

Emerging application of Google Trends searches on “conjunctivitis” for tracing the course of COVID-19 pandemic

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Abstract

Purpose: The aim of the present study was to use Google Trends for evaluating the association between the internet searches of the term “conjunctivitis” and the daily new cases of COVID-19.

Methods: The relative search volume (RSV) of conjunctivitis from January 1 to April 16, 2019 (control group), January 1 to April 16, 2020 (first wave), and October 1 to December 31, 2020 (second wave) was obtained using Google Trends in Italy, France, United Kingdom, and United States. The number of COVID-19 daily new cases in the same countries were retrieved from Worldometer. Lag time correlation analyses were performed to evaluate the relationship between RSV and daily new cases (Pearson’s correlation coefficient).

Results: During the first wave, the lagged RSV of conjunctivitis was significantly correlated with the number of COVID-19 daily new cases in all investigated countries. The highest correlation coefficients were obtained with a lag of 16 days in Italy ($R=0.868$), 18 days in France ($R=0.491$), 15 days in United Kingdom ($R=0.883$), and 14 days in United States ($R=0.484$) (all $p < 0.001$). Conversely, no significant correlations were found in the second wave and in the control group.

Conclusion: Google Trends searches on conjunctivitis were significantly correlated with COVID-19 daily new cases during the first wave in Italy, France, United Kingdom, and United States, with a lag of 14–18 days. Repeating the analysis for the second wave, however, no significant correlations were found in any of the investigated countries.

Keywords

COVID-19, coronavirus, Google Trends, conjunctivitis, infodemiology

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Introduction

The history of the COVID-19 pandemic began with the intuition of Dr. Li Wenliang, a young Chinese ophthalmologist who first raised the alarm about a cluster of patients with SARS-like pneumonia at Wuhan Central Hospital. Subsequently, he contracted COVID-19 from an asymptomatic woman with glaucoma and died from the disease.¹ Since then, the pandemic has had a profound impact on several aspects of ophthalmology, including eye care services, delivery of surgery, and training.^{2–6}

Since the virus could be transmissible through the ocular surface, and viral RNA was identified in tears of patients with conjunctivitis but not in those without, the assessment of the prevalence of ocular involvement in patients with

COVID-19 has crucial clinical implications.^{7,8} Previous studies reported the presence of conjunctivitis in a variable percentage of COVID-19 patients going from 0.8%

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to 31.6%.⁹⁻¹¹ A few possible explanations can be postulated regarding this discrepancy. Firstly, diagnostic criteria used for including patients in the COVID-19 population vary across the studies, and some of them included both “suspected” and “confirmed” cases.¹¹ Secondly, although severe cases of conjunctivitis can be diagnosable even at the bedside, milder cases may require slit lamp examination, which is not feasible for patients self-isolating at home. Thirdly, the recording of ocular symptoms or signs, particularly in milder forms, may be not a priority for medical staff in situations of high workload as registered in the first wave of the current pandemic. Finally, in some cases ocular symptoms may appear several days before the onset of fever or respiratory symptoms, thus making the association difficult to be detected.¹²

Recently, web searches for health-related information are being considered a valuable source of data able to depict the collective health trends.¹³ In particular, Google Trends (GT) is an online system of internet hit-search volumes that has been proposed as a surrogate marker for the evaluation of the public awareness of a disease.¹⁴ In case of infectious outbreaks, it could serve as a digital epidemiological tool to track disease activity and course.¹⁵ During the ongoing COVID-19 pandemic, internet surveillance with GT on various extraocular signs and symptoms of the disease was recently employed with good performance to monitor the disease course and to forecast the trends of daily new cases.¹⁶⁻¹⁸

The present study aims at exploring the emerging role of GT for monitoring the web searches on “conjunctivitis” at the time of COVID-19 outbreak and for tracing pandemic course.

Methods

Google Trends is an online tool that presents the relative search volume (RSV) of searches made in a given country and period in the Google search engine (<https://trends.google.com/trends/>). The RSV is a normalized index that ranges from 0 to 100, with 100 indicating the peak of popularity.¹⁹ In the present study, we performed a GT search for conjunctivitis in Italy, France, United Kingdom, and United States. These countries were selected because they are large western countries that experienced a high number of COVID-19 cases during the study period. Non-western countries were not included due to potential differences regarding access and use of Internet. We searched the term “conjunctivitis” and the translation in Italian (“congiuntivite”) and French language (“conjonctivite”). The time period was set from January 1 to April 16, 2020, which corresponded to the first wave of the pandemic in all the investigated countries. A corresponding comparison period was set from January 1 to April 16, 2019 (control period). Moreover, the search was repeated for the time period from October 1 to December 31, 2020, which corresponded to

the second wave of the pandemic. Searches were repeated using the GT topic function that automatically includes all the terms related to the conjunctivitis topic.

The number of COVID-19 daily new cases were retrieved from Worldometer (<https://www.worldometers.info/>). The sources of the website include the Italian Ministry of Health, the French platform data.gouv.fr, The United Kingdom Department of Health and Social Care, and the United States Department of Health and Human Services.

All statistical analyses were performed using Stata (version 14). The correlations between the conjunctivitis RSV and COVID-19 daily new cases were evaluated using Pearson’s correlation coefficient. We used lag time correlation analyses for up to 25 days to evaluate the temporal relationships between these data in order to find the best correlation. In particular, we started by examining, for each country separately, the correlations between COVID-19 daily new cases and the contemporary daily RSV. Then we iteratively examined the correlations between COVID-19 daily new cases and lagged daily RSV, augmenting by one the number of lags at each iteration. Finally, we extracted the highest correlation value, and its corresponding lag time. A coefficient whose *p* was found to be lower than 0.05 was considered statistically significant.

Results

The RSV for conjunctivitis and COVID-19 daily new cases from January 1 to April 16, 2020 in Italy, France, United Kingdom, and United States are reported in Figure 1.

In all countries, we observed both peaks and an upward trend in conjunctivitis-related Google searches occurring prior to the time window in which the highest numbers of new COVID19 cases were registered. Such evidence was consistent across all countries despite the high volatility in the time trends.

The correlation analysis between the number of COVID-19 daily new cases and the RSV is reported in Table 1.

During the first wave, a statistically significant correlation between COVID-19 daily new cases and the RSV was found in Italy ($R=0.507$, $p<0.001$), United Kingdom ($R=0.423$, $p<0.001$) and United States ($R=0.203$, $p=0.036$). The correlation coefficients changed with lag time: the highest coefficient was obtained with a lag of 16 days for Italy ($R=0.868$, $p<0.001$), 18 days for France ($R=0.491$, $p<0.001$), 15 days for United Kingdom ($R=0.883$, $p<0.001$), and 14 days for United States ($R=0.484$, $p<0.001$).

To rule out whether searches were driven by individuals actually suffering the symptoms, the analysis was repeated using data retrieved with the GT topic function (Table 2). A statistically significant correlation between COVID-19 daily new cases and the RSV was found in Italy ($R=0.298$,

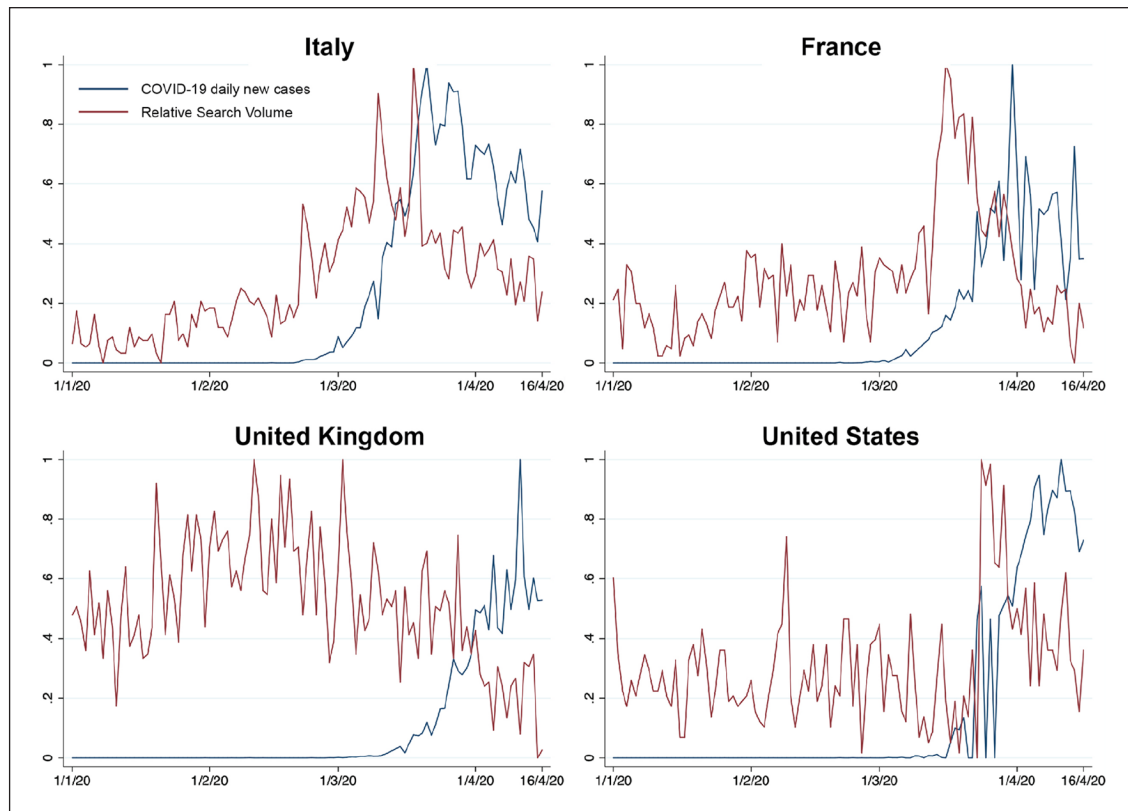


Figure 1. Plot of relative search volume (in red) and COVID-19 daily new cases (in blue). Both distributions were rescaled on a 0–1. Calendar date on the X-axis.

Table 1. Correlation analysis between the number of COVID-19 daily new cases and the research search volume of conjunctivitis during the control period (January 1 to April 16, 2019), first wave (January 1 to April 16, 2020), and second wave (October 1 to December 12, 2020).

Daily new cases	Control	Control top lag	First wave	First wave top lag	Second wave	Second wave top lag
Italy	0.193	0.185 (16 days)	0.507*	0.868* (16 days)	0.089	0.16 (8 days)
France	-0.147	-0.175 (18 days)	-0.185	0.491* (18 days)	0.134	0.27 (11 days)
United Kingdom	-0.153	0.052 (20 days)	0.423*	0.883* (15 days)	0.115	0.19 (16 days)
United States	0.014	0.226 (14 days)	0.203*	0.484* (14 days)	0.073	0.093 (4 days)

Top lag refers to the highest correlation coefficient and the correspondent number of days obtained in time-lag correlation analysis.

* $p < 0.05$.

Table 2. Correlation analysis between the number of COVID-19 daily new cases and the research search volume of the terms related to the conjunctivitis topic during the first wave.

Daily new cases	First wave	First wave top lag
Italy	0.298*	0.718* (18 days)
France	0.121*	0.652* (18 days)
United Kingdom	0.132	0.232* (24 days)
United States	0.169	0.116 (19 days)

Top lag refers to the highest correlation coefficient and the correspondent number of days obtained in time-lag correlation analysis.

* $p < 0.05$.

$p < 0.001$) and France ($R=0.121, p < 0.001$). We observe a change in correlation similar to the one reported in Table 1: the highest correlation coefficient was obtained with a lag of 18 days for Italy ($R=0.718, p < 0.001$), and 18 days for France ($R=0.121, p < 0.001$). Conversely, no significant correlations were found for United Kingdom and United States (both $p > 0.05$), although for the United Kingdom we observed a statistically significant correlation value with a lag of 24 days ($R=0.232, p < 0.001$).

In order to rule out potential seasonality issues in conjunctivitis RSV, the correlation analysis was repeated using the RSV observed during the same time period of previous year (control period). As shown in Table 1, the number of

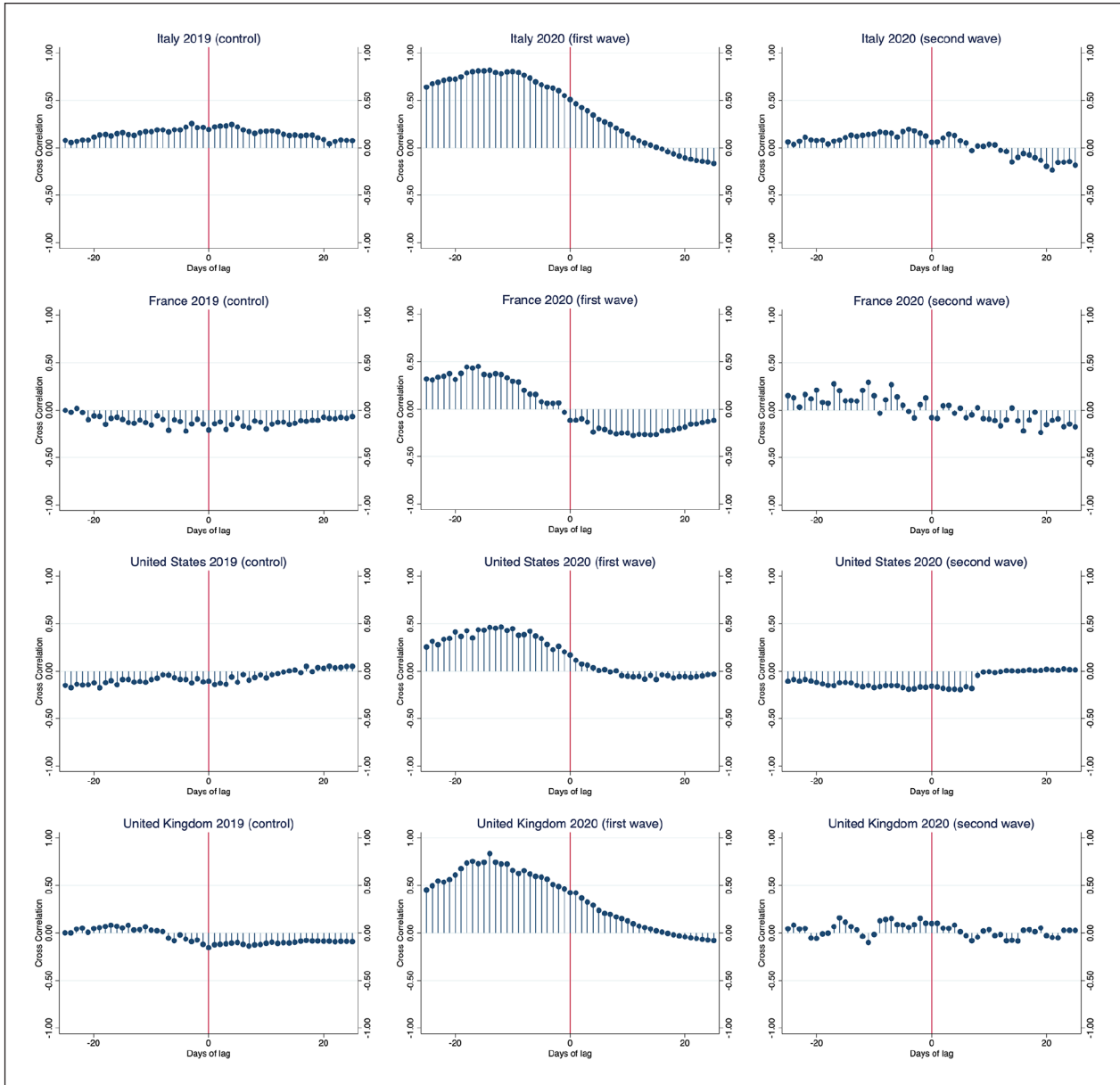


Figure 2. A series of cross correlograms are constructed by calculating the cross correlation at different match positions between the number of COVID-19 daily new cases and relative search volume observed at different lags. The X-axis indicates the number of days of lag, the Y-axis shows the correlation values.

COVID-19 daily new cases showed no significant correlation with both the RSV and the corresponding lagged RSV (all $p > 0.05$). Similarly, no significant correlation between the number of COVID-19 daily new cases during the second wave and both the RSV and the corresponding lagged RSV was found (all $p > 0.05$) (Table 1).

Figure 2 shows the cross-correlograms for Italy, France, United Kingdom, and United States. The central side of the panel tracks the cross correlation between the number of COVID-19 daily new cases and RSV during the first wave. The correlation coefficient reached its maximum in correspondence of a backward shift of 14 to 18 days in RSV, then

it progressively faded away. The left and the right sides of the panel indicates a non-significant correlation between the number of COVID-19 daily new cases and RSV during the control period and second wave, respectively.

Discussion

In the present study, we investigated the association between internet searches related to conjunctivitis and COVID-19 pandemic course. The study revealed a positive and significant association between the RSV of conjunctivitis-related terms and the number of COVID-19 daily new

cases during the first wave in all the investigated countries except for France. In order to exclude the possible confounding effect of the seasonal variation of conjunctivitis internet searches on the aforementioned associations, we evaluated the correlation between COVID-19 daily cases and the RSV of conjunctivitis in the same period of the previous year and we did not find any significant evidence of correlations.

Furthermore, the correlations changed with lag time, and in all countries the highest correlation was found with a time lag of the RSV ranging from 14 to 18 days. This indicates that the peak in the search interest for conjunctivitis occurred before the incidence peak of COVID-19 cases. This time lag might have been caused by the peak of news about the epidemic coming from other countries where the virus has previously spread.¹⁹ This could explain why countries affected later by COVID-19 (United Kingdom and United States) had a shorter lag compared to Italy and France. Previous studies evaluating the association between the COVID-19 outbreak and the internet searches of other terms disease-related reported a shorter time lag compared to that one recorded in our study.^{16–18} In particular, two studies reported a lag time of 10–14 days between the searches of coronavirus and pneumonia.^{16,17} Similarly, the web searches of COVID, COVID pneumonia, and COVID heart were strongly correlated with COVID-19 daily new cases in United States with a lag of 12–14 days.¹⁸ If we postulate that the increases in internet searches are driven by individuals actually suffering the symptoms, another possible explanation for the longer time lag detected in our study is that COVID-19 patients may have experienced ocular symptoms and conjunctivitis before the onset of fever or respiratory symptoms directly related to COVID-19. This scenario cannot be excluded since in the largest case series available in the literature, the appearance of conjunctivitis several days before the systemic symptoms has been described in a non-negligible proportion of COVID-19 patients.¹² To assess whether the search interest were driven by symptoms, the analysis was repeated using the GT “topic function,” which automatically includes all the terms related to a specific topic. This analysis confirmed the correlation between search interest and daily new cases in Italy, France, and partially in the United Kingdom, while for the United States associations were no longer significant.

Stronger correlations were found in Italy and United Kingdom compared to France and United States. Several factors may have contributed to this different trend. Firstly, testing criteria for COVID-19 diagnosis as well as capacity vary considerably across countries, and this may have a significant effect on the reporting of daily incidence. Moreover, in United States there was an initial delay in testing, which might explain the weaker correlation between the trends of search-interest and the daily incidence.²⁰ Finally, economic, social, and cultural differences

between the countries may also contribute to the different results.

Deiner et al.²¹ recently performed a similar study assessing the search interest for 18 terms from spring 2015 to spring 2020. Elevated search frequency for terms representing sore, red and burning eyes were found in spring 2020 compared with previous years, particularly in English and Spanish, suggesting a relationship between conjunctivitis and COVID-19. The searches for the English term “conjunctivitis” slightly increased in the early spring months of 2020 but decreased in the later spring months. The authors noted that school closure and social distancing might also have reduced the spread of infectious conjunctivitis, thus affecting the search interest to some extent.²¹

To verify whether the second wave of the pandemic triggered another spike in search interest for ocular symptoms terms, we repeated our analysis for the time period covering October 1 to December 31, 2020. Interestingly, no significant correlations between conjunctivitis-related terms and the number of COVID-19 daily new cases were found for any of the countries investigated. There are several possible explanations for this result. First, conjunctivitis might have become a less common symptom. Different studies have documented a changing clinical presentation of COVID-19 during the second wave, possibly due to the emergence of new variants and/or the effect of starting vaccinal campaigns.^{22,23} Alternatively, the substantial increase in web searches observed during the first wave could have been driven mostly by the media clamour rather than by individuals actually suffering the symptoms. In fact, GT is considered a surrogate marker of public awareness of a disease, and previous studies conducted in fields other than COVID-19 pandemic documented significant spikes in internet searches of a disease in correspondence of major media coverage.^{14,24,25} This reduces the possible utility of internet searches of conjunctivitis as a tool for forecasting future COVID-19 waves. Recently, however, the internet searches of other symptoms were successfully used to anticipate the second and third wave of the infections.²⁶ Thus, Google Trends may still represent a useful tool for the digital surveillance of COVID-19.

In conclusion, during the first wave, the internet searches of conjunctivitis were significantly correlated with the trends of COVID-19 daily new cases in all the investigated countries with a delay of 14–20 days. During the second wave, however, no significant correlation was found in any country. Further epidemiological data and analyses of other symptoms are still needed to prove if internet searches can represent a useful tool for tracing COVID-19.

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