

Smell and taste dysfunction during the COVID-19 pandemic: an infodemiological analysis

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Abstract. – OBJECTIVE: Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection can cause smell and taste dysfunction. We aimed to investigate the general community's interest in smell dysfunction (SD) and taste dysfunction (TD) using Google Trends to compare results with more common symptoms associated with SARS-CoV-2 infection, such as fever and cough.

MATERIALS AND METHODS: Relative Search Volumes (RSVs) for the English terms "Smell", "Taste", "Fever" and "Cough", filtered by the category "Health", were collected from 2018 through 2020. Moreover, RSVs using synonyms of "Taste" and "Smell" in 5 European languages were analyzed.

RESULTS: The worldwide mean RSVs for "Fever", "Cough", "Smell", and "Taste" during 2020 were 49%, 34%, 8% and 9%, respectively. RSVs associated with the search terms "Fever" and "Cough" showed a peak between February and March 2020, as did "Smell" and "Taste". Even though RSVs were much lower, they were highly correlated ($r=0.890$). RSVs obtained from "Smell" and "Taste" in five European languages (German, English, French, Italian and Spanish) had similar temporal trends.

CONCLUSIONS: Our findings show the level of the general population's interest for early symptoms, suggesting that their interest in SARS-CoV-2 infection symptoms, such as SD and TD, was scarce but peaked during the pandemic outbreak.

Key Words:

COVID-19, SARS-CoV-2 infection, Google trends, Otorhinolaryngology, Smell dysfunction, Taste dysfunction.

Introduction

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the virus that causes

Coronavirus disease 2019 (COVID-19) was first reported in December 2019 in Wuhan, China, and COVID-19 was declared a pandemic in March 2020. Symptoms of the SARS-CoV-2 infection included smell dysfunction (SD) and taste dysfunction (TD), and the latter could be present in the absence of rhinitis, representing in some subjects the only manifestations of COVID-19¹. The U.S. Centers for Disease Control and Prevention (CDC) and the World Health Organization (WHO) added "new loss of taste or smell" to their list of symptoms related to COVID-19 on 21 April and 5 May 2020². Husain et al³ reported that in subjects with SARS-CoV-2 infection, smell or taste loss was present in 4.0% of patients, and the proportion of females with smell or taste loss was higher. Moreover, these symptoms were more likely to be present in individuals aged 10-20 years, while differences in ethnicity, smoking status and comorbidity burden were not detected, and mortality was lower among COVID-19 patients with SD and TD³. The prevalence of SD and TD was different in the investigated populations. A recent systematic review and meta-analysis (104 studies, >38000 patients) found that SD and TD were present in 43% and 45% of cases, respectively, with an overall prevalence of chemosensory dysfunction in 48% of patients studied⁴. Moreover, the prevalence of SD or TD or both decreased with older age and male sex; and Caucasians had a three-fold higher prevalence of chemosensory dysfunctions than Asians⁴. Now, we are also aware of the prevalence of these symptoms in COVID-19 infection in health care workers, with important public social implications⁵. A study based on anonymous questionnaires from

1041 health care workers in the UK showed that 62% of all participants, at the onset of the first wave of the COVID-19 pandemic, reported losing their sense of smell/taste in the previous 2 months, and in 17% of cases, this was the only symptom. The most frequent COVID-19-related symptoms were fatigue (65%), cough (43%) and fever (40%). Overall, 49% of subjects did not have symptoms severe enough to curtail their work activity and continued to work as normal during that period. Among the responders, 91% of participants reported at least one of the following symptoms: chemesthesis (sensation of burning, cooling or tingling) in the nose or mouth, parosmia, and phantosmia (35%, 42%, and 34%, respectively)². Some of these participants reported that when seeking advice regarding self-isolation, health authorities told them to continue working, as loss of sense of smell and/or taste had yet to be recognized as official symptoms of COVID-19 (Public Health England included loss of smell and taste as official symptoms on 20th May). Thus, it is likely that a significant proportion of health care workers who continued to work were contagious at that time². On these premises, Lechner et al² concluded that loss of sense of smell/taste could be useful as part of a targeted mass screening, and that increased awareness of COVID-19 symptoms, in particular the loss of sense of smell, and implementation of due measures might play crucial role in the management of this disease. However, these data are mainly based on subjective assessment, hinting that the general population should be aware of symptom meaning.

Infodemiology is an emerging and interesting area of research that analyzes the distribution and circulation of medical information in an electronic medium and is able to assess the consciousness of the general population about a specific disease. Ciaffi et al⁶, by using Google Trends (GT), observed a strong and significant temporal correlation between volumes and patterns of queries for the specific search terms linked to COVID-19 infection and the increase in admissions to intensive care units or the number of new deaths from SARS-CoV-2 infection in Italy⁶. They suggested that analysis of GT data could have a complementary role to conventional public health surveillance systems in anticipating future outbreaks⁷.

Since the presence of otorhinolaryngology symptoms could be related to SARS-CoV-2 infection, we decided to investigate the general

community's interest in SD and TD using GT and compared these results with more common symptoms associated with SARS-CoV-2 infection, such as fever and cough.

Materials and Methods

GT allows us to obtain information about the general population's trends on the Worldwide Web, using appropriate keywords for specific interest areas and/or specific periods of time. Importantly, Google TrendsTM is a public, open-access tool (<https://trends.google.com/trends/>) capable of analyzing patterns and volumes of queries referred to as search terms⁸.

Search results are given in terms of percentages representing Relative Search Volumes (RSVs) during a temporal interval but not in terms of absolute search volumes. Moreover, this search activity is proportionately expressed in a data series using a 0-to-100 normalized scale during a selected period of time.

GT enables the comparison of RSVs in a given period of time and between different geographic areas, and RSVs can be standardized by adjusting the percentage for population size.

To detect the general population's interest in SD and TD, we compared the RSVs either worldwide or among European countries by analyzing the search terms "Smell" and "Taste", plus two other common terms related to COVID-19 infection such as "Cough" and "Fever"^{6,7}.

As a first step, we extrapolated RSVs for the English terms "Smell", "Taste", "Fever" and "Cough", filtering the research by the category "Health" to avoid nonhealth related results that could hamper the examination. The evaluation period was from January 1st, 2018, to December 31st, 2020. This range was selected to compare pre- and post-COVID-19 data. All countries were included in the first evaluation, and data were divided by the geographical position included in the five continents. The second step was to describe the correlation between the COVID-19 outbreak and the specific GT search volumes among the European countries. We translated the search terms "Taste" and "Smell" into 5 European languages (German, English, French, Italian, and Spanish). Thus, we used the following words: "Geruchssinn" for "Taste" and "Geschmackssinn" for "Smell" in German; "Goût" for "Taste" and "Odeur" for "Smell" in

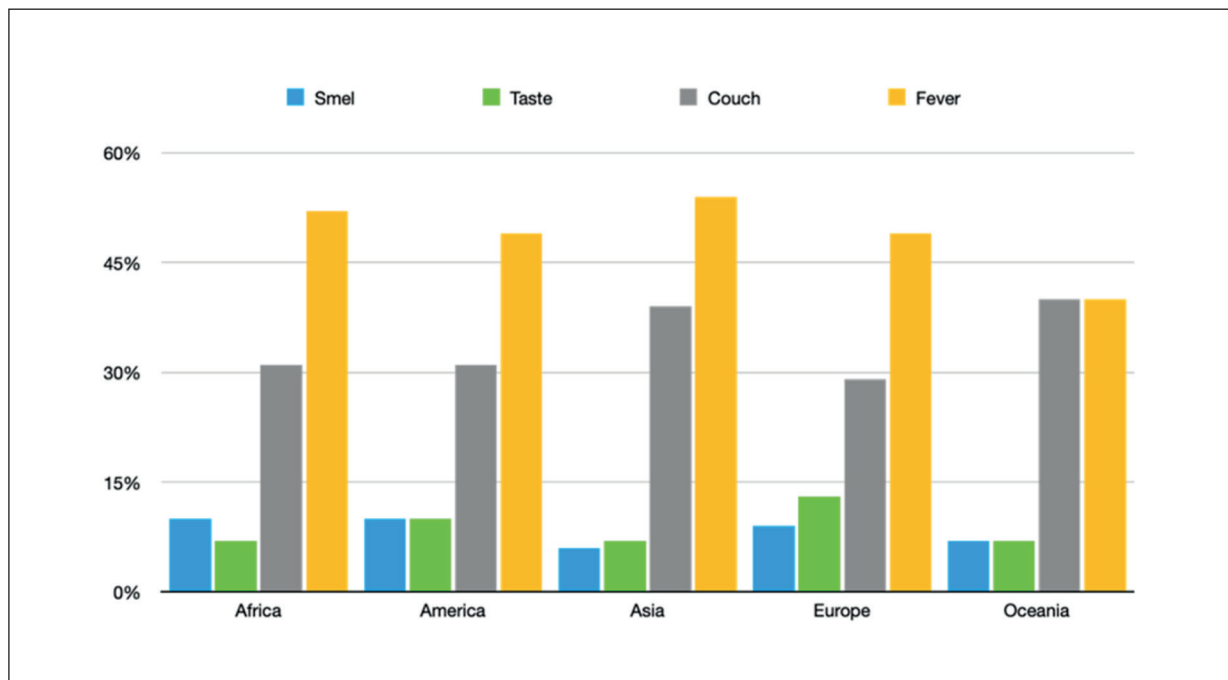


Figure 1. The RSVs obtained from “Smell”, “Taste”, “Fever” and “Cough” during 2020 on the five continents.

French; “Gusto” for “Taste” and “Odore” for “Smell” in Italian; “Gusto” for “Taste” and “Olfato” for “Smell” in Spanish.

Data analysis and statistical evaluation were performed to evaluate RSV variations between 2020 and the two previous years for each searched term. The associations were tested by Pearson’s coefficient of correlation after RSV logarithmic transformation. Statistic Package for Microsoft Excel (Microsoft Corp., Albuquerque, New Mexico, USA) was used. A two-sided $p < 0.05$ was considered statistically significant.

Results

The worldwide mean RSVs for “Fever”, “Cough”, “Smell”, and “Taste” during 2020 were approximately 49%, 34%, 8% and 9%, respectively. Data obtained in the five continents are shown in Figure 1. The RSV distributions of the four English words “Smell”, “Taste”, “Fever” and “Cough” from January 1st, 2018, to December 31st, 2020, are shown in Figure 2. As expected, “Fever” and “Cough” RSVs showed a cyclic trend prior to 2020, characterized by spikes in winter months and troughs during summer months. Moreover, between February

and March 2020, RSVs associated with the search terms “Fever” and “Cough” showed a peak due to the COVID-19 pandemic outbreak. In the same period, RSVs obtained from the search terms “Smell” and “Taste” had similar spikes, which were not previously evident. RSVs obtained from “Smell” and “Taste” were weakly related prior to the COVID-19 pandemic, but the correlation was strong during 2020 ($r = 0.890$) (Figure 3).

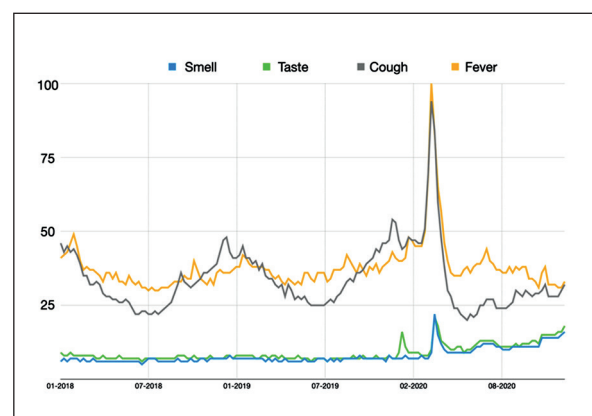


Figure 2. Worldwide RSV distribution of the four English words “Smell”, “Taste”, “Fever” and “Cough” from 1st January 2018 to 31st December 2020.

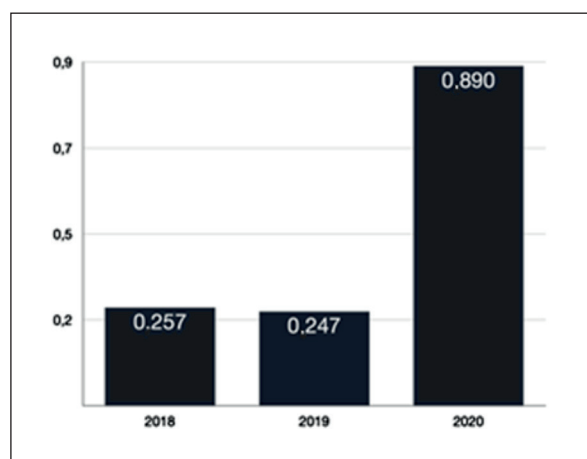


Figure 3. Correlation rates between RSVs of “Taste” and “Smell” in 2018, 2019 and 2020.

RSVs obtained from “Smell” and “Taste” in the five European languages (German, English, French, Italian and Spanish) are reported in Figure 4. RSVs had a similar trend, depicting an evident spike in the first quarter of 2020 for both search terms, “Taste” and “Smell”.

Discussion

To the best of our knowledge, this is the first study describing the infodemiology of SD and

TD. Although SD and TD are common early symptoms in patients with COVID-19⁹, our findings show that they are relatively unknown to the general population when GT is analyzed using English language. Overall, the RSVs obtained from “Smell” and “Taste” were four to five times less than the values obtained from “Fever” and “Cough”. Moreover, RSVs revealed a quite similar pattern, even when European languages were used.

Smell impairment represents a frequent finding in SARS-CoV-2 infection, and it has been suggested that the identification of smell symptoms could be an alternative or complementary tool to nasal and throat swabs used in rapid screening¹⁰. In a large cross-sectional study, Lechien et al¹¹ described SD and TD frequently occurring in cases of COVID-19 infection. The pathogenesis of SD and TD is still a matter of debate and could be an effect of central involvement of the olfactory bulb or peripheral damage to olfactory receptor cells located in the nasal neuroepithelium, both related to neurotropism of COVID-19. TD seems to follow SD as a consequence of alterations in olfactory perception¹². In clinical practice, SD and TD were evaluated by questionnaires or self-reported symptoms during physical examination¹³⁻¹⁵, suggesting that patients should have been aware of the conditions.

Ciaffi et al^{6,7} used GT and evaluated knowledge of common symptoms of COVID-19 in-

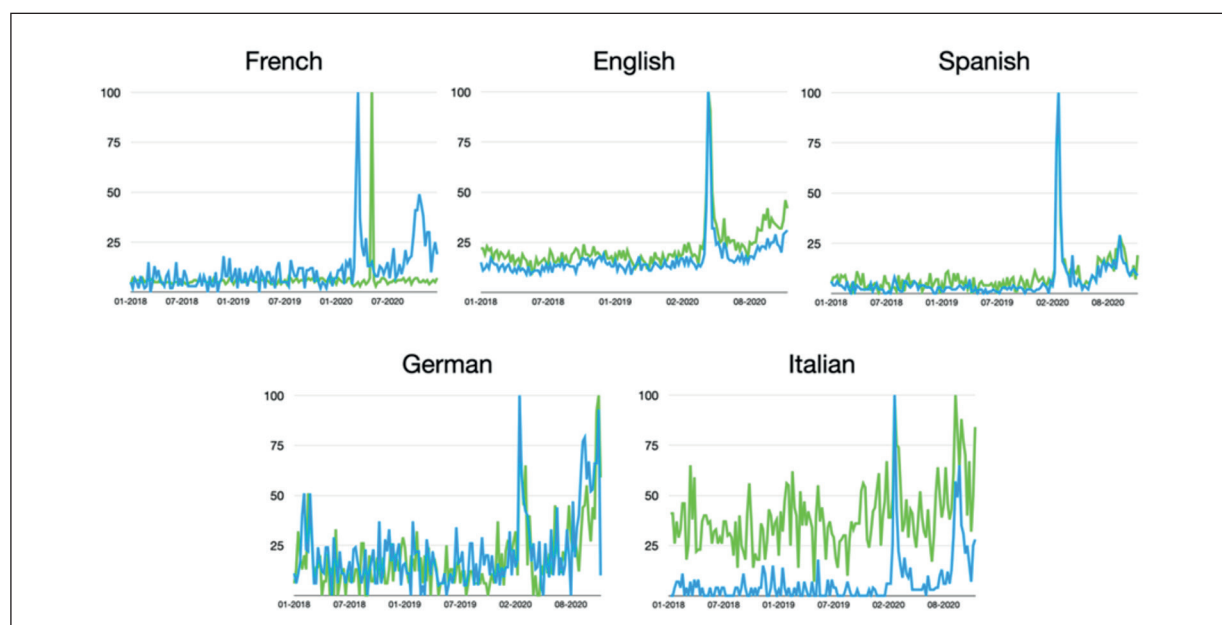


Figure 4. Trends of RSVs for “Smell” and “Taste” in the German, English, French, Italian and Spanish languages.

fection using RSVs associated with the Italian terms for “Fever” (“Febbre”) and “Cough” (“Tosse”). They were able to predict the increase in admissions to intensive care units and the number of new deaths from SARS-CoV-2 infection in Italy^{6,7}. In contrast, anosmia was strongly and independently associated with a milder clinical course in outpatients^{16,17}. A sex investigation of OD and TD incidence revealed that they are more frequent in females than in males¹⁹, according to the milder clinical manifestations of COVID-19 infection in women^{19,20}. This difference has been ascribed to the female hormonal profile in which estrogen improves upper and lower airway defenses²⁰.

In the last two decades, the internet and social media have become even more popular, and for many people around the world, they represent an important source of information. Furthermore, using these media, we can investigate and analyze, in real time, an incredible amount of data originating from people searches. Opinions, attention, knowledge and attitudes could be measurable by friendly and freely available tools such as GT, and these searches could be limited to specific health topics. Analysis of the distribution and circulation of public health information in an electronic medium could be used for surveillance purposes (infoveillance) to evaluate information flows^{8,21,22}. If symptoms are well known by the general population, evaluation of search volumes performed using the internet could allow the early detection of acute disease outbreaks²³. In this paper, we used infodemiology as a tool to evaluate the awareness of the general population about SARS-CoV-2 infection symptoms, which could be similar to those simply secondary to flu or cold. Different rhinotropic viruses can cause SD and TD, but before 2020, we did not detect any peak demonstrating public interest. Our results show that from the onset of the COVID-19 pandemic, the general population used the internet to search for information about symptoms such as “Cough” and “Fever”, well-known symptoms of infectious diseases. However, “Taste” and “Smell” were scarcely searched before the pandemic outbreak, but in 2020, consciousness that both symptoms could be due to SARS-CoV-2 infection increased. Moreover, such a finding was true for many European citizens, as demonstrated by similar results obtained evaluating references to the terms in 5 European languages.

The COVID-19 pandemic also induced deep changes in the field of remote communication in

all branches of medicine, including ENT, with some pros and cons^{24,25}. On the one hand, there are several advantages for health workers, such as easier participation and lower financial costs for conferences and teaching. On the other hand, remote patient consultation has seen a dramatic increase due to higher accessibility and reduced risk of infection transmission. However, a high level of caution is needed since patients need an examination to obtain a diagnosis^{24,25}. On these premises, communication between health care professionals and the general population plays a crucial role, with positive effects on prevention and early diagnosis. Infodemiology could be a useful, easy, and inexpensive tool. During the COVID-19 pandemic, the ENT community has demonstrated strong adaptability to rapid change, enhanced clinical pathways and networks, and widespread use of digital technology²⁶, even in a breakdown period characterized by a plethora of novel and sudden daily changes to clinical practice²⁷. However, during the COVID-19 pandemic, in-hospital mortality increased, especially in subjects with a high burden of comorbidities²⁸, and different efforts were made to understand how to improve the survival of hospitalized patients^{29,30}.

Conclusions

Our findings show that interest in early symptoms suggesting SARS-CoV-2 infection is scarce in the general population. In our opinion, GT, positively tested in different health topics³¹⁻³⁴, could represent an effective tool with which to examine general population interest in the evaluation of SARS-CoV-2 infection. Health care professionals, including ENTs, should be prepared to interpret data derived from internet searches and take advantage of this technology in terms of an increased opportunity to help patients understand and evaluate such information. If this help is lacking, patients’ knowledge may not improve properly with the use of the internet. The reliability of health information is a problem that health care professionals should take into consideration. The internet is now a formidable widespread source of information, with pros and cons, that is replacing more traditional scientific means of attaining information. Thus, health care professionals should not miss their involvement in such a process.

Limitations

We are aware of the limitations of this study. First, in describing GT, we investigated RSVs using English search terms, but 5 national European languages were tested, obtaining similar results. Second, we described the entire world and did not focus on precise areas. Third, we could not define age, gender, race, or education levels in our search for subjects since it is not possible to obtain any association between individuals and queries in the Google database. Fourth, our data do not represent epidemiological findings since infodemiology is based on the general population's knowledge about a given condition. Population knowledge is based on information campaigns; therefore, media coverage could be a major determinant of search volumes, inducing overestimation of benefits, exaggeration of claims, and conflicts of interest that could not be disclosed³⁵. Subsequently, our data could be exposed to this limitation. Finally, the technology used in this study is Web 1.0, so different platforms belonging to Web 2.0, such as Twitter, could give different results.

Conflict of Interest

The Authors declare that they have no conflict of interests.

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Ethical Considerations

We performed this study using Google Trends data. Thousands of daily online health-related search queries provide information on collective health trends and are recorded through information repositories such as Google Trends. Google Trends [<http://www.google.com/trends/>] is a public sampling database of actual search requests performed using the Google search engine that is anonymized, categorized, and aggregated. According to Google [<https://support.google.com/trends/answer/4365533?hl=en>]: "GT normalizes search data to make comparisons between terms easier. Each data point is divided by the total searches of the geography and time range it represents to compare relative popularity. The resulting numbers are then scaled on a range of 0 to 100 based on a topic's proportion to all searches on all topics." As only de-identified information was used, specific ethics approval was not required for this study.

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Authorship Statement

AC, RC, CP, AC, ADG, SP, RM, FF designed the work; AC, RC, FF acquired and analysed data; AC, RC, CP, AC, ADG, SP, RM, FF drafted, revised, and approved the manuscript; AC, RC, CP, AC, ADG, SP, RM, FF agree to be accountable for all aspects of the work.

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