

# Olfactory and Gustatory Dysfunction in COVID-19: A Global Bibliometric and Visualized Analysis

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## Abstract

**Objectives:** Coronavirus illness (COVID-19) has been found to alter infected people's sense of smell and taste. However, the pathobiology of this virus is not yet known. Therefore, it is critical to investigate the influence of COVID-19 infection on olfactory and gustatory processes. Therefore, we use bibliometric analysis on COVID-19 and olfactory and/or gustatory dysfunction publications to provide studies perspective.

**Methods:** A bibliometric literature search was performed in the Scopus database. The number and type of publications, countries for publications, institutional sources for publications, journals for publications, citation patterns, and funding agencies were analyzed using Microsoft Excel or VOSviewer. In addition, the VOSviewer 1.6.17 software was used to analyze and visualize hotspots and collaboration patterns between countries.

**Results:** Scopus has published 187088 documents for COVID-19 in all study fields at the time of data collection (July 26, 2021). A total of 1740 documents related to olfactory and/or gustatory dysfunction were recovered. The countries most relevant by the number of publications were the United States (n = 362, 20.80%), Italy (n = 255, 14.66%), and the United Kingdom (n = 173, 9.94%). By analyzing the terms in the titles and abstracts, we identified 2 clusters related to olfactory and/or gustatory dysfunction research, which are “diagnosis and test methods” and “prognosis and complications of the disease.”

**Conclusions:** This is the first bibliometric analysis of publications related to COVID-19 and olfactory and/or gustatory dysfunction. This study provides academics and researchers with useful information on the publishing patterns of the most influential publications on COVID-19 and olfactory and/or gustatory dysfunction. Olfactory and/or gustatory dysfunction as indices of suspicion for the empirical diagnosis of coronavirus infection is a new hotspot in this field.

## Keywords

COVID-19, olfactory, gustatory, Scopus, bibliometric

## Introduction

The pandemic coronavirus disease 2019 (COVID-19) pandemic has been strongly struck globally since it started in late 2019 and has affected different aspects of life.<sup>1</sup> Although vaccines are available, we need 70% to 80% of the population with active immunity through infection or vaccines to cut down the disease chain.<sup>2</sup> The disease has an incubation period of 2 to 14 days, and certain cases remain asymptomatic. Importantly, symptoms of COVID-19 are not limited to respiratory manifestations, including pneumonia, but they exceed the ability to affect the nervous system.<sup>3</sup> Olfactory and gustatory disorders are among the most prevalent peripheral neurological symptoms due to infection with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).<sup>4</sup> These symptoms were first described by Mao et al in the second month of 2020.<sup>3</sup> Taste and smell deficits are caused by dysfunction of gustatory cells and

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smell sensory neurons resulting from viral infection and an inflammatory process that lead to result damage of surrounding non-neuronal cells.<sup>5</sup> Although the loss of taste and smell may be the initial symptoms of COVID-19,<sup>4</sup> clinicians should pay more attention to these dysfunctions and should not neglect them.

Interestingly, some individuals may have anosmia and ageusia before other symptoms.<sup>4</sup> Therefore, relying on symptoms of loss of taste and smell could be followed, especially in patients who require early management or quarantine, as the polymerase chain reaction (PCR) test does not fully guarantee the detection of COVID-19 infection.<sup>6,7</sup> As a result, the World Health Organization considered anosmia and ageusia as key symptoms of COVID-19.<sup>8</sup>

Globally, the estimated prevalence of anosmia and ageusia due to COVID-19 varies between countries,<sup>3,9-16</sup> even between different ethnic groups.<sup>17</sup> A previous publication reported that 88% had taste problems and around 85% had smell disorders.<sup>9</sup> Furthermore, a large survey documented a prevalence of 65.03%,<sup>12</sup> and another study somehow reported similar results, 68% for olfactory dysfunction and 71% for ageusia.<sup>14</sup> In 2 other studies with a small sample size, the first showed that 33.9% had anosmia or dysgeusia.<sup>10</sup> The second found that nearly all study participants (98%) had a variant degree of olfactory dysfunction.<sup>13</sup> In a large review, the reported percentage of olfactory dysfunction was 48.47% from 27 studies, 41.47% had gustatory disorder after analysis of 20 studies. Both disorders were recognized in 13 articles with an overall prevalence of 35.04%.<sup>18</sup> It also appears that women are more likely to experience these symptoms.<sup>10,15,16</sup> Regarding the recovery period, a study showed that most infected patients regained taste and smell function within 21 days.<sup>19</sup> Based on these variations in results, it is recommended to deeply recognize and characterize the prevalence, severity, and recovery of olfactory and gustatory functions through large case-control studies.<sup>20</sup>

In the literature, many articles have been published on olfactory and/or gustatory dysfunction in COVID-19 worldwide. A bibliometric study is required to introduce this topic uniquely and comprehensively and provide evidence-based practice. As the pandemic progressed, bibliometric assessments on a wide range of issues were published in COVID-19.<sup>21-24</sup> A bibliometric analysis serves as the foundation for determining the most significant publications and publishing trends in a particular field of interest. They were carried out to determine the key topics of the research chronology, the most respected publications, institutes, and prolific contributing countries in a given subject. Therefore, we use bibliometric analysis to guide future research priorities by evaluating the most relevant scientific research on COVID-19 and olfactory and/or gustatory dysfunction and analyzing current hot topics. This study can significantly contribute

to the allocation and refinement of research agendas for neurological research in general and the clinical and pathophysiology of COVID-19 infection research.

## Methods

### Study Design

Bibliometric techniques were used to perform a descriptive cross-sectional analysis of publications relevant to olfactory and/or gustatory dysfunction in COVID-19.

### Database Used

Data were retrieved from the Scopus database on July 26, 2021. In bibliometric analysis, the Scopus database is often utilized. It was also chosen since it is the most comprehensive database and can provide complete information for visualization.

### Search Strategy

The method used in previous bibliometric analyses influenced the search strategy for the current study. The use of appropriate and relevant keywords is critical to improving the accuracy of the findings, and it has a direct impact on the findings of the bibliometric study. We have followed the following steps to carry out this investigation to discover studies relevant to olfactory and/or gustatory dysfunction in COVID-19:

**Step 1:** Several recent systematic reviews on olfactory and/or gustatory dysfunction in COVID-19 were evaluated to retrieve the relevant keywords.<sup>18,25-32</sup> Some of these keywords were extracted from the Medline MeSH search for the words “olfactory and gustatory” in Medline. All the following “terms” were used in our study: “Smell\*” OR “Hyposmia\*” OR “Anosmia\*” “Olfact\*” OR “Olfact\*” OR “Dysosmia\*” OR “chemosensory\*”) OR “chemosensory\*” OR “taste\*” OR “Dysgeusias\*” OR “Dysgeusias\*” OR “gustation\*” OR “Parageusia\*” OR “Parageusia\*” OR “chemosensory\*” OR “Hypogeusia\*.” An asterisk (\*) wildcard or truncated character is used to extend the range of possible studies to include all terms beginning with truncated phrases.

**Step 2:** To fulfill the study objectives, keywords related to COVID-19 entered into the Scopus engine were selected from relevant bibliometric studies on COVID-19.<sup>33-35</sup>

**Step 3:** All collected keywords related to COVID-19 were entered as “Article Title/Abstract/Keywords” in the Scopus engine. We then restricted our collected publications in this step to all those included in their title or/and Abstract “olfactory and gustatory” and related terms.

**Step 4:** As in previous bibliometric studies, all retrieved documents were evaluated and analyzed using the

**Table 1.** The Top 10 Countries Having the Most COVID-19 Studies on Olfactory and/or Gustatory Dysfunction.

Ranking	Country	No. of publications	%
1st	United States	362	20.80
2nd	Italy	255	14.66
3rd	United Kingdom	173	9.94
4th	France	154	8.85
5th	India	151	8.68
6th	Spain	122	7.01
7th	Germany	105	6.03
8th	Belgium	82	4.71
9th	Brazil	82	4.71
10th	Turkey	77	4.43

following various bibliometric indicators: total number of publications to measure global productivity; journals and publication types to assess topic dissemination; citation patterns to determine publications which are considered highly influential; scientific collaboration between countries to show how they related to others; core terms to show clusters of research topics.

**Step 5:** To determine the collaborative relationships between countries/regions and the hotspots related to COVID-19 and olfactory and gustatory research, the VOSviewer 1.6.17 software was applied to construct network visualization maps.<sup>36</sup> VOSviewer can categorize terms into distinct clusters based on co-occurrence analysis, and the different colors indicate different clusters.<sup>36</sup>

### Ethical Approval

This scientometric study was based on bibliometric data without animal or human data. As a result, there was no need for ethical approval.

## Results

### General Description of the Retrieved Publications

Scopus has published 187088 documents on COVID-19 in all study fields at the time of data collection (July 26, 2021). A total of 1740 documents related to olfactory and/or gustatory dysfunction were retrieved. Of these, 1165 (66.95%) were research articles, 315 (18.1%) were reviews, 165 (9.48%) were letters, and 95 (5.45%) were classified as others.

### Countries Distribution

There were found documents from 111 countries published between January 1, 2020 and July 26, 2021. The first 10 countries in Table 1 produced 89.82% of published

documents related to COVID-19 studies on olfactory and/or gustatory dysfunction. The countries most relevant by number of publications were the United States (n=362, 20.80%), Italy (n=255, 14.66%), United Kingdom (n=173, 9.94%), France (n=154, 8.85%), and India (n=151, 8.68%). The global collaboration network during the period analyzed in the study is represented in Figure 1.

### Institutions Distribution

As shown in Table 2, 10 institutions published more than 34 articles, and the institutions with the first and second number of published articles were in Belgium and France. Among them, 3 institutes were from France, and 3 institutes were from Belgium. The total number of articles published by the *Université de Mons* and *Universite Paris-Saclay* was 49 and 47, respectively.

### Contributions of Funding Agencies

Table 3 lists the top 10 funding agencies with the most COVID-19 studies on olfactory and/or gustatory dysfunction. Three agencies were from the United States and 3 agencies were from the UK. The *National Institutes of Health* came first, with 62 studies supported. The *National Institute of Health Research* came in third (n=19), while the *US Department of Health and Human Services* came second (n=35).

### Journals Contribution

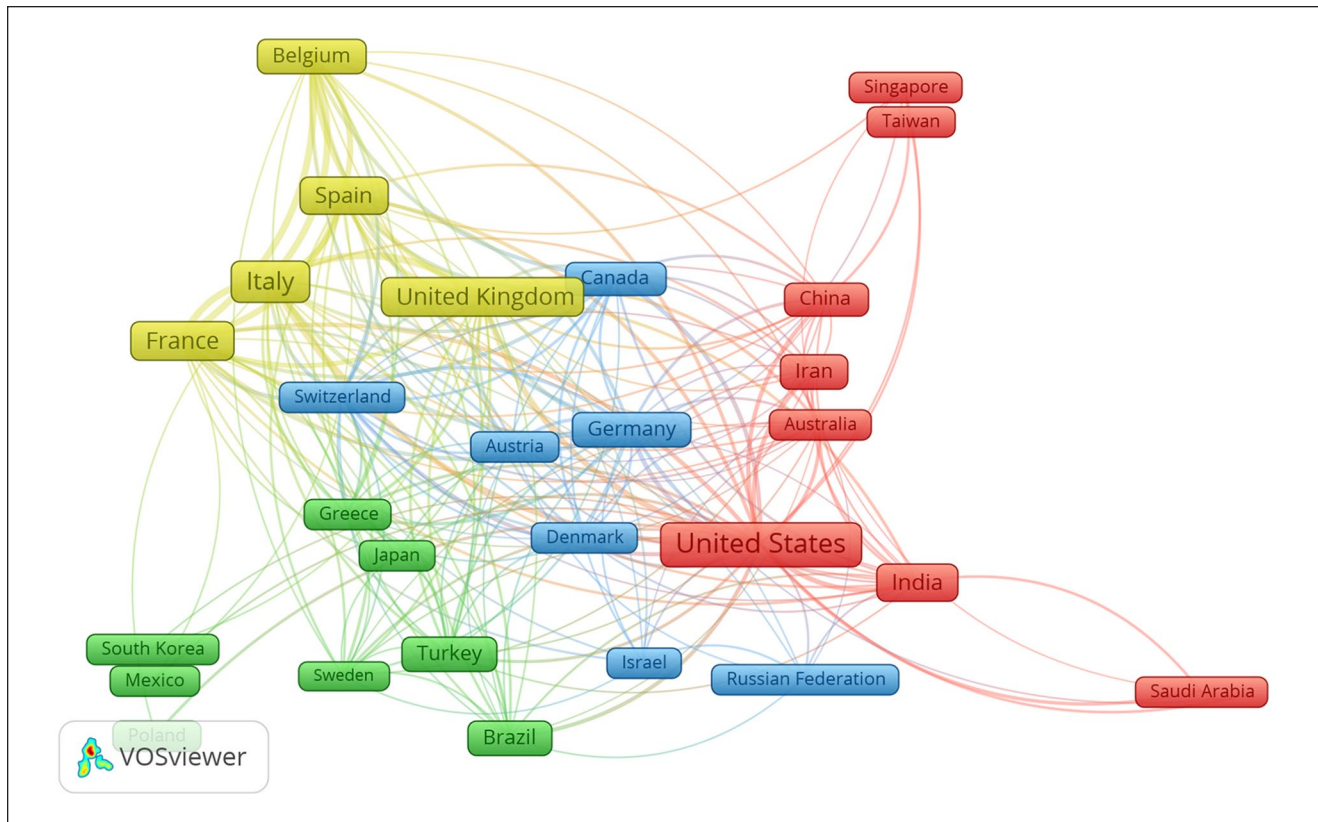
The top 13 journals published 317 (18.21%) of the publications (Table 4). *The European Archives of Oto Rhino Laryngology* were ranked first with 44 articles (2.53%) each, followed by the *Indian Journal of Otolaryngology and Head and Neck Surgery* (n=35; 2.01%).

### Citation Analysis

According to citation analysis, the retrieved articles got 23 660 citations, with an average of 13.6 per article and an h-index of 68. The number of citations ranged from 0 to 2293. About 868 of the retrieved articles had 1 or fewer citations, while 413 received 10 or more citations. The top 10 most-cited papers received 6124 citations in all (Table 5). The total citations of these articles that were the most cited articles citing COVID-19 and olfactory and gustatory research ranged from 264 to 2293.<sup>3,4,9-14,20,37</sup>

### Research Themes

To detect directions and topics in most COVID-19 studies on olfactory and/or gustatory dysfunction, we used VOSviewer software to examine the distribution of



**Figure 1.** Global collaboration network of countries co-authorships. Of the 111 countries, 29 had at least 20 publications.

**Table 2.** The Top 10 Institutes Having the Most COVID-19 Studies on Olfactory and/or Gustatory Dysfunction.

Ranking	Institution	Country	n	%
1st	Université de Mons	Belgium	49	2.82
2nd	Universite Paris-Saclay	France	47	2.70
3rd	Inserm	France	43	2.47
4th	Université de Versailles Saint-Quentin-en-Yvelines	France	43	2.47
5th	Université Libre de Bruxelles	Belgium	39	2.24
5th	Centre Hospitalier Universitaire Saint Pierre, Brussels	Belgium	39	2.24
7th	University College London	UK	38	2.18
8th	Guy's and St Thomas' NHS Foundation Trust	U.K.	36	2.07
8th	Hopital Foch	France	36	2.07
10th	Università degli Studi di Napoli Federico II	Italy	35	2.01

co-occurrence terms. Two significant clusters emerged by mapping terms in titles and abstracts with a minimum of 50 occurrences, reflecting 2 essential research themes. For example, in Figure 2, of the 27106 terms, 194 terms occurred at least 50 times, distributed in 2 clusters: Cluster #1, shown by red frames, includes those terms commonly found in studies related to diagnosis and test methods, and Cluster #2, indicated by green dots, includes terms commonly found in studies related to prognosis and complications of the disease.

### Discussion

This is the first bibliometric study to summarize the most relevant evidence on COVID-19 and olfactory and/or gustatory dysfunction. Scientific research is the key instrument for developing therapies and obtaining new medical knowledge. Bibliometric analysis can help researchers do analyses of publication activities in connection with citations, journals, institutes, and so on. In addition, it categorizes and provides information about the structure of the research field. Therefore, the study aimed to perform a

**Table 3.** The Top 10 Funding Agencies Having the Most COVID-19 Studies on Olfactory and/or Gustatory Dysfunction.

Ranking	Funding agencies	Country	No. of publication	%
1st	National Institutes of Health	USA	62	3.56
2nd	U.S. Department of Health and Human Services	USA	35	2.01
3rd	National Institute for Health Research	USA	19	1.09
4th	European Commission	Belgium	18	1.03
4th	National Natural Science Foundation of China	China	18	1.03
6th	Medical Research Council	UK	16	0.92
7th	Wellcome Trust	U.K.	13	0.75
8th	Coordenação de Aperfeiçoamento de Pessoal de Nível Superior	Brazil	9	0.52
8th	Fundação de Amparo à Pesquisa do Estado de São Paulo	Brazil	9	0.52
8th	UK Research and Innovation	UK	9	0.52

**Table 4.** The Top 13 Journals Having the Most COVID-19 Studies on Olfactory and/or Gustatory Dysfunction.

Ranking	Journal	n	%	IF <sup>a</sup>
1st	European Archives of Oto Rhino Laryngology	44	2.53	2.503
2nd	Indian Journal of Otolaryngology and Head and Neck Surgery	35	2.01	NA
3rd	American Journal of Otolaryngology Head and Neck Medicine and Surgery	31	1.78	1.808
3rd	International Forum of Allergy and Rhinology	31	1.78	3.858
5th	Otolaryngology Head and Neck Surgery United States	27	1.55	3.497
6th	Plos One	26	1.49	3.240
7th	Neurological Sciences	19	1.09	3.307
8th	International Journal of Infectious Diseases	18	1.03	3.623
8th	Journal of Medical Virology	18	1.03	2.327
9th	ACS Chemical Neuroscience	17	0.98	4.418
9th	Laryngoscope	17	0.98	3.325
9th	Rhinology	17	0.98	3.681
9th	Scientific Reports	17	0.98	4.379

<sup>a</sup>IF is the impact factor for 2020 journals listed in Clarivate Analytics, Incites Journal Citation Reports.

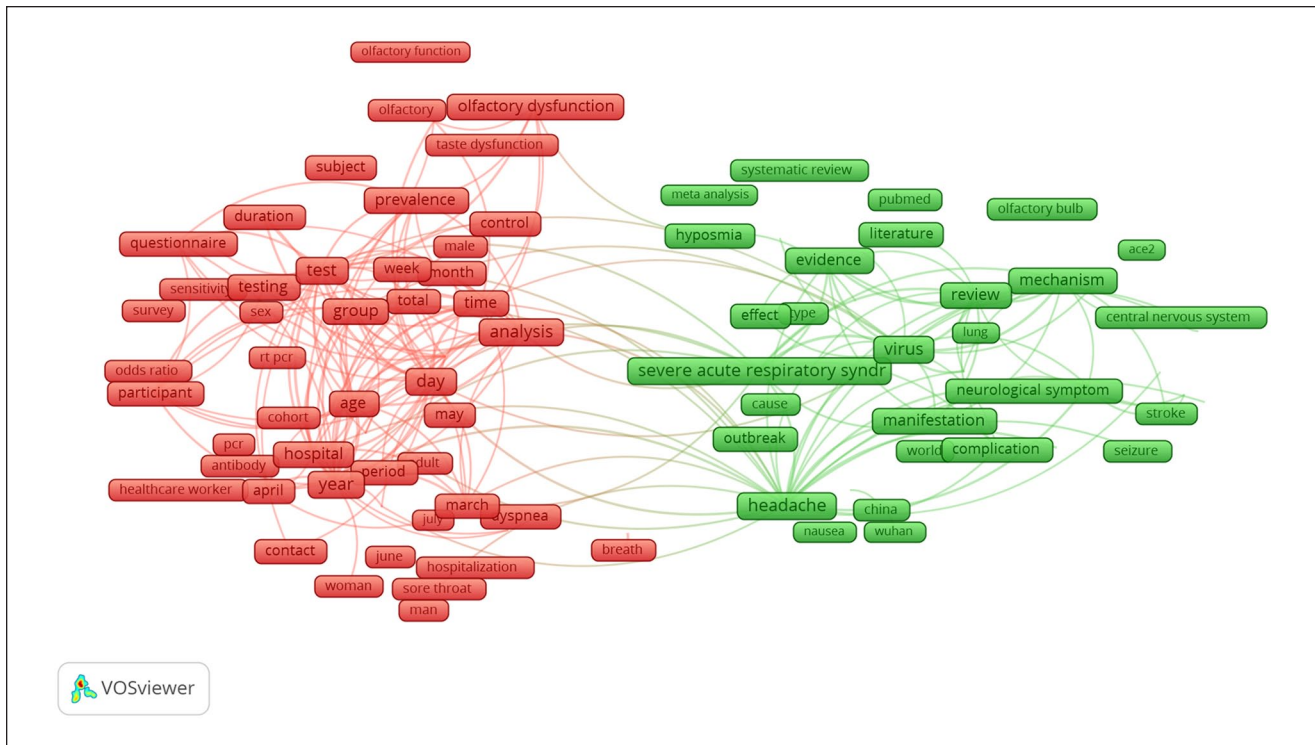
**Table 5.** List of the Top 10 Cited Articles for Coronavirus Disease 2019 Studies Related to Olfactory and/or Gustatory Dysfunction Between January 1, 2020, and July 26, 2021.

Ranking	Authors	Year	Source title	Cited by
1 <sup>st</sup>	Mao et al <sup>3</sup>	2020	<i>JAMA Neurology</i>	2293
2 <sup>nd</sup>	Lechien et al <sup>9</sup>	2020	<i>European Archives of Oto-Rhino-Laryngology</i>	946
3 <sup>rd</sup>	Giacomelli et al <sup>10</sup>	2020	<i>Clinical Infectious Diseases</i>	499
4 <sup>th</sup>	Pollán et al <sup>11</sup>	2020	<i>The Lancet</i>	484
5 <sup>th</sup>	Ellul et al <sup>20</sup>	2020	<i>The Lancet Neurology</i>	445
6 <sup>th</sup>	Menni et al <sup>12</sup>	2020	<i>Nature Medicine</i>	357
7 <sup>th</sup>	Gutiérrez-Ortiz et al <sup>37</sup>	2020	<i>Neurology</i>	288
8 <sup>th</sup>	Moein et al <sup>13</sup>	2020	<i>International Forum of Allergy and Rhinology</i>	279
9 <sup>th</sup>	Vaira et al <sup>4</sup>	2020	<i>Laryngoscope</i>	269
10 <sup>th</sup>	Yan et al <sup>14</sup>	2020	<i>International Forum of Allergy and Rhinology</i>	264

bibliometric analysis on COVID-19 and olfactory and/or gustatory dysfunction.

According to the current investigation findings, the USA and the UK have the greatest number of publications on

COVID-19 and olfactory and/or gustatory dysfunction. This result might be attributed to several reasons, including its large population, being one of the countries most affected by the COVID-19 pandemic, considerable resources for



**Figure 2.** Social network analysis of the most common terms in the retrieved literature titles/abstracts related to articles on olfactory and/or gustatory dysfunction published in the field of COVID-19. The terms are represented by nodes (circles), while links (lines) connect the nodes. The names in the circles for the most co-occurrence terms, and the diameters of the circles are proportional to their overall link strength. Related terms are colored the same (clusters), and clusters are organized thematically.

medical research, and well-developed and structured data management systems. In addition, the economic base plays a vital role in funding scientific research in the current study. The bulk of the top 10 funding agencies was headquartered in the USA and the UK. Thus, most of the articles related to COVID-19 and olfactory and/or gustatory dysfunction have come from high-income countries, with little input from low- and middle-income countries. Several bibliometric analysis studies have also revealed that the USA and the UK are the most productive countries in COVID-19 research production.<sup>38-40</sup>

The highest cited article on our top 10 list with 682 citation counts was about neurological complications due to COVID-19 by Mao et al<sup>3</sup> published in *JAMA Neurology*. This early study described peripheral neurological complications that occurred due to COVID-19, such as taste and smell disorders. It also explained that patients with severe disease were more likely to have such neurological symptoms.

The second most cited article with 946 citations was on olfactory and gustatory dysfunction by Lechien et al<sup>9</sup> published in the *European Archives of Oto-Rhino-Laryngology*. This study aimed to report the prevalence of smell and taste dysfunction among the COVID-19 population in several European centers. The results revealed that 88% had taste

problems, and around 85% complained of smell problems. Furthermore, it was noticed that taste and smell problems had a significant relationship ( $P < .001$ ).

The third article cited with 499 citations was about the prevalence of olfactory and gustatory dysfunctions by Giacomelli et al<sup>10</sup> published in *Clinical Infectious Diseases*. This article was carried out with 59 hospitalized COVID-19 to assess their gustatory and olfactory functions. About 20 out of 59 patients (33.9%) had anosmia or dysgeusia, and 11 had both. Young adults and female gender were both associated with these disorders.

The paper by Pollán et al,<sup>11</sup> published in *The Lancet*, was the fourth most cited article. This large publication, published in Spain, found that 49.1% of confirmed COVID-19 patients experienced a loss of smell or had 3 or more COVID-19 symptoms for the point of care test and around 54% for the immunoassay. Finally, the paper by Ellul et al,<sup>20</sup> published in *The Lancet Neurology*, was the fifth most cited article. This review concluded that olfactory and gustatory disorders were prevalent in patients with COVID-19, and they might occur alone without other manifestations. Therefore, case-control studies are substantial to better identify and characterize these dysfunctions in COVID-19 individuals.

The paper by Menni et al,<sup>12</sup> published in *Nature Medicine*, was the sixth most cited article. This large survey was based

on the COVID-19 symptoms reported using a mobile application individually. Anosmia and ageusia were commonly seen in COVID-19 people who tested positive (65.03%), higher than in individuals who had a negative test. This study also showed that olfactory and gustatory dysfunctions could predict SARS-CoV-2 infection. The paper by Gutiérrez-Ortiz et al,<sup>37</sup> published in *Neurology*, was the seventh most cited article. This article characterized 2 confirmed COVID-19 cases reported to have Miller Fisher syndrome and polyneuritis cranialis. One of these was for a 50-year-old male patient who complained of loss of smell, taste, and other symptoms. After 14 days of treatment, the nervous system manifestations were fully recovered, except for the gustatory and olfactory functions.

The paper by Moein et al,<sup>13</sup> published in the *International Forum on Allergy and Rhinology*, was the eighth-most cited article. The authors of this article participated in examining the prevalence and extent of olfactory disorders in COVID-19 patients using a test consisting of forty odorants. Among the 60 participants, 59 (98%) had a variant degree of olfactory dysfunction. Therefore, the study concluded that such a test might be appropriate to recognize COVID-19 individuals who require early treatment.

The ninth most cited article was by Vaira et al<sup>4</sup> and published in the *Laryngoscope*. The authors advised ear, nose, and throat (ENT) physicians to focus on the issue of taste and smell dysfunction, as these symptoms may be the only or early characteristics of COVID-19. Furthermore, the researchers recommended a comprehensive understanding of the reasons beyond these dysfunctions, which helps to recognize the pathogenesis of SARS-CoV-2. The tenth most cited article was by Yan et al<sup>14</sup> and published in the *International Forum on Allergy and Rhinology*. This study was conducted on 1880 participants who presented influenza-like manifestations. Of all patients tested positive for COVID-19, 68% had olfactory dysfunction, and 71% had ageusia. These proportions were much higher than those who were tested negative. It should be noted that olfactory and gustatory problems were significantly associated with COVID-19 positive results.

Highly cited research has been proposed to be regarded as landmark studies in a related subject, potentially producing substantial improvements in clinical practice. However, these studies also reveal that, while clinical neurologists are highly engaged in research, much of the published work has focused on the diagnosis, prognosis, and consequences of COVID-19, with little effort on the treatment of olfactory and/or gustatory dysfunction.

## Strengths and Limitations

Although it provides the reader with comprehensive information on the research output and the insight characteristics of the research outcomes on COVID-19 and olfactory and/or

gustatory dysfunction, it also has limitations inherent in bibliometric approaches. First, only data from the Scopus database were obtained, and a few studies that were not included in Scopus were missed. On the other hand, Scopus is the most widely used database for bibliometric analysis<sup>41-46</sup>; data from Scopus might constitute the majority of information to some degree. Second, there were no citation data for recently published studies. Third, because the online database is constantly updated, there is some variation between our bibliometric research results and the actual findings. In this regard, new publications are still being published, and many new publications are likely to appear in the coming months.

## Conclusions

This is the first bibliometric analysis of publications related to COVID-19 and olfactory and/or gustatory dysfunction. This study provides academics and researchers with useful information on the publishing patterns of the most influential publications on COVID-19 and olfactory and/or gustatory dysfunction. Olfactory and/or gustatory dysfunction as indices of suspicion for the empirical diagnosis of coronavirus infection is a new hotspot in this field.

## Declaration of Conflicting Interests

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