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

Pooja Jain1  Ankita Aggarwal1✉  Kanwaljeet Garg2

1Department of Radiodiagnosis, VMMC and Safdarjung Hospital, Ansari Nagar, New Delhi, India
2Department of Neurosurgery, All India Institute of Medical Sciences, New Delhi, India

Indian J Radiol Imaging 2022;32:166–181.

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. Imaging plays an indispensable role for timely identification of all these varied viral manifestations for better patient outcomes.

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, linear opacities, interlobular septal thickening, subpleural curvilinear lines, bronchial wall thickening, lymph node enlargement, pleural effusion, subcardial effusion. The expeditious spread of the COVID-19 pandemic has been paralleled by an equally rapid publication of concerning 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.

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

| 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

| 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     |
| Ghomarrezanezhad, 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.
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 articles 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,
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.
and correlation of radiological progression with clinical course. 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 ($n = 2,616$).

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 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.
| 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)                      | Inciardi, RM (2020), JAMA Cardiol    | 563            | 281.5       |
| 9.  | 10.1148/radiol.2020200463        | Chest CT Findings in Coronavirus Disease 2019 (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         |
|  | DOI | Title                                                                 | Reference | Volume | Pages |
|---|-----|----------------------------------------------------------------------|-----------|--------|-------|
| 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 Imag | 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.compbimed.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 |
|   | DOI                  | Title                                                                 | Journal, Year, Volume, Pages |
|---|---------------------|----------------------------------------------------------------------|------------------------------|
| 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/CLI.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 |
|   | DOI                                | Title                                                                                           | Authors                        | Journal                          | Volume | Impact Factor |
|---|-----------------------------------|-------------------------------------------------------------------------------------------------|--------------------------------|----------------------------------|--------|---------------|
| 45.| 10.3348/jkr.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/rlr.00000000000000674     | 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/rtl.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            |

(Continued)
| No. | DOI               | Title                                                                 | Authors               | Journal                        | Year | Impact Factor |
|-----|------------------|----------------------------------------------------------------------|-----------------------|--------------------------------|------|---------------|
| 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            |
| No. | DOI | Title                                                                 | Author(s)                                                                 | Journal            | Volume | Issue |
|-----|-----|----------------------------------------------------------------------|--------------------------------------------------------------------------|--------------------|--------|-------|
| 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.compbioimed.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 | COVIDDiagnosis-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   |

(Continued)
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.cradi.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.compbimed.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.

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 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.
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
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

---

**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.
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, Gholamrezaeezad 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 MB. COVID-19 variant radiological findings with high lightening other coronavirus family (SARS and MERS) findings: radiological impact and findings spectrum of coronavirus (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. Rezvyan 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):234
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, CitSpace 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, Ardebari 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