Use of Google Trends database during the COVID-19 pandemic: systematic review

Elena Kornellia | Rizma Adlia Syakurah

Abstract  Public concern about the high number of COVID-19 cases has caused many people to seek information related to the virus. The large number of searches regarding information via Google search will create trend data that are processed in graphical form by displaying keywords from searches made. These trends can be accessed via Google Trends. This study aimed to provide an overview of the use of Google Trends during the COVID-19 pandemic. This study used a systematic review method. Article searches were conducted through four databases, namely, Cochrane, Europe PMC, PubMed, and Science Direct. The literature search included articles published from January 2020 to September 2022 using the PRISMA guidelines. After reviewing 33 articles, it was found that there was an increase in searches for terms related to COVID-19 in the Google Trends database. During the COVID-19 pandemic, Google Trends was widely used to predict positive cases and deaths due to COVID-19, connoting the high public interest in the delta vaccine variant compared to other vaccine variants, increasing public interest regarding the symptoms of COVID-19; anosmia, a drastic increase in public interest in telehealth during a pandemic, the effects of a pandemic that trigger stress and worsen a person’s mental health, and prevention efforts made by consuming adequate vitamins and nutrients to increase the body’s resistance. In addition, several search engines from other countries and social media were used to complement the use of Google Trends. The Google Trends database can be used as an effective tool for estimating trends in the ongoing COVID-19 pandemic outbreak and as a reference for the government in making decisions regarding policies implemented to control COVID-19.

Keywords: COVID-19, Google Trends, systematic review

1. Introduction

The horrendous pneumonia outbreak at the end of December 2019 appeared with an unknown cause. The disease was first discovered in the city of Wuhan. The cause of pneumonia, namely, a type of novel coronavirus, was identified by researchers on January 7, 2020. COVID-19 (coronavirus disease 2019) and SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2) were the names the WHO officially gave for the disease (Levani et al 2021). To date, COVID-19 has become an unresolved problem. Positive cases of COVID-19 in the world as of August 29, 2022, reached 601 million and were responsible for 6.49 million deaths. America ranked first in the highest number of cases, followed by India in second and Brazil in third. Indonesia ranked 19th, with a total of 6.3 million cases and 157 thousand deaths. The number of positive cases of COVID-19 in the world is increasing compared to a few months ago. This is due to the emergence of new Subvariant Omicron Viruses, namely, BA.4 and BA.5.

The increasing cases of COVID-19 and the emergence of new subvariants have caused concern and anxiety for the community. This concern is based on ignorance in responding to the COVID-19 pandemic, encouraging people to seek information related to COVID-19 via the Internet. The internet is the most widely used medium by the public to look for and obtain information. Most of the information search is done through the Google platform. The large number of searches regarding information via Google search will create trending data that are processed in graphical form by displaying keywords from searches made, and these can be accessed via Google Trends. Google Trends displays trending graphs from the information that has been aggregated and several related queries in the form of words inserted by people in the community to obtain the desired information. Furthermore, it displays location trends that perform many searches with keywords from that information. In general, Google Trends is used for marketing and economic purposes to see trends in the current market, but it has also been used in the health sector in particular to provide information about population behavior and phenomena related to health and health surveillance.

There have been many uses of Google Trends for the COVID-19 pandemic situation. For example, research was conducted on predicting the incidence of COVID-19 through Google Trends data analysis in Iran (Ayyoubzadeh et al 2020). Other studies also explored health communication through Google Trends and news coverage of COVID-19 in eight countries (Ming et al 2021). Google Trends research was also conducted in Indonesia regarding the analysis of public interest in immune
Numerous studies have been conducted on the use of Google Trends, but there has been no systematic review regarding the use of Google Trends during the COVID-19 pandemic. In addition, several studies on this topic have existed in the last two years. Therefore, the authors conducted a systematic review that aimed to identify the results of existing research regarding the use of the Google Trends database during the COVID-19 pandemic in a more comprehensive manner.

2. Method

This study was a systematic review using PRISMA guidelines to identify the use of the Google Trends database during the COVID-19 pandemic. The search was conducted from December 19, 2022, to January 4, 2023, using four databases: Cochrane, Europe PMC, PubMed, and Science Direct. The article search included articles published from January 2020 to September 2022. This research used the keywords “Google Trends” AND “COVID-19” OR “Coronavirus”, AND “Predicting”, AND “Analysis”, AND “Search”. Inclusion criteria were used, which included articles published from 2020-2022, articles in English, full texts, research articles, and articles with cross-sectional quantitative studies.

One reviewer (EK) conducted the data collection, extraction, and examination stages for the included study. Piloted forms were used for data extraction, which included the literature title, author, year, research design used in the article, research objectives, and research results. Following removal of duplicates and inaccessible studies, the reviewer screened the titles and abstracts using predetermined inclusion and exclusion criteria. Each article was read in its entirety to determine its eligibility.

Three reviewers (EK, MI, and AF) worked independently during the quality assessment stage, while one author (RAS) with experience in the public health discipline reviewed the extracted data. The Joanna Briggs Institute (JBI) critical appraisal checklist for cross-sectional studies was used to evaluate the quality of the studies' methods. A consensus was reached for every difference in opinion on eligibility assessments. Studies with a literature score ≥ 50% were finally chosen to be reviewed.

3. Results

3.1. Study Selection

From the electronic search results, 1173 studies were collected, out of which 1172 titles were filtered out after eliminating duplicates with the same title. Subsequently, 858 articles were excluded for not having a relevant topic, and 135 studies were dismissed after an in-depth examination of the abstracts. After screening the full text of 179 studies, 123 studies did not cover Google Trends, and 21 did not include COVID-19, leading to their exclusion. Of the remaining 35 studies with a cross-sectional study design, quality assessment was conducted using the JBI Critical Appraisal (Table 1). However, two studies did not meet the requirements of the JBI, ultimately leaving 33 studies for review (Figure 1).

There were 23 articles that explained the prediction of COVID-19 cases with Google Trends (Abbas et al 2021; Ahmed et al 2021; Akpan et al 2021; Ayyoubzadeh et al 2020; Foa et al 2022; Higgins et al 2020; Husnayain et al 2020; Jimenez et al 2020; Jun et al 2021; Kurian et al 2020; Lippi et al 2020; Liu et al 2023; Mattiuzzi and Lippi 2020; Mavragani and Gkillas, 2020; Peng et al 2020, 2021; Rabiolo et al 2021; Samadbeik et al 2022; Szmuda et al 2020; Venkatesh and Gandhi 2020; Vijay et al 2021; Yousefinaghani et al 2021; Yuan et al 2020). Furthermore, one article discussed COVID-19 vaccination (Cheng, 2022), two articles discussed anosmia (Madden and Feldman, 2021; Panuganti et al 2020), one article discussed telehealth (Arshad Ali et al 2020), four articles discussed mental health (Silverio-Murillo et al 2021; de la Rosa et al 2022; Sycińska-Dziarnowska et al 2021; Knipe et al 2021), one article discussed vitamins (Cimke and Yıldırım Gürkan 2021) and one article discussed nutrition (Kushwaha et al 2021). In addition, some articles used a combination of Google Trends and search engines from each country as well as social media. One article used Naver and Google Trends (Husnayain et al 2020), one article used Baidu Index and Google Trends (Higgins et al 2020) and two articles used Twitter and Google Trends (Panuganti et al 2020; Yousefinaghani et al 2021).

4. Discussion

Keyword searches on Google are based on health literacy read by the public. According to Ratzan and Parker, health literacy is the ability of individuals to obtain, process, and understand health service information to make decisions related to health appropriately (Oktarina 2020). Health literacy also influences shaping the behavior of daily life that supports full health. This encourages people to search for this information through digital media, especially the Google platform, because phrases cannot be searched on Google if they do not obtain health information. This study found that several countries with high literacy rates utilized Google Trends during the pandemic. Google Trends data on “coronavirus” are utilized at the national and state levels in the United States to explore the correlation between COVID-19 cases, new deaths, and online interest in the virus (Mavragani and Gkillas 2020). In Spain, which has the fifth-highest number of detected COVID-19 cases globally, internet search patterns can unveil the intricate clinical progression of the disease (Jimenez et al 2020). These data can be used to predict and monitor the local spread of COVID-19 before widespread laboratory testing becomes available and can guide the current public...
health response. Additionally, in South Korea, the public health risk of COVID-19 is higher during local and international events, especially among women, specific age groups, and individuals in affected areas, as indicated by Google Trends RSV and Naver RSV (Husnayain et al 2020).

<table>
<thead>
<tr>
<th>Study</th>
<th>Question</th>
<th>Score (Y%)</th>
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<tbody>
<tr>
<td>Checilia Cheng (2022)</td>
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<td>75</td>
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<td>Xiaoling Yuan et al (2020)</td>
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<td>75</td>
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<tr>
<td>Ikpe Justice Akpan et al (2021)</td>
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<td>62.5</td>
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<td>Alberto Jimenez et al (2020)</td>
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<td>75</td>
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<td>Mostafa Abba, et al (2021)</td>
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<td>50</td>
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<td>Tomas Szmuda et al (2020)</td>
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<td>50</td>
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<td>Atina Husnayaini et al (2020)</td>
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<td>Mahnaz Samadbeik et al (2022)</td>
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<td>Mavragani et al (2020)</td>
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<td>Alessandro Rabiolo et al (2021)</td>
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<td>Venkatesh U, Gandhi P (2020)</td>
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<td>Yousefinaghani S et al (2021)</td>
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<td>Higgins T et al (2020)</td>
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<td>Zhimin Liu (2022)</td>
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<td>Yuanyuan Peng et al (2021)</td>
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<td>Sayed Mohammad Ayyoubzadeh et al (2020)</td>
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<td>Sibtain Ahmad et al</td>
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<td>Giuseppe Lippi et al (2020)</td>
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<tr>
<td>Camilla Mattiuzzi and Giuseppe Lippi (2021)</td>
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<td>Roberto Stefan et al (2022)</td>
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<td>V. Vijay et al (2021)</td>
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<td>Kurian S et al (2020)</td>
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<td>Cimke S and Yildrim Gurkan D (2021)</td>
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<td>Yuanyuan Peng et al (2020)</td>
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<td>Seung-Pyo Jun et al (2021)</td>
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<td>Kushwaha S et al (2021)</td>
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<td>Madden K and Feldman B (2021)</td>
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<td>De la Rosa P et al (2022)</td>
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<td>Sycinska-Dziaranowska M et al (2021)</td>
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<td>Knipe D et al (2021)</td>
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Information:
- **Yes**;
- **No**;
- **Unclear**;
- **Not Applicable**
Amid the COVID-19 pandemic, enhancing people’s digital health literacy through innovative methods that enable them to effectively search, comprehend, and apply health information to manage health issues is crucial. Adequate health literacy is significant, as it can impact social, cultural, and individual factors, ultimately affecting the availability of healthcare services. Digital health literacy skills, including searching, locating, selecting, evaluating, comprehending, comparing, and applying health information, are essential for online health services (Syah et al. 2020). Hence, although everyone can access the internet, not everyone can find health-related information (Table 2).

**Figure 1** PRISMA 2009 flow diagram of study search and selection.
### Table 2 Article Summary.

<table>
<thead>
<tr>
<th>No.</th>
<th>Authors</th>
<th>Study Design and Data Analysis</th>
<th>Objective</th>
<th>Results and Description</th>
<th>Keywords</th>
<th>Timeline</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(Cheng 2022)</td>
<td>Cross-Sectional with retrospective design. Correlation analysis between time lag and active browsing</td>
<td>Investigate public interest in variants of COVID-19 and vaccination disease prevention measures during the vaccine rollout period COVID-19.</td>
<td>The results showed that public interest in the COVID-19 variant was more significant during the variant's dominant period Delta compared before this period. Time-series cross-correlation analysis revealed positive temporal associations (greater public interest accompanied by increases in national vaccination rates) tended to occur more frequently and at earlier time lags than negative temporal associations.</td>
<td>&quot;covid variant&quot;, &quot;covid alpha&quot;, &quot;covid beta&quot;, &quot;covid delta&quot;</td>
<td>13-19 December 2020 to 19-25 September 2021</td>
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<td>2</td>
<td>(Yuan et al. 2020)</td>
<td>Cross-Sectional with Pearson’s correlation of term search interest with new cases and deaths of COVID-19</td>
<td>Using population-based data and a semiparametric model, we are testing the relationship of search interest to the daily incidence/new cases and deaths of COVID-19 in the United States.</td>
<td>The daily incidence and deaths of COVID-19 appear to have peaked on April 10. 4-day follow-up with prospectively collected data showed moderate to good accuracy for predicting new cases (Pearson r=0.641 to -0.833) and poor to good accuracy for recent daily deaths (Pearson r=0.365 to 0.935).</td>
<td>&quot;COVID&quot;, &quot;COVID-19&quot;, &quot;Coronavirus&quot;, &quot;Cough&quot;, &quot;Pneumonia&quot;, &quot;COVID Pneumonia&quot;, &quot;COVID Heart&quot;, &quot;COVID Diabetes&quot;, &quot;High Temperature&quot;, &quot;SARS-CoV2&quot;</td>
<td>1 March to 7 April 2020</td>
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<td>3</td>
<td>(Akpan et al. 2021)</td>
<td>Cross-Sectional with correlation analysis between conspiracy theories and public health actions</td>
<td>To determine what we learn about the COVID-19 pandemic through web searches, examine the relationship between what people know about COVID-19 and attitudes toward public health guidelines, and analyze the impact of misinformation and conspiracy theories about the COVID-19 pandemic on people’s attitudes toward public health measures.</td>
<td>Based on the PCA results and the log-linear and predictive model, ConsP Theory1 (keyword &quot;@9G&quot;) was identified as a predictor of community behavior towards public health measures (PubHealthMes1). Although the correlation of misinformation (keywords &quot;COVID-19,&quot; &quot;hoax,&quot; &quot;virus hoax,&quot; &quot;common cold,&quot; and others) and ConsP Theory2 (keywords &quot;eat bleach&quot;) with PubHealthMes1 (keywords &quot;social distancing,&quot; &quot;handwashing,&quot; &quot;isolation,&quot; and others) were r=0.83 and r=-0.11, respectively, both of which were not statistically significant (P=.27 and P=.13, respectively).</td>
<td>&quot;nCoV&quot;, &quot;2019-nCoV&quot;, &quot;SARS-CoV-2&quot;, &quot;COVID-19&quot;, &quot;pandemic&quot;, &quot;coronavirus&quot;, &quot;SARS&quot;, &quot;MERS-CoV&quot;, &quot;MERS&quot;, &quot;virus&quot;, &quot;influenza&quot;, &quot;social distancing&quot;, &quot;wear a facial mask&quot; &quot;wash hands&quot;</td>
<td>1 January to 30 June 2020</td>
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<td>4</td>
<td>(Jimenez et al. 2020)</td>
<td>Cross-Sectional analysis and correlation between the incidence of COVID-19 in Spain and search data provided by Google Trends.</td>
<td>This study aimed to determine whether Google Trends data collected for searches using multiple keywords during the COVID-19 pandemic could predict the number of COVID-19 cases.</td>
<td>Correlation test results show evolution the COVID-19 pandemic can be predicted in Spain up to 11 days in advance.</td>
<td>&quot;cansancio-sociedad&quot;, &quot;coronavirus&quot;, &quot;COVID 19&quot;, &quot;covid 19&quot;, &quot;covid19&quot;, &quot;diareia&quot;, &quot;dolor de garganta&quot;, &quot;fiebre&quot;, &quot;neumonia&quot;, &quot;perdita olfato&quot;, &quot;toso&quot;</td>
<td>20 February to 20 May 2020</td>
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<tr>
<td>Method</td>
<td>Study</td>
<td>Literature</td>
<td>Results/Findings</td>
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<td>Cross-Sectional with correlation analysis between COVID-19 epidemiology (incidents and deaths) with online searches in each specific country.</td>
<td>Samuda et al (2020)</td>
<td>Cross-Sectional with correlation analysis between COVID-19 epidemiology (incidents and deaths) with online searches in each specific country.</td>
<td>Overall, online searches for COVID-19 do not correlate with actual incidence and deaths of COVID-19. The mean Spearman correlation for the event was 0.20 (range 0.66 to 0.76), and for death was 0.35 (range 0.75 to 0.85). European online searches are highly synchronized; Spearman’s correlation averaged 0.93 (range 0.62 to 0.99). Online searches for COVID-19 in Europe are not correlated with epidemiology but are strongly associated with international WHO announcements.</td>
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<td>Cross-Sectional correlation analysis between the time of emergence of new cases of COVID-19 and internet searches is influenced.</td>
<td>Husnayain et al (2020)</td>
<td>Cross-Sectional correlation analysis between the time of emergence of new cases of COVID-19 and internet searches is influenced.</td>
<td>The number of queries related to COVID-19 in South Korea increased during local events, including local transmission, approval of coronavirus test kits, implementation of drive-through coronavirus tests, shortage of face masks, and widespread campaigns for social distancing as well as during international events such as the announcement of a Health Emergency Society of International Concern by the World Health Organization. Online queries were also stronger among women (r=0.763-0.823; the use of Google Trends and Naver RSV to explore patterns of public health risk perception can help target risk communication from multiple perspectives, including time, population characteristics, and location.</td>
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<td>Cross-Sectional with correlation analysis between RSV from COVID-19, coronavirus, and the weekly total number of COVID-19 cases in that time interval.</td>
<td>Samadbeik et al (2022)</td>
<td>Cross-Sectional with correlation analysis between RSV from COVID-19, coronavirus, and the weekly total number of COVID-19 cases in that time interval.</td>
<td>All search terms related to COVID-19 in Iran gained the highest popularity value (relative search volume = 100) in the first eight weeks of the pandemic, and then this value assumes a downward trend over time. Based on factor analysis, the Relative Search Volume (RSV) factor 1 term (related to corona [in Persian] and corona) has a low significant relationship with COVID-19 epidemiological data at one, two, and three-week intervals. Although, the RSV of the term factor 2 (associated with COVID [in Persian], COVID-19, and coronavirus) correlates with the weekly total number of cases of COVID-19 in that time lag. This study supports the adoption of Google Trends as an epidemiological surveillance tool. Still, it is necessary to consider that mass media and other confounders can significantly affect RSV.</td>
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<td>Cross-Sectional with correlation analysis to monitor and estimate the aim of this research is to monitor and estimate the predictability of COVID-19.</td>
<td>Mavragani &amp; Gkillas (2020)</td>
<td>Cross-Sectional with correlation analysis to monitor and estimate the aim of this research is to monitor and estimate the predictability of COVID-19.</td>
<td>The estimated model shows strong predictability of COVID-19. In line with previous work suggesting that</td>
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between Google Trends and COVID-19 data.

<table>
<thead>
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<th>Study</th>
<th>Design</th>
<th>Methodology</th>
<th>Findings</th>
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<tbody>
<tr>
<td>11 (Venkatesh &amp; Gandhi, 2020)</td>
<td>Cross-Sectional with correlation analysis</td>
<td>Given the increasing threat of the coronavirus disease 2019 (COVID-19), the correlation for Google Trends of the search terms “coronavirus” and “corona” is high (r &gt; 0.7) to cumulative daily and new COVID-19 cases for the lag period from 9 to 21 days. The maximum lag period for predicting COVID-19 cases was found with a News search for the term “coronavirus,” with 21 days; that is, the search volume for “coronavirus” peaked 21 days before the peak number of cases reported by disease surveillance systems.</td>
<td>“coronavirus”, “COVID”, “COVID-19”, “corona”, “virus”</td>
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<td>12 (Yousefinaghani et al 2021)</td>
<td>Cross-Sectional with correlation analysis</td>
<td>This study aimed to conduct a comparative study to understand the potential for Twitter and Google search activities to be used in the COVID-19 pandemic early warning systems in Canada and the United States. The results show that Twitter and Google Trends perform better at detecting the onset of the second wave in Category II than in Category I status. The prediction of the first wave in this study outperformed the detection of the second wave. There are several reasons that cause the correlation to fade when the pandemic lasts a few weeks, namely (1) people start to feel tired of the pandemic and tend not to follow public health practices, (2) subjects related to COVID-19 such as “cough,” “fever,” “sore throat,” “shortness of breath,” “tiredness,” “loss of smell.”</td>
<td>“abdominal pain,” “ageusia,” “anorexia,” “bone pain,” “chills,” “conjunctivitis,” “cough,” “diarrhea,” “eye pain,” “fatigue,” “fever,” “headache,” “myalgia,” “nasal congestion,” “nausea,” “rhinorrhea,” “shortness of breath,” “sore throat,” “tearing.”</td>
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Note: The online real-time data is valuable in monitoring and forecasting epidemics and outbreaks, it is evident that such an infodemiology approach can assist public health policymakers in tackling the most critical issues: flattening the curve, allocating health resources, and improving effectiveness and readiness of individual health care systems.
This study aimed to apply digital epidemiology to the current COVID-19 pandemic to determine the utility of providing additional epidemiological information about this disease outbreak and evaluating this methodology in future pandemics.

The goal of this study is to extract more granular signals from publicly available data to predict the future spread of SARS-CoV-2.

We included some Google Trends signals as extra regressors in the prophet model to predict the number of future COVID-19 cases and found that these signals significantly improve the model. Based on these results, it would be helpful to integrate these signals with other COVID-19 forecasting models.

Our model can accurately predict daily new confirmed cases of COVID-19 in most countries and regions. Of the 215 countries and territories studied, 198 (92.1%) had an MAE <10, and 187 (87.0%) had a Pearson correlation coefficient >0.8. For 215 countries and territories, the average MAE was 5.42 (range 0.26-15.32), the average RMSE was 9.27 (range 1.81-24.40), the average Pearson correlation coefficient was 0.89 (range 0.08-0.99), and the average Spearman correlation coefficient was 0.84 (range 0.2-1.00).

By integrating past occurrence data and Google Trends, machine learning algorithms can accurately predict the incidence of COVID-19 in most countries and regions seven days into the future.

The linear regression model predicts events with an RMSE of 7.562 (SD 6.492). The most effective factor besides the previous day’s incident was the frequency of searching for the topic of hand washing, hand sanitizer, and antiseptic. RMSE
the LSTM model is 27187 (SD 20705). Data mining algorithms can be used to predict outbreak trends. These predictions can support policymakers and healthcare managers to plan and allocate healthcare resources accordingly.

"sanitizer," "ethanol," "antiseptic," "case," "new cases."

17 (Ahmed et al 2021) Cross-Sectional with correlation analysis between Google search terms and the positive case rate of COVID-19. The purpose of this research is to study the usefulness of historical data. A Google Trends search to show if there is one correlation between web-based information and disease cases. The real coronavirus 2019 (COVID-19) and what it is. Such data can be used to predict disease patterns spikes.

Highest peak correlation with case series weekly, with a backlog of 1 week, recorded for loss of smell and loss of taste. Model combined yields modest performance for predict positive cases. Linear regression models revealed loss of smell (adjusted R. 2 of 0.7) with a lag time series of 1 week, 2 a week and three weeks were significant as predictors. Best of the number of weekly positive cases. This research analysis explains that Google trends can be essential for anticipating and predicting pandemic patterns and preparedness ahead of time in an unprecedented pandemic crisis.


18 (Lippi et al 2020) Cross-Sectional with correlation analysis between the number of newly diagnosed COVID-19 cases and Google search volume. This study aims to explore whether Google search volume is useful for predicting the trajectory of the coronavirus disease 2019 (COVID-19) outbreak in Italy.

Peak weekly Google searches for "fiber" (fever), "tossed" (cough), and "dyspnea" (dyspnea) are 1.7-, 2.2- and 7.7 times higher than the week before the diagnosis of the first national case. No correlation significant difference was found between the number of newly diagnosed COVID-19 cases and Google search volume of "tossed" (cough) and "fiber" (fever), while "dyspnea" (dyspnea) were significantly correlated (r = 0.50; p = 0.034). Correlation between newly diagnosed cases of COVID-19 and "cough" (cough; r=0.65; p=0.008) or "fever" (fever; 0.69; p=0.004) became statistically significant with a delay of 3 weeks. All the symptoms are also significantly interrelated and correlated. Continuously monitoring Google search volume and mapping its origin is a valuable instrument to help predict and identify the local recurrence of COVID-19.


The first week of February 2020 and the end of May 2020.

19 (Mattuzzi & Lippi, 2020) Cross-Sectional with correlation analysis between Google search volume for COVID-19 and several search terms. The research objective is to see how Google Trends works in predicting COVID-19 cases.

Our analysis of Google search trends showed that despite several typical symptoms and atypical searches by US people interrogating Google to retrieve information about COVID-19, cough and (on the lower level) sputum appear to be the most correlated with COVID-19 search. Therefore, monitor Google search volume for these terms can be useful.
<table>
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<th>Page</th>
<th>(Foa et al 2022)</th>
<th>Cross-Sectional with correlation analysis between search terms on Google and subjective well-being during the COVID-19 pandemic</th>
<th>This study examined whether the lockdown worsened or increased the citizens' overall well-being.</th>
<th>Descriptive trend and series models indicate that negative mood is associated with implementing the lockdown return to baseline within 1-3 weeks of applying lockdown, whereas intensity of the pandemic, as measured by the death rate from COVID-19 infection, continues to be linked with depression effect. The results support the hypothesis that the severity of the pandemic country specificity was the main contributor to the increased negative impact observed during the COVID-19 pandemic.</th>
<th>June 30, 2019, to June 21, 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>(Vijay et al 2021)</td>
<td>Cross-Sectional with correlation analysis between searching for information about wildlife and cases of COVID-19 using Google.</td>
<td>This study aimed to investigate changes in public information seeking on topics at the intersection of health and the environment during the COVID-19 pandemic.</td>
<td>Emerging zoonotic diseases, such as COVID-19, exist at the intersection of human and environmental health. Interest and support from the public are needed to maximize the effectiveness of policies to combat the current pandemic and prevent zoonotic outbreaks in the future. Here, we use internet browsing data from the United States to investigate search changes in public information on topics at the intersection of health and the environment during the COVID-19 pandemic. Using the breakpoint detection method, we identified a marked increase in interest in 'wildlife trade,' 'bats,' and 'pangolins' in the early stages of the pandemic (on January 12, January 19, and January 26, 2020, respectively). Network analysis also revealed increased connectivity between terms related to human and environmental health, as well as the emergence of search terms that are showing greater interest in the trade and consumption of wildlife. During a pandemic, connectivity in the network between the coronavirus keyword and the conservation keyword increases, which we measure using the number of unique connections (edge connectivity, k'(G)) and the number of paths simple (Sp) between keywords. Both measures of network connectivity increased between 'coronavirus' and 'bat' or 'pangolin' (Δk'(G) = 1, Sp = 37), and between 'coronavirus' and 'conservation' (Δk'(G) = 1, Sp = 160). These findings suggest that policies and outreach efforts to involve</td>
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</tr>
<tr>
<td>22</td>
<td>(Kurian et al 2020)</td>
<td>Cross-Sectional with correlation analysis between COVID-19 search data with keywords on Google Trends and total COVID-19 cases.</td>
<td>This study aims to evaluate whether a digital surveillance model using Google Trends can obtain accurate data on the 2019 coronavirus disease and whether predictions can be made regarding new cases. Among the ten keywords analyzed from Google Trends, face masks, Lysol, and COVID stimulus checks had the strongest correlations when looking at the United States, with R values of 0.88, 0.82, and 0.79, respectively. Pearson's lag and lead correlations were assessed for each state and all ten keywords from 16 days before the first case in each state to 16 days after the first case. Some states saw strong correlations up to 16 days before the first reported cases. Information from this research can enable the preparation and planning of sound healthcare systems.</td>
<td>22 January 2020 to 6 April 2020.</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>(Çimke &amp; Yıldırım Gürkan, 2021)</td>
<td>Cross Sectional</td>
<td>This study uses Google Trends data to determine interest in using vitamins during the COVID-19 pandemic. The findings from this study determined that the vitamin trend reached 100 RSV in March 2020, when COVID-19 was declared a pandemic. Vitamins D and C are the most sought-after types of vitamins in Turkey and worldwide. It was determined that a search consisting of a combination of COVID-19 and vitamins was done. Public interest in vitamins has increased since the start of the COVID-19 pandemic.</td>
<td>&quot;vitamin&quot;, &quot;COVID-19&quot;, &quot;immunity&quot;, &quot;vitamin D&quot;, &quot;vitamin C&quot;, &quot;vitamin E&quot;, &quot;vitamin A&quot;. January 1, 2016, to August 30, 2020</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>(Peng et al 2020)</td>
<td>Cross-Sectional with correlation analysis between Google search volume data and daily confirmed new cases.</td>
<td>This study aims to develop a model from a few countries to predict epidemic alert levels worldwide. Our model performed well in 154 (76.2%) countries, each with no more than four misclassified samples. Across these 154 countries, the accuracy is 0.8133, and the kappa coefficient is 0.6828. While in 202 countries, the accuracy is 0.7527, and the kappa coefficient is 0.5841. The proposed algorithm based on Random Forest Classification and nine features performs better compared to other machine learning methods and models with different numbers of elements. Models developed from 20 countries with Google Trends data and random forest classifications can be applied to predict epidemic warning levels in most countries worldwide.</td>
<td>&quot;coronavirus,&quot; &quot;pneumonia,&quot; &quot;cough,&quot; &quot;diarrhea,&quot; &quot;fatigue,&quot; &quot;fever,&quot; &quot;nasal congestion,&quot; &quot;rhinorrhea.&quot; January 10 to April 23, 2020</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>(Jun et al 2021)</td>
<td>Cross-Sectional with correlation analysis between RSV on Google Trends and new cases.</td>
<td>This research aims to empirically demonstrate subsequent changes in human behavior and their impact on public awareness of COVID-19 by tracking Google search data before and after the WHO pandemic declaration. The pandemic declaration increased public awareness and increased information seeking about COVID-19 by more than 20%. In addition, this rapid rise in RSV also reflects the interest in testing for COVID-19 and encourages individuals to get tested, which helps identify new cases. This research provides a theoretical foundation for using RSV and the implications for understanding and strategically &quot;coronavirus&quot;, &quot;new cases&quot;, &quot;new deaths&quot;. March 11 to March 18, 2020</td>
<td></td>
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Kornellia and Syakurah (2023)

leveraging public awareness and behavior in situations where WHO and governments have to roll out policies in response to outbreaks of new infectious diseases such as COVID-19.

26 (Kushwaha et al 2021) Cross-Sectional with correlation analysis between selected query terms and COVID-19 cases

This study aimed to determine information-seeking behavior on nutritional immunity during COVID-19 in India. The peak search data can be linked to the announcement date of the COVID-19 guidelines. All nutrition terms showed a significant increase in average monthly percentage change. A higher-than-average daily increase in COVID-19 cases led to a higher-than-average increase in nutritional period RSV, with the most important association after 14 to 27 days. The highest average relative search volume for nutrition terms came from South India (49.34±7.43) and the lowest from West India (31.10±6.30). There has been a significant increase in Google searches on nutritional immunity during COVID-19 in India.


This study aimed to determine the relative correlation of Twitter and Google Search users' trend of loss of smell to the daily incidence of coronavirus disease 2019 (COVID-19) in the United States, compared to other symptoms of acute respiratory syndrome coronavirus 2 (SARS-CoV-2).

Google searches and tweets of all non-odor (0.744 and 0.761) and COVID-19 symptoms (0.899 and 0.848, respectively) correlated more strongly with disease occurrence than odor loss (0.564 and 0.539). Twitter users who tweeted about the loss of smell during the study period were more likely to be female (52%) than users who more commonly tweeted about COVID-19 (47%). The frequency of Tweets and Google Searches related to smell loss increased significantly (>2.5 standard deviations) following high-read media publications linking smell loss and SARS-CoV-2 infection. The frequency of Google searches and tweets about fever and shortness of breath is a more robust indicator of the occurrence of COVID-19 than anosmia.

28 (Silverio-Murillo et al 2021) Cross-Sectional with correlation analysis of lockdowns during the COVID-19 pandemic and Google searches related to mental health

This study examined the relationship between COVID-19 lockdowns and Google searches for mental health in 11 Latin American countries.

We found three main patterns. First, the search for insomnia peaks but then declines. Second, stress-seeking, anxiety, and grief increased and remained high during the lockdown. Third, there was no substantial change in searches related to depression or suicide after the lockdown. Regarding potential mechanisms, our results show that suicide-seeking and insomnia decreased after each country's income support passed. In contrast, in countries with higher rates of COVID-19-related mortality, the search for insomnia, stress, and anxiety increased more. Lots.

29 (Madden & Feldman, 2021) Cross-Sectional with correlation analysis of whether changes in US search data around anosmia could precede changes in SARS-CoV-2 cases and deaths before

This study aimed to analyze United States search data before the first press release of anosmia as an initial symptom. Only New York showed a significant increase in anosmia-related terms during the pandemic year and a considerable lag (6 days) between increased search activity and the number of cases/deaths attributed to SARS-CoV-2. There is no evidence from search activity indicating an...
anosmia was recognized as a unique symptom. Earlier spread of SARS-CoV-2 than previously reported. Changes in search activity preceded increases in COVID-19 cases/deaths when data was examined regionally, but only at the site of the largest outbreak in New York state.

30 (de la Rosa et al 2022) Cross-Sectional with correlation analysis between lockdown duration and tightening with Google searches for four mental health concepts. This study aimed to examine the relationship between strictness and lockdown duration by Google searches for four mental health concepts (i.e., "Anxiety," "Depression," "Suicide," "Mental Health") in nine countries (i.e., Hungary, India, Iran, Italy, Paraguay, Serbia, South Africa, Spain, Turkey) during the COVID-19 pandemic. A negative association was found between overall lockdown tightness and "Depression." Lockdown duration and the most stringent stay-at-home requirements were negatively associated with "Anxiety." Policies that recommended or required the cancellation of public events demonstrated a negative relationship with "Depression." In contrast, the relationship between policies requiring some or all school levels to be closed and "Depression" was positive. In short, this study provides further evidence to suggest the potential of Google Trends to be utilized as a data source for understand how populations in different parts of the world can be affected by public health measures (including lockdowns) that implemented in response to the global health crisis. Our findings can used in conjunction with other evidence (e.g., mental health surveillance studies) to inform the development of sensitive locking strategies to the mental health needs of people living in different parts of the world the world during a future public health crisis.

31 (Arshad Ali et al 2020) Cross-Sectional with correlation analysis between new cases of COVID-19 and deaths and public interest in telehealth. The main objective of this study was to evaluate the association between the number of new COVID-19 cases, and deaths reported each day and the associated change in the Google Trends RSV from telehealth over six months. A modest, positive correlation was established between global interest in telehealth and new cases (p=0.307, p-value=0.001) and deaths (p=0.469, p-value=0.001) reported worldwide. The United States (US), India, and Bangladesh were found to have a fair, positive correlation between the public interest in telehealth and new cases and deaths of COVID-19 that emerged. United Kingdom (UK) and Italy show a poor positive correlation between increasing new cases or deaths and RSV. Similar statistics are recorded for Chile's daily new topics. For Turkey, a fair, positive correlation between further deaths and RSV, while a poor positive correlation between new cases and RSV was observed. No significant correlation was observed for the other selected countries. Public interest has continued to increase in telehealth during the COVID-19 pandemic. Telemedicine can provide remote consultations and health care that patients need.
4.1. Google Trends Utilization Classification

4.1.1. Predictions of COVID-19 cases

Google Trends is an effective tool for forecasting the ongoing trend of the COVID-19 pandemic outbreak. Previous studies have found a high correlation between Google searches for COVID-19 symptoms and a diagnosis of SARS-CoV-2 infection, which can be used to direct resources if necessary (Ahmed et al. 2021). Several studies have also explained that digital epidemiology can be utilized to provide useful surveillance data for disease outbreaks such as COVID-19. Although trends in certain online searches for these diseases are influenced by media coverage, many search terms reflect the clinical manifestations of the disease and show strong correlations with cases and deaths (Higgins et al. 2020).

4.1.2. Vaccination

Vaccination is the first line of action in COVID-19 mitigation plans in many countries, and health authorities around the world have advocated that their populations be vaccinated to prevent COVID-19 infection. While global vaccination rates were low at the start of the rollout period, vaccination rates gradually accelerated in May and June 2021 (Ritchie et al. 2020). Medical reports have shown that the Delta variant has the highest infection, transmission, and symptom severity rates and is a cause for concern. According to some research, public interest in the COVID-19 variant was greater during the Delta vaccine dominant period than before this period, as seen from the high number of vaccine-related searches on Google Trends (Cheng, 2022).

4.1.3. Symptoms

Anosmia is one of the most characteristic symptoms of COVID-19, starting with loss of smell in sufferers. The correlation between the incidence of COVID-19 and the frequency of Google searches related to COVID-19 symptoms, i.e., loss of smell from the same period (1 January 2019 to 8 April 2019) was discovered. This confirmed that infodemiological trends in COVID-19 symptoms were indeed unique in the era of COVID-19. 19. The results reveal that Google searches and tweets about COVID-
19, shortness of breath, fever, and odorlessness combined are more strongly correlated with the incidence of COVID-19, indicating that parameters related to loss of smell may be more sensitive to COVID-19 (Panuganti et al 2020).

4.1.4. Effect

During the COVID-19 pandemic, one of the effects that arose was mental health. These results are in line with previous research showing that Google searches for the keywords insomnia, stress, anxiety, and sadness increased after the lockdown policy was implemented during the COVID-19 pandemic (Silverio-Murillo et al 2021). The degree of association between lockdowns and searching for insomnia or stress was greater in countries with high pandemic intensity.

4.1.5. Telehealth

A study by Arshad Ali et al (2020) explained that the use of Google Trends is significantly correlated worldwide between RSV for remote treatment, positive cases, and deaths from COVID-19. Google Trends user searches have been extensively analysed and used in the context of health problems and their solutions. An example of the dramatic increase in public interest in remote medicine during the COVID-19 pandemic is Ethiopia, which shows the highest level of interest in Google searches for remote medicine.

4.1.6. Prevention

4.1.6.1. Vitamins

Some vitamins are indicated to be effective in strengthening the immune system (Shakoor et al 2021). During the COVID-19 pandemic, the media often mentioned that vitamins contributed to both protection from illness and the healing process if sick. Vitamin C is most sought after in Turkey as well as around the world. The trend of vitamin C reached 100 RSV in 2020 because it is believed to be useful for preventing infectious diseases. Vitamin C supplements support respiratory defense mechanisms, prevent viral infections, and have antihistamine properties that can improve flu-like symptoms and reduce the duration and severity of infections. In addition, vitamin D is the most sought-after vitamin in Turkey in winter and reaches the second-highest RSV value after vitamin C. This is due to the lack of sunshine in Turkey during winter. Vitamin D has an important role in modulating both innate and adaptive immune responses (Aranow 2011).

4.1.6.2. Nutrition

Fulfilling nutritional needs is crucial to increase strong body immunity to be protected from viral infections. This is in line with previous research that the Indian people show interest in the search for nutrition for the prevention of COVID-19. Interest in the day of increase in cases is also moderately correlated in terms of nutrition (Kushwaha et al 2021). Several studies predict COVID-19 outbreaks in various parts of the world using Google Trends data. In addition, Google Trends provides access to data regarding enormous population coverage, making it a valuable tool for accessing public health and nutrition behaviors.

4.2. Collaboration Between Google Trends, Local Search Portals, and Social Media

4.2.1. Naver

Some studies used information searches about COVID-19 with Google Trends and Naver (Husnayain et al 2020). People in South Korea access more information via Naver when compared to Google; hence, it can become a substitute for Google in this country. The studies’ findings explain that Naver RSV has the potential to be used for health risk assessment and disease prediction (Husnayain et al 2020). Combining Google Trends and Naver RSVs can be useful for targeting risk communications in terms of the time of day and population characteristics, and Google Trends RSV only reveals patterns by communication with time and location.

4.2.2. Baidu Index

The Baidu Index (BI) is a local search portal and the most popular portal in China (Huang et al 2017). The two online searches, BI and Google Trends, were used to compare search results related to COVID-19 to predict keywords such as anosmia and dysgeusia during the COVID-19 pandemic. The use of Google Trends and BI makes it easy to obtain information related to search terms that are widely used by Chinese people.

4.2.3. Twitter

Twitter, as a social media platform, enables real-time research into user-generated opinions, feelings, and health status with shared demographic data. Therefore, Twitter can serve as an essential adjunct for Google Trends users in infodemiological investigations (Panuganti et al 2020).

4.3. Benefits of Predictive Analysis

https://www.malque.pub/ojs/index.php/mr
4.3.1. Promotional Media Provider

Previous research explained that the search rate for the terms vaccination, vitamins and nutrition, as well as symptoms of anosmia on Google, increased, indicating that people want to vaccinate, obtain good vitamins and nutrition, and know about the symptoms of anosmia (Cheng, 2022; Çimke and Yıldırım Gü尔kan, 2021; Kushwaha et al 2021; Madden and Feldman, 2021; Panuganti et al 2020). The government can take advantage of this by making good health promotion media. Efforts can be made by the government, for instance, by making educational posters or videos about vaccinations, vitamins, nutrition, and anosmia whose content is short and easy for everyone to understand. These pieces of information can be shared with many people and make them interested in seeking additional information from promotional media by searching for information through online platforms. In addition, the government can provide access to quality publications about health so that people obtain clear and accurate information. The purpose of promotional media related to vaccination is to increase the level of coverage of people who have had vaccinations.

4.3.2. Call Center Creation

One of the impacts of the COVID-19 pandemic is mental health. Efforts that need to be made regarding mental health are to prevent people from being affected by such issues and to help them handle them if affected. In fact, there are still many people who have a stigma towards people with mental disorders. This causes the person to find it difficult to get treatment. The government can make personal prevention efforts through call centers. Thus, people who feel they have symptoms related to mental health can receive education, counselling, and psychological assistance from the call center.

4.3.3. Policy Making

Governments can make policies easily and quickly by simply looking at the Google Trends database. Easily accessible Google Trends data can be used to enhance their efforts in analysing public anxiety during major outbreaks, which in turn will help them to maximize risk communication to change people’s behavior (Rizqullah and Syakurah, 2020). In addition, governments can leverage Google Trends to improve efforts in analysing and developing integrated risk and crisis communication strategies that involve public behavior interventions against pandemics (Rizqullah and Syakurah, 2021). Leveraging such data can help countries fight pandemics and prepare for outbreaks before they occur to minimize morbidity and mortality as well as possible financial losses.

4.3.4. Increasing the Digitalization of Health Services

The COVID-19 pandemic has forced people to avoid direct contact, so many people are using telehealth and telemedicine during the pandemic. Telemedicine can help sick people obtain good, high-quality care without exposure to terminally ill patients. Noticing trends in global interest in telemedicine during the COVID-19 outbreak can help us shape better healthcare policies and strategies. Previous studies explained that there was a significant increase in search terms on Google Trends for telehealth during the pandemic (Arshad Ali et al 2020). However, previous surveys indicated a lack of adequate infrastructure and available telemedicine monitoring networks. This will make it difficult for people to carry out remote treatment. Consequently, it is necessary to increase the digitization of health services to make it easier for people to use telehealth and telemedicine.

4.4. Utilization of Google Trends in Policy Making

Google Trends has the potential to be complementary data to the existing surveillance data. To be adopted in policy formulation or to strengthen a policy, for example, early detection or determination of outbreaks, it is necessary to confirm between data from Google Trends and official data, both central and regional (Husnayain et al 2019).

Google Trends can be used to express what people are looking for at a given time and location. It can be used to monitor public requests and the most searched topics, although it cannot be used to reveal individual characteristics as conventional surveillance systems do (Bragazzi et al 2017). Therefore, Google Trends cannot replace existing surveillance systems but can serve to complement them (Milinovich et al 2014).

Various research results on communicable and noncommunicable diseases show the potential of Google Trends to monitor disease. In the context of evidence-based policy, one of the duties of policymakers is to receive scientific evidence and then examine and confirm it with evidence in the field. Combining Google Trends with surveillance systems can strengthen the formulation of early warning system policies (Husnayain et al 2020).

5. Final considerations

Google Trends has proven to be an effective tool during the COVID-19 pandemic for estimating trends and providing references to the government in making decisions regarding policies implemented as a strategy for controlling COVID-19 outbreaks. By analysing the Google Trends database, search increases for COVID-19 can be observed. The search trends during
the pandemic are helpful in predicting positive cases, COVID-19-related deaths, vaccinations, anosmia symptoms, telehealth services, COVID-19 effects on mental health, and prevention efforts such as vitamins and nutrition.

Ethical Considerations

Not Applicable.

Conflict of Interest

The authors declare no conflict of interest.

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