Scientometric Analysis of Top 100 Most Cited Articles on Imaging in COVID-19: The Pandemic of Publications

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Abstract

The coronavirus disease 2019 (COVID-19) pandemic in 2020 was paralleled by an equally overwhelming publication of scientific literature. This scientometric analysis was performed to evaluate the 100 most cited articles on COVID-19 imaging to highlight research trends and identify common characteristics of the most cited works. A search of the Web of Science database was performed using the keywords "COVID CT," "COVID Radiograph," and "COVID Imaging" on June 29, 2021. The 100 top cited articles found were arranged in descending order on the basis of citation counts and citations per year and relevant data were recorded. Our search revealed a total of 4,862 articles on COVID-19 imaging published in the years 2020 to 2021. The journal with maximum number of publications ($n = 22$), citation count ($n = 8,788$), and impact was *Radiology*. Citations for the top 100 articles ranged from 70 to 1,742 with the most cited article authored by A.I. Tao and published in *Radiology*. Two authors tied at first spot, having maximum impact, with both having 5 publications and a total of 3,638 citations among them. China was the leading country with both the maximum number of publications ($n = 49$) and total citations ($n = 13,892$), the United States coming second in both. This study evaluates publication and citation trends in literature and shows that the countries most affected by the pandemic early on have contributed to the majority of the literature. Furthermore, it will help radiologists to refer to the most popular and important article texts on which to base their unbiased and confident diagnoses.

Keywords
► COVID CT
► COVID-19 imaging
► scientometric

Introduction

Coronavirus disease 2019 (COVID-19) initially broke out in Wuhan, China, in December 2019,[1–6] with rapid transcontinental spread leading to it being declared a public health emergency on January 30, 2020.[7–10] Keeping with its name, though the Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2) predominantly affects the respiratory system it is rather a multisystemic disease.[11,12] The virus exhibits neurotropic properties being found in the brain and cerebrospinal fluid.[13] Cardiovascular complications

include acute coronary syndrome, myocarditis, arrhythmias, and shock.[14] Imaging plays an indispensable role for timely identification of all these varied viral manifestations for better patient outcomes.[11]

The rapid publications of imaging findings in COVID-19 infection have immensely helped clinicians in diagnosing the disease early and preventing its further spread. The imaging hallmark of COVID-19 in chest includes bilateral and peripheral subsegmental ground glass densities.[1–5,8–10,15,16] Other imaging findings include consolidations,[1–4,8–10,15,16] nodules, reticulations,[1–4,9,15,16] interlobular septal thickening,[1,2,4,8,9,15] linear opacities,[1,4,8] subpleural curvilinear lines,[1,4,16] bronchial wall thickening,[4,15] lymph node enlargement,[1,4,8,10,15,16] pleural effusion,[1,4,8,10,15,16] and pericardial effusion.[4]

The expeditious spread of the COVID-19 pandemic has been paralleled by an equally rapid publication of concerning scientific literature leading to an abundance of content for the scientific community. Based on these articles published in the past 1 year, we performed a scientometric analysis that can help radiologists to make an informed reading choice and thereby target the most relevant research in an era of time constraints. The top 100 most cited articles were selected as these were the articles that had the maximum impact both in terms of social and geographical reach and in influencing scientific norms and thereby were most relevant. It also assesses the progress and contributions made at the level of individuals, institutions, countries, and journals.

Methods

Search Strategy
A title-specific search of the Web of Science database was executed using the keywords "COVID CT," "COVID Radiograph," and "COVID Imaging" on June 29, 2021, and all the abstracts were screened for suitable articles. The inclusion criteria were articles strictly focusing on imaging findings and criterion related to COVID-19 and published in peer-reviewed journals. The 100 most cited articles were selected and reviewed by the authors.

Data
The articles were arranged in descending order based on number of citations. The parameters assessed were the title of the articles, authors, corresponding authors, country of origin, journal of publication, year of publication, and citation count.

Analysis
The statistical analysis was performed using R software (R Foundation for Statistical Computing, Vienna, Austria) employing the "bibliometrix" package. The VOSviewer software (Van Eck and Waltman, Leiden University, Leiden, The Netherlands) was also used to plot network and overlay plots.[17]

Scientometric Parameters
The following statistical parameters were considered during the analysis:

Hirsch (H)-index:[18] author's number of publications and number of citations, reviewed in other articles.

G-index:[18] a variant of H-index that gives credit for the most cited papers; it is the highest rank where the sum of the citations is larger than the square of rank.

M-index:[18] another variant of the H-index that displays H-index per year since first publication.

Citation per year:[18] calculated by dividing the total number of citations by the total number of years.

These parameters are presented as tables and figures and explained further in the result section.

Results

Article Analysis
Our search yielded a total of 4,862 articles. The main information regarding our citation analysis is summarized in ►Table 1. Based on our inclusion criteria, the 100 topmost

Table 1 Main Information about data

Description	Results
Main information about data	
Timespan	2020–2021
Sources (journals, books, etc.)	50
Documents	100
Average years from publication	0.99
Average citations per document	232.6
Average citations per year per document	116.9
References	1,772
Document types	
Article	77
Editorial material	4
Letter	5
Review	14
Document contents	
Keywords plus (ID)	102
Author's keywords (DE)	160
Authors	
Authors	837
Author appearances	980
Authors of single-authored documents	0
Authors of multi-authored documents	837
Authors' collaboration	
Single-authored documents	0
Documents per author	0.119
Authors per document	8.37
Co-authors per documents	9.8
Collaboration index	8.37

cited articles focusing on COVID-19 imaging from 50 sources were assorted and analyzed, of which 77 were original articles, 14 were review articles, 4 were editorials, and 5 were letters to editors. All of these articles were published in 2020 and 2021. The retrieved articles received 232.6 mean citations per document and 116.9 mean citations per year per document, respectively. These 100 articles were authored by a total of 837 authors with the total appearances of these authors numbering 980.

Year of Publication

All of the 100 included articles were published in 2020 and 2021. Total number of references was 1,772.

Top Authors

These 100 articles were authored by a grand total of 837 authors, with none of the articles being single authored. An average of 8.37 authors and 9.8 co-authors was present per document with the number of documents per author being 0.119. The two top authors were LM Xia and M Chung, both having five publications with an H- and G-index of 5. Total citations of these authors were 2,616 and 1,022, respectively, with a total of 3,638 citations among them. The authors' H-index, G-index, and M-index were evaluated and are summarized in ►Table 2. The

individual author's impact visualized as H-index is shown in ►Fig. 1.

Country of Origin of Articles

Most of the research work was published from China with a frequency of 49, followed by the United States with a frequency of 17. Italy rounds off the top three with a frequency of 9. ►Fig. 2 shows the countries color coded based on publication numbers, with these three top countries highlighted in the darkest blue color.

Most Cited Countries

►Fig. 3 and ►Table 3 show the top 15 countries contributing to the highest number of total citations. China leads the chart having a maximum of 13,892 total citations with an average of 283.5 citations per article. On second place was the United States with approximately a fourth of this number at 3,472 total citations with an average of 204.2 citations per article. Third on the list with 1,402 total citations and 155.8 citations per article was Italy.

Most Collaborating Countries

China had the maximum number of 49 publications, of which 40 were from China itself whereas only 9 were multiple country publications (MCPs). The United States

Table 2 Top authors' total citations and impact factors

Author	H-Index	G-Index	M-Index	Total citations	NP	PY-Start
Xia, LM	5	5	2.5	2,616	5	2020
Chung, M	5	5	2.5	1,022	5	2020
Li, KW	4	4	2	978	4	2020
Li, SL	4	4	2	978	4	2020
Bernheim, A	4	4	2	886	4	2020
Jacobi, A	4	4	2	886	4	2020
Sverzellati, N	4	4	2	702	4	2020
Liu, J	3	3	1.5	1,172	3	2020
Huang, MQ	3	3	1.5	873	3	2020
Gholamrezanezhad, A	3	3	1.5	848	3	2020
Fayad, ZA	3	3	1.5	775	3	2020
Chen, LL	3	3	1.5	646	3	2020
Fang, Z	3	3	1.5	646	3	2020
Guo, DJ	3	3	1.5	646	3	2020
Li, CM	3	3	1.5	646	3	2020
Li, Y	3	3	1.5	637	3	2020
Prokop, M	3	3	1.5	613	3	2020
Kanne, JP	3	3	1.5	576	3	2020
Ng, MY	3	3	1.5	539	3	2020
Liu, F	3	3	1.5	433	3	2020

Abbreviations: G-Index, variant of Hirsch index; H-Index, Hirsch index; M-Index, variant of Hirsch index; NP, number of publication; PY, publication year.
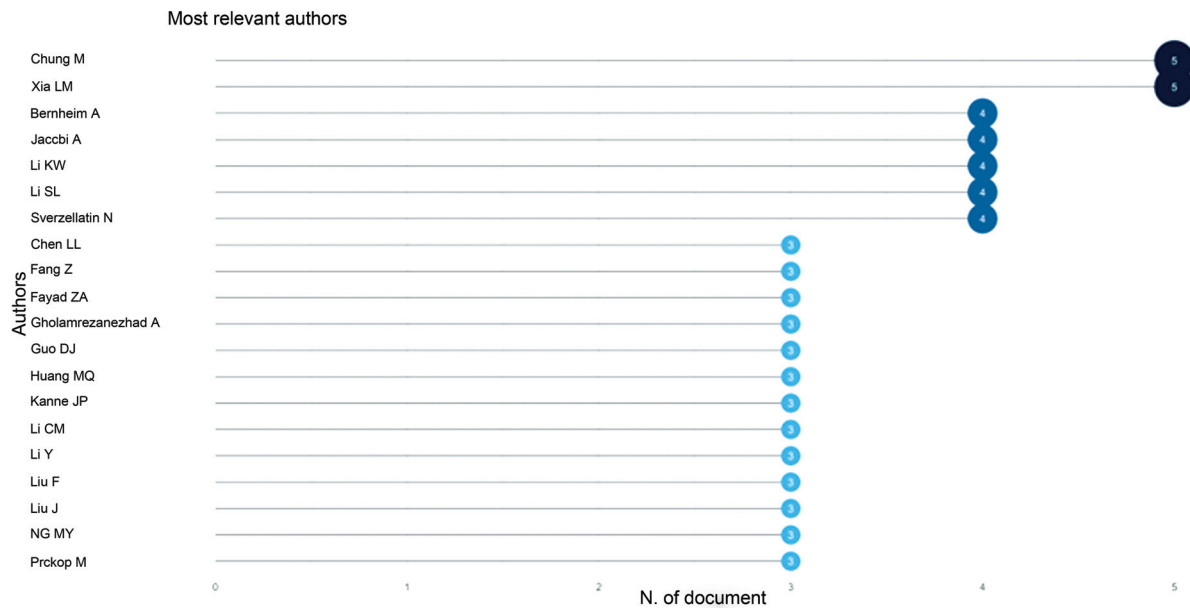
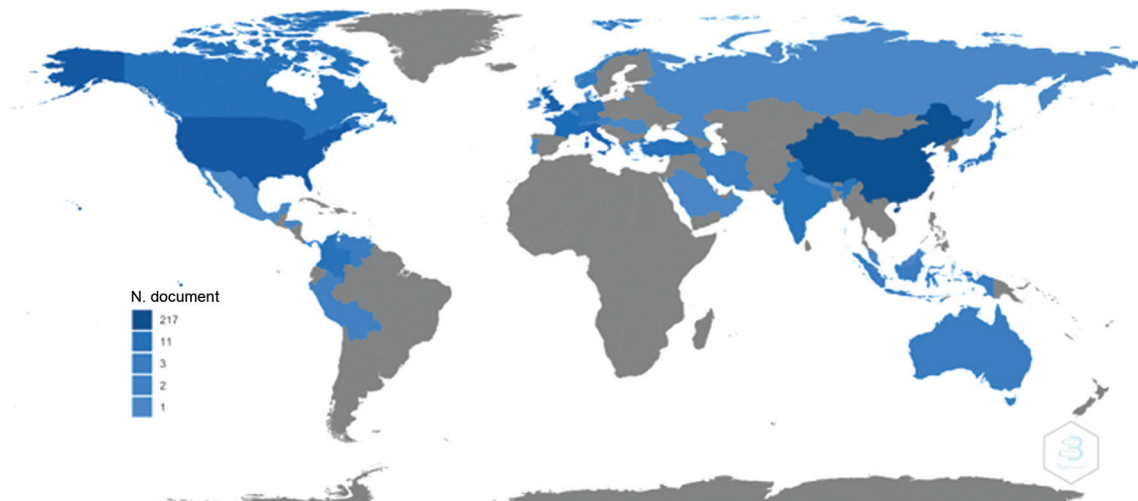**Fig. 1** Line graph showing author's impact factor.

Fig. 2 World map by country-specific publications.

and Italy lay at the second and third positions with a total of 17 and 9 publications, respectively. The MCP ratio among these three was highest for the United States at 0.294. Overall highest MCP of 1 was found for Germany, Colombia, and Iran, all of which had a single MCP each. The MCP ratio is analyzed and summarized in ►**Table 4**.

Most Frequently Encountered Terms in Titles
The titles of the 100 retrieved articles were looked through for the terms that were most regularly encountered. Interestingly, the most commonly used words were acute respiratory syndrome ($n = 18$) and pneumonia ($n = 16$), with

China ($n = 11$) and Wuhan ($n = 10$) rounding off the top four. Coronavirus ($n = 8$) lies at sixth position (►**Figs. 4** and **5**).

Most Cited Documents
The top 100 most cited articles are summarized in ►**Table 5**. All the three top cited articled were published in February 2020. The topmost cited article ($n = 1,142$) was by Tao et al, "Correlation of Chest CT and RT-PCR Testing for Coronavirus Disease 2019 (COVID-19) in China: A Report of 1014 Cases," published in *Radiology*. The second most cited ($n = 917$) study was published in *The Lancet* by Shi et al,
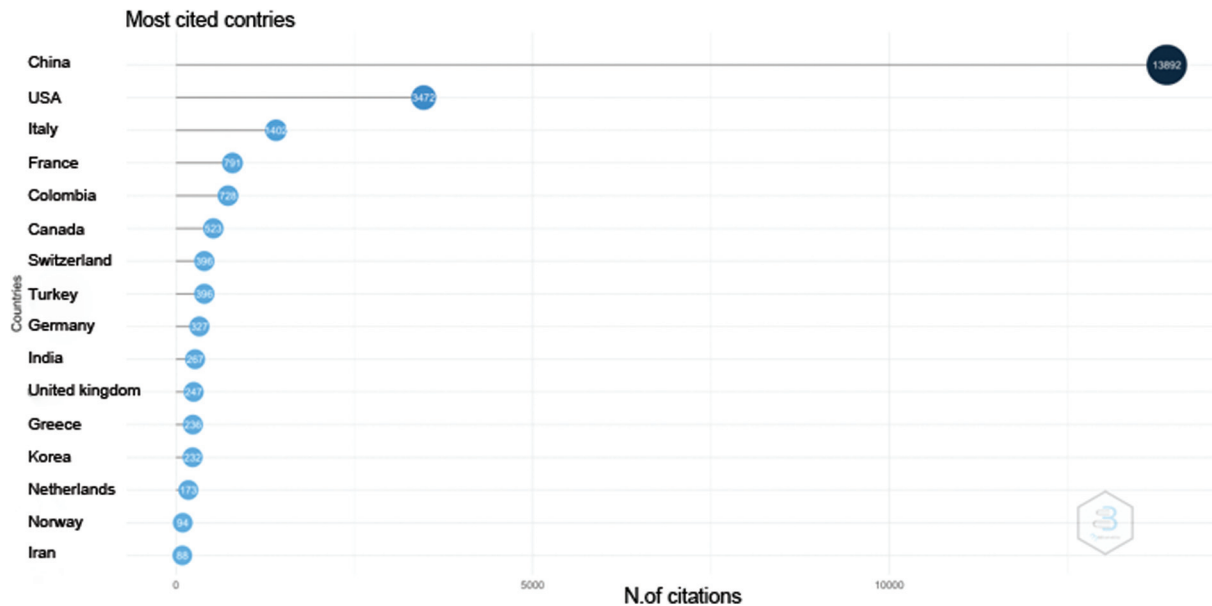
Fig. 3 Line graph showing number of citations by the top 16 countries.

Table 3 Countries with top total and average citations

Country	Total citations	Average article citations
China	13,892	283.5
United States	3,472	204.2
Italy	1,402	155.8
France	791	158.2
Colombia	728	728
Canada	523	261.5
Switzerland	396	198
Turkey	396	132
Germany	327	327
India	267	89
United Kingdom	247	82.3
Greece	236	236
Korea	232	232
Netherlands	173	173
Norway	94	94

"Radiological Findings from 81 Patients with COVID-19 Pneumonia in Wuhan, China: A Descriptive Study." Rounding off the top three ($n = 623$) was the retrospective review by Pan et al published in *Radiology*, assessing the "Time Course of Lung Changes at Chest CT during Recovery from Coronavirus Disease 2019 (COVID-19)." ►**Fig. 6** shows the most cited documents.

Most Relevant Sources

The top journal with the maximum number of 22 published articles was *Radiology. American Journal of Roentgenology* and *European Radiology* tied at second spot with seven publications each. *Radiology* was also the journal with the maximum citation count of 8,788 followed by *American Journal of Roentgenology* and *Lancet Infectious Diseases* at 2,044 and 1,504 total citations, respectively. ►**Fig. 7** shows the top three journals in different shades of blue color. The scientometric parameters (H-index, G-index, and M-index) were analyzed and are listed in ►**Table 6**. The impact factor of the journals is shown in ►**Fig. 8**.

Discussion

Scientometric analyses summarize and organize vast volumes of data on specific topics of interest, helping readers to keep track of global scientific developments. The spread of the novel coronavirus was such that the world came to a standstill in 2020. The novel coronavirus is the seventh member of the Coronaviridae family to infect humans.[5,8]

Reverse transcriptase-polymerase chain reaction (RT-PCR) used for COVID-19 diagnosis[19,20] has debatable accuracy, with sensitivities ranging from 71 to 98%.[20] This emphasizes the importance of imaging in COVID-19 diagnosis. Several imaging scoring systems have been devised[1,4,10,21] allowing triaging of patients for prompt clinical decision-making[17] and timely isolation.[8] These scores assess the percentage of lung involvement and thereby allow for more reporting uniformity.[1,4,10] COVID-19 Reporting and Data System introduced by the Dutch Radiological Society graded pulmonary involvement from 1 to 5, with suspicion levels ranging from very low to very high, respectively.[21] Temporal changes in computed tomography (CT) findings were also assessed by authors.[1,8]

Familiarity with and early recognition of COVID-19 imaging findings are vital due to accelerated disease timeline

Table 4 Countries with highest publications and international collaboration

Country	Articles	Frequency	SCP	MCP	MCP_Ratio
China	49	0.49	40	9	0.184
United States	17	0.17	12	5	0.294
Italy	9	0.09	7	2	0.222
France	5	0.05	3	2	0.4
India	3	0.03	2	1	0.333
Turkey	3	0.03	2	1	0.333
United Kingdom	3	0.03	3	0	0
Canada	2	0.02	2	0	0
Switzerland	2	0.02	1	1	0.5
Colombia	1	0.01	0	1	1
Germany	1	0.01	0	1	1
Greece	1	0.01	1	0	0
Iran	1	0.01	0	1	1
Korea	1	0.01	1	0	0
Netherlands	1	0.01	1	0	0

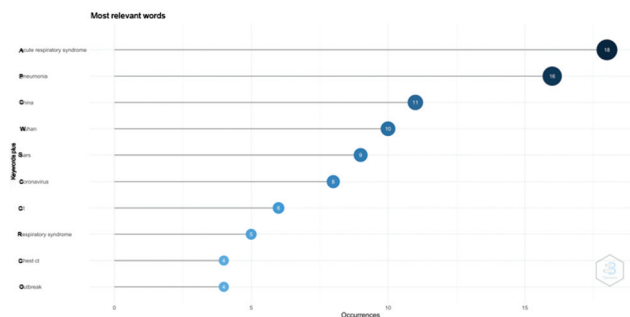Abbreviations: MCP, multiple country publication; SCP, single country publication.

Fig. 4 Line graph showing the most frequent words found in titles during search.

Fig. 5 Tree diagram showing the most frequent words found in titles during search.

and correlation of radiological progression with clinical course.[5]

Our scientometric analysis revealed that the top two articles that received the maximum citations were retrospective studies evaluating chest CT findings in COVID-19 patients at the very start of the pandemic and thereby laid the early foundations for research. The most cited study was by Tao et al, published in *Radiology* journal, which showed that chest CT could be a more reliable, practical, and rapid method to diagnose and assess COVID-19 in view of the shortcomings and high false negative rates of the RT-PCR test. This was vital as early isolation was essential for disease containment. Establishing CT as an alternative diagnostic tool, publication right at the start of the pandemic, original research type study, and publication in an esteemed journal contributed to high citation numbers for the article.

The second most cited study was by Shi et al published in *The Lancet*, which highlighted the CT findings in subclinical and clinical COVID-19 patients and assessed radiological progression and treatment response.

The top two authors bearing the maximum impact with highest H-, G-, and M-indices included LM Xia and M Chung. The most cited author was LM Xia ($n = 2,616$).

The analysis revealed that the bulk of the research came from China, the land where it all began, leading the publication ($n = 49$) and citation ($n = 13,892$) charts by huge margins. Most of these publications were single country publications. Not surprisingly, the United States came second in both with nearly a third as many publications ($n = 17$) and a fourth as many

Table 5 Most globally cited documents

T	DOI	Paper	Authors/Journal	Total citation	TC per year
1.	10.1148/radiol.2020200642	Correlation of Chest CT and RT-PCR Testing for Coronavirus Disease 2019 (COVID-19) in China: A Report of 1014 Cases	Ai, T. (2020), Radiology	1,742	871
2.	10.1016/S1473-3099(20)30086-4	Radiological Findings from 81 Patients with COVID-19 Pneumonia in Wuhan, China: A Descriptive Study	Shi, HS (2020), Lancet Infect Dis	1,304	652
3.	10.1148/radiol.2020200370	Time Course of Lung Changes at Chest CT during Recovery from Coronavirus Disease 2019 (COVID-19)	Pan, F (2020), Radiology	941	470.5
4.	10.1148/radiol.2020200432	Sensitivity of Chest CT for COVID-19: Comparison to RT-PCR	Fang, YC (2020), Radiology	854	427
5.	10.1016/j.tmaid.2020.101623	Clinical, Laboratory and Imaging Features of COVID-19: A Systematic Review and Meta-Analysis	Rodriguez-Morales, AJ (2020), Travel Med Infect Di	728	364
6.	10.1148/radiol.2020200343	Chest CT for Typical Coronavirus Disease 2019 (COVID-19) Pneumonia: Relationship to Negative RT-PCR Testing	Xie, XZ (2020), Radiology	661	330.5
7.	10.1148/radiol.2020201187	COVID-19-associated Acute Hemorrhagic Necrotizing Encephalopathy: Imaging Features	Poyiadji, N (2020), Radiology	628	314
8.	10.1001/jamacardio.2020.1096	Cardiac Involvement in a Patient with Coronavirus Disease 2019 (COVID-19)	Inciardi, RM (2020), JAMA Cardiol	563	281.5
9.	10.1148/radiol.2020200463	Chest CT Findings in Coronavirus Disease-19 (COVID-19): Relationship to Duration of Infection	Bernheim, A (2020), Radiology	556	278
10.	10.1148/radiol.2020200490	Coronavirus Disease 2019 (COVID-19): A Perspective from China	Zu, ZY (2020), Radiology	498	249
11.	10.2214/AJR.20.23034	Coronavirus Disease 2019 (COVID-19): A Systematic Review of Imaging Findings in 919 Patients	Salehi, S (2020), Am J Roentgenol	495	247.5
12.	10.2214/AJR.20.22954	Coronavirus Disease 2019 (COVID-19): Role of Chest CT in Diagnosis and Management	Li, Y (2020), Am J Roentgenol	436	218
13.	10.2214/AJR.20.22976	Relation Between Chest CT Findings and Clinical Conditions of Coronavirus Disease (COVID-19) Pneumonia: A Multicenter Study	Zhao, W, (2020), Am J Roentgenol	413	206.5
14.	10.1021/acsnano.0c02624	Diagnosing COVID-19: The Disease and Tools for Detection	Udugama, B (2020), ACS Nano	411	205.5
15.	10.1007/s00330-020-06801-0	Chest CT Manifestations of New Coronavirus Disease 2019 (COVID-19): A Pictorial Review	Ye, Z (2020), Eur Radiol	402	201
16.	10.1002/ppul.24718	Clinical and CT Features in Pediatric Patients with COVID-19 Infection: Different Points from Adults	Xia, W (2020), Pediatr Pulm	390	195

Table 5 (*Continued*)

17.	10.1148/radiol.2020200823	Performance of Radiologists in Differentiating COVID-19 from Non-COVID-19 Viral Pneumonia at Chest C	Bai, HX (2020), Radiology	377	188.5
18.	10.1097/RLI.0000000000000672	The Clinical and Chest CT Features Associated with Severe and Critical COVID-19 Pneumonia	Li, KH (2020), Invest Radiol	356	178
19.	10.1148/radiol.2020201160	Frequency and Distribution of Chest Radiographic Findings in Patients Positive for COVID-19	Wong, HYF. (2020), Radiology	352	176
20.	10.1007/s00259-020-04735-9	Imaging and Clinical Features of Patients with 2019 Novel Coronavirus SARS-CoV-2	Xu, X (2020), Eur J Nucl Med Mol I	340	170
21.	10.1016/j.jinf.2020.02.016	Clinical Characteristics and Imaging Manifestations of the 2019 Novel Coronavirus Disease (COVID-19): A Multi-Center Study in Wenzhou city, Zhejiang, China	Yang, WJ (2020), J Infection	332	166
22.	10.1001/jamacardio.2020.3557	Outcomes of Cardiovascular Magnetic Resonance Imaging in Patients Recently Recovered from Coronavirus Disease 2019 (COVID-19)	Puntmann, VO (2020), JAMA Cardiol	327	163.5
23.	10.1097/INF.0000000000002660	Coronavirus Infections in Children Including COVID-19: An Overview of the Epidemiology, Clinical Features, Diagnosis, Treatment and Prevention Options in Children	Zimmermann, P (2020), Pediatr Infect Dis J	313	156.5
24.	10.1016/j.ejrad.2020.108961	Diagnosis of the Coronavirus Disease (COVID-19): rRT-PCR or CT?	Long, CQ (2020), Eur J Radiol	287	143.5
25.	10.2214/AJR.20.22975	CT Features of Coronavirus Disease 2019 (COVID-19) Pneumonia in 62 Patients in Wuhan, China	Zhou, SC (2020), Am J Roentgenol	274	137
26.	10.1148/radiol.2020200905	Using Artificial Intelligence to Detect COVID-19 and Community-Acquired Pneumonia Based on Pulmonary CT: Evaluation of the Diagnostic Accuracy	Li, L (2020), Radiology	271	135.5
27.	10.1148/radiol.2020201365	The Role of Chest Imaging in Patient Management during the COVID-19 Pandemic: A Multinational Consensus Statement from the Fleischner Society	Rubin, GD (2020), Radiology	268	134
28.	10.1148/radiol.2020200843	Temporal Changes of CT Findings in 90 Patients with COVID-19 Pneumonia: A Longitudinal Study	Wang, YH (2020), Radiology	248	124
29.	10.1016/j.compbiomed.2020.103792	Automated Detection of COVID-19 Cases Using Deep Neural Networks with X-Ray Images	Ozturk, T (2020), Comput Biol Med	238	119
30.	10.1007/s13246-020-00865-4	COVID-19: Automatic Detection from X-Ray Images Utilizing Transfer Learning with Convolutional Neural Networks	Apostolopoulos, ID (2020), Phys Eng Sci Med	236	118

(*Continued*)

Table 5 (*Continued*)

31.	10.3348/kjr.2020.0132	Chest Radiographic and CT Findings of the 2019 Novel Coronavirus Disease (COVID-19): Analysis of Nine Patients Treated in Korea	Yoon, SH (2020), Korean J Radiol	232	116
32.	10.1148/radiol.2020201544	Acute Pulmonary Embolism Associated with COVID-19 Pneumonia Detected with Pulmonary CT Angiography	Grillet, F (2020), Radiology	228	114
33.	10.1148/radiol.2020201561	Acute Pulmonary Embolism in Patients with COVID-19 at CT Angiography and Relationship to D-Dimer Levels	Leonard-Lorant, I (2020), Radiology	224	112
34.	10.1016/j.jinf.2020.02.017	Clinical and Computed Tomographic Imaging Features of Novel Coronavirus Pneumonia Caused by SARS-CoV-2	Xu, YH (2020), J Infection	221	110.5
35.	10.1097/RLI.0000000000000670	Chest CT Findings in Patients with Coronavirus Disease 2019 and Its Relationship with Clinical Features	Wu, J (2020), Invest Radiol	220	110
36.	10.1148/radiol.2020201237	Chest CT Features of COVID-19 in Rome, Italy	Caruso, D (2020), Radiology	204	102
37.	10.2214/AJR.20.22969	Radiology Perspective of Coronavirus Disease 2019 (COVID-19): Lessons from Severe Acute Respiratory Syndrome and Middle East Respiratory Syndrome	Hosseiny, M (2020), Am J Roentgenol	185	92.5
38.	10.1148/radiol.2020201473	CO-RADS: A Categorical CT Assessment Scheme for Patients Suspected of Having COVID-19—Definition and Evaluation	Prokop, M (2020), Radiology	173	86.5
39.	10.1016/j.chest.2020.04.003	The Role of Chest Imaging in Patient Management During the COVID-19 Pandemic: A Multinational Consensus Statement from the Fleischner Society	Rubin, GD (2020), Chest	172	86
40.	10.1007/s00330-020-06817-6	CT Image Visual Quantitative Evaluation and Clinical Classification of Coronavirus Disease (COVID-19)	Li, KW (2020), Eur Radiol	170	85
41.	10.1016/j.jacr.2020.02.008	Coronavirus (COVID-19) Outbreak: What the Department of Radiology Should Know	Kooraki, S (2020), J Am Coll Radiol	168	84
42.	10.2214/AJR.20.22961	Early Clinical and CT Manifestations of Coronavirus Disease 2019 (COVID-19) Pneumonia	Han, R (2020), Am J Roentgenol	154	77
43.	10.1093/cid/ciaa243	Clinical Features and Short-Term Outcomes of 102 Patients with Coronavirus Disease 2019 in Wuhan, China	Cao, JL (2020), Clin Infect Dis	152	76
44.	10.1016/j.jinf.2020.03.007	Clinical and CT Imaging Features of the COVID-19 Pneumonia: Focus on Pregnant Women and Children	Liu, HH (2020), J Infection	151	75.5

Table 5 (*Continued*)

45.	10.3348/kjr.2020.0146	False-Negative Results of Real-Time Reverse-Transcriptase Polymerase Chain Reaction for Severe Acute Respiratory Syndrome Coronavirus 2: Role of Deep-Learning-Based CT Diagnosis and Insights from Two Cases	Li, DS (2020), Korean J Radiol	151	75.5
46.	10.1097/RLI.0000000000000674	Clinical and High-Resolution CT Features of the COVID-19 Infection: Comparison of the Initial and Follow-up Changes	Xiong, Y (2020), Invest Radiol	148	74
47.	10.1038/s41591-020-0931-3	Artificial Intelligence–Enabled Rapid Diagnosis of Patients with COVID-19	Mei, XY (2020), Nat Med	147	73.5
48.	10.1148/radiol.2020201433	Well-aerated Lung on Admitting Chest CT to Predict Adverse Outcome in COVID-19 Pneumonia	Colombi, D (2020), Radiology	138	69
49.	10.1097/RTI.0000000000000524	Radiological Society of North America Expert Consensus Statement on Reporting Chest CT Findings Related to COVID-19. Endorsed by the Society of Thoracic Radiology, the American College of Radiology, and RSNA - Secondary Publication	Simpson, S (2020), J Thorac Imag	136	68
50.	10.1007/s00259-020-04734-w	18F-FDG PET/CT Findings of COVID-19: A Series of Four Highly Suspected Cases	Qin, CX (2020), Eur J Nucl Med Mol I	135	67.5
51.	10.1007/s00330-020-06865-y	COVID-19 Patients and the Radiology Department – Advice from the European Society of Radiology (ESR) and the European Society of Thoracic Imaging (ESTI)	Revel, MP (2020), Eur Radiol	124	62
52.	10.1016/S0140-6736(20)32656-8	6-Month Consequences of COVID-19 in Patients Discharged from Hospital: A Cohort Study	Huang, CL (2021), Lancet	122	122
53.	10.1002/jmv.25871	C-Reactive Protein Correlates with Computed Tomographic Findings and Predicts Severe COVID-19 Early	Tan, CC (2020), J Med Virol	118	59
54.	10.1148/radiol.2020201629	Diagnosis, Prevention, and Treatment of Thromboembolic Complications in COVID-19: Report of the National Institute for Public Health of the Netherlands	Oudkerk, M (2020), Radiology	116	58
55.	10.1038/s41598-020-76550-z	COVID-Net: A Tailored Deep Convolutional Neural Network Design for Detection of COVID-19 Cases from Chest X-Ray Images	Wang, LD (2020), Sci Rep-UK	112	56
56.	10.1016/j.clinimag.2020.04.001	Portable Chest X-Ray in Coronavirus Disease-19 (COVID-19): A Pictorial Review	Jacobi, A (2020), Clin Imag	111	55.5
57.	10.1016/S1473-3099(20)30134-1	COVID-19 Pneumonia: What has CT Taught Us?	Lee, EYP (2020), Lancet Infect Dis	110	55

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Table 5 (*Continued*)

58.	10.1111/liv.14449	Clinical Characteristics of Non-ICU Hospitalized Patients with Coronavirus Disease 2019 and Liver Injury: A Retrospective Study	Xie, HS (2020), Liver Int	109	54.5
59.	10.1007/s00247-020-04656-7	Chest Computed Tomography in Children with COVID-19 Respiratory Infection	Li, W (2020), Pediatr Radiol	105	52.5
60.	10.1016/j.hrthm.2020.05.001	Recognizing COVID-19-related myocarditis: The possible pathophysiology and proposed guideline for diagnosis and management	Siripanthong, B (2020), Heart Rhythm	104	52
61.	10.1111/anae.15082	Point-of-Care Lung Ultrasound in Patients with COVID-19–A Narrative Review	Smith, MJ (2020), Anesthesia	101	50.5
62.	10.1016/j.diii.2020.03.014	COVID-19 Pneumonia: A Review of Typical CT Findings and Differential Diagnosis	Hani, C (2020), Diagn Interv Imag	99	49.5
63.	10.1016/j.jacr.2020.03.006	Coronavirus Disease 2019 (COVID-19) CT Findings: A Systematic Review and Meta-Analysis	Bao, CP (2020), J Am Coll Radiol	98	49
64.	10.1016/j.eclinm.2020.100433	COVID-19 in 7780 Pediatric Patients: A Systematic Review	Hoang, A (2020), Eclinicalmedicine	96	48
65.	10.1007/s00431-020-03684-7	SARS-COV-2 Infection in Children and Newborns: A Systematic Review	Liguoro, I (2020), Eur J Pediatr	95	47.5
66.	10.1002/jmv.25822	Imaging and Clinical Features of Patients with 2019 Novel Coronavirus SARS-CoV-2: A Systematic Review and Meta-Analysis	Cao, YH (2020), J Med Virol	95	47.5
67.	10.1093/ehjci/jeaa072	COVID-19 Pandemic and Cardiac Imaging: EACVI Recommendations on Precautions, Indications, Prioritization, and Protection for Patients and Healthcare Personnel	Skulstad, H (2020), Eur Heart J-Card Imag	94	47
68.	10.1016/j.ejrad.2020.108941	CT Manifestations of Coronavirus Disease-2019: A Retrospective Analysis of 73 Cases by Disease Severity	Liu, KC (2020), Eur J Radiol	93	46.5
69.	10.1016/j.ijid.2020.03.040	Epidemiological, Clinical Characteristics of Cases of SARS-CoV-2 Infection with Abnormal Imaging Findings	Zhang, XL (2020), Int J Infect Dis	93	46.5
70.	10.1007/s10096-020-03901-z	Classification of COVID-19 Patients from Chest CT Images Using Multi-Objective Differential Evolution-Based Convolutional Neural Networks	Singh, D (2020), Eur J Clin Microbiol	91	45.5
71.	10.1177/0846537120913033	CT Imaging and Differential Diagnosis of COVID-19	Dai, WC (2020), Can Assoc Radiol J	90	45
72.	10.1007/s00330-020-06827-4	The Role of Imaging in 2019 Novel Coronavirus Pneumonia (COVID-19)	Yang, WJ (2020), Eur Radiol	90	45
73.	10.1016/S1473-3099(20)30367-4	Hypoxaemia Related to COVID-19: Vascular and Perfusion Abnormalities on Dual-Energy CT	Lang, M (2020), Lancet Infect Dis	90	45

Table 5 (*Continued*)

74.	10.1016/j.cmpb.2020.105581	CoroNet: A Deep Neural Network for Detection and Diagnosis of COVID-19 from Chest X-Ray Images	Khan, AI (2020), Comput Meth Prog Bio	88	44
75.	10.1016/j.compbiomed.2020.103795	Application of Deep Learning Technique to Manage COVID-19 in Routine Clinical Practice Using CT Images: Results of 10 Convolutional Neural Networks	Ardakani, AA (2020), Comput Biol Med	88	44
76.	10.1016/j.ijid.2020.02.043	2019-Novel Coronavirus Severe Adult Respiratory Distress Syndrome in Two Cases in Italy: An Uncommon Radiological Presentation	Albarello, F (2020), Int J Infect Dis	88	44
77.	NA	Diabetes and COVID-19: A Major Challenge in Pandemic Period?	Chakraborty, C (2020), Eur Rev Med Pharmaco	88	44
78.	10.2214/AJR.20.22959	Clinical Features and Chest CT Manifestations of Coronavirus Disease 2019 (COVID-19) in a Single-Center Study in Shanghai, China	Cheng, ZH (2020), Am J Roentgenol	87	43.5
79.	10.1016/j.jinf.2020.04.004	CT Imaging and Clinical Course of Asymptomatic Cases with COVID-19 Pneumonia at Admission in Wuhan, China	Meng, H (2020), J Infection	87	43.5
80.	10.1016/j.mehy.2020.109761	COVIDiagnosis-Net: Deep Bayes-SqueezeNet Based Diagnosis of the Coronavirus Disease 2019 (COVID-19) from X-Ray Images	Ucar, F (2020), Med Hypotheses	87	43.5
81.	10.1016/j.cell.2020.04.045	Clinically Applicable AI System for Accurate Diagnosis, Quantitative Measurements, and Prognosis of COVID-19 Pneumonia Using Computed Tomography	Zhang, K (2020), Cell	87	43.5
82.	10.1016/j.jcmg.2020.05.004	Cardiac Involvement in Patients Recovered from COVID-2019 Identified Using Magnetic Resonance Imaging	Huang, L (2020), JACC-Cardiovasc Imag	85	42.5
83.	10.1148/radiol.2020202040	COVID-19-Associated Diffuse Leukoencephalopathy and Microhemorrhages	Radmanesh, A (2020), Radiology	85	42.5
84.	10.1016/j.thromres.2020.04.011	Pulmonary Embolism in Patients with COVID-19: Time to Change the Paradigm of Computed Tomography	Rotzinger, DC (2020), Thromb Res	83	41.5
85.	10.1148/radiol.2020201908	Abdominal Imaging Findings in COVID-19: Preliminary Observations	Bhayana, R (2020), Radiology	81	40.5
86.	10.1111/echo.14664	Our Italian Experience Using Lung Ultrasound for Identification, Grading and Serial Follow-Up of Severity of Lung Involvement for Management of Patients with COVID-19	Vetrugno, L (2020), Echocardiogr-J Card	80	40
87.	10.1007/s00330-020-06969-5	Association of "Initial CT" Findings with Mortality in Older Patients with Coronavirus Disease 2019 (COVID-19)	Li, Y (2020), Eur Radiol	79	39.5

Table 5 (*Continued*)

88.	10.1007/s10072-020-04375-9	Acute Stroke Management Pathway during Coronavirus-19 Pandemic	Baracchini, C (2020), Neurol Sci	79	39.5
89.	10.1007/s11547-020-01200-3	COVID-19 Outbreak in Italy: Experimental Chest X-Ray Scoring System for Quantifying and Monitoring Disease Progression	Borghesi, A (2020), Radiol Med	79	39.5
90.	10.1016/S0140-6736(20)30728-5	A Role for CT in COVID-19? What Data Really Tell Us So Far	Hope, MD (2020), Lancet	78	39
91.	10.1016/j.rmed.2020.105980	Diagnostic Performance between CT and Initial Real-Time RT-PCR for Clinically Suspected 2019 Coronavirus Disease (COVID-19) Patients Outside Wuhan, China	He, JL (2020), Resp Med	77	38.5
92.	10.1007/s00330-020-07033-y	Chest CT Score in COVID-19 Patients: Correlation with Disease Severity and Short-Term Prognosis	Francone, M (2020), Eur Radiol	76	38
93.	10.1016/j.acra.2020.03.003	Coronavirus Disease (COVID-19): Spectrum of CT Findings and Temporal Progression of the Disease	Li, MZ (2020), Acad Radiol	76	38
94.	10.1212/NXI.0000000000000789	COVID-19-Related Acute Necrotizing Encephalopathy with Brain Stem Involvement in a Patient with Aplastic Anemia	Dixon, L (2020), Neurol-Neuroimmunol	74	37
95.	10.1148/radiol.2020201754	Clinical and Chest Radiography Features Determine Patient Outcomes in Young and Middle-Aged Adults with COVID-19	Toussie, D (2020), Radiology	72	36
96.	10.1016/j.crad.2020.03.003	An Update on COVID-19 for the Radiologist - A British Society of Thoracic Imaging Statement	Rodrigues, JCL (2020), Clin Radiol	72	36
97.	10.1148/radiol.2020201491	Artificial Intelligence Augmentation of Radiologist Performance in Distinguishing COVID-19 from Pneumonia of Other Origin at Chest CT	Bai, HX (2020), Radiology	71	35.5
98.	10.1016/j.compbiomed.2020.103805	COVID-19 Detection Using Deep Learning Models to Exploit Social Mimic Optimization and Structured Chest X-Ray Images Using Fuzzy Color and Stacking Approaches	Togacar, M (2020), Comput Biol Med	71	35.5
99.	10.1016/j.jaut.2020.102473	Characteristics and Prognostic Factors of Disease Severity in Patients with COVID-19: The Beijing Experience	Sun, Y (2020), J Autoimmun	70	35
100.	10.1007/s00330-020-06816-7	Coronavirus Disease 2019: Initial Chest CT Findings	Zhou, ZM (2020), Eur Radiol	70	35

Abbreviations: DOI, digital object identifier; TC, total citation.

citations ($n = 3,472$), mostly a combined effect of high case rates and mortalities and superior research infrastructure. Italy rounded off the top three in publications. This is on trend with the countries maximally affected by the coronavirus early on.

The most frequently encountered terms in the titles were "acute respiratory syndrome," "pneumonia," and "China," with both "coronavirus" and "COVID-19" not making it to top three. This is not surprising as while "acute respiratory syndrome" and "pneumonia" are generic terms, the virus has
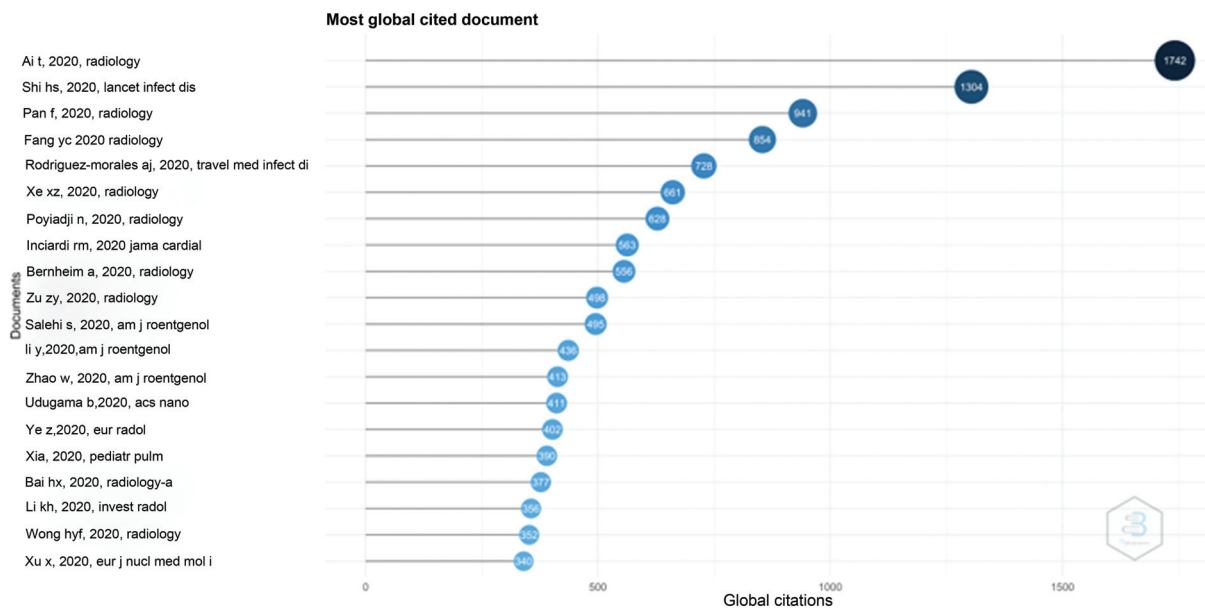
Most global cited document

Fig. 6 Line graph showing the most cited documents.
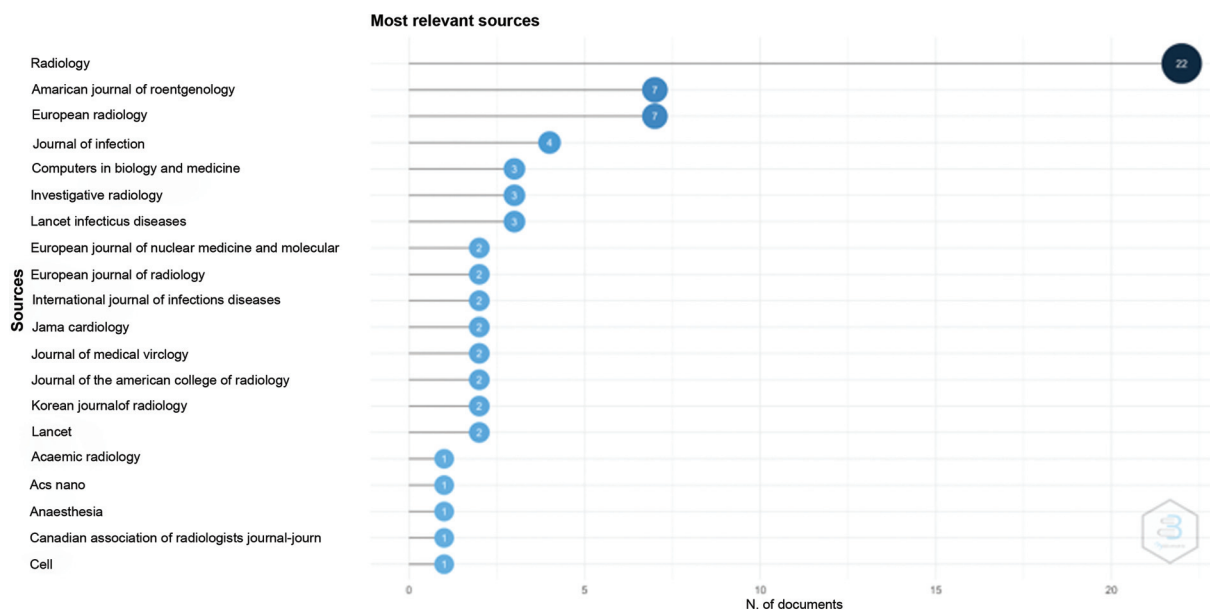
Most relevant sources

Fig. 7 Line graph showing the most relevant journals.

been mentioned by several synonyms including but not limited to COVID, COVID-19, coronavirus, SARS-CoV-2, etc.

Radiology journal topped the charts having both the maximum number of publications and impact with the highest H-, G-, and M-indices. *American Journal of Roentgenology* and *European Radiology* earned the second and third spots in both these lists. *Radiology* also had the maximum number of total citations ($n = 8,788$), more than quadruple of those of *American Journal of Roentgenology* ($n = 2,044$). This comes as no surprise since it is one of the most reputed and

prestigious journals having a large readership and impact in the field of radiology.

Limitations

This scientometric analysis though exhaustive is ridden with a few limitations owing to its nature. First, the article pool was extracted from a single database, which can possibly miss a highly cited article. Second, since specific terms were used to retrieve the articles, articles not directly using these

Table 6 Journals with highest impact factor and total citations

Source	H-Index	G-Index	M-Index	Total citations	NP	PY-Start
Radiology	22	22	11	8,788	22	2020
American Journal of Roentgenology	7	7	3.5	2,044	7	2020
European Radiology	7	7	3.5	1,011	7	2020
Journal of Infection	4	4	2	791	4	2020
Computers in Biology and Medicine	3	3	1.5	397	3	2020
Investigative Radiology	3	3	1.5	724	3	2020
Lancet Infectious Diseases	3	3	1.5	1,504	3	2020
European Journal of Nuclear Medicine and Molecular Imaging	2	2	1	475	2	2020
European Journal of Radiology	2	2	1	380	2	2020
International Journal of Infectious Diseases	2	2	1	181	2	2020
JAMA Cardiology	2	2	1	890	2	2020
Journal of Medical Virology	2	2	1	213	2	2020
Journal of the American College of Radiology	2	2	1	266	2	2020
Korean Journal of Radiology	2	2	1	383	2	2020
Lancet	2	2	1	200	2	2020
Academic Radiology	1	1	0.5	76	1	2020
ACS Nano	1	1	0.5	411	1	2020
Anesthesia	1	1	0.5	101	1	2020
Canadian Association of Radiologists Journal-Journal De L Association Canadienne Des Radiologistes	1	1	0.5	90	1	2020
Cell	1	1	0.5	87	1	2020

Abbreviations: G-Index, variant of Hirsch index; H-Index, Hirsch index; M-Index, variant of Hirsch index; NP, number of publication; PY, publication year.
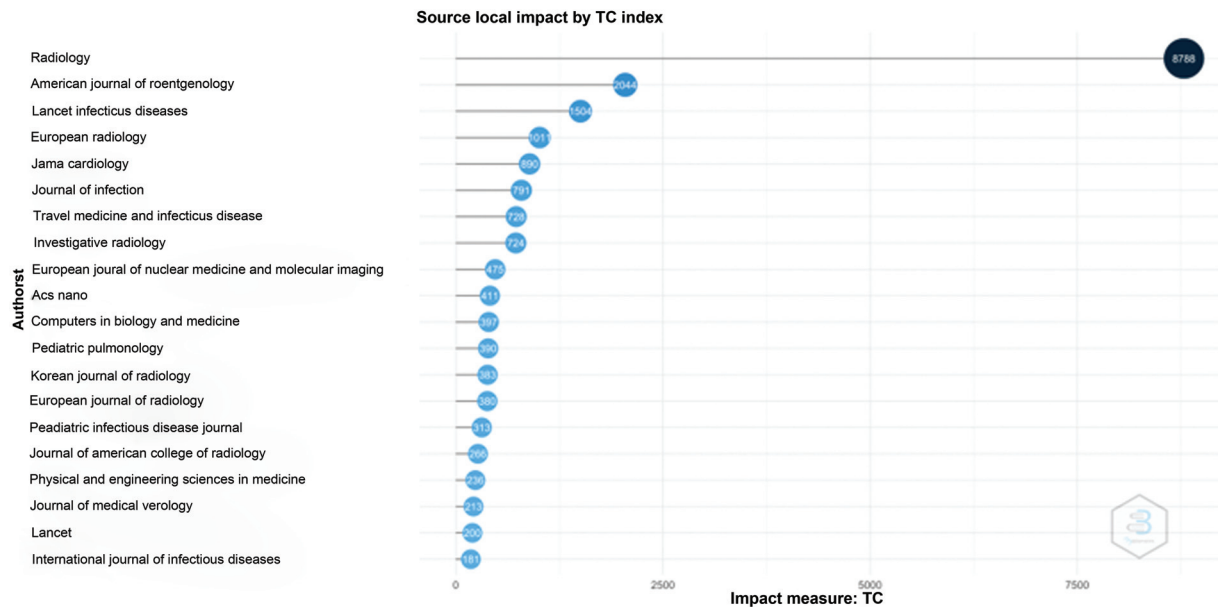

Fig. 8 Line graph showing the impact factor of journals by total citations.

terms may have been excluded. Third, self-citations, in-house bias, and omission bias can lead to skewed results. Exclusion from the shortlisted articles does not undermine the significance of such missed articles.

Conclusion

In the middle of a pandemic that has overshadowed all other medical and surgical problems, this scientometric analysis

will help radiologists to refer to the most popular and important article texts on which to base their unbiased and confident diagnoses. It will help reduce the innumerable false positive COVID-19 impressions currently based on imaging and aid in classifying these innumerable "ground glass densities" correctly into their myriad underlying causes thereby reducing societal stigma. Additionally, since majority of the literature pertaining to COVID-19 is from the past year itself, this analysis will help authors understand which articles, authors, and journals created the maximum impact. Factors favoring high citation numbers included: publication timelines, as articles published early on formed the basis for scientific knowledge and therefore were referenced more; original research type studies and studies describing imaging finding for diagnosis and follow-up of COVID-19, as these were most relevant in day-to-day clinical scenarios; and journal of publication, as all the top cited articles were published in esteemed journals of high repute, reach, and readability. The impact of the pandemic and superior research infrastructure appears to be the two most important factors for top author and country citations.

Conflict of Interest
None declared.

References

1 Wang Y, Dong C, Hu Y, et al. Temporal changes of CT findings in 90 patients with COVID-19 pneumonia: a longitudinal study. Radiology 2020;296(02):E55–E64

2 Hosseiny M, Kooraki S, Gholamrezanezhad A, Reddy S, Myers L. Radiology perspective of Coronavirus Disease 2019 (COVID-19): lessons from Severe Acute Respiratory Syndrome and Middle East Respiratory Syndrome. AJR Am J Roentgenol 2020;214(05): 1078–1082

3 Kolta MF, Ghonimy MBI. COVID-19 variant radiological findings with high lightening other coronavirus family (SARS and MERS) findings: radiological impact and findings spectrum of corona virus (COVID-19) with comparison to SARS and MERS. Egypt J Radiol Nucl Med 2020;51(01):172

4 Wasilewski PG, Mruk B, Mazur S, Półtorak-Szymczak G, Sklinda K, Walecki J. COVID-19 severity scoring systems in radiological imaging - a review. Pol J Radiol 2020;85:e361–e368

5 Shi H, Han X, Jiang N, et al. Radiological findings from 81 patients with COVID-19 pneumonia in Wuhan, China: a descriptive study. Lancet Infect Dis 2020;20(04):425–434

6 Rodriguez-Morales AJ, Cardona-Ospina JA, Gutiérrez-Ocampo E, et al; Latin American Network of Coronavirus Disease 2019- COVID-19 Research (LANCOVID-19). Electronic address: https://www.lancovid.org. Clinical, laboratory and imaging features of COVID-19: a systematic review and meta-analysis. Travel Med Infect Dis 2020;34:101623

7 Long C, Xu H, Shen Q, et al. Diagnosis of the Coronavirus disease (COVID-19): rRT-PCR or CT? Eur J Radiol 2020;126:108961

8 Bernheim A, Mei X, Huang M, et al. Chest CT findings in Coronavirus Disease-19 (COVID-19): relationship to duration of infection. Radiology 2020;295(03):200463

9 Li Y, Xia L. Coronavirus Disease 2019 (COVID-19): role of chest CT in diagnosis and management. AJR Am J Roentgenol 2020;214 (06):1280–1286

10 Yang R, Li X, Liu H, et al. Chest CT Severity Score: an imaging tool for assessing severe COVID-19. Radiol Cardiothorac Imaging 2020;2(02):e200047

11 Revzin MV, Raza S, Warshawsky R, et al. Multisystem imaging manifestations of COVID-19, Part 1: viral pathogenesis and pulmonary and vascular system complications. Radiographics 2020; 40(06):1574–1599

12 Roberts CM, Levi M, McKee M, Schilling R, Lim WS, Grocott MPW. COVID-19: a complex multisystem disorder. Br J Anaesth 2020; 125(03):238–242

13 Wu Y, Xu X, Chen Z, et al. Nervous system involvement after infection with COVID-19 and other coronaviruses. Brain Behav Immun 2020;87:18–22

14 Kang Y, Chen T, Mui D, et al. Cardiovascular manifestations and treatment considerations in COVID-19. Heart 2020;106(15): 1132–1141

15 Hafez MAF. The mean severity score and its correlation with common computed tomography chest manifestations in Egyptian patients with COVID-2019 pneumonia. Egypt J Radiol Nucl Med 2020;51(01):254

16 Qin L, Yang Y, Cao Q, et al. A predictive model and scoring system combining clinical and CT characteristics for the diagnosis of COVID-19. Eur Radiol 2020;30(12):6797–6807

17 Synnestvedt MB, Chen C, Holmes JH. CiteSpace II: visualization and knowledge discovery in bibliographic databases. AMIA Annu Symp Proc 2005;2005:724–728

18 Choudhri AF, Siddiqui A, Khan NR, Cohen HL. Understanding bibliometric parameters and analysis. Radiographics 2015;35 (03):736–746

19 Tahamtan A, Ardebili A. Real-time RT-PCR in COVID-19 detection: issues affecting the results. Expert Rev Mol Diagn 2020;20(05): 453–454

20 Watson J, Whiting PF, Brush JE. Interpreting a Covid-19 test result. BMJ 2020;369:m1808

21 Prokop M, van Everdingen W, van Rees Vellinga T, et al; COVID-19 Standardized Reporting Working Group of the Dutch Radiological Society. CO-RADS: a categorical CT assessment scheme for patients suspected of having COVID-19-definition and evaluation. Radiology 2020;296(02):E97–E104