Top 100 Most Cited Neurologic and Neurosurgical Articles on COVID-19: A Bibliometric Analysis

Kevin Ivan P. Chan[1], Katrina Hannah D. Ignacio[2], Abdelsimar Tan Omar II[1], Kathleen Joy O. Khu[1]

■ OBJECTIVE: **With the exponential growth of literature on coronavirus disease 2019 (COVID-19), we aimed to identify and characterize the 100 most cited COVID-19–related articles in neurology and neurosurgery.**

■ METHODS: **In March 2021, we performed a title-specific search of the Scopus database using ("neurology" or "neurologic" or "neurosurgery" or "neurosurgical") and "COVID" as our search query term without date restrictions. The top 100 most cited English-language articles were obtained and reviewed.**

■ RESULTS: **Our search yielded 9648 articles published from December 2019 to March 2021. Bibliometric analysis of the top 100 articles found that the most cited article had a citation count of 1741 and was the first to report on the detailed neurologic manifestations of the disease; *Neurology* had the most number of publications; the majority of the primary authors were neurologists, but 35% were from nonneuroscience specialties; the United States, Italy, the United Kingdom, China, and Germany were the top contributors, with a combined total of 77%; most of the publications were correspondence or editorial articles; and most articles discussed the neurologic manifestations and complications of patients with COVID-19.**

■ CONCLUSIONS: **This study identified the top 100 most cited neurologic or neurosurgical COVID-19–related articles published to date. This list can be used to identify high-impact studies that will help health care practitioners in clinical decision making and researchers in navigating key areas of study and guiding future research.**

INTRODUCTION

In December 2019, the first case of coronavirus disease 2019 (COVID-19) was reported in Wuhan, China.[1] In a span of just 1 year, the causative infectious agent severe acute respiratory syndrome coronavirus 2 has infected >100 million people and caused >2 million deaths worldwide, making it the most challenging global health crisis of the century.[2] Aside from the massive health care response, the international scientific community has also responded to this novel disease promptly and vigorously with >450,000 articles[3] published about COVID-19 in a little over a year since its first emergence, and the number of articles have been increasing exponentially.

Despite being primarily a respiratory illness, COVID-19 has been found to involve other organ systems, with gastrointestinal,[4] hepatobiliary,[4] cardiovascular,[5] dermatologic,[6] renal,[7] hematologic,[8] ophthalmic,[9] and neurologic manifestations.[10] One of the earliest studies on the neurologic manifestations of the disease found that as many as 36.4% of patients with COVID-19 presented with central nervous system symptoms, while 8.9% had involvement of the peripheral nervous system.[11] Since that study, patients with COVID-19 have been reported to exhibit various neurologic manifestations and sequelae, and the virus has been implicated in a wide array of neurologic diseases.[12]

With the exponential growth of literature related to COVID-19, highlighting the most impactful articles in the neurosciences is imperative. Identifying key studies would help clinicians in evidence-based decision making and researchers in mapping out what is known about the neurologic manifestations of the disease. In this study, we performed a bibliometric analysis to identify and determine the characteristics of the top 100 most cited neurologic or neurosurgical COVID-19–related articles published to date.

MATERIALS AND METHODS

Search Strategy

In March 2021, we performed a title-specific search of the SCOPUS database to identify highly cited articles in the field of neurology and neurosurgery in relation to COVID-19. We used ("neurology" or "neurologic" or "neurosurgery" or "neurosurgical") and "COVID" as our query term. English-language articles reporting on any neurologic aspect of COVID-19 (clinical or radiologic features, health service delivery, pathophysiology, medical or surgical treatment) were included in the study. Indexed articles that were conference proceedings or book chapters were excluded.

The results were arranged in descending order according to the citation count. The top 100 most cited articles were obtained and reviewed by the authors. Two reviewers (K.P.C., K.D.I.) screened all studies based on study titles and abstracts available and evaluated the articles independently.

Data Collection and Analysis

The article title, primary author, primary author's specialty, institution, country of origin, journal of publication, citation count, study category, and content were obtained for the top 100 most cited articles. Study categories included case reports, case series, prospective or retrospective cohort studies, reviews (systematic reviews, narrative reviews, or meta-analyses), randomized controlled trials, editorials, and laboratory studies. The impact factor, SCImago Journal Rank, and quartile rank were obtained as well. SCImago Journal Rank is a parameter that determines the importance of a journal for the scientific community, a value calculated based on the number of listed citations and the scientific reputation of the journal.[13] When the authors of an article had >1 affiliation, the department, institution, and country of origin were defined by the affiliation of the first author of the article. Data were presented using descriptive statistics.

RESULTS

Our search found 9971 articles published from December 2019 to March 16, 2021, with 9,648 articles written in English. From this list, the top 100 articles with the highest citation counts were obtained (see **Supplemental Table 1** for complete list). When ≥2 articles had equal citation counts, all the articles with the same number of citations shared the corresponding rank with consequent adjustment of the following ranks. The top 20 most cited articles are listed in **Table 1**.

The top 100 articles have been cited 14,760 times, with an average citation index per item of 143.3 and a median of 85. The most cited article, with 1741 citations, was "Neurologic Manifestations of Hospitalized Patients with Coronavirus Disease 2019 in Wuhan, China" by Mao et al., published in JAMA Neurology in April 2020.

The articles were published in 60 different journals, with Neurology having the highest number of publications (n = 7), closely followed by JAMA Neurology (n = 6) (**Table 2**). The overwhelming majority of the primary authors were neurologists (n = 54), followed by otorhinolaryngologists (n = 11), neurosurgeons (n = 6), and radiologists (n = 6) (**Table 3**). Two authors had multiple publications in the list: L.A. Vaira with 3

articles (ranks 11, 68, and 100) and J. Zhao with 2 articles (ranks 51 and 74).

The top 100 articles originated from 19 different countries (**Table 4**), with the United States contributing 32 articles, followed by Italy (16 articles), United Kingdom (14 articles), China (12 articles), and Germany (5 articles). Harvard Medical School in Boston, Massachusetts, USA, and University Hospital of Sassari in Sassari, Italy, were the institutions that contributed the most articles (4 and 3 articles, respectively) (**Table 5**).

Most of the articles were correspondence or editorials, followed by reviews and retrospective studies (**Figure 1**). More than half of the articles described the clinical features and outcomes of the neurologic manifestations and systemic involvement in COVID-19 cases (**Figure 2**).

DISCUSSION

To the best of our knowledge, the present bibliometric analysis is the first to focus on articles about COVID-19 published in the fields of neurology and neurosurgery. We have identified the seminal articles that may help health care practitioners in clinical decision making for patients with COVID-19 with nervous system manifestations. We also hope that the list may guide researchers in navigating the areas of importance and identify the current gaps in knowledge in the clinical neurosciences.

The large number of articles that were found after the search and the high number of citations for the top 100 articles point to the unprecedented volume of studies that have been done on the various aspects of COVID-19.[14] This reflects the vigorous response of the international scientific community to the disease that has become the greatest public health threat faced by nations across the world.

This bibliometric analysis found that Neurology, the official journal of the American Academy of Neurology, published the highest number of articles. This journal recognized the need for up-to-date studies on the management of neurologic complications of COVID-19 and has set up an expedited peer review system,[15] a strategy that has also been employed by several other journals.

The impact factor of the journals where the top 100 articles were published ranged from 0.294 to 74.699, with an average of 10.57. Only 2% of the articles were published in a journal with an impact factor of <1. The top 5 journals that published the highest number of articles were consistently in either the first or second quartile in their respective fields (**Table 2**).

Among the specialties, neurology contributed the most to the top 100 cited articles, as expected. The other neuroscience specialties (neurosurgery, neuropsychiatry, basic neurosciences) combined with neurology to comprise 65% of the top articles. However, it is noteworthy that a number of nonneurologic specialties have produced impactful articles as well, with the other 35% written by authors from nonneuroscience specialties such as otorhinolaryngology, radiology, and pathology. This finding reflects and underscores the multidisciplinary approach to managing COVID-19.[16]

Five countries were responsible for 77% of the articles. This is consistent with the results of other bibliometric analyses that place China, the United States, Italy, and the United Kingdom among

Table 1. Top 20 Cited Articles

Rank	Title	First Author	Journal
1	Neurologic Manifestations of Hospitalized Patients with Coronavirus Disease 2019 in Wuhan, China.	Mao, L.	*JAMA Neurology*
2	The Neuroinvasive Potential of SARS-CoV2 May Play a Role in the Respiratory Failure of COVID-19 Patients	Li, Y.	*Journal of Medical Virology*
3	Olfactory and Gustatory Dysfunctions as a Clinical Presentation of Mild-to-Moderate Forms of the Coronavirus Disease (COVID-19): A Multicenter European Study	Lechien, J.R.	*European Archives of Otorhinolaryngology*
4	Large-Vessel Stroke as a Presenting Feature of COVID-19 in the Young	Oxley, T.J.	*New England Journal of Medicine*
5	A First Case of Meningitis/Encephalitis Associated with SARS-Coronavirus-2	Moriguchi, T.	*International Journal of Infectious Diseases*
6	Nervous System Involvement After Infection with COVID-19 and Other Coronaviruses	Wu, Y.	*Brain, Behavior, and Immunity*
7	Central Nervous System Manifestations of COVID-19: A Systematic Review	Asadi-Pooya, A.A.	*Journal of the Neurologic Sciences*
8	Neurological Associations of COVID-19	Ellul, M.A.	*The Lancet Neurology*
9	Miller Fisher Syndrome and Polyneuritis Cranialis in COVID-19	Gutierrez-Ortiz, C.	*Neurology*
10	Characteristics of Ischaemic Stroke Associated with COVID-19	Beyrouti, R.	*Journal of Neurology, Neurosurgery and Psychiatry*
11	Anosmia and Ageusia: Common Findings in COVID-19 Patients	Vaira, L.A.	*Laryngoscope*
12	Central Nervous System Involvement by Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2)	Paniz-Mondolfi, A.	*Journal of Medical Virology*
13	Smell Dysfunction: A Biomarker for COVID-19	Moein, S.T.	*International Forum of Allergy and Rhinology*
14	COVID-19 Presenting as Stroke	Avula, A.	*Brain, Behavior, and Immunity*
15	Guillain Barre Syndrome Associated with COVID-19 Infection: A Case Report	Sedaghat, Z.	*Journal of Clinical Neuroscience*
16	Are We Facing a Crashing Wave of Neuropsychiatric Sequelae of COVID-19? Neuropsychiatric Symptoms and Potential Immunologic Mechanisms	Troyer, E.A.	*Brain, Behavior, and Immunity*
17	Neurological and Neuropsychiatric Complications of COVID-19 in 153 Patients: A UK-wide Surveillance Study	Varatharaj, A.	*The Lancet Psychiatry*
18	SARS-CoV-2 and Stroke in a New York Healthcare System	Yaghi, S.	*Stroke*
18	Self-Reported Olfactory Loss Associates with Outpatient Clinical Course in COVID-19	Yan, C.H.	*International Forum of Allergy and Rhinology*
20	Dementia Care During COVID-19	Wang, H.	*The Lancet*

the top 4 countries performing COVID-19—related research.[16-18] Intuitively, China had a significant proportion of the most cited articles because it is where the disease was first described. Similarly, Italy was one of the early hotspots of the pandemic. The burden of disease in the United States and the United Kingdom peaked at the end of 2020,[18-20] resulting in a larger number of COVID-19 patients. The United States, the United Kingdom, Italy, and Germany are also classified as high-income countries, which spend a greater percentage of their gross domestic product on research and development compared with lower income countries.[21] These countries have also been identified as scientifically advanced, with the most positive ranking in terms of scientific capacity.[22,23]

Another finding was that 36% of the published articles in the list were multicountry collaborations. A report on research productivity output in the pre—COVID-19 era showed that 1 out of 5 publications involved >1 country,[24] but in our bibliometric analysis, the ratio increased to 1 out of 3.[23] These publications had an average of 2.1 collaborations between authors from different countries, but the study with the highest number involved authors from 10 different countries.[25] In this article, the authors recommended the establishment of local and international registries to report COVID-19 cases with neurologic manifestations to help define the true neuroepidemiological status of the disease.[25] These collaborations highlight the active involvement and scientific globalism in response to the crisis.[26]

Table 2. Top Journals in the 100 Cited Articles

Journal	Number of Articles	SJR	IF	Quartile
Neurology	7	3.01	8.770	Q1
JAMA Neurology	6	4.49	13.608	Q1
Brain, Behavior, and Immunity	5	2.58	6.633	Q1
Stroke	5	3.1	7.19	Q1
Acta Neurochirurgica	4	0.75	1.817	Q1
International Forum of Allergy and Rhinology	4	1.28	1.284	Q1
European Journal of Neurology	3	1.7	4.516	Q1
Journal of Medical Virology	3	0.86	3.376	Q2
Journal of Neurological Sciences	3	0.996	3.115	Q2
Journal of Neurology, Neurosurgery and Psychiatry	3	3.27	8.234	Q1
Radiology	3	2.99	7.931	Q1
The Lancet	3	14.55	60.392	Q1
The Lancet Neurology	3	11.26	30.039	Q1

SJR, SCImago Journal Rank; IF, impact factor (as of 2019—2020).

Table 3. Specialties of the Primary Author Contributing to Top 100 Cited Articles

Specialty	Number of Articles
Neurology	54
Otorhinolaryngology	11
Neurosurgery	6
Radiology	6
Pathology	5
Neurobiology/basic neuroscience	4
Psychiatry	3
Pulmonary and critical care	3
Anesthesiology	2
General medicine	2
Internal medicine	2
Medical physics/engineering	2
Cardiology	1
Histology	1
Ophthalmology	1

Sharing knowledge and experiences accelerates the understanding of a novel disease and hastens the establishment of practice guidelines.[26]

The article titled "Neurologic Manifestations of Hospitalized Patients with Coronavirus Disease 2019 in Wuhan, China" by Mao et al. was the most cited article. In this retrospective review of 214 patients in Wuhan, China, the epicenter of the outbreak, it was found that 36.4% of patients with COVID-19 presented with neurologic manifestations that mostly occurred early in the course of the disease (median: 1—2 days).[11] This article was the first to report in detail on neurologic manifestations in patients with COVID-19. It was posted as a preprint on medRxiv on February 25, 2020[27] and was later published online in *JAMA Neurology* on April 10, 2020. It is not surprising that a landmark article such as this, published in a high-impact journal, was the most cited article on COVID-19 and neurology since the pandemic started. This study alerted clinicians and researchers regarding the involvement of the nervous system by COVID-19 and has been pivotal in subsequent management and research strategies for the disease. In fact, several other articles in the top 100 have cited this study as well.

A review of the second to fifth most cited studies in the series showed that all were published during the early part of the pandemic (February to April 2020). The second most cited study was the first to elaborate on the neuroinvasive potential of the disease and proposed a model of how the virus affected the central nervous system.[28] The third to fifth most cited studies reported novel neurologic manifestations of COVID-19.[29-31]

It was previously thought that the virus merely affected the respiratory system and spared the nervous system, but this was proven to be incorrect as more and more articles shed light onto the spectrum of neurologic signs and symptoms brought about by COVID-19.[32] In fact, more than half of the studies (53%) in the analysis were descriptions of the neurologic involvement in COVID-19 and outcomes. The rest of the articles discussed health service delivery (21%), pathophysiologic mechanisms (15%), radiologic findings (6%), and treatment (5%) (Figure 2).

One of the most important neurologic symptoms distinctly associated with COVID-19 was olfactory dysfunction, which was discussed in 13 of 100 articles. Moein et al.[33] even suggested that smell dysfunction was a potential biomarker for COVID-19 infection and could be used in some cases to identify patients in need of early treatment or quarantine. Other neurologic presentations included autoimmune polyneuropathies (Guillain-Barré syndrome,[34-37] Miller Fisher syndrome[38]), seizures,[39,40] and meningitis.[31,41]

There were 16 articles in the top 100 that showed association of the infection with cerebrovascular disease. The earliest of these articles were case reports of patients with COVID-19 presenting with stroke, followed by case series and cohort studies of patients with COVID-19 in different centers in whom stroke was diagnosed. Ischemic stroke was more common than intracranial hemorrhage,[42] and ischemic strokes have been found to occur in patients with COVID-19 who were <50 years old.[30] It was postulated that hypercoagulability and endothelial dysfunction contributed to strokes in patients with COVID-19,[43] and the presence of cerebrovascular disease in patients with COVID-19 has been suggested to be a negative prognostic factor.[42,43]

Table 4. Countries of Origin of Top 100 Cited Articles

Country	Number of Articles
United States	32
Italy	16
United Kingdom	14
China	12
Germany	5
Spain	4
France	3
Iran	3
Belgium	2
Canada	2
Pakistan	2
Brazil	1
Colombia	1
Indonesia	1
Japan	1
Netherlands	1
Poland	1
Singapore	1
Switzerland	1

Figure 1. Types of articles published in the top 100 most cited articles.

There were 21 studies that discussed the impact of the pandemic on patients with neurologic diseases such as stroke, demyelinating disease, movement disorder, and neuromuscular

Table 5. Institutions with More Than 1 Article in the Top 100 Articles

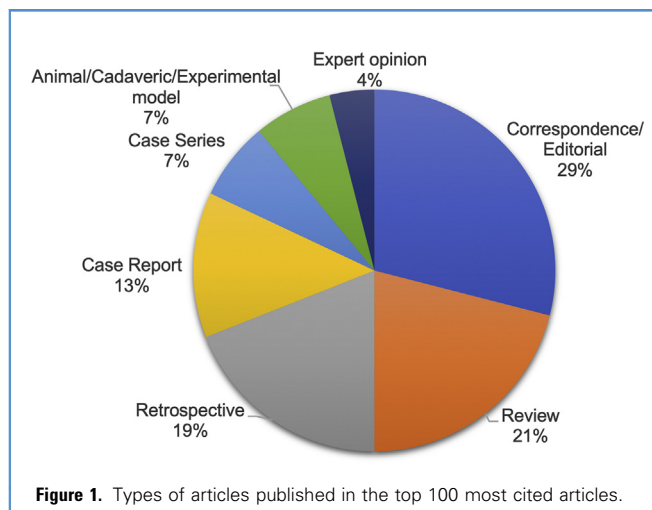| Institution	Number of Articles
Harvard Medical School, United States	4
University Hospital of Sassari, Italy	3
Fudan University, China	2
Huazhong University of Science and Technology, China	2
Icahn School of Medicine at Mount Sinai, United States	2
New York University, United States	2
Peking University, China	2
Thomas Jefferson University, United States	2
University of Brescia, Italy	2
University of California San Diego, United States	2
University of California San Francisco, United States	2
University of Cambridge, United Kingdom	2
University of Toronto, Canada	2
Weill Cornell Medical College, United States	2

disorder. There was concern over fewer patients with acute stroke going to the hospital for fear of contracting the infection, resulting in treatment delays.[44] It was also during the pandemic that the protected stroke code was developed and implemented. Khosravani et al.[45] presented an algorithm developed for stroke codes in pandemic times that involved screening, personal protective equipment, and crisis resource management, and this was adapted in other institutions as well.[45]

Of the top 100 articles, 5 discussed the impact of COVID-19 on neurosurgery. These articles highlighted the reorganization and adjustment that neurosurgeons faced during the pandemic and described the shift in practices. Two articles focused on endoscopic procedures that posed an additional, unique risk to neurosurgeons owing to the high nasal viral titers and potential for aerosol generation during nasal surgery. The authors advocated the safety of the surgical team and proposed recommendations
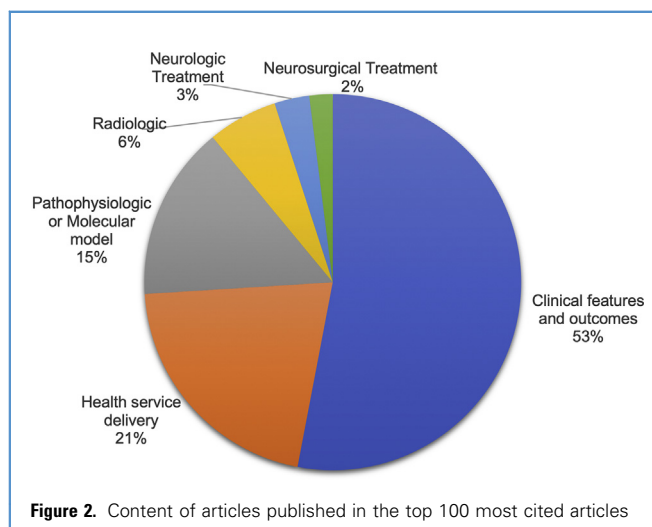

Figure 2. Content of articles published in the top 100 most cited articles

and mitigation strategies.[46,47] The letter to the editor by Burke et al.[48] proposed an algorithm and checklist for a contingency plan for neurosurgical patients during the pandemic. Their article established a set of protocols for scheduling of neurosurgical cases that could be adapted for use in local neurosurgical practices.

Although the search query was performed in March 2021, the studies in the top 100 included only articles published from March to November 2020. When the studies were arranged in chronological order, the first 10 articles published were different from the last 10 in terms of article type and content. Studies that were published during the early part of the pandemic (February to April 2020) were either case reports of the neurologic manifestations of COVID-19 (ranks 1, 9, and 33) or articles on how COVID-19 would impact the management of neurologic diseases (ranks 20, 32, 36, 51, 63, 67, and 87). In comparison, the studies published in October to November 2020 dealt with the neuroradiologic (ranks 57, 61, and 63) and neuropathologic (ranks 61 and 98) aspects of the disease as well as the neurologic complications (ranks 17, 25, and 63). This may reflect the evolution of our understanding of the disease over time.

Almost one third of the articles were correspondence or editorial articles. This was probably due to the novel nature of the disease, as it was only very recently described. There were no randomized controlled trials or prospective studies in the top 100 and very few retrospective studies. Previous literature on the characteristics of COVID-19 publications reported the same findings.[49,50] Our study highlights the need for more rigorous and high-quality study designs, possibly involving multiple high-volume centers, to investigate the neurologic complications of the disease.

The top 100 most cited articles have highlighted the most impactful articles in the field of neurology and neurosurgery. These represent seminal contributions and discoveries that are the driving force of how we currently manage COVID-19 patients with neurologic involvement. The content of the articles have evolved from clinical presentation to diagnostic findings to treatment strategies and practice recommendations and are invaluable in our fight against the scourge of the pandemic.

Limitations

This study has several limitations. First, we performed our search using only the SCOPUS database. Second, only English-language publications were included in the study. Articles that were written in other languages (e.g., Chinese) were not included. Third, owing to the exponential increase in the number of studies, the list of the top cited articles is expected to change over time. Lastly, citation count is only an indirect measure of scientific impact and may be influenced by other factors, such as journal accessibility and reputation.

CONCLUSIONS

This study has identified the top 100 most cited neurologic or neurosurgical COVID-19—related articles published to date. Because of the exponential growth of the literature on this emerging disease, a bibliometric analysis is useful to identify high-impact studies that help health care practitioners in clinical decision making and researchers in mapping key areas of study and identifying gaps in knowledge.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Kevin Ivan P. Chan: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing — original draft, Writing — review & editing. **Katrina Hannah D. Ignacio:** Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing — original draft, Writing — review & editing. **Abdelsimar Tan Omar:** Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing — original draft, Writing — review & editing. **Kathleen Joy O. Khu:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing — original draft, Writing — review & editing.

REFERENCES

1. Srivastava N, Baxi P, Ratho RK, Saxena SK. Global trends in epidemiology of coronavirus disease 2019 (COVID-19). *Coronavirus Disease 2019 (COVID-19)*. 2020:9-21. https://doi.org/10.1007/978-981-15-4814-7_2. Accessed October 17, 2021.

2. Singh R, Kang A, Luo X, et al. COVID-19: current knowledge in clinical features, immunological responses, and vaccine development. *FASEB J*. 2021;35:1-23.

3. Dimensions COVID-19 Report. *Digital Science*; 2021. Available at: https://reports.dimensions.ai/covid-19/. Accessed May 29, 2021.

4. Patel KP, Patel PA, Vunnam RR, et al. Gastrointestinal, hepatobiliary, and pancreatic manifestations of COVID-19. *J Clin Virol*. 2020;128:104386.

5. Kochi AN, Tagliari AP, Forleo GB, Fassini GM, Tondo C. Cardiac and arrhythmic complications in patients with COVID-19. *J Cardiovasc Electrophysiol*. 2020;31:1003-1008.

6. Genovese G, Moltrasio C, Berti E, Marzano AV. Skin manifestations associated with COVID-19: current knowledge and future perspectives. *Dermatology*. 2021;237:1-12.

7. Winkelmayer WC, Khairallah P, Charytan DM. Nephrology and COVID-19. *JAMA*. 2020;324:1137.

8. Agbuduwe C, Basu S. Haematological manifestations of COVID-19: from cytopenia to coagulopathy. *Eur J Haematol*. 2020;105:540-546.

9. Sen M, Honavar SG, Sharma N, Sachdev MS. COVID-19 and eye: a review of ophthalmic manifestations of COVID-19. *Indian J Ophthalmol*. 2021;69:488-509.

10. Collantes MEV, Espiritu AI, Sy MCC, Anlacan VMM, Jamora RDG. Neurological manifestations in COVID-19 infection: a systematic review and meta-analysis. *Can J Neurol Sci*. 2021;48:66-76.

11. Mao L, Jin H, Wang M, et al. Neurologic manifestations of hospitalized patients with coronavirus disease 2019 in Wuhan, China. *JAMA Neurol*. 2020;77:683-690.

12. Sharifian-Dorche M, Huot P, Osherov M, et al. Neurological complications of coronavirus infection; a comparative review and lessons learned during the COVID-19 pandemic. *J Neurol Sci*. 2020; 417:117085.

13. Panagopoulos D, Karydakis P, Giakoumettis D, Themistocleous M. The 100 most cited papers about brain metastases. *World Neurosurg*. 2020;138: 98-114.

14. Kambhampati SBS, Vaishya R, Vaish A. Unprecedented surge in publications related to COVID-19 in the first three months of pandemic: a bibliometric analytic report. *J Clin Orthop Trauma*. 2020; 11(Suppl 3):S304-S306.

15. American Academy of Neurology. COVID-19 and neurologic disease. Available at: https://www.neurology.org/covid. Accessed April 4, 2021.

16. De Felice F, Polimeni A. Coronavirus disease (COVID-19): a machine learning bibliometric analysis. *In Vivo*. 2020;34(3 Suppl):1613-1617.

17. Gong Y, Ma T, Xu Y, et al. Early research on COVID-19: a bibliometric analysis. *Innovation (N Y)*. 2020;1:100027.

18. Zyoud SH, Al-Jabi SW. Mapping the situation of research on coronavirus disease-19 (COVID-19): a preliminary bibliometric analysis during the early stage of the outbreak. *BMC Infect Dis*. 2020;20:1-8.

19. Gupta S, Kumar Patel K, Sivaraman S, Mangal A. Global epidemiology of first 90 days into COVID-19 pandemic: disease incidence, prevalence, case fatality rate and their association with population density, urbanisation and elderly population. *J Health Manag*. 2020;22:117-128.

20. Rozanova L, Temerev A, Flahault A. Comparing the scope and efficacy of COVID-19 response strategies in 16 countries: an overview. *Int J Environ Res Public Health*. 2020;17:1-17.

21. World Bank. *World Development Report 2021: Data for Better Lives*. Washington, DC: World Bank; 2021.

22. Wagner CS, Brahmakulam I, Jackson B, Wong A, Yoda T. *Building Capacity in Developing Countries?*. Santa Monica, CA: RAND; 2001.

23. Lee JJ, Haupt JP. Scientific globalism during a global crisis: research collaboration and open access publications on COVID-19. *High Educ (Dordr)*. 2021;81:949-966.

24. National Science Board, National Science Foundation. Publication Output: U.S. Trends and International Comparisons. Science and Engineering Indicators 2020. Available at: https://ncses.nsf.gov/pubs/nsb20206/. Accessed October 17, 2021.

25. Román GC, Spencer PS, Reis J, et al. The neurology of COVID-19 revisited: a proposal from the Environmental Neurology Specialty Group of the World Federation of Neurology to implement international neurological registries. *J Neurol Sci*. 2020;414:116884.

26. Bump J, Friberg P, Harper DR. International collaboration and COVID-19: what are we doing and where are we going? *BMJ*. 2021;372:n180.

27. Mao L, Wang M, Chen S, et al. Neurological manifestations of hospitalized patients with COVID-19 in Wuhan, China: a retrospective case series study. Posted online February 25, 2020. medRxiv 20026500. https://doi.org/10.1101/2020.02.22.20026500. Accessed May 29, 2021.

28. Li YC, Bai WZ, Hashikawa T. The neuroinvasive potential of SARS-CoV2 may play a role in the respiratory failure of COVID-19 patients. *J Med Virol*. 2020;92:552-555.

29. Lechien JR, Chiesa-Estomba CM, De Siati DR, et al. Olfactory and gustatory dysfunctions as a clinical presentation of mild-to-moderate forms of the coronavirus disease (COVID-19): a multicenter European study. *Eur Arch Otorhinolaryngol*. 2020; 277:2251-2261.

30. Oxley TJ, Mocco J, Majidi S, et al. Large-vessel stroke as a presenting feature of COVID-19 in the young. *N Engl J Med*. 2020;382:e60.

31. Moriguchi T, Harii N, Goto J, et al. A first case of meningitis/encephalitis associated with SARS-coronavirus-2. *Int J Infect Dis*. 2020;94:55-58.

32. Josephson SA, Kamel H. Neurology and COVID-19. *JAMA*. 2020;324:1139.

33. Moein ST, Hashemian SMR, Mansourafshar B, Khorram-Tousi A, Tabarsi P, Doty RL. Smell dysfunction: a biomarker for COVID-19. *Int Forum Allergy Rhinol*. 2020;10:944-950.

34. Alberti P, Beretta S, Piatti M, et al. Guillain-Barré syndrome related to COVID-19 infection. *Neurol Neuroimmunol Neuroinflamm*. 2020;7:e741.

35. Sedaghat Z, Karimi N. Guillain Barre syndrome associated with COVID-19 infection: a case report. *J Clin Neurosci*. 2020;76:233-235.

36. Virani A, Rabold E, Hanson T, et al. Guillain-Barré syndrome associated with SARS-CoV-2 infection. *IDCases*. 2020;20:e00771.

37. Camdessanche JP, Morel J, Pozzetto B, Paul S, Tholance Y, Botelho-Nevers E. COVID-19 may induce Guillain-Barré syndrome. *Rev Neurol (Paris)*. 2020;176:516-518.

38. Gutiérrez-Ortiz C, Méndez-Guerrero A, Rodrigo-Rey S, et al. Miller Fisher syndrome and polyneuritis cranialis in COVID-19. *Neurology*. 2020;95: e601-e605.

39. Vollono C, Rollo E, Romozzi M, et al. Focal status epilepticus as unique clinical feature of COVID-19: a case report. *Seizure*. 2020;78:109-112.

40. Dixon L, Varley J, Gontsarova A, et al. COVID-19-related acute necrotizing encephalopathy with brain stem involvement in a patient with aplastic anemia. *Neurol Neuroimmunol Neuroinflamm*. 2020;7: e789.

41. Duong L, Xu P, Liu A. Meningoencephalitis without respiratory failure in a young female patient with COVID-19 infection in Downtown Los Angeles, early April 2020. *Brain Behav Immun*. 2020; 87:33.

42. Li Y, Li M, Wang M, et al. Acute cerebrovascular disease following COVID-19: a single center, retrospective, observational study. *Stroke Vasc Neurol*. 2020;5:279-284.

43. Hess DC, Eldahshan W, Rutkowski E. COVID-19-related stroke. *Transl Stroke Res*. 2020;11:322-325.

44. Richter D, Eyding J, Weber R, et al. Analysis of nationwide stroke patient care in times of COVID-19 pandemic in Germany. *Stroke*. 2021;52:716-721.

45. Khosravani H, Rajendram P, Notario L, Chapman MG, Menon BK. Protected code stroke: hyperacute stroke management during the coronavirus disease 2019 (COVID-19) pandemic. *Stroke*. 2020;51:1891-1895.

46. Workman AD, Welling DB, Carter BS, et al. Endonasal instrumentation and aerosolization risk in the era of COVID-19: simulation, literature review, and proposed mitigation strategies. *Int Forum Allergy Rhinol*. 2020;10:798-805.

47. Patel ZM, Fernandez-Miranda J, Hwang PH, et al. Letter: Precautions for endoscopic transnasal skull base surgery during the COVID-19 pandemic. *Neurosurgery*. 2020;87:E66-E67.

48. Burke JF, Chan AK, Mummaneni V, et al. Letter: The coronavirus disease 2019 global pandemic: a neurosurgical treatment algorithm. *Neurosurgery*. 2020;87:E50-E56.

49. Di Girolamo N, Meursinge Reynders R. Characteristics of scientific articles on COVID-19 published during the initial 3 months of the pandemic. *Scientometrics*. 2020;125:795-812.

50. Kagan D, Moran-Gilad J, Fire M. Scientometric trends for coronaviruses and other emerging viral infections. *GigaScience*. 2020;9:giaa085.

Supplemental Table 1. Top 100 Cited Articles

Rank	Title	First Author	Journal	Citations
1	Neurologic Manifestations of Hospitalized Patients with Coronavirus Disease 2019 in Wuhan, China.	Mao, L.	*JAMA Neurology*	1741
2	The Neuroinvasive Potential of SARS-CoV2 May Play a Role in the Respiratory Failure of COVID-19 Patients	Li, Y.	*Journal of Medical Virology*	757
3	Olfactory and Gustatory Dysfunctions as a Clinical Presentation of Mild-to-Moderate Forms of the Coronavirus Disease (COVID-19): A Multicenter European Study	Lechien, J.R.	*European Archives of Otorhinolaryngology*	724
4	Large-Vessel Stroke as a Presenting Feature of COVID-19 in the Young	Oxley, T.J.	*New England Journal of Medicine*	698
5	A First Case of Meningitis/Encephalitis Associated with SARS-Coronavirus-2	Moriguchi, T.	*International Journal of Infectious Diseases*	624
6	Nervous System Involvement After Infection with COVID-19 and Other Coronaviruses	Wu, Y.	*Brain, Behavior, and Immunity*	515
7	Central Nervous System Manifestations of COVID-19: A Systematic Review	Asadi-Pooya, A.A.	*Journal of the Neurologic Sciences*	245
8	Neurological Associations of COVID-19	Ellul, M.A.	*The Lancet Neurology*	228
9	Miller Fisher Syndrome and Polyneuritis Cranialis in COVID-19	Gutierrez-Ortiz, C.	*Neurology*	223
10	Characteristics of Ischaemic Stroke Associated with COVID-19	Beyrouti, R.	*Journal of Neurology, Neurosurgery and Psychiatry*	219
11	Anosmia and Ageusia: Common Findings in COVID-19 Patients	Vaira, L.A.	*Laryngoscope*	216
12	Central Nervous System Involvement by Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2)	Paniz- Mondolfi, A.	*Journal of Medical Virology*	211
13	Smell Dysfunction: A Biomarker for COVID-19	Moein, S.T.	*International Forum of Allergy and Rhinology*	209
14	COVID-19 Presenting as Stroke	Avula, A.	*Brain, Behavior, and Immunity*	191
15	Guillain Barre Syndrome Associated with COVID-19 Infection: A Case Report	Sedaghat, Z.	*Journal of Clinical Neuroscience*	187
16	Are We Facing a Crashing Wave of Neuropsychiatric Sequelae of COVID-19? Neuropsychiatric Symptoms and Potential Immunologic Mechanisms	Troyer, E.A.	*Brain, Behavior, and Immunity*	178
17	Neurological and Neuropsychiatric Complications of COVID-19 in 153 Patients: A UK-wide Surveillance Study	Varatharaj, A.	*The Lancet Psychiatry*	169
18	SARS-CoV-2 and Stroke in a New York Healthcare System	Yaghi, S.	*Stroke*	158
18	Self-Reported Olfactory Loss Associates with Outpatient Clinical Course in COVID-19	Yan, C.H.	*International Forum of Allergy and Rhinology*	158
20	Dementia Care During COVID-19	Wang, H.	*The Lancet*	154
21	Endonasal Instrumentation and Aerosolization Risk in the Era of COVID-19: Simulation, Literature Review, and Proposed Mitigation Strategies	Workman, A.D.	*International Forum of Allergy and Rhinology*	153
22	Acute-Onset Smell and Taste Disorders in the Context of COVID-19: A Pilot Multicentre Polymerase Chain Reaction Based Case—Control Study	Beltran-Corbellina, A.	*European Journal of Neurology*	151
23	Neuropathogenesis and Neurologic Manifestations of the Coronaviruses in the Age of Coronavirus Disease 2019: A Review	Zubair, A.S.	*JAMA Neurology*	146
24	Neuropathological Features of Covid-19	Solomon, I.H.	*New England Journal of Medicine*	137
25	The Emerging Spectrum of COVID-19 Neurology: Clinical, Radiological and Laboratory Findings	Paterson, R.W.	*Brain*	133
26	Acute Cerebrovascular Disease Following COVID-19: A Single Center, Retrospective, Observational Study	Li, Y.	*Stroke and Vascular Neurology*	129
27	Dementia Prevention, Intervention, and Care: 2020 Report of the Lancet Commission	Livingston, G.	*The Lancet*	127
				Continues

Rank	Title	First Author	Journal	Citations
28	Letter: Precautions for Endoscopic Transnasal Skull Base Surgery During the COVID-19 Pandemic	Patel, Z.M.	Neurosurgery	125
29	Guillain-Barré Syndrome Related to COVID-19 Infection	Alberti, P.	Neurology: Neuroimmunology and Neuroinflammation	121
30	Neurologic Manifestations in Hospitalized Patients with COVID-19: The ALBACOVID Registry	Romero-Sanchez, C.M.	Neurology	119
31	Presentation of New Onset Anosmia During the COVID-19 Pandemic	Hopkins, C.	Rhinology	122
32	Protected Code Stroke: Hyperacute Stroke Management During the Coronavirus Disease 2019 (COVID-19) Pandemic	Khosravani, H.	Stroke	114
33	Guillain-Barré Syndrome Associated with SARS-CoV-2 Infection	Virani, A.	IDCases	112
34	Neurological Manifestations of COVID-19 and Other Coronavirus Infections: A Systematic Review	Montalvan, V.	Clinical Neurology and Neurosurgery	111
35	Smell and Taste Dysfunction in Patients with COVID-19	Xydakis, M.S.	The Lancet Infectious Diseases	109
36	The Prevalence of Olfactory and Gustatory Dysfunction in COVID-19 Patients: A Systematic Review and Meta-Analysis	Tong, J.Y.	Otolaryngology—Head and Neck Surgery	108
36	COVID-19: ICU Delirium Management During SARS-CoV-2 Pandemic	Kotfis, K.	Critical Care	108
38	COVID-19 and Stroke—A Global World Stroke Organization Perspective	Markus, H.S.	International Journal of Stroke	106
39	New Onset Acute Symptomatic Seizure and Risk Factors in Coronavirus Disease 2019: A Retrospective Multicenter Study	Lu, L.	Epilepsia	104
40	SARS-CoV-2 Can Induce Brain and Spine Demyelinating Lesions	Zanin, L.	Acta Neurochirurgica	103
40	Neuropathology of COVID-19: A Spectrum of Vascular and Acute Disseminated Encephalomyelitis (ADEM)-like Pathology	Reichard, R.R.	Acta Neurochirurgica	103
40	COVID-19-Related Stroke	Hess, D.C.	Translational Stroke Research	103
43	Neurological Complications of Coronavirus and COVID-19	Carod-Artal, F.J.	Revista de Neurologia	97
44	Non-Neuronal Expression of SARS-CoV-2 Entry Genes in the Olfactory System Suggests Mechanisms Underlying COVID-19-Associated Anosmia	Brann, D.H.	Science Advances	96
45	Status of SARS-CoV-2 in Cerebrospinal Fluid of Patients with COVID-19 and Stroke	Al Saiegh, F.	Journal of Neurology, Neurosurgery and Psychiatry	94
46	Anticipating and Mitigating the Impact of the COVID-19 Pandemic on Alzheimer's Disease and Related Dementias	Brown, E.E.	American Journal of Geriatric Psychiatry	93
47	Guillain-Barré syndrome Following COVID-19: New Infection, Old Complication?	Padroni, M.	Journal of Neurology	91
47	Meningoencephalitis without Respiratory Failure in a Young Female Patient with COVID-19 Infection in Downtown Los Angeles, Early April 2020	Duong, L.	Brain, Behavior, and Immunity	91
49	Neuroinfection May Contribute to Pathophysiology and Clinical Manifestations of COVID-19	Steardo, L.	Acta Physiologica	90
50	Does SARS-CoV-2 Invade the Brain? Translational Lessons from Animal Models	Natoli, S.	European Journal of Neurology	89
51	Challenges and Potential Solutions of Stroke Care during the Coronavirus Disease 2019 (COVID-19) Outbreak	Zhao, J.	Stroke	86
52	Magnetic Resonance Imaging Alteration of the Brain in a Patient with Coronavirus Disease 2019 (COVID-19) and Anosmia	Politi, L.S.	JAMA Neurology	85
53	Impact of Cerebrovascular and Cardiovascular Diseases on Mortality and Severity of COVID-19—Systematic Review, Meta-Analysis, and Meta-Regression	Pranata, R.	Journal of Stroke and Cerebrovascular Diseases	84

Supplemental Table 1. Continued

Continues

Rank	Title	First Author	Journal	Citations
Supplemental Table 1. Continued				
53	Treating Multiple Sclerosis and Neuromyelitis Optica Spectrum Disorder During the COVID-19 Pandemic	Brownlee, W.	*Neurology*	84
55	An Italian Programme for COVID-19 Infection in Multiple Sclerosis	Sormani, M.P.	*The Lancet Neurology*	83
56	The Baffling Case of Ischemic Stroke Disappearance from the Casualty Department in the COVID-19 Era	Morelli, N.	*European Neurology*	82
57	Brain MRI Findings in Patients in the Intensive Care Unit with COVID-19 Infection	Kandemirli, S.G.	*Radiology*	81
57	Management of Post-Acute COVID-19 in Primary Care	Greenhalgh, T.	*The British Medical Journal*	81
57	COVID-19 Presenting with Ophthalmoparesis from Cranial Nerve Palsy	Dinkin, M.	*Neurology*	81
57	Neurological Manifestations in COVID-19 Caused by SARS-CoV-2	Baig, A.M.	*CNS Neuroscience and Therapeutics*	81
61	Brain MRI Findings in Severe COVID-19: A Retrospective Observational Study	Kremer, S.	*Radiology*	80
61	Neuropilin-1 Facilitates SARS-CoV-2 Cell Entry and Infectivity	Cantuti-Castelvetri, L.	*Science*	80
63	Risk of Ischemic Stroke in Patients with Coronavirus Disease 2019 (COVID-19) versus Patients with Influenza	Merkler, A.E.	*JAMA Neurology*	78
63	COVID-19—Associated Diffuse Leukoencephalopathy and Microhemorrhages	Radmanesh, A.	*Radiology*	78
63	Neurological Manifestations and Complications of COVID-19: A Literature Review	Ahmad, I.	*Journal of Clinical Neuroscience*	78
63	The COVID-19 Pandemic and the Use of MS Disease—Modifying Therapies	Giovannoni, G.	*Multiple Sclerosis and Related Disorders*	78
67	The Impact of the COVID-19 Pandemic on Parkinson's Disease: Hidden Sorrows and Emerging Opportunities	Helmich, R.C.	*Journal of Parkinson's Disease*	76
68	Olfactory and Gustatory Function Impairment in COVID-19 Patients: Italian Objective Multicenter-Study	Vaira, L.A.	*Head and Neck*	74
69	Neurosurgery During the COVID-19 Pandemic: Update from Lombardy, Northern Italy	Zoia, C.	*Acta Neurochirurgica*	73
69	Stroke in Patients with SARS-CoV-2 Infection: Case Series	Morassi, M.	*Journal of Neurology*	73
71	Letter: The Coronavirus Disease 2019 Global Pandemic: A Neurosurgical Treatment Algorithm	Burke, J.F.	*Neurosurgery*	71
72	Steroid-Responsive Encephalitis in Coronavirus Disease 2019	Pilotto, A.	*Annals of Neurology*	70
73	COVID-19: A Global Threat to the Nervous System	Koralnik, I.J.	*Annals of Neurology*	69
74	Impact of the COVID-19 Epidemic on Stroke Care and Potential Solutions	Zhao, J.	*Stroke*	68
75	Guillain-Barré Syndrome During SARS-CoV-2 Pandemic: A Case Report and Review of Recent Literature	Scheidl, E.	*Journal of Peripheral Nervous System*	66
76	Clinical Characteristics and Outcomes in Patients with Coronavirus Disease 2019 and Multiple Sclerosis	Louapre, C.	*JAMA Neurology*	65
77	Two Patients with Acute Meningoencephalitis Concomitant with SARS-CoV-2 Infection	Bernard-Valnet, R.	*European Journal of Neurology*	64
77	Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) and the Central Nervous System	De Felice, F.G.	*Trends in Neurosciences*	64
77	Focal Status Epilepticus as Unique Clinical Feature of COVID-19: A Case Report	Vollono, C.	*Seizure*	64
80	SARS-CoV-2 Detected in Cerebrospinal Fluid by PCR in a Case of COVID-19 Encephalitis	Huang, Y.H.	*Brain, Behavior, and Immunity*	62
				Continues

Rank	Title	First Author	Journal	Citations
	Supplemental Table 1. Continued			
80	Consensus for Prevention and Management of Coronavirus Disease 2019 (COVID-19) for Neurologists	Jin, H.	*Stroke and Vascular Neurology*	62
80	Acute Stroke Care Is at Risk in the Era of COVID-19: Experience at a Comprehensive Stroke Center in Barcelona	Rudilosso, S.	*Stroke*	62
83	Concomitant Neurological Symptoms Observed in a Patient Diagnosed with Coronavirus Disease 2019	Yin, R.	*Journal of Medical Virology*	61
83	COVID-19 and Neuromuscular Disorders	Guidon, A.C.	*Neurology*	61
83	COVID-19 May Induce Guillain-Barré Syndrome	Camdessanche, J.P.	*Revue Neurologique*	61
86	The Neurology of COVID-19 Revisited: A Proposal from the Environmental Neurology Specialty Group of the World Federation of Neurology to Implement International Neurological Registries	Roman, G.C.	*Journal of Neurological Sciences*	60
87	Neurotropism of SARS-CoV 2: Mechanisms and Manifestations	Conde-Cardona, G.	*Journal of Neurological Sciences*	59
87	Headaches Associated with Personal Protective Equipment—A Cross-Sectional Study Among Frontline Healthcare Workers During COVID-19	Ong, J.J.	*Headache*	59
87	Impact of the COVID-19 Pandemic on Parkinson's Disease and Movement Disorders	Papa, S.M.	*Movement Disorders*	59
90	Early Evidence of Pronounced Brain Involvement in Fatal COVID-19 Outcomes	Von Weyhern, C.H.	*The Lancet*	58
90	Early Guillain-Barré Syndrome in Coronavirus Disease 2019 (COVID-19): A Case Report from an Italian COVID-Hospital	Ottaviani, D.	*Neurological Sciences*	58
90	The Impact of COVID-19 on Neurosurgeons and the Strategy for Triaging Non-Emergent Operations: A Global Neurosurgery Study	Jean, W.C.	*Acta Neurochirurgica*	58
93	Neurological Implications of COVID-19 Infections	Needham, E.J.	*Neurocritical Care*	57
94	COVID-19-Related Acute Necrotizing Encephalopathy with Brain Stem Involvement in a Patient with Aplastic Anemia	Dixon, L.	*Neurology: Neuroimmunology and Neuroinflammation*	56
94	The Spectrum of Neurologic Disease in the Severe Acute Respiratory Syndrome Coronavirus 2 Pandemic Infection: Neurologists Move to the Frontlines	Pleasure, S.J.	*JAMA Neurology*	56
96	Potential Neurological Symptoms of COVID-19	Wang, H.Y.	*Therapeutic Advances in Neurologic Disorders*	56
97	Neurological Manifestations of COVID-19: A Systematic Review and Current Update	Whittaker, A.	*Acta Neurologica Scandinavica*	54
98	Neuropathology of Patients with COVID-19 in Germany: A Post-Mortem Case Series	Matschke, J.	*The Lancet Neurology*	53
98	Early Postmortem Brain MRI Findings in COVID-19 Non-Survivors	Coolen, T.	*Neurology*	53
100	Neurological Manifestations of Patients with COVID-19: Potential Routes of SARS-CoV-2 Neuroinvasion from the Periphery to the Brain	Li, Z.	*Frontiers of Medicine*	52
100	Potential Pathogenesis of Ageusia and Anosmia in COVID-19 Patients	Vaira, L.A.	*International Forum of Allergy and Rhinology*	52
100	Olfactory Dysfunction in COVID-19: Diagnosis and Management	Whitcroft, K.L.	*JAMA*	52
100	COVID-19 Is Catalyzing the Adoption of Teleneurology	Klein, B.C.	*Neurology*	52