric study undertaken. This scientometrics analysis will help locate the most productive journals, authors, institutions, most specialized countries and their research areas, most productive countries, most productive

research areas, yearly publication output, growth pattern etc., that are relevant to their research. This analysis mainly concentrates on sieving out the active and inactive research areas of HCQ Research publications of the top fifteen productive nations. So that, scientific community of this domain can focus more on static research areas of their corresponding countries to make them more active.

Objectives

This study mainly analyses the research publication trend of hydroxychloroquine during the period 1989 to 10th June 2020. The following research questions are addressed by this study

1. To identify the top prolific journals, authors, and organizations in the field of HCQ research publications
2. To analyze the annual output and exponential growth model of HCQ publications
3. To find out thirty-five of the most prolific research sub-specialized areas of HCQ publications and its output in the fifteen most leading countries.
4. To measure the relative priority index, thematic or subject specialization index, and relative specialization index of the top fifteen countries in this discipline's thirty-five sub-specialized research areas for the identification of active and inactive research areas of HCQ research publications of corresponding countries.
5. To analyze yearly citations received and publication efficiency index of HCQ research articles.

Data Collection

Data requisite for this study was extracted from the web of Science Core database for the timespan 1989 to present, which includes three main citation indexes, such as Science Citation Index Expanded (SCI-EXPANDED), Social Sciences Citation Index, Arts and Humanities Citation Index (A&HCI). The Keywords "Hydroxychloroquine," "HCQ," and "Plaquenil" were used by selecting the topic search field in the basic search box of the web of science core database for extracting data. Timespan has been chosen for the year 1989 to 2020. Data were downloaded from the database on 10th June 2020. A total of 4886 data were found to be available in this database during the prescribed time frame. All essential data such as total publication output, year-wise, author wise, journal wise, institution wise, country wise, research area-wise lists required for this study were refined and imported to CSV excel files. Analyzing data more accurately for measuring SSI, RPI and RSI, the top thirty-five research areas of HCQ publications refined one by one. Each thirty-five research areas country-wise list refined and imported to excel files. The top productive fifteen countries have been taken for cross analyzing the data, and each country's research area wise list has been refined and exported to excel sheets. The country-wise research output of other subject areas (other than the top thirty-five research areas) was also collected and tabulated in the excel file. Concerned statistical techniques and tools were employed to measure exported data according to the objectives of the analysis.

Limitation of the Study

Two limitations perceived during the analysis are as follows:

1. Variations in the number of records found while taken the refined and downloaded fifteen country-wise lists of research areas. However, thirty-five research area-wise country share taken as final.
2. One hundred forty-two data were missed in the database while cross-analyzed the total number of research areas wise and country-wise research output lists.

METHODOLOGY

Mainly five methods and techniques of scientometrics are used to analyze HCQ publications. These include Exponential Growth Model, Relative Priority Index, Thematic or subject specialization index, Relative Specialization Index and Publication Efficiency Index.

In order to measure the exponential growth pattern of HCQ research publications, observed data of research output has been applied in the equation of the expected number of publications.

$Y = K + ab^x$ Here, 'Y' is the expected number of publications.

K is the asymptote, and a and b are constants. K can be calculated from the formula,

$$K = \frac{1}{N}\left[S_1 - \frac{(s_2 - s_1)}{(b^n - 1)}\right] \quad (1)$$

Where,

S1, S2 and S3 are the three subtotals to find out the value of K.

$S = \left[\frac{\text{Total No. of Years}}{3}\right]^{th}$ subtotal of successive years. The constants a and b are calculated by the equation,

$a = \frac{(s_2 - s_1)(b-1)}{(b^n - 1)^2} b^n$ is the difference between subtotals and can be calculated as,

$$b^n = \frac{s_3 - s_2}{s_2 - s_1} \quad b = \left(\frac{s_3 - s_2}{s_2 - s_1}\right) 1/n$$

X = Unit of time n = Number of years

The relative Priority Index is a statistical tool for applying cross-national comparisons. This index is similar to the Activity Index proposed by Fame (1977)[8] subsequently used among others by Nagpaul (1995)[9] Schubert and Braun (1986),[10] Carpenter *et al*. (1988)[11] and Sangam, S. L. (2018)[12]

$$\text{Relative Priority Index (RPI)} = \frac{(N_{ij} / N_{io})}{(N_{oj} / N_{oo})} \times 100$$

Where,

"N_{ij} = the number of publications of the country 'i' is subfield j

N_{io} = the number of publications of the country 'i' is in all subfields

N_{oj} = the number of publications of all countries (viz., the total world output) is subfield j

N_{oo} = the number of publications of all countries is in all subfields."

The value of R

RPI = 100 indicates that the research priority for a given subfield corresponds precisely to the average of all countries. i.e., RPI = 100 indicates, average priority

RPI > 100 indicates, higher than average priority

RPI < 100 indicates, lower than average priority

No country can have high or low priority in all subfields. From the value of RPI, we can compare

1. The priorities of a given country to different subfields in a given time.
2. The priorities of different countries to a given subfield in a given time.
3. The priorities of the given subfield in different periods.

The Thematic or subject specialization index of a country (a region or an institution) the ratio of its world share is one particular discipline to its world share for all disciplines. (Glänzel, W. (2000),[13] Romo-Fernández., *et al*. (2011),[14] Arencibia-Jorge, R. (2016),[15] Zacca-González, G. (2018).[16] TSI/SSI can be measured in two methods. Two methods generate the same result. In the first method,

Thematic or subject specialization index in discipline

$$\text{'i'} = \frac{\text{Publication World share of the country in discipline i}}{\text{Publication World share of the country for all discipline}}$$

Where publications world share of the country is defined as the number of publications of a country (a region or an institution) divided by the number of worldwide publications, expressed as a percentage (%).

Country World Share (%) is discipline 'i' (i.e., Publication World Share of Country in discipline i)

$$= \frac{\text{Number of publications in discipline 'i' of a country}}{\text{Total number of worldwide publications in discipline 'i'}} \times 100$$

Where discipline 'i' is particular disciplines taken for the study

In the second method, the Thematic or subject specialization index is measured by the equation,

$$\text{"TSI/SSI} = \frac{(X_\alpha / X_t)}{(Y_\alpha / Y_t)}$$

Where,

X_α = number of articles published by group X in discipline α

X_t = Total Number of articles published by reference group X

Y_α = number of articles published by group Y in discipline α

X_t = Total Number of articles published by reference group Y

This equation of TSI/SSI is similar to RPI without the multiplication of 100."

In both methods, if the value of TSI/ SSI is higher than 1, it indicates that the country specializes in that particular discipline. TSI/ SSI is less than one denotes that that country is not specialized in that discipline. If it is equal to one, that country shows a neutral situation means no relative specialization in that particular discipline. Here, the first method took for analyzing the thematic or subject specialization index of HCQ publications.

Glänzel (2003)[17] has been introduced the Relative Specialization index (RSI).

$$\text{RSI} = \frac{P1 - 1}{P1 + 1}$$

According to him, the values of RSI lie between −1 and +1.

If the rate of RSI is equal to −1, it denotes that research in that field is lower than average activity. If RSI is equal to zero, it indicates moderate or average research activity. If RSI is equal to 1, it displays all the research activity is more remarkable than the average priority index and occurred in that area only. No research activity occurred in other fields. It is balanced the positive values of RSI with the negative ones.

Citation measures the number of times articles cited by other researchers for writing their research paper. Analysis of PEI implemented for estimating relative research effort, and this analysis is based upon the citations received to the research articles by the authors. The formula of Guan, J. and Ma, M. (2007)[18] is applied to measure PEI.

$$PEI = \frac{TNC_i / TNC_t}{TNP_i / TNP_t}$$

Where,

TNC_i=Total number of Citations received for a specific year 'i'

TNC_t =Total number of Citations received for all years

TNP_i = Total number of Publications output in a particular year 'i'

TNP_t = Total number of Publications output for all years

If PEI > 1 signifies that impact and research effort is higher for the corresponding particular year. If PEI =1, it implies the average research impact and if PEI < 1, it denotes the low research influence of research articles.

ANALYSIS AND RESULTS

Prolific Journals, Authors, Organizations of HCQ Publications

Journal of Rheumatology has 216 (4.42%) articles in HCQ research publications, and it is found to be a high-yielding journal. Lupus is the second leading journal with 211(4.32%) of article output. The journal 'Annals of The Rheumatic Diseases' occupies the third position with 188(3.85%) scholarly articles. The other top 15 journals of this subject, its publication output and percentages are listed in Figure 1. Analysis manifest that Petri M is the most fruitful author in the field of hydroxychloroquine with 82(1.68%) scholarly articles, followed by Costedoat-Chalumeau N with 75(1.54%). The third-place hold by Piette JC with 55(1.13%) articles. The top ten authors of HCQ publications depict in Figure 2 with its number of publications and its percentage of 4886. The leading fructuous organisation of HCQ research publications is *Assistance Publique – Hôpitaux de Paris* (*AP-HP*), with 253 (5.18%) research articles. It is the largest university hospital trust in Paris. The public research university 'Sorbonne University of Paris itself and the University of London is the other dominant institutions with 141 (2.89%) articles. The University of California System occupies third place with 132(2.7%) article output. Other leading organizations are listed in Figure 3.

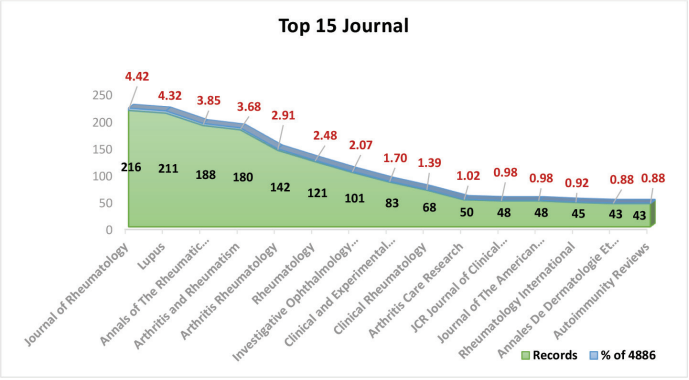

Figure 1: Top 15 Journals of HCQ Research Publications.

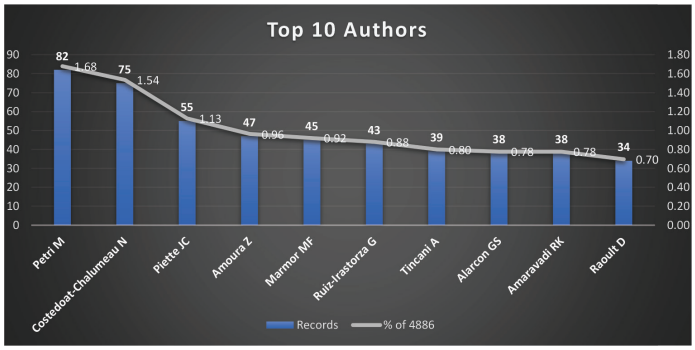

Figure 2: Top ten Authors of HCQ Research Publications.

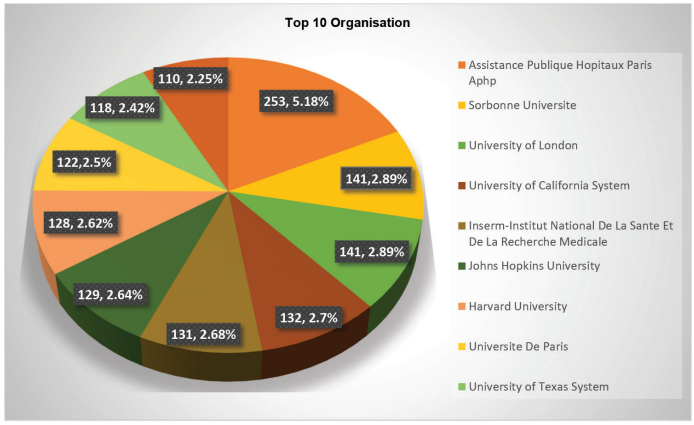

Figure 3: Top 10 Organisation of HCQ research publications.

Annual output and Exponential Growth model of HCQ Publications

Thirty-one and half-year analyses of HCQ publications indicate that the highest research output occurred in 2019 with 525 (10.74%) publications. From 2015 onwards, there is a gradual hike in the HCQ publications, and for the year 2020, data taken till 10th June. From 1989 to 2019, step by step, development in publications was noted. However, in 1994, 1977, 2000, 2003, 2008, 2014, 2020, some declines were perceived. The total research output during the period of study is 4886. The annual output of HCQ publications is denoted by the letter 'f 'in table 1. The expected number of publications of HCQ is calculated through the equation, p or $Y = K + ab^x$. to identifying whether the publication output of HCQ research publications follows an exponential growth pattern or not.

$$b^n = \frac{s_3 - s_2}{s_2 - s_1}$$

$$b = \left(\frac{s_2 - s_2}{s_2 - s_1}\right) 1/n$$

$$S = \left[\frac{\text{Total No. of Years}}{3}\right]^{th}$$

$$= 32/3$$

$$=10.67 = 11^{th} \text{ years' sum of publications}$$

S_1 = 11th years' sum of publications (i.e., the sum of 1th to 11th years of publications) = 646

S_2 = 22th years' sum of publications (i.e., the sum of 12th to 22nd years of publications) = 1147

S_3 = 33th years' sum of publications. Here only 32 years taken for the study, So, S_3 = 32 (i.e., the sum of 23th to 32th years of publication) = 3093

Here, n = 11 years (number of subtotal years)

$$\therefore b^{11} = \frac{(3093 - 1147)}{(1147 - 646)} = 3.88$$

$$\therefore b = (3.88)^{(1/11)} = 1.13$$

$$a = \frac{(s_2 - s_1)(b - 1)}{(b^n - 1)^2}$$

$$= \frac{(1147 - 646) \times (1.13 - 1)}{(3.88 - 1)^2} = 7.83$$

$$K = \frac{1}{N}\left[S_1 - \frac{(s_2 - s_1)}{(b^n - 1)}\right]$$

$$= \frac{1}{11}\left[646 - \frac{(1147 - 646)}{(3.88 - 1)}\right]$$

$$= 42.91$$

In 1993, 1995 to 1999, 2001, 2002, 2007, 2013 to 2019 observed value is higher than the expected value of publication output. From 2013 onwards, publications outgrowth is higher than the expected output. But in 2014, data was found to be lower than in 2013. Out of 32 remaining years, the other sixteen years publication output is lower than the expected values. Chi-square test of goodness of fit implemented to identify the exponential growth model of HCQ research publications. The calculated Chi-square value X^2 from Table 1 is 308.15. It is found to be considerably higher than the critical Chi-square value of 43.773 at a 0.05 (5%) level of significance for 30 degrees of freedom. So, it can be concluded that 95% of HCQ research publications do not fit with the exponential growth model. There is only a 5% of chance of rejection. The yearly output versus the expected annual output of HCQ publications is illustrated in Figure 4. Blueline indicates the

Table 1: Annual out and EGR of HCQ publications for 1989 to 10/06/2020.

X	Years (Y)	Observed No. of Publications (f)	Expected No. of Publications (p/Y) $Y = K+ab^x$	(f-p)	$(f-p)^2$	$(f-p)^2/p$
1	1989	10	51.76	-41.76	1743.72	33.69
2	1990	21	52.91	-31.91	1018.13	19.24
3	1991	36	54.21	-18.21	331.53	6.12
4	1992	42	55.68	-13.68	187.05	3.36
5	1993	69	57.34	11.66	136.04	2.37
6	1994	56	59.21	-3.21	10.31	0.17
7	1995	87	61.33	25.67	658.90	10.74
8	1996	96	63.73	32.27	1041.64	16.35
9	1997	69	66.43	2.57	6.60	0.10
10	1998	74	69.49	4.51	20.34	0.29
11	1999	86	72.94	13.06	170.44	2.34
S1		**646**				
12	2000	74	76.85	-2.85	8.12	0.11
13	2001	96	81.26	14.74	217.23	2.67
14	2002	101	86.25	14.75	217.65	2.52
15	2003	74	91.88	-17.88	319.73	3.48
16	2004	95	98.25	-3.25	10.54	0.11
17	2005	99	105.44	-6.44	41.49	0.39
18	2006	99	113.57	-14.57	212.29	1.87
19	2007	123	122.76	0.24	0.06	0.00
20	2008	120	133.14	-13.14	172.55	1.30
21	2009	127	144.87	-17.87	319.16	2.20
22	2010	139	158.12	-19.12	365.55	2.31
S2		**1147**				
23	2011	167	173.10	-6.10	37.17	0.21
24	2012	182	190.02	-8.02	64.33	0.34
25	2013	257	209.15	47.85	2290.09	10.95
26	2014	243	230.76	12.24	149.92	0.65
27	2015	303	255.18	47.82	2287.17	8.96
28	2016	333	282.77	50.23	2523.03	8.92
29	2017	395	313.95	81.05	6568.78	20.92
30	2018	436	349.19	86.81	7536.41	21.58
31	2019	525	389.00	136.00	18495.03	47.54
32	2020 till 10/06/2020	252	434.00	-182.00	33122.44	76.32
S3		**3093**			**X2**	**308.15**

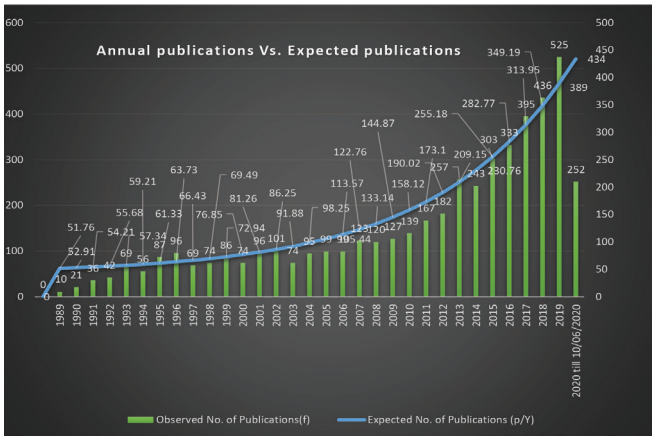

Figure 4: The annual number of publications vs Expected No. of publications of HCQ Research from 1989 to 10/06/2020.

expected number of publications throughout the year. But in many years observed line of publications (green bars) is lower than the expected number of publications. From Figure 4, it is visible that the yearly outgrowth of HCQ research publications does not follow the exponential growth pattern. Observed yearly outgrowth is lower than expected outgrowth, especially at the beginning and middle stages of growth.

Thirty-five most prolific research sub-specialized group of HCQ publications and its publication output in fifteen most leading countries

The top active 35 research area sub-specialities of HCQ and its research share from the most productive 15 countries from 1989 to 10th June 2020 are listed in Table 2. Row of Table 2 denotes the most active research sub-specialities, and columns constitute the most active research sub-spec most leading countries. The largest number of research publications on HCQ is coming under the research area Rheumatology with 1764 articles. The second place of research rank was Dermatology with 448 articles, followed by General Internal with 438 research publications. Other research areas in their decreasing order of research output are listed in Table 2. Research output other than the top thirty-five sub-specialities and its share of research in the selected top15 countries entered in the Sl.No.36.of Table 2. The analysed data of Table 2 indicates that the most number of research share is from USA (2170) followed by France (566); England(483); China(410); Canada(382); Italy (342); Germany (252); Netherland (199);Spain(181); Australia (173);Brazil(155); South Korea (130); India (128); Japan (127) and Turkey (116).

Relative Priority Index and Thematic/subject specialization index

Relative Priority Index

Data in Table 2, i.e., thirty-five most prolific research sub-specialized group of HCQ publications and its publication output in fifteen most leading countries used for the study of Relative Priority Index of HCQ publications

For analyzing the Relative Priority Index of HCQ research publications substituting the relevant data of Table 2 in the RPI equation. For example, for finding the PI of Rheumatology of the country Australia,

The number of publications of country 'Australia' is subfield Rheumatology (N_{ij})=32

The number of publications of country 'Australia' is in all subfields (N_{io})=173

The number of publications of all countries is subfield Rheumatology (N_{oj})=1764

The number of publications of all countries is in all subfields (N_{oo})=5911

Relative Priority Index (RPI) of Australia in the Research area 'Rheumatology. '

$$= \frac{(N_{ij}/N_{io})}{(N_{oj}/N_{oo})} \times 100 = \frac{(32/173)}{(1764/5911)} \times 100 = \frac{0.185}{0.298} \times 100$$
$$= 0.62 \times 100 = 62$$

Here, the value of RPI of Australia in the sub-specialized Rheumatology area is less than 100, which means that Australia gave less priority in the Rheumatology research area during the period 1989 to 10th June 2020. This value is put in Table 3 serial no.1 of rheumatology under the first column of Australia. Likewise, substituting the other values of article outputs of Table 2 in the equation of RPI, all the other Priority Indices of each fifteen countries in thirty-five subspecialized research areas were measured and illustrated in the corresponding columns Table 3. Priority Indices of countries that are higher than average priorities (>100) specified by shaded cells. Uppermost value of Relative Priority Index exhibited by the research sub-specialized area 'Orthopaedics' (524) of the Netherland. It indicates that most active sub-specialized HCQ publications are coming under the Orthopaedics research area of the country Netherland. The next prolific active research area of HCQ is the Biophysics of Japan. It shows the Relative Priority Index value of 499. The third active sub-specialized research area is 'Health care and Sciences' of Japan, indicating the RPI Value of 490. The analysis points out that out of 540 measured values of Priority indices, 209 subfields of the research area show higher RPI value (i.e., RPI>100). Hence these fields are active research fields of HCQ publications. Four sub-specialized research areas of HCQ, such as Rheumatology of Italy, Ophthalmology of Canada, Paediatrics of Canada, Public environmental, occupational health of USA, indicates an average RPI rate of 100. That means these four research fields are neither active nor inactive. These are neutral. The other

Table 2: Country-wise research share of HCQ Publications

Sl.No.	Research Area Sub Specialities	County wise share															
		Australia	Brazil	Canada	England	France	Germany	India	Italy	Japan	Netherlands	Peoples r China	South Korea	Spain	Turkey	USA	Total World output
1	Rheumatology	32	56	141	193	136	91	22	102	36	109	56	40	76	40	642	1764
2	Dermatology	10	9	12	30	61	36	10	27	20	5	7	8	7	15	146	448
3	General internal medicine	21	5	25	27	77	18	9	15	3	16	24	12	23	6	108	438
4	Pharmacology pharmacy	25	9	26	22	36	9	15	28	8	5	45	4	12	5	117	388
5	Ophthalmology	6	8	25	20	22	28	5	16	0	1	9	19	4	20	185	385
6	Immunology	12	5	19	15	36	5	3	40	6	13	16	4	19	4	97	288
7	Oncology	3	2	13	10	13	5	1	4	8	1	32	4	4	2	108	204
8	Research experimental medicine	1	0	4	10	6	5	6	12	0	1	29	4	4	4	43	137
9	Cell biology	5	1	5	6	11	4	2	5	4	4	30	2	1	1	53	133
10	Biochemistry molecular biology	5	3	3	11	10	3	8	3	9	2	16	4	2	0	37	116
11	Hematology	8	11	11	6	6	0	9	5	3	0	19	0	0	0	32	113
12	Chemistry	8	11	11	6	6	0	9	5	3	0	19	0	0	0	32	112
13	Cardiovascular system cardiology	5	3	2	17	15	3	3	10	2	3	3	1	5	0	42	111
14	Infectious diseases	3	3	4	3	24	0	0	6	1	6	1	3	3	0	26	79
15	Toxicology	2	3	3	7	9	1	2	3	1	2	4	1	1	5	27	78
16	Pediatrics	4	3	5	5	11	5	4	4	1	1	2	0	3	1	23	77
17	Allergy	2	0	0	0	7	2	1	5	1	1	0	1	2	0	29	67
18	Neurosciences neurology	2	0	8	2	5	3	2	2	2	3	5	0	2	0	21	66
19	Science technology other topics	3	2	3	5	7	1	1	2	0	1	16	2	0	1	22	64
20	Respiratory system	3	0	2	6	6	5	0	4	0	4	3	0	1	2	26	61
21	Obstetrics gynecology	3	2	1	13	6	1	1	6	3	0	2	0	0	0	21	52
22	Microbiology	1	3	2	2	15	0	1	2	0	3	2	1	2	0	12	49
23	Urology nephrology	0	1	5	4	1	4	2	3	1	0	8	0	0	0	19	48
24	Endocrinology metabolism	0	0	1	6	0	0	4	3	1	3	4	0	0	0	14	44
25	Public environmental occupational health	3	3	2	3	7	0	1	1	1	1	0	4	1	0	14	38
26	Surgery	0	0	2	2	0	2	0	1	0	1	1	1	1	0	23	35
27	Gastroenterology hepatology	0	0	0	4	3	2	1	2	2	0	1	0	0	0	12	34
28	Pathology	0	0	3	0	2	1	3	3	0	0	4	0	0	0	17	34
29	Transplantation	0	1	9	3	1	2	1	1	0	0	1	1	1	0	20	31
30	Biophysics	1	0	4	1	0	0	1	0	3	0	4	1	0	0	12	28
31	Reproductive biology	0	2	1	6	2	0	2	0	1	0	1	0	1	0	8	22
32	Virology	0	0	1	0	1	1	1	3	1	1	0	0	0	0	11	21
33	Physiology	0	0	2	1	0	0	0	1	2	1	6	0	0	1	5	20
34	Health care sciences services	1	0	2	1	0	0	0	1	2	1	6	0	0	1	5	19
35	Orthopedics	1	0	2	4	1	1	0	0	0	3	1	0	0	0	2	17
36	Other subject areas	3	9	23	32	23	14	2	17	2	7	33	13	6	8	159	290
	Total	173	155	382	483	566	252	132	342	127	199	410	130	181	116	###	5911

Table 3: Relative Priority Index of HCQ research articles

Sl.No.	Research Areas Sub-specialization	Countries															Total	Average	Rank of Research area Sub-Specialization
		Australia	Brazil	Canada	England	France	Germany	India	Italy	Japan	Netherlands	China	South Korea	Spain	Turkey	USA			
1	RheumatologY	62	121	124	134	81	121	58	100	95	184	46	103	141	116	99	1582	105	8
2	Dermatology	76	77	41	82	142	188	103	104	208	33	23	81	51	171	89	1469	98	13
3	General Internal Medicine	164	44	88	75	184	96	95	59	32	109	79	125	171	70	67	1458	97	14
4	Pharmacology Pharmacy	220	88	104	69	97	54	167	125	96	38	167	47	101	66	82	1521	101	12
5	Ophthalmology	53	79	100	64	60	171	60	72	0	8	34	224	34	265	131	1354	90	17
6	Immunology	142	66	102	64	131	41	48	240	97	134	80	63	215	71	92	1586	106	7
7	Oncology	50	37	99	60	67	57	23	34	183	15	226	89	64	50	144	1197	80	22
8	Research Experimental Medicine	25	0	45	89	46	86	202	151	0	22	305	133	95	149	85	1434	96	15
9	Cell Biology	128	29	58	55	86	71	69	65	140	89	325	68	25	38	109	1356	90	17
10	Biochemistry Molecular Biology	147	99	40	116	90	61	199	45	361	51	199	157	56	0	87	1708	114	5
11	Hematology	242	371	151	65	55	0	368	76	124	0	242	0	0	0	77	1772	118	4
12	Chemistry	244	375	152	66	56	0	371	77	125	0	245	0	0	0	78	1787	119	3
13	Cardiovascular System Cardiology	154	103	28	187	141	63	125	156	84	80	39	41	147	0	103	1452	97	14
14	Infectious Diseases	130	145	78	46	317	0	0	131	59	226	18	173	124	0	90	1537	102	11
15	Toxicology	88	147	60	110	121	30	118	66	60	76	74	58	42	327	94	1470	98	13
16	Pediatrics	177	149	100	79	149	152	240	90	60	39	37	0	127	66	81	1548	103	10
17	Allergy	102	0	0	0	109	70	69	129	69	44	0	68	97	0	118	876	58	25
18	Neurosciences Neurology	104	0	188	37	79	107	140	52	141	135	109	0	99	0	87	1277	85	19
19	Science Technology Other Topics	160	119	73	96	114	37	0	54	0	46	360	142	0	80	94	1375	92	16
20	Respiratory System	168	0	51	120	103	192	0	113	0	195	71	0	54	167	116	1350	90	17
21	Obstetrics Gynecology	197	147	30	306	121	45	89	199	269	0	55	0	0	0	110	1567	104	9
22	Microbiology	70	233	63	50	320	0	94	71	0	182	59	93	133	0	67	1434	96	15
23	Urology Nephrology	0	79	161	102	22	195	192	108	97	0	240	0	0	0	108	1305	87	18
24	Endocrinology Metabolism	0	0	35	167	0	0	420	118	106	203	131	0	0	0	87	1266	84	20

Table 3: Relative Priority Index of HCQ research articles

25	Public Environmental Occupational Health	270	301	81	97	192	0	122	45	122	78	0	479	86	0	100	1974	132	1
26	Surgery	0	0	88	70	0	134	0	49	0	85	41	130	93	0	179	870	58	25
27	Gastroenterology Hepatology	0	0	0	144	92	138	136	102	274	0	42	0	0	0	96	1024	68	24
28	Pathology	0	0	137	0	61	69	407	153	0	0	170	0	0	0	136	1133	76	23
29	Transplantation	0	123	449	118	34	151	149	56	0	0	47	147	105	0	176	1555	104	9
30	Biophysics	122	0	221	44	0	0	165	0	499	0	206	162	0	0	117	1535	102	11
31	Reproductive Biology	0	347	70	334	95	0	420	0	212	0	66	0	148	0	99	1790	119	3
32	Virology	0	0	74	0	50	112	220	247	222	141	0	0	0	0	143	1208	81	21
33	Physiology	0	0	155	61	0	0	0	86	465	149	433	0	0	255	68	1672	111	6
34	Health Care Sciences Services	180	0	163	64	0	0	0	91	490	156	455	0	0	268	72	1940	129	2
35	Orthopedics	0	0	182	288	61	138	0	0	0	524	85	0	0	0	0	1511	101	12
36	Other Subject Areas	35	118	123	135	83	113	48	101	32	72	164	204	68	0	149	1586	106	7
	Total	3712	3397	3714	3595	3357	2693	4916	3367	4720	3113	4873	2786	2278	2297	3661	52479		
	Average	103.11	94.3508	103.159	99.8664	93.259	74.8078	136.555	93.5186	131.103	86.4668	135.37	77.4021	63.2765	63.8121	101.693			
	Rank of countries	4	7	4	6	8	11	1	7	3	9	2	10	13	12	5			

327 sub-specialized research area exhibits a lower Relative Priority Index (i.e., RPI<100). It manifests that these 327 research fields are lower active areas of HCQ research. Average Relative Priority Index values specified that India gives more priority in the HCQ research than the other leading countries with an RPI value of 137. China holds the second position in HCQ research, indicating an RPI value of 135. Average RPI values of HCQ research sub-fields show that Public Environmental Occupational Health got the highest priority with the value 132. Health Care Science and Services hold the second position with a PI value of 129, followed by Chemistry (119). Status of other research areas available from Table 3 with its average RPI Values.

Thematic or subject specialization index (TSI/SSI)

The primary method mentioned in the methodology part of this article has been used to analyze TSI/ SSI. For this, first, it is required to analyze the country-wise share of each sub-specialized research area. Relevant data in Table 2 is employed for analyzing each country-wise share of all thirty-five sub-specialized research areas of HCQ publications.

For example,

Publication World Share of Australia in the sub-specialized research area of 'Rheumatology.'

$$= \frac{\text{Number of publications in Rhuematology of a country}}{\text{Total number of worldwide publications in Rheumatology}} \times 100$$

$$= \frac{32}{1764} \times 100 = 1.81$$

Similarly, for analyzing the thematic or subject specialization index of other sub-specialized research areas, first identified the world share of each research area and those values displayed in Table 4. The row of Table 4 constitutes the thirty-five prolific sub-specialized research area of HCQ publications, and columns depict the most productive fifteen nations.

∴ Thematic or subject specialization index of 'Rheumatology' of Australia (TSI/SSI)

$$= \frac{\text{Publication World share of Australia in 'Rheumatology'}}{\text{Publication World share of Australia for all discipline}}$$

Publication World Share of Australia in 'Rheumatology' = 1.81

Publication world share of Australia for all disciplines = 2.93

$$\therefore \text{SI of 'Rheumatology' of Australia} = \frac{1.81}{2.93} = 0.62$$

It is substituting all specific values of Table 4 in the Thematic or subject specialization index equation. And thus obtained the value of TSI/SSI of all thirty-five-research sub-specialized

Table 4: Country-wise research share of HCQ Publications

Sl.No.	Research Area Sub Specialization	Total World output	Countrywise share of Publications in total Publications														
			Australia	Brazil	Canada	England	France	Germany	India	Italy	Japan	Netherlands	China	South Korea	Spain	Turkey	USA
1	Rheumatology	1764	1.81	3.17	7.99	10.94	7.71	5.16	1.25	5.78	2.04	6.18	3.17	2.27	4.31	2.27	36.39
2	Dermatology	448	2.23	2.01	2.68	6.70	13.62	8.04	2.23	6.03	4.46	1.12	1.56	1.79	1.56	3.35	32.59
3	General Internal Medicine	438	4.79	1.14	5.71	6.16	17.58	4.11	2.05	3.42	0.68	3.65	5.48	2.74	5.25	1.37	24.66
4	Pharmacology Pharmacy	388	6.44	2.32	6.70	5.67	9.28	2.32	3.61	7.22	2.06	1.29	11.60	1.03	3.09	1.29	30.15
5	Ophthalmology	385	1.56	2.08	6.49	5.19	5.71	7.27	1.30	4.16	0.00	0.26	2.34	4.94	1.04	5.19	48.05
6	Immunology	288	4.17	1.74	6.60	5.21	12.50	1.74	1.04	13.89	2.08	4.51	5.56	1.39	6.60	1.39	33.68
7	Oncology	204	1.47	0.98	6.37	4.90	6.37	2.45	0.49	1.96	3.92	0.49	15.69	1.96	1.96	0.98	52.94
8	Research Experimental Medicine	137	0.73	0.00	2.92	7.30	4.38	3.65	4.38	8.76	0.00	0.73	21.17	2.92	2.92	2.92	31.39
9	Cell Biology	133	3.76	0.75	3.76	4.51	8.27	3.01	1.50	3.76	3.01	3.01	22.56	1.50	0.75	0.75	39.85
10	Biochemistry Molecular Biology	116	4.31	2.59	2.59	9.48	8.62	2.59	4.31	2.59	7.76	1.72	13.79	3.45	1.72	0.00	31.90
11	Hematology	113	7.08	9.73	9.73	5.31	5.31	0.00	7.96	4.42	2.65	0.00	16.81	0.00	0.00	0.00	28.32
12	Chemistry	112	7.14	9.82	9.82	5.36	5.36	0.00	8.04	4.46	2.68	0.00	16.96	0.00	0.00	0.00	28.57
13	Cardiovascular System Cardiology	111	4.50	2.70	1.80	15.32	13.51	2.70	2.70	9.01	1.80	2.70	2.70	0.90	4.50	0.00	37.84
14	Infectious Diseases	79	3.80	3.80	5.06	3.80	30.38	0.00	0.00	7.59	1.27	7.59	1.27	3.80	3.80	0.00	32.91
15	Toxicology	78	2.56	3.85	3.85	8.97	11.54	1.28	2.56	3.85	1.28	2.56	5.13	1.28	1.28	6.41	34.62
16	Pediatrics	77	5.19	3.90	6.49	6.49	14.29	6.49	5.19	5.19	1.30	1.30	2.60	0.00	3.90	1.30	29.87
17	Allergy	67	2.99	0.00	0.00	0.00	10.45	2.99	1.49	7.46	1.49	1.49	0.00	1.49	2.99	0.00	43.28
18	Neurosciences Neurology	66	3.03	0.00	12.12	3.03	7.58	4.55	3.03	3.03	3.03	4.55	7.58	0.00	3.03	0.00	31.82
19	Science Technology Other Topics	64	4.69	3.13	4.69	7.81	10.94	1.56	0.00	3.13	0.00	1.56	25.00	3.13	0.00	1.56	34.38
20	Respiratory System	61	4.92	0.00	3.28	9.84	9.84	8.20	0.00	6.56	0.00	6.56	4.92	0.00	1.64	3.28	42.62
21	Obstetrics Gynecology	52	5.77	3.85	1.92	25.00	11.54	1.92	1.92	11.54	5.77	0.00	3.85	0.00	0.00	0.00	40.38
22	Microbiology	49	2.04	6.12	4.08	4.08	30.61	0.00	2.04	4.08	0.00	6.12	4.08	2.04	4.08	0.00	24.49
23	Urology Nephrology	48	0.00	2.08	10.42	8.33	2.08	8.33	4.17	6.25	2.08	0.00	16.67	0.00	0.00	0.00	39.58
24	Endocrinology Metabolism	44	0.00	0.00	2.27	13.64	0.00	0.00	9.09	6.82	2.27	6.82	9.09	0.00	0.00	0.00	31.82
25	Public Environmental Occupational Health	38	7.89	7.89	5.26	7.89	18.42	0.00	2.63	2.63	2.63	2.63	0.00	10.53	2.63	0.00	36.84
26	Surgery	35	0.00	0.00	5.71	5.71	0.00	5.71	0.00	2.86	0.00	2.86	2.86	2.86	2.86	0.00	65.71
27	Gastroenterology Hepatology	34	0.00	0.00	0.00	11.76	8.82	5.88	2.94	5.88	5.88	0.00	2.94	0.00	0.00	0.00	35.29
28	Pathology	34	0.00	0.00	8.82	0.00	5.88	2.94	8.82	8.82	0.00	0.00	11.76	0.00	0.00	0.00	50.00

Table 4: Country-wise research share of HCQ Publications

29	Transplantation	31	0.00	3.23	29.03	9.68	3.23	6.45	3.23	3.23	0.00	0.00	3.23	3.23	3.23	0.00	64.52
30	Biophysics	28	3.57	0.00	14.29	3.57	0.00	0.00	3.57	0.00	10.71	0.00	14.29	3.57	0.00	0.00	42.86
31	Reproductive Biology	22	0.00	9.09	4.55	27.27	9.09	0.00	9.09	0.00	4.55	0.00	4.55	0.00	4.55	0.00	36.36
32	Virology	21	0.00	0.00	4.76	0.00	4.76	4.76	4.76	14.29	4.76	4.76	0.00	0.00	0.00	0.00	52.38
33	Physiology	20	0.00	0.00	10.00	5.00	0.00	0.00	0.00	5.00	10.00	5.00	30.00	0.00	0.00	5.00	25.00
34	Health Care Sciences Services	19	5.26	0.00	10.53	5.26	0.00	0.00	0.00	5.26	10.53	5.26	31.58	0.00	0.00	5.26	26.32
35	Orthopedics	17	5.88	0.00	11.76	23.53	5.88	5.88	0.00	0.00	0.00	17.65	5.88	0.00	0.00	0.00	11.76
36	Other Subject Areas	290	1.03	3.10	7.93	11.03	7.93	4.83	1.03	5.86	0.69	2.41	11.38	4.48	2.07	2.76	54.83
	Total	5911	2.93	2.62	6.46	8.17	9.58	4.26	2.17	5.79	2.15	3.37	6.94	2.20	3.06	1.96	36.71

areas of HCQ publications of fifteen countries and is displayed in Table 5. Out of 540 specialization indices of fifteen countries, 209 indicates higher TSI/ SSI (i.e., SI>1) and is denoted by shaded cells. Like Relative Priority Index, Thematic or subject specialization index also found to be topmost in 'Orthopaedics' (TSI/SSI=5.24) research area of Netherland, followed by 'Biophysics' of Japan (TSI/SSI=4.99) and 'Health care and Sciences services' of Japan (TSI/SSI=4.90). Precisely like the Priority Indices, 327 sub-specialized research area exhibits lower Specialization Indices (TSI/ SSI<1). Four research areas of HCQ, such as Rheumatology of Italy, Ophthalmology of Canada, Paediatrics of Canada, Public environmental occupational health of USA, indicates a neutral situation that means there is no specialization in the corresponding areas (TSI/ SSI=1). From the analysis of RPI and SSI, both the values of Table 3 and Table 4 are found to be similar without the multiplication of 100 in Table 3. So, it is evident that the second method to find out SSI, which is mentioned in the methodology part, gives the same result as that of the first approach. From the average value of Specialization Indices of Table 5, it can distinguish that India is more specialized in the HCQ research publication among the fifteen most productive countries with the SSI value of 1.37. China occupies the second rank with an SSI value of 1.35. Japan occupies the third position with an SSI rate of 1.31. The fourth position shared by two countries such as Canada and Australia (1.03) followed by the USA (1.02), England (1), Brazil and Italy (0.94), France (0.93), Netherlands (0.86), South Korea (0.77), Germany (0.75), Turkey (0.64) and Spain (0.63). SI values signify those six countries like India, China, Japan, Canada, Australia, and the USA specialized in HCQ research publications. England is neutral in this discipline. Other eight countries not specialized in the HCQ research area. The rank of countries in HCQ research specialization is specified in the last row of Table 5. During the study period highest specialized research area sub-specializations of HCQ publications are found to be Public Environmental Occupational Health, with an average SI value of 1.32. The second specialized research area is Health Care Science and Services (1.29). The third position occupied Chemistry (119), and the remaining specialization ranks of research areas are obtainable from Table 5. With the average SI values. Of thirty-six (including other research areas), seventeen sub-specialized fields show high research specialization with an average SSI value greater than one. Nineteen exhibits lower average specialization Indices during the study period. SSI and RPI of the top fifteen selected countries of HCQ publications is demonstrated in Figure 5. Also, SSI and RPI of the top thirty-five research areas of HCQ publications is illustrated in Figure 6.

Table 5: Thematic / Subject Specialization Index of HCQ research articles

Sl.No.	Research Area Sub Specialization	Thematic/Subject Specialization Index of Countries															Total	Average	Rank of Research area Sub-Specialization
		Australia	Brazil	Canada	England	France	Germany	India	Italy	Japan	Netherlands	China	South Korea	Spain	Turkey	USA			
1	Rheumatology	0.62	1.21	1.24	1.34	0.81	1.21	0.58	1.00	0.95	1.84	0.46	1.03	1.41	1.16	0.99	15.82	1.05	8
2	Dermatology	0.76	0.77	0.41	0.82	1.42	1.88	1.03	1.04	2.08	0.33	0.23	0.81	0.51	1.71	0.89	14.69	0.98	13
3	General Internal Medicine	1.64	0.44	0.88	0.75	1.84	0.96	0.95	0.59	0.32	1.09	0.79	1.25	1.71	0.70	0.67	14.58	0.97	14
4	Pharmacology Pharmacy	2.20	0.88	1.04	0.69	0.97	0.54	1.67	1.25	0.96	0.38	1.67	0.47	1.01	0.66	0.82	15.21	1.01	12
5	Ophthalmology	0.53	0.79	1.00	0.64	0.60	1.71	0.60	0.72	0.00	0.08	0.34	2.24	0.34	2.65	1.31	13.54	0.90	17
6	Immunology	1.42	0.66	1.02	0.64	1.31	0.41	0.48	2.40	0.97	1.34	0.80	0.63	2.15	0.71	0.92	15.86	1.06	7
7	Oncology	0.50	0.37	0.99	0.60	0.67	0.57	0.23	0.34	1.83	0.15	2.26	0.89	0.64	0.50	1.44	11.97	0.80	22
8	Research Experimental Medicine	0.25	0.00	0.45	0.89	0.46	0.86	2.02	1.51	0.00	0.22	3.05	1.33	0.95	1.49	0.85	14.34	0.96	15
9	Cell Biology	1.28	0.29	0.58	0.55	0.86	0.71	0.69	0.65	1.40	0.89	3.25	0.68	0.25	0.38	1.09	13.56	0.90	17
10	Biochemistry Molecular Biology	1.47	0.99	0.40	1.16	0.90	0.61	1.99	0.45	3.61	0.51	1.99	1.57	0.56	0.00	0.87	17.08	1.14	5
11	Hematology	2.42	3.71	1.51	0.65	0.55	0.00	3.68	0.76	1.24	0.00	2.42	0.00	0.00	0.00	0.77	17.72	1.18	4
12	Chemistry	2.44	3.75	1.52	0.66	0.56	0.00	3.71	0.77	1.25	0.00	2.45	0.00	0.00	0.00	0.78	17.87	1.19	3
13	Cardiovascular System Cardiology	1.54	1.03	0.28	1.87	1.41	0.63	1.25	1.56	0.84	0.80	0.39	0.41	1.47	0.00	1.03	14.52	0.97	14
14	Infectious Diseases	1.30	1.45	0.78	0.46	3.17	0.00	0.00	1.31	0.59	2.26	0.18	1.73	1.24	0.00	0.90	15.37	1.02	11
15	Toxicology	0.88	1.47	0.60	1.10	1.21	0.30	1.18	0.66	0.60	0.76	0.74	0.58	0.42	3.27	0.94	14.70	0.98	13
16	Pediatrics	1.77	1.49	1.00	0.79	1.49	1.52	2.40	0.90	0.60	0.39	0.37	0.00	1.27	0.66	0.81	15.48	1.03	10
17	Allergy	1.02	0.00	0.00	0.00	1.09	0.70	0.69	1.29	0.69	0.44	0.00	0.68	0.97	0.00	1.18	8.76	0.58	25
18	Neurosciences Neurology	1.04	0.00	1.88	0.37	0.79	1.07	1.40	0.52	1.41	1.35	1.09	0.00	0.99	0.00	0.87	12.77	0.85	19
19	Science Technology Other Topics	1.60	1.19	0.73	0.96	1.14	0.37	0.00	0.54	0.00	0.46	3.60	1.42	0.00	0.80	0.94	13.75	0.92	16
20	Respiratory System	1.68	0.00	0.51	1.20	1.03	1.92	0.00	1.13	0.00	1.95	0.71	0.00	0.54	1.67	1.16	13.50	0.90	17
21	Obstetrics Gynecology	1.97	1.47	0.30	3.06	1.21	0.45	0.89	1.99	2.69	0.00	0.55	0.00	0.00	0.00	1.10	15.67	1.04	9
22	Microbiology	0.70	2.33	0.63	0.50	3.20	0.00	0.94	0.71	0.00	1.82	0.59	0.93	1.33	0.00	0.67	14.34	0.96	15
23	Urology Nephrology	0.00	0.79	1.61	1.02	0.22	1.95	1.92	1.08	0.97	0.00	2.40	0.00	0.00	0.00	1.08	13.05	0.87	18
24	Endocrinology Metabolism	0.00	0.00	0.35	1.67	0.00	0.00	4.20	1.18	1.06	2.03	1.31	0.00	0.00	0.00	0.87	12.66	0.84	20
25	Public Environmental Occupational Health	2.70	3.01	0.81	0.97	1.92	0.00	1.22	0.45	1.22	0.78	0.00	4.79	0.86	0.00	1.00	19.74	1.32	1
26	Surgery	0.00	0.00	0.88	0.70	0.00	1.34	0.00	0.49	0.00	0.85	0.41	1.30	0.93	0.00	1.79	8.70	0.58	25

Table 5: Thematic / Subject Specialization Index of HCQ research articles

27	Gastroenterology Hepatology	0.00	0.00	0.00	1.44	0.92	1.38	1.36	1.02	2.74	0.00	0.00	0.42	0.00	0.00	0.96	10.24	0.68	24
28	Pathology	0.00	0.00	1.37	0.00	0.61	0.69	4.07	1.53	0.00	0.00	0.00	1.70	0.00	0.00	1.36	11.33	0.76	23
29	Transplantation	0.00	1.23	4.49	1.18	0.34	1.51	1.49	0.56	0.00	0.00	0.00	0.47	1.47	1.05	1.76	15.55	1.04	9
30	Biophysics	1.22	0.00	2.21	0.44	0.00	0.00	1.65	0.00	4.99	0.00	2.06	1.62	0.00	1.17	15.35	1.02	11	
31	Reproductive Biology	0.00	3.47	0.70	3.34	0.95	0.00	4.20	0.00	2.12	0.00	0.66	0.00	1.48	0.00	0.99	17.90	1.19	3
32	Virology	0.00	0.00	0.74	0.00	0.50	1.12	2.20	2.47	2.22	1.41	0.00	0.00	0.00	0.00	1.43	12.08	0.81	21
33	Physiology	0.00	0.00	1.55	0.61	0.00	0.00	0.00	0.86	4.65	1.49	4.33	0.00	0.00	2.55	0.68	16.72	1.11	6
34	Health Care Sciences Services	1.80	0.00	1.63	0.64	0.00	0.00	0.00	0.91	4.90	1.56	4.55	0.00	0.00	2.68	0.72	19.40	1.29	2
35	Orthopeadics	2.01	0.00	1.82	2.88	0.61	1.38	0.00	0.00	0.00	5.24	0.85	0.00	0.00	0.00	0.32	15.11	1.01	12
36	Other Subject Areas	0.35	1.18	1.23	1.35	0.83	1.13	0.48	1.01	0.32	0.72	1.64	2.04	0.68	1.41	1.49	15.86	1.06	7
	Total	37.12	33.97	37.14	35.95	33.57	26.93	49.16	33.67	47.20	31.13	48.73	27.86	22.78	22.97	36.61	524.79		
	Average	1.03	0.94	1.03	1.00	0.93	0.75	1.37	0.94	1.31	0.86	1.35	0.77	0.63	0.64	1.02			
	Rank Of Countries	4	7	4	6	8	11	1	7	3	9	2	10	13	12	5			

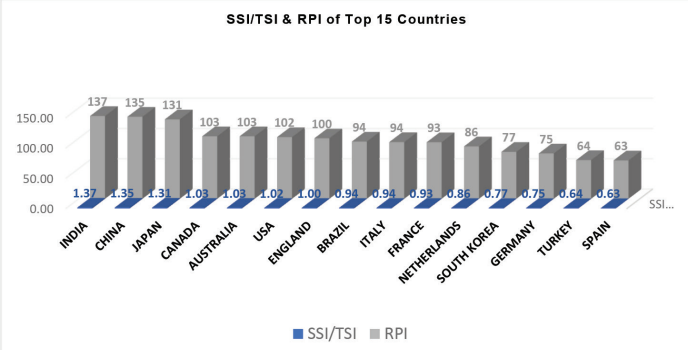

Figure 5: SSI/TSI & RPI of Top 15 countries in HCQ Research Publications.

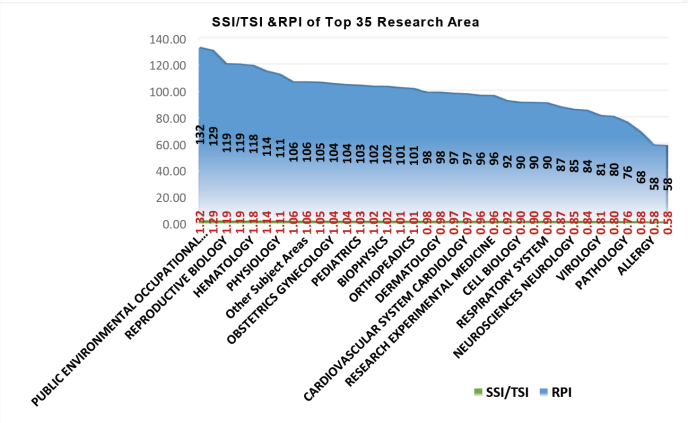

Figure 6: SSI/TSI & RPI of Top 35 Research areas sub-specialization of HCQ Research Publications.

Relative Specialization Index (RSI)

Values of RPI from Table 3 has been taken for measuring the relative specialization index of HCQ publications.

For example, relative specialization index of 'Rheumatology' of Australia =

$$= \frac{\text{PI value of Rheumatology' of Australia} - 1}{\text{PI value of Rheumatology' of Australia} + 1}$$

$$= \frac{62-1}{62+1} = 0.968 \approx 1$$

In the same manner, all other RSI values are measured in Table 6. Out of 540 measured RSI values, 120 values shows – 1, and it is highlighted with shaded cells in Table 6. Research activity in these one hundred and twenty sub-specialized subject areas of HCQ research publications is lower than the average research activity. From Table 2, it can visible that the research output of these sub-specialized subject areas is zero. So, all countries belonging to these 120 sub-specialized areas need to prioritize their research activity in these fields. No average value (i.e., RSI ≠ 0) is observed from the 540 calculated RSI. All the other 420 sub-specialized subjects are greater than the average value(RSI>0). Hence, it can assume that

Table 6: Relative Specialization Index of HCQ research articles.

Sl.No	Research Areas Sub-specialization	Countries															Total	Average
		Australia	Brazil	Canada	England	France	Germany	India	Italy	Japan	Netherlands	china	South Korea	Spain	Turkey	USA		
1	Rheumatology	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	15	1
2	Dermatology	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	15	1
3	General Internal Medicine	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	15	1
4	Pharmacology Pharmacy	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	15	1
5	Ophthalmology	1	1	1	1	1	1	1	1	-1	1	1	1	1	1	1	12	1
6	Immunology	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	15	1
7	Oncology	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	14	1
8	Research Experimental Medicine	1	-1	1	1	1	1	1	1	-1	1	1	1	1	1	1	11	1
9	Cell Biology	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	15	1
10	Biochemistry Molecular Biology	1	1	1	1	1	1	1	1	1	1	1	1	1	-1	1	13	1
11	Hematology	1	1	1	1	1	-1	1	1	1	-1	1	-1	-1	-1	1	5	0
12	Chemistry	1	1	1	1	1	-1	1	1	1	-1	1	-1	-1	-1	1	5	0
13	Cardiovascular System Cardiology	1	1	1	1	1	1	1	1	1	1	1	1	1	-1	1	13	1
14	Infectious Diseases	1	1	1	1	1	-1	-1	1	1	1	1	1	1	-1	1	9	1
15	Toxicology	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	15	1
16	Pediatrics	1	1	1	1	1	1	1	1	1	1	1	-1	1	1	1	13	1
17	Allergy	1	-1	-1	-1	1	1	1	1	1	1	-1	1	1	-1	1	5	0
18	Neurosciences Neurology	1	-1	1	1	1	1	1	1	1	1	1	-1	1	-1	1	9	1
19	Science Technology Other Topics	1	1	1	1	1	1	-1	1	-1	1	1	1	-1	1	1	9	1
20	Respiratory System	1	-1	1	1	1	1	-1	1	-1	1	1	-1	1	1	1	7	0
21	Obstetrics Gynecology	1	1	1	1	1	1	1	1	1	-1	1	-1	-1	-1	1	7	0
22	Microbiology	1	1	1	1	1	-1	1	1	-1	1	1	1	1	-1	1	9	1
23	Urology Nephrology	-1	1	1	1	1	1	1	1	1	-1	1	-1	-1	-1	1	5	0
24	Endocrinology Metabolism	-1	-1	1	1	-1	-1	1	1	1	1	1	-1	-1	-1	1	1	0
25	Public Environmental Occupational Health	1	1	1	1	1	-1	1	1	1	1	-1	1	1	-1	1	9	1
26	Surgery	-1	-1	1	1	-1	1	-1	1	-1	1	1	1	1	-1	1	3	0
27	Gastroenterology Hepatology	-1	-1	-1	1	1	1	1	1	1	-1	1	-1	-1	-1	1	1	0
28	Pathology	-1	-1	1	-1	1	1	1	1	-1	-1	1	-1	-1	-1	1	-1	0
29	Transplantation	-1	1	1	1	1	1	1	1	-1	-1	1	1	1	-1	1	7	0
30	Biophysics	1	-1	1	1	-1	-1	1	-1	1	-1	1	1	-1	-1	1	1	0
31	Reproductive Biology	-1	1	1	1	1	-1	1	-1	1	-1	1	-1	1	-1	1	3	0
32	Virology	-1	-1	1	-1	1	1	1	1	1	1	-1	-1	-1	-1	1	1	0
33	Physiology	-1	-1	1	1	-1	-1	-1	1	1	1	1	-1	-1	1	1	1	0
34	Health Care Sciences Services	1	-1	1	1	-1	-1	-1	1	1	1	1	-1	-1	1	1	3	0
35	Orthopedics	1	-1	1	1	1	1	-1	-1	-1	1	1	-1	-1	-1	1	1	0
36	Other Subject Areas	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	15	1
Total		17	10	31	29	25	15	21	29	17	17	29	6	9	-4	35		
Average		0	0	1	1	1	0	1	1	0	0	1	0	0	0	1		

Table 7: Citation analysis and PEI of HCQ Research Publications.

Sl.No.	Publication Year	No.of Records (X)	Citations	% of Citations	Average Citations per Paper (ACPP)	PEI
1	1989	**10**	913	0.91	**91.30**	**4.45**
2	1990	21	816	0.81	38.86	1.89
3	1991	36	1337	1.33	37.14	1.81
4	1992	42	1709	1.70	40.69	1.98
5	1993	69	2163	2.16	31.35	1.53
6	1994	56	1621	1.62	28.95	1.41
7	1995	87	2050	2.04	23.56	1.15
8	1996	96	4160	4.15	43.33	2.11
9	1997	69	2000	2.00	28.99	1.41
10	1998	74	2272	2.27	30.70	1.50
11	1999	86	3268	3.26	38.00	1.85
12	2000	74	2661	2.65	35.96	1.75
13	2001	96	3126	3.12	32.56	1.59
14	2002	101	3941	3.93	39.02	1.90
15	2003	**74**	4423	4.41	**59.77**	**2.91**
16	2004	95	2339	2.33	24.62	1.20
17	2005	**99**	4403	4.39	**44.47**	**2.17**
18	2006	99	4006	4.00	40.46	1.97
19	2007	123	4149	4.14	33.73	1.64
20	2008	120	2985	2.98	24.88	1.21
21	2009	127	3879	3.87	30.54	1.49
22	2010	139	4596	4.58	33.06	1.61
23	2011	167	**6018**	6.00	36.04	1.76
24	2012	182	5241	5.23	28.80	1.40
25	2013	257	4973	4.96	19.35	0.94
26	2014	243	**5382**	5.37	22.15	1.08
27	2015	303	5146	5.13	16.98	0.83
28	2016	333	3978	3.97	11.95	0.58
29	2017	395	3154	3.15	7.98	0.39
30	2018	436	2317	2.31	5.31	0.26
31	2019	525	910	0.91	1.73	0.08
32	2020	252	311	0.31	1.23	0.06
Total		**4886**	**100247**	**100.00**	**983.48**	**47.93**
				Average		1.50

satisfactory research activity is conducting in these sub-fields. Notably, the RSI value of the USA in all 35 research fields is found to be one. Hence it is perceived that the USA gives remarkable research performance in HCQ research. The RSI values of the eight sub-specialized fields of HCQ is found to be higher than the average value (i.e., RSI=1), So research activity in these fields such as rheumatology, dermatology, general internal medicine, pharmacology pharmacy, immunology, oncology, cell biology and toxicology in all countries is appreciatable. The average RSI value of Australia, Brazil, Germany, Japan, Netherland, South Korea, Spain, and Turkey is zero. So, the overall research performance of these eight countries in HCQ research is average (i.e., RSI=0). Other seven countries such as Canada, England, France, India, Italy, China and USA prioritize HCQ research. Average RSI values of seventeen sub-fields such as haematology, chemistry, allergy, respiratory system, obstetrics-gynaecology, urology nephrology, endocrinology metabolism, surgery, gastroenterology hepatology, pathology, transplantation, biophysics, reproductive biology, virology, physiology, health care sciences services, and orthopaedics indicate average research performance in all fifteen top productive countries. Other eighteen sub-specialized subject areas like rheumatology, dermatology, general internal medicine, pharmacology pharmacy, ophthalmology, immunology, oncology, research experimental medicine, cell biology, biochemistry molecular biology, cardiovascular system cardiology, infectious diseases, toxicology, paediatrics, neurosciences neurology, science technology other topics, microbiology, public environmental, occupational health exhibit adequate research performance.

Citation Analysis and Publication Efficiency Index

The influence of HCQ research articles in the scientific community is measured by analyzing citations received for its articles. HCQ publications attained the highest citation of 6018(6%) in the year 2011. And it is for 167 research publications. The second highest citations, 5382 (5.37%) received in 2014 for 243 articles. While analyzing citations, it is essential to consider the number of publications too. Analysis of PEI implemented for the cross-comparisons of citations with the number of publications of HCQ. Table 7 demonstrated year-wise citations, the average citations received per paper and the PEI of HCQ.

From Table 7 it can identify that while the rate of ACPP increased, the rate of PEI also increased. So, they are directly proportional to each other. The value of PEI (4.45) and ACPP (91.30) was topmost in 1989 since ten articles of the corresponding year achieved 913 citations. So, the research output of HCQ has dramatically influenced the research community in that year. Seventy-four articles published in 2003 gained 4423 (4.41%) citations, which is the second fruitful year of this field. Third, highly influential articles were published in 2005—Ninety-nine articles of this year 4403 (4.39%) citations. Out of thirty-two measured rates, twenty-five values of PEI are greater than one, so the research impact of HCQ articles is found to be high in those years. In 2013 and from 2015 onwards rate of PEI is decreasing. Articles published in recent years may attain more citations in the coming years. Anyway, the average value of PEI indicates that the overall research effort and impact is HCQ articles is excellent.

satisfactory research activity is conducting in these sub-fields. Notably, the RSI value of the USA in all 35 research fields is found to be one. Hence it is perceived that the USA gives remarkable research performance in HCQ research. The RSI values of the eight sub-specialized fields of HCQ is found to be higher than the average value (i.e., RSI=1), So research activity in these fields such as rheumatology, dermatology, general internal medicine, pharmacology pharmacy, immunology, oncology, cell biology and toxicology in all countries is appreciatable. The average RSI value of Australia, Brazil, Germany, Japan, Netherland, South Korea, Spain, and Turkey is zero. So, the overall research performance of these eight countries in HCQ research is average (i.e., RSI=0). Other seven countries such as Canada, England, France, India, Italy, China and USA prioritize HCQ research. Average RSI values of seventeen sub-fields such as haematology, chemistry, allergy, respiratory system, obstetrics-gynaecology, urology nephrology, endocrinology metabolism, surgery, gastroenterology hepatology, pathology, transplantation, biophysics, reproductive biology, virology, physiology, health care sciences services, and orthopaedics indicate average research performance in all fifteen top productive countries. Other eighteen sub-specialized subject areas like rheumatology, dermatology, general internal medicine, pharmacology pharmacy, ophthalmology, immunology, oncology, research experimental medicine, cell biology, biochemistry molecular biology, cardiovascular system cardiology, infectious diseases, toxicology, paediatrics, neurosciences neurology, science technology other topics, microbiology, public environmental, occupational health exhibit adequate research performance.

Citation Analysis and Publication Efficiency Index

The influence of HCQ research articles in the scientific community is measured by analyzing citations received for its articles. HCQ publications attained the highest citation of 6018(6%) in the year 2011. And it is for 167 research publications. The second highest citations, 5382 (5.37%) received in 2014 for 243 articles. While analyzing citations, it is essential to consider the number of publications too. Analysis of PEI implemented for the cross-comparisons of citations with the number of publications of HCQ. Table 7 demonstrated year-wise citations, the average citations received per paper and the PEI of HCQ.

From Table 7 it can identify that while the rate of ACPP increased, the rate of PEI also increased. So, they are directly proportional to each other. The value of PEI (4.45) and ACPP (91.30) was topmost in 1989 since ten articles of the corresponding year achieved 913 citations. So, the research output of HCQ has dramatically influenced the research community in that year. Seventy-four articles published in 2003 gained 4423 (4.41%) citations, which is the second fruitful year of this field. Third, highly influential articles were published in 2005—Ninety-nine articles of this year 4403 (4.39%) citations. Out of thirty-two measured rates, twenty-five values of PEI are greater than one, so the research impact of HCQ articles is found to be high in those years. In 2013 and from 2015 onwards rate of PEI is decreasing. Articles published in recent years may attain more citations in the coming years. Anyway, the average value of PEI indicates that the overall research effort and impact is HCQ articles is excellent.

CONCLUSION

Analysis indicates that HCQ publication shows neither uniform increase nor decrease during the selected period of study. Some fluctuations throughout the study can observe. The Chi-square test proves that HCQ research output does not follow an exponential growth pattern. The remarkable efficiency and quality of HCQ research articles and their impact were confirmed with the PEI examination. RPI and TSI/SSI rates determine the priorities and specialization of each fifteen countries in each thirty-five sub-specialized research areas in the selected time era. Analysis indicates that the highest number of HCQ research publications is from the research area of Rheumatology, and the highest number of articles share is from the USA. Still, the average TSI/ SSI and RPI show that Public Environmental Occupational Health is the most sub-specialized research area, and India is the top specialized country of HCQ publications. China, Japan, Canada, Australia and the USA are the other specialized countries of HCQ research. 'Orthopaedics' of the Netherland is the most active sub-specialized research field of HCQ publications. RSI values indicate 120 static sub-specialized research fields of fifteen countries, and it also demonstrates the overall research performance of countries in HCQ research. RSI prove that research running of the USA is sufficient in all thirty-five sub-specialized fields of HCQ research. Analysis of PEI certifies, the overall publication efficiency and research impact of HCQ articles are honourable. This analysis help researchers to detect the active and inactive research fields of HCQ publication of different countries from 1989. Hence researchers can focus on the inactive areas to make them more active. It also helps the different countries recognize their strength and weaknesses in their research in the selected areas of analysis. This study mainly supports the scientific community for identifying the leading journals, authors, research institutions, and countries of HCQ research publications.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ABBREVIATIONS

HCQ: Hydroxychloroquine; **RPI:** Relative Priority Index; **SSI:** Subject Specialization Index; **TSI:** Thematic Specialization Index; **RSI:** Relative Specialisation Index; **ACPP:** Average Citations Per Paper; **PEI:** Publication Efficiency Index.

REFERENCES

1. Li X, Wang Y, Agostinis P, Rabson A, Melino G, Carafoli E, *et al*. Is hydroxychloroquine beneficial for COVID-19 patients? Cell Death Disease. 2020;11(7):512. doi: 10.1038/s41419-020-2721-8. PMID 32641681.
2. Lofgren SM, Nicol MR, Bangdiwala AS, Pastick KA, Okafor EC, Skipper CP, *et al*. Safety of hydroxychloroquine among outpatient clinical trial participants for COVID-19. In: Open forum infectious diseases. Oxford: Oxford University Press; 2020;7:11.
3. Skipper CP, Pastick KA, Engen NW, Bangdiwala AS, Abassi M, Lofgren SM, *et al*. Hydroxychloroquine in nonhospitalized adults with early COVID-19: A randomized trial. Annals of Internal Medicine . 2020;173(8):623-31. doi: 10.7326/M20-4207, PMID 32673060.
4. Mehra MR, Desai SS, Ruschitzka F, Patel AN. RETRACTED: Hydroxychloroquine or chloroquine with or without a macrolide for treatment of COVID-19: A multinational registry analysis. The Lancet. 2020;395(10240):1820.
5. Derwand R, Scholz M. Does zinc supplementation enhance the clinical efficacy of chloroquine/hydroxychloroquine to win today's battle against COVID-19?. Medical Hypotheses. 2020;142:109815. doi: 10.1016/j.mehy.2020.109815.
6. Geleris J, Sun Y, Platt J, Zucker J, Baldwin M, Hripcsak G, *et al*. Observational study of hydroxychloroquine in hospitalized patients with Covid-19. New England Journal of Medicine. 2020;382(25):2411-8. doi: 10.1056/NEJMoa2012410, PMID 32379955.
7. Gautret P, Lagier J, Parola P, Hoang VT, Meddeb L, Sevestre J, *et al*. Clinical and microbiological effect of a combination of hydroxychloroquine and azithromycin in 80 COVID-19 patients with at least a six-day follow up: A pilot observational study. Travel Medicine and Infectious Disease. 2020;34:101663. doi: 10.1016/j.tmaid.2020.101663, PMID 101663.
8. Frame JD. Mainstream research in Latin America and the Caribbean. Interciencia. 1977;2(3):143-8.
9. Nagpaul PS, Sharma L. Science in the eighties: A typology of countries based on inter-field priorities. Scientometrics. 1995;34(2):263-83. doi: 10.1007/BF02020424.
10. Schubert A, Braun T. Relative indicators and relational charts for comparative assessment of publication output and citation impact. Scientometrics. 1986;9(5):281-91.
11. Carpenter MP, Gibb F, Harris M, Irvine J, Martin BR, Narin F. Bibliometric profiles for British academic institutions: An experiment to develop research output indicators. Scientometrics. 1988;14(3-4):213-33. doi: 10.1007/BF02020076.
12. Sangam SL, Arali UB, Patil CG, Rousseau R. Growth of the hepatitis literature over the period 1976-2015: What can the relative priority index teach us?. Scientometrics. 2018;115(1):351-68. doi: 10.1007/s11192-018-2668-z.
13. Glänzel W. Science in Scandinavia: A bibliometric approach. Scientometrics. 2000;48(2):121-50. doi: 10.1023/A:1005640604267.
14. Romo-Fernández LM, López-Pujalte C, Guerrero Bote VPG, Moya-Anegón F. Analysis of Europe's scientific production on renewable energies. Renewable Energy. 2011;36(9):2529-37. doi: 10.1016/j.renene.2011.02.001.
15. Arencibia-Jorge R, Corera-Alvarez E, Chinchilla-Rodríguez Z, De Moya-Anegón F. Scientific output of the emerging Cuban biopharmaceutical industry: A scientometric approach. Scientometrics. 2016;108(3):1621-36. doi: 10.1007/s11192-016-2023-1.
16. Zacca-González G, Chinchilla-Rodríguez Z, Vargas-Quesada B. Medical scientific output and specialization in Latin American countries. Scientometrics. 2018;115(3):1635-50. doi: 10.1007/s11192-018-2717-7.
17. Glänzel W. Bibliometrics as a Research Field: A course on theory and application of bibliometric indicators. 2003.
18. Guan J, Ma N. A bibliometric study of China's semiconductor literature compared with other major Asian countries. Scientometrics. 2007;70(1):107-24. doi: 10.1007/s11192-007-0107-7.