



Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.



# The Popularity of the Biologically-Based Therapies During Coronavirus Pandemic Among the Google Users in the USA, UK, Germany, Italy and France

Elif Günelan<sup>a,\*</sup>, İrem Kaya Cebioğlu<sup>b</sup>, Özge Çonak<sup>c</sup>

<sup>a</sup> Department of Nutrition and Dietetics, Istanbul Health and Technology University, Faculty of Health Science, Istanbul, Turkey

<sup>b</sup> Department of Nutrition and Dietetics, Yeditepe University, Faculty of Health Science, Istanbul, Turkey

<sup>c</sup> Program of Medical Documentation and Secretariat, Istanbul Esenyurt University, Vocational School of Health Service, Istanbul, Turkey

## ARTICLE INFO

### Keywords:

Coronavirus  
COVID-19  
Functional foods  
Immunity  
Supplements  
Misinformation

## ABSTRACT

**Object:** The aim of this retrospective infodemiological study was to evaluate people's interests in biologically-based (B-B) complementary and alternative medicine (CAM) therapies such as herbs, foods, and supplements during the coronavirus pandemic via analysis of Google search engine statistics.

**Design & settings:** The category, period, and regions selected in the Google Trends were "health," "15 January–15 May 2020," in the United States of America (USA), the United Kingdom (UK), Germany, Italy, and France, respectively. The most commonly searched herbs, foods and supplements ( $n = 32$ ) during the pandemic were determined from a pool of keywords ( $n = 1286$ ) based on the terms' relative search volumes (RSVs) within the last five years. Correlation analyses were conducted to investigate associations between coronavirus-related parameters with each keyword's RSV for each country. Selected keywords ( $n = 25$ ) were analyzed using the gtrendsR package in the R programming language; the ggplot2 package was used to visualize the data, the Prophet package was used to estimate the time series, and the dplyr package was used to create the data frame.

**Results:** Significantly strong positive correlations were identified between daily RSVs of the terms "black seed," "vitamin C," "zinc," and "quercetin," and search queries for "coronavirus" and "COVID-19" in the USA (Spearman's correlation coefficient  $> 0.8$ ,  $p < 0.05$ ), and between the RSVs of the terms "vitamin C" and "zinc," and daily search queries for "coronavirus" and/or "COVID-19" in the UK (Spearman's correlation coefficient  $> 0.8$ ,  $p < 0.05$ ).

**Conclusion:** Google Trends can be a beneficial tool for following public interest in identifying outbreak-related misinformation, and scientific studies and statements from authorities and the media play a potential role in driving internet searches.

## 1. Introduction

The discovery of a novel coronavirus that caused a new infectious disease, termed coronavirus disease (COVID-19), first appeared in Wuhan, China in late December 2019.<sup>1</sup> As a result of easy human-to-human transmission, the outbreak has spread worldwide, leading the World Health Organization (WHO) to declare the COVID-19 outbreak a global pandemic.<sup>2</sup> People infected with the virus mostly experience respiratory tract symptoms, such as cough and dyspnea, as well as fever. Although most infected people will experience only moderate respiratory illness and will recover without requiring specific

treatment, in elderly people and those with underlying chronic diseases, such as diabetes and chronic respiratory or pulmonary disorders, the virus is more likely to cause serious problems and can even result in death.<sup>3</sup>

Recommended public health practices, including personal hygiene, social distancing, the use of personal protective equipment, and quarantining of infected individuals are all of vital importance in slowing transmission.<sup>4</sup> Apart from these recommendations, some studies have highlighted the importance of maintaining optimal nutritional status to help protect against COVID-19 by ensuring a well-functioning immune system.<sup>5</sup> Several studies have focused on the effects of dietary

\* Corresponding author at: Department of Nutrition and Dietetics, Faculty of Health Science, Istanbul Health and Technology University, Seyitnizam District, Mevlana Street, 34015 Zeytinburnu, Istanbul, Turkey.

E-mail address: [elif.gunalan@istun.edu.tr](mailto:elif.gunalan@istun.edu.tr) (E. Günelan).

<https://doi.org/10.1016/j.ctim.2021.102682>

Received 7 September 2020; Received in revised form 28 December 2020; Accepted 8 February 2021

Available online 15 February 2021

0965-2299/© 2021 The Author(s). Published by Elsevier Ltd. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

supplements to strengthen the immune system to support antioxidant mechanisms that could help effectively protect against COVID-19.<sup>5–10</sup> In addition, some experts, social media outlets, and internet sites have urged people to purchase dietary supplements or/and consume specific functional foods as additional measures to “boost” their immune systems.<sup>11</sup> As a result of such marketing, the sales of dietary supplements such as zinc and elderberry have increased by as much as 255 % and 415 %, respectively, during the single-week period ending March 8, 2020.<sup>12</sup> In response, the United States (U.S.) Food and Drug Administration have sent warning letters to multiple companies selling products based on false promises about protection against or treatment of SARS-CoV-2 infection.<sup>13</sup>

Although the authorities have declared that no food or supplement is able to prevent SARS-CoV-2 infection, people frequently continue to search for, purchase, and consume specific herbs, foods, and commercial supplements. In this context, the internet plays a vital role in providing information about public health. During the COVID-19 pandemic, individuals have frequently searched for COVID-19-related terms in hopes of alleviating their concerns about the virus and to obtain information.<sup>14–19</sup> Therefore, we hypothesized that B-B therapies used in complementary and alternative medicine (CAM) would be searched by Google users during the outbreak. The aim of the study was to investigate and compare the relative search volumes (RSVs) of herbs, foods and supplements related to the COVID-19 pandemic across the United States of America (USA), the UK, Germany, Italy, and France during the period of January 15–May 15, 2020.

## 2. Material and methods

### 2.1. Study design

This study was planned as a retrospective infodemiological study to explore spontaneous Google search engine statistics. The research did not require Ethics committee approval. Google Trends (GT) is a tool that allows for reverse data engineering and the monitoring of changes in public interests. GT provides the data as RSVs, which are also known as search queries. Accordingly, the highest interest in a search query is expressed as a value of 100, whereas insufficient data is expressed as a

value of 0. GT collects data globally and segments it into countries, territories, and cities; it also allows for the analysis of trends in terms during a specific time period.<sup>20</sup> In the study design, the term “health” was selected as the search category, as it reflects the health-related properties of supplements and foods. The search period was defined as January 15–May 15, 2020 due to the fact that the second COVID-19-related death in China occurred on January 15, 2020, and it was this date that searches related to the virus started to appear in the relevant data on GT.<sup>17</sup> Lastly, the RSV values of all keywords were evaluated across the USA, the UK, Italy, Germany, and France; these countries were selected as they are all English-speaking countries with a huge number of COVID-19 cases, and the dates of the first confirmed cases in these countries were all relatively close (January 20–31, 2020).<sup>21</sup>

### 2.2. Selection of keywords

The process of keyword selection is shown in Fig. 1. Initially, the names of herbs & herbal supplements, functional foods, vitamins, minerals and other types of supplements (n = 1263) were obtained using the Natural Medicines Comprehensive Database (<http://www.naturaldatabase.com/>);<sup>22</sup> in addition, the names of other foods and supplements were obtained from the literature (n = 23). All of these were included in the keyword pool (n = 1286) for the present study. The keywords were searched in the “health” category, worldwide, over the last five years. Keywords were selected from this pool based on the following two criteria:

- To exclude the effect of seasonal factors on the search queries, the RSV value of each potential keyword needed to have the highest possible value (100) during the COVID-19 period when compared with Google searches for the same terms within the last five years. According to this criterion, 1218 keywords were excluded from the study.
- GT also provides the related searches pertaining to keywords; selected keywords which were used as herbs, foods or supplements in B-B therapies were included in the study. Keywords with searches unrelated to health, such as cosmetics, hygiene, masks, and

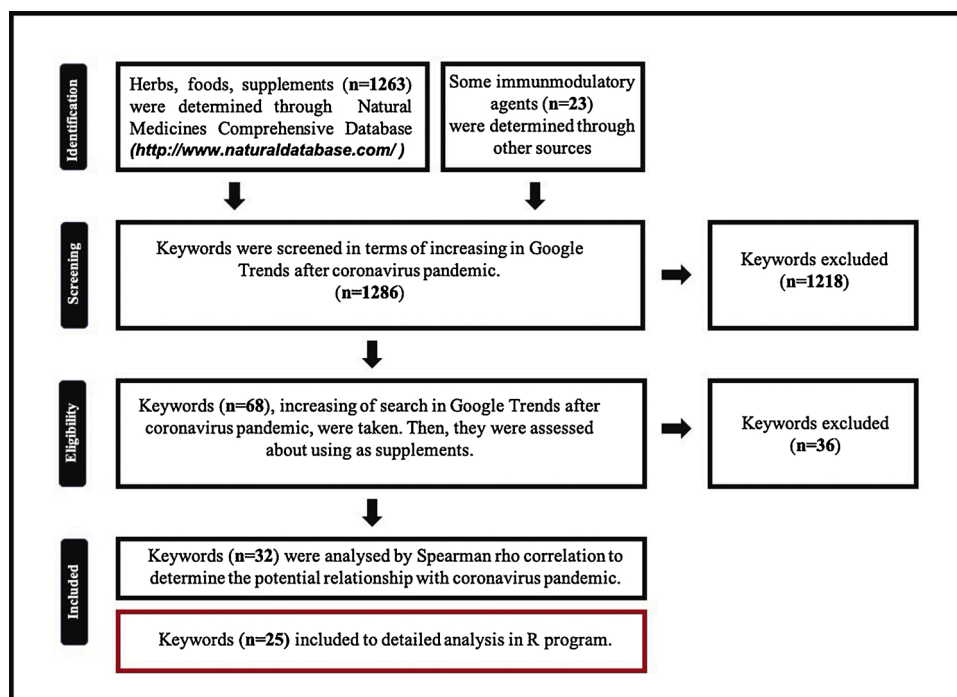


Fig. 1. The schematic view of determination process of keywords.

disinfectants, were excluded from the study to avoid the effects of confounding variables. Based on B-B therapies, which include naturally occurring substances, the National Center for Complementary and Integrative Health classification<sup>23</sup> for alternative treatments was used to select the keywords (n = 32).

The 32 selected keywords were categorized into four groups, which included herbs & herbal supplements (n = 12), functional foods (n = 9), vitamins & minerals (n = 7), and other types of supplements (n = 4). These four categories are summarized in Supplementary Table 1.

2.3. Data collection

Initially, the time trends for the RSVs of the “coronavirus” and “immunity” keywords were searched around the world within the search period. The RSV data were obtained in an .xls format from GT, and correlations were assessed between the daily RSV values of the “coronavirus” and “immunity” keywords. This step could be important for speculating about the reasons certain foods and supplements have

been used to try to combat the COVID-19 pandemic.

Subsequently, the keyword search query data were collected for each country in the “health” category within the search period; the daily RSV data were obtained in an .xls format from GT. This step was repeated for the “coronavirus” and “COVID-19” keywords. The daily numbers of new cases and the cumulative case counts of COVID-19 infections in the USA, the UK, Italy, Germany, and France were obtained for each day of the defined search period.<sup>24</sup> To determine the potential associations between the keywords’ RSV scores and COVID-19-related parameters, such as daily and cumulative case numbers and the RSV values of “coronavirus” and “COVID-19,” correlation analyses were conducted for each country. According to the results, the search queries of 25 keywords searched by individuals in these five countries may have been more related to the COVID-19 pandemic.

2.4. Statistical analyses

Data were analyzed using Statistical Package for the Social Sciences (SPSS) software, version 21 (SPSS Inc., Chicago, Illinois, USA). To

Table 1

The moderately, highly and very highly correlations between RSV values of keywords with daily data about coronavirus related parameters in the USA, UK, Germany, Italy and France through 15 January- 15 May 2020. Data represents as spearman correlation coefficients (r<sub>s</sub>) and p values. r<sub>s</sub>: 0.40-0.59 indicates to moderately correlation; r<sub>s</sub>: 0.60-0.79 indicates to highly correlation; r<sub>s</sub>: 0.79-0.99 indicates to very highly correlation. \*Correlation is significant at the .05 level. \*\*Correlation is significant at the .01 level. USA; United States of America, UK; United Kingdom, GER; Germany, IT; Italy; FR; France.

	Countries	Daily New Cases of Coronavirus		The Number of COVID-19 Cases		RSV Scores of “coronavirus”		RSV Scores of “COVID-19”		
		r <sub>s</sub>	p	r <sub>s</sub>	p	r <sub>s</sub>	p	r <sub>s</sub>	p	
Herbs & Herbal Supplements	Acerola	FR	.15	.11	-.11	.23	.44**	.000	.29**	.000
	Astragalus	USA	-.09	.33	-.25**	.21	.76**	.000	.68**	.000
	Andrographis	USA	.15	.11	.16	.08	.55**	.000	.54**	.000
		UK	.18*	.05	.13	.14	.45**	.000	.39**	.000
	Cinchona	USA	.35**	.000	.30**	.001	.49**	.000	.52**	.000
	Comfrey	USA	.41**	.000	.43**	.000	.01	.86	.09	.30
		UK	.52**	.000	.51**	.000	.20*	.03	.24**	.01
	Echinacea	USA	.10	.26	.09	.33	.75**	.000	.64**	.000
		UK	-.08	.41	-.14	.12	.42**	.000	.29**	.001
	Elderberry	IT	.07	.44	-.35**	.000	.60**	.000	.20*	.03
		FR	.27**	.00	.04	.03	.56**	.000	.44**	.000
	Goldenseal	USA	-.28**	.00	-.37**	.03	.55**	.000	.35**	.000
	Mullein	USA	.165	.07	.21*	.03	.52**	.000	.55**	.000
	Oregano Oil	USA	.40**	.000	.40**	.000	.73**	.000	.74**	.000
	Black Seed	USA	.13	.14	.03	.75	.78**	.000	.62**	.000
		USA	.57**	.000	.53**	.000	.82**	.000	.83**	.000
	Garlic	UK	.60**	.000	.53**	.000	.74**	.000	.76**	.000
		USA	.34**	.000	.35**	.000	.68**	.000	.68	.000
Ginger	UK	.51**	.000	.47**	.000	.53**	.000	.52**	.000	
	USA	.44**	.000	.40**	.000	.63**	.000	.64**	.000	
Lemon	UK	.26**	.000	.22*	.01	.42**	.000	.42**	.000	
	USA	.61**	.000	.70**	.000	.38**	.000	.53**	.000	
Orange	UK	.59**	.000	.55**	.000	.48**	.000	.51**	.000	
	USA	.22*	.01	.16	.09	.78**	.000	.65**	.000	
Propolis	FR	.59**	.000	.43**	.000	.70**	.000	.71**	.000	
	USA	.09	.33	.08	.40	.65**	.000	.57**	.000	
Sumac	FR	.24**	.01	-.10	.29	.46**	.000	.35**	.000	
Niacinamide	USA	.44**	.000	.50**	.000	.29**	.001	.40**	.000	
	USA	.39**	.000	.49**	.000	-.09	.31	.01	.89	
Vitamin A	UK	.36**	.000	.44**	.000	-.02	.82	.07	.44	
	USA	.33**	.000	.25**	.01	.62**	.000	.58**	.000	
Vitamin C	USA	.47**	.000	.48**	.000	.95**	.000	.91**	.000	
	UK	.62**	.000	.55**	.000	.94**	.000	.89**	.000	
Vitamin D	GER	.45**	.000	-.01	.96	.74**	.000	.62**	.000	
	IT	.27**	.000	.003	.97	.44**	.000	.30**	.001	
Zinc	FR	.18*	.05	-.01	.89	.42**	.000	.29**	.001	
	UK	.54**	.000	.63**	.000	.38**	.000	.43**	.000	
Beta Glucan	USA	.51**	.000	.48**	.000	.88**	.000	.84**	.000	
	FR	.62**	.000	.58**	.000	.33**	.000	.50**	.000	
Monolaurin	USA	.03	.71	.07	.49	.49**	.000	.43**	.000	
	USA	.20*	.02	.21*	.00	.62**	.000	.60**	.000	
Quercetin	USA	.60**	.000	.65**	.000	.85**	.000	.91**	.000	
	UK	.35**	.000	.24**	.01	.46**	.000	.45**	.000	

determine whether each variable's data were normally distributed, the Shapiro-Wilk test was performed. Spearman's rho correlation analysis was used to analyze the correlation between the RSV values of the keywords and daily numbers of new cases, the cumulative number of COVID-19 cases, and the RSV values of the "coronavirus" and "COVID-19" keywords. Statistical significance was defined as  $p < 0.05$ .

### 2.5. Further analysis in R programming language

According to the correlation analysis results, selected herbs, foods and supplements ( $n = 25$ ) were analyzed in detail across countries using the R programming language, a free of charge, open source software that is used for statistical analysis and graphic design (R statistical software, [www.R-project.org](http://www.R-project.org)).<sup>25</sup> In this study, time series analysis was performed and visualized using RStudio (Version 4.0.2) programmed in R. The line charts and time series analysis were used to evaluate Google search trends across countries. The data were collected using the gtrendsR package in R. The GT package in the R program lists information for

Great Britain (GB) instead of the UK.

The ggplot2 package was used to visualize the data, the Prophet package was used to estimate the time series data, and the dplyr package was used to create the data frame quickly and consistently. The predicted trends were identified by the time series analysis of the data. In this context, Prophet applies a procedure to estimate time series data based on a model in which nonlinear trends are suitable for annual, weekly, and daily seasonal effects. According to the actual search trends within the search spectrum, it further estimates the search trends of keywords for other time periods. Prophet works best with time series data that exhibit strong seasonal effects, and it is robust against missing data and changes in trends, and it typically handles outliers.<sup>26</sup>

### 3. Results

Initially, a significantly positive correlation was identified between the RSV values of the keywords "coronavirus" and "immunity" (Spearman's correlation coefficient = 0.89;  $p < 0.05$ ). "COVID-19 immune

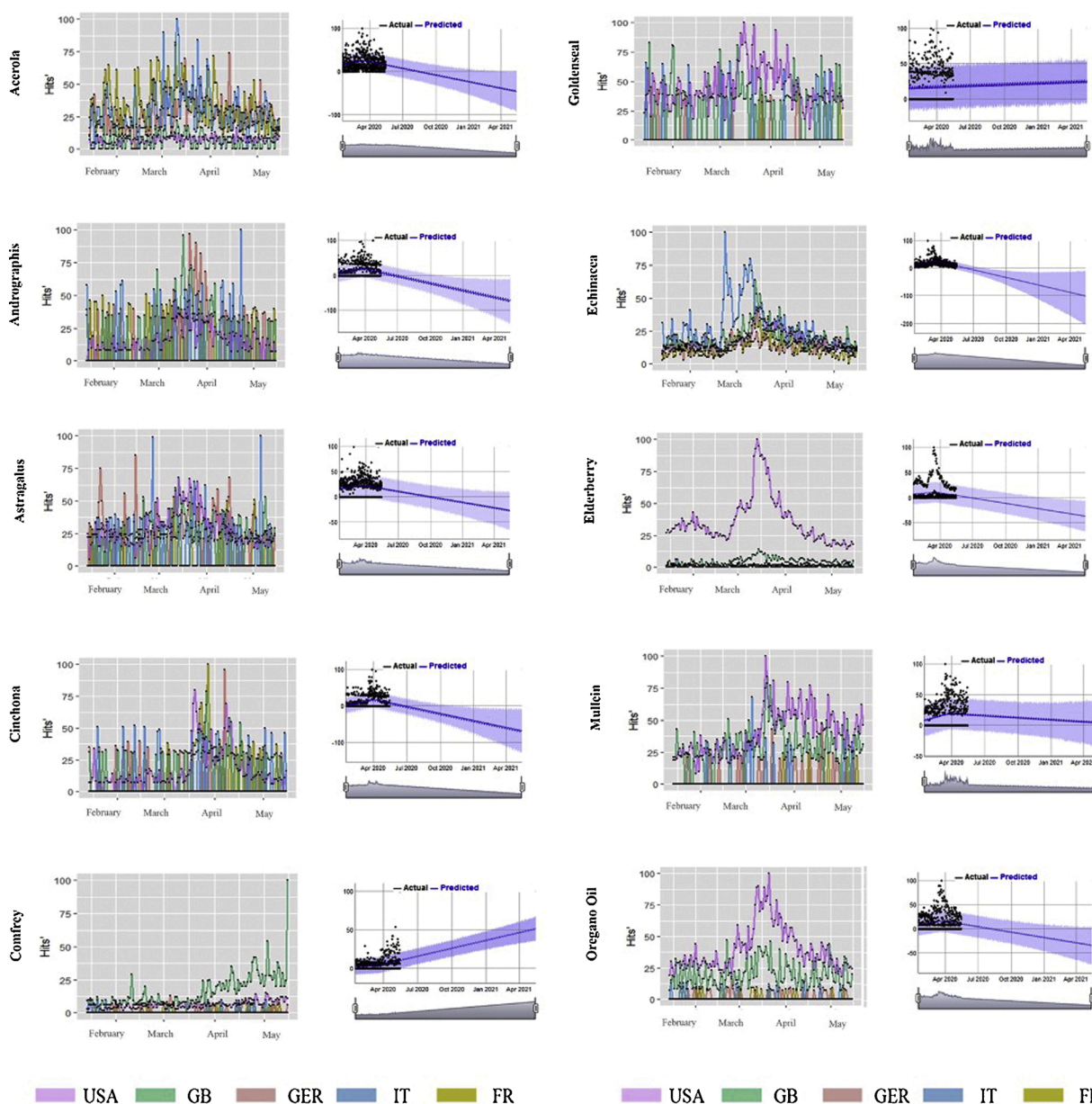
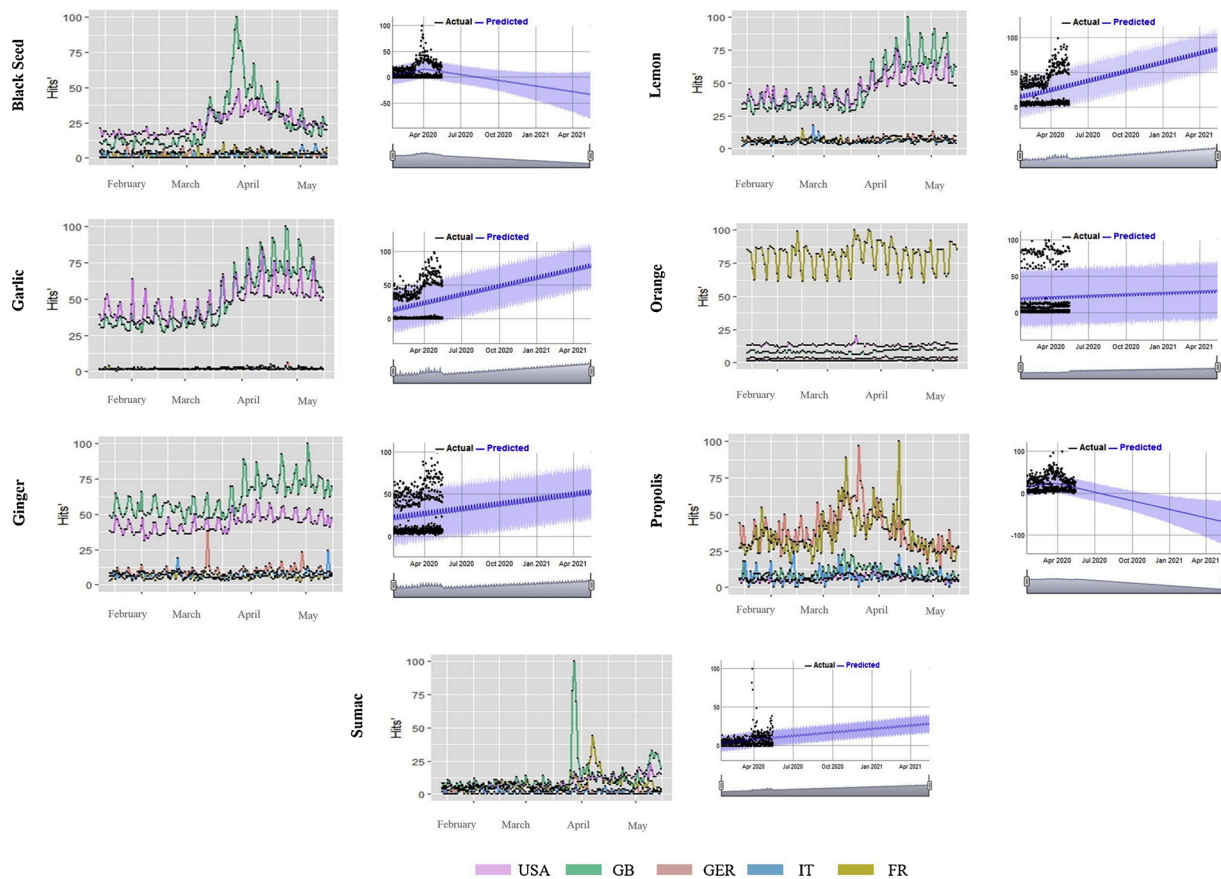


Fig. 2. The search curves of herbs & herbal supplements across the USA, GB, Germany, Italy, and France during the period of January 15–May 15 2020. Both actual and predicted search curves also present.



**Fig. 3.** The search curves of certain functional foods across the USA, GB, Germany, Italy, and France during the period of January 15–May 15 2020. Both actual and predicted search curves also present.

system,” “coronavirus and immune system,” “how to boost your immune system,” and “immune system booster” were mostly searched as immunity-related keywords. In contrast, moderate, strong, and very strong correlations were observed between the RSV values of the keywords and COVID-19 pandemic-related parameters in the USA, the UK, Germany, Italy, and France (Table 1). Accordingly, very strong positive correlations were identified between the daily RSV values of the keywords “black seed,” “vitamin C,” “zinc,” and “quercetin” and search queries of “coronavirus” and/or “COVID-19” in the USA (Spearman’s correlation coefficient  $> 0.8$ ,  $p < 0.05$ ). In addition, a strong positive correlation was also observed between the RSV values of the keywords “vitamin C” and “zinc” and daily search trends of “coronavirus” and/or “COVID-19” in the UK (Spearman’s correlation coefficient  $> 0.8$ ,  $p < 0.05$ ) (Table 1).

Among the herbs & herbal supplements category, “echinacea” was frequently searched in the Google search engine by individuals in Italy in February–March of the study period, whereas “comfrey” was mostly searched by those in GB in April–May. During the COVID-19 outbreak, “elderberry” was searched most more often by Google users in the USA. Lastly, the keywords “mullein” and “oregano oil” were highly searched by the public in the USA and GB in April–May (Fig. 2). For many keywords in this group, the actual trends of the total search volume in five countries were all very similar. For example, the RSV trends of herbs & herbal supplements increased at the beginning of the COVID-19 pandemic, but later decreased during the search period. The predicted search trend estimates relatively decreased compared with those at the beginning of the outbreak (Fig. 2).

The “black seed,” “garlic,” “ginger,” and “lemon” keywords were highly searched by individuals in the USA and GB during the outbreak. The keyword “orange” was especially searched by those in France,

whereas “propolis” was highly searched by those in Germany and France in February–May 2020. In addition, the keyword “sumac” was highly searched in GB for a very short time during the search period (Fig. 3). It was found that the actual search queries of the keywords “black seed” and “propolis” initially increased, then decreased during the search period. In addition, the predicted search trends for these keywords tended to decrease. Both the actual and predicted search trends for “garlic,” “ginger,” and “lemon” increased relative to the trends prior to the beginning of the pandemic.

In the vitamins & minerals group, the keywords “vitamin A,” “vitamin C” and “vitamin D” keywords were all searched much more frequently in the USA, GB, and Germany than in France and Italy during the pandemic. The keyword “niacinamide” was searched in GB, whereas “zinc” was queried most frequently by Google users in the USA, GB, and France during the outbreak. The graphs of the searches for “vitamin C” and “zinc” initially increased, then later decreased in February–May 2020. The predicted search trends for these words are expected to decrease in the future. Additionally, both the actual and predicted search curves for the “vitamin A,” “vitamin D” and “niacinamide” keywords showed that the search queries were higher than those before the COVID-19 pandemic (Fig. 4).

In the other supplements group, the keyword “beta-glucan” was mostly searched by people in Germany and GB, whereas “quercetin” was highly searched by the public of the USA (Fig. 5). In the actual search graphs of the “beta-glucan,” “monolaurin” and “quercetin” keywords, the search trends initially increased, but later decreased during the search period. According to Fig. 5, the estimated search curves are expected to decrease.

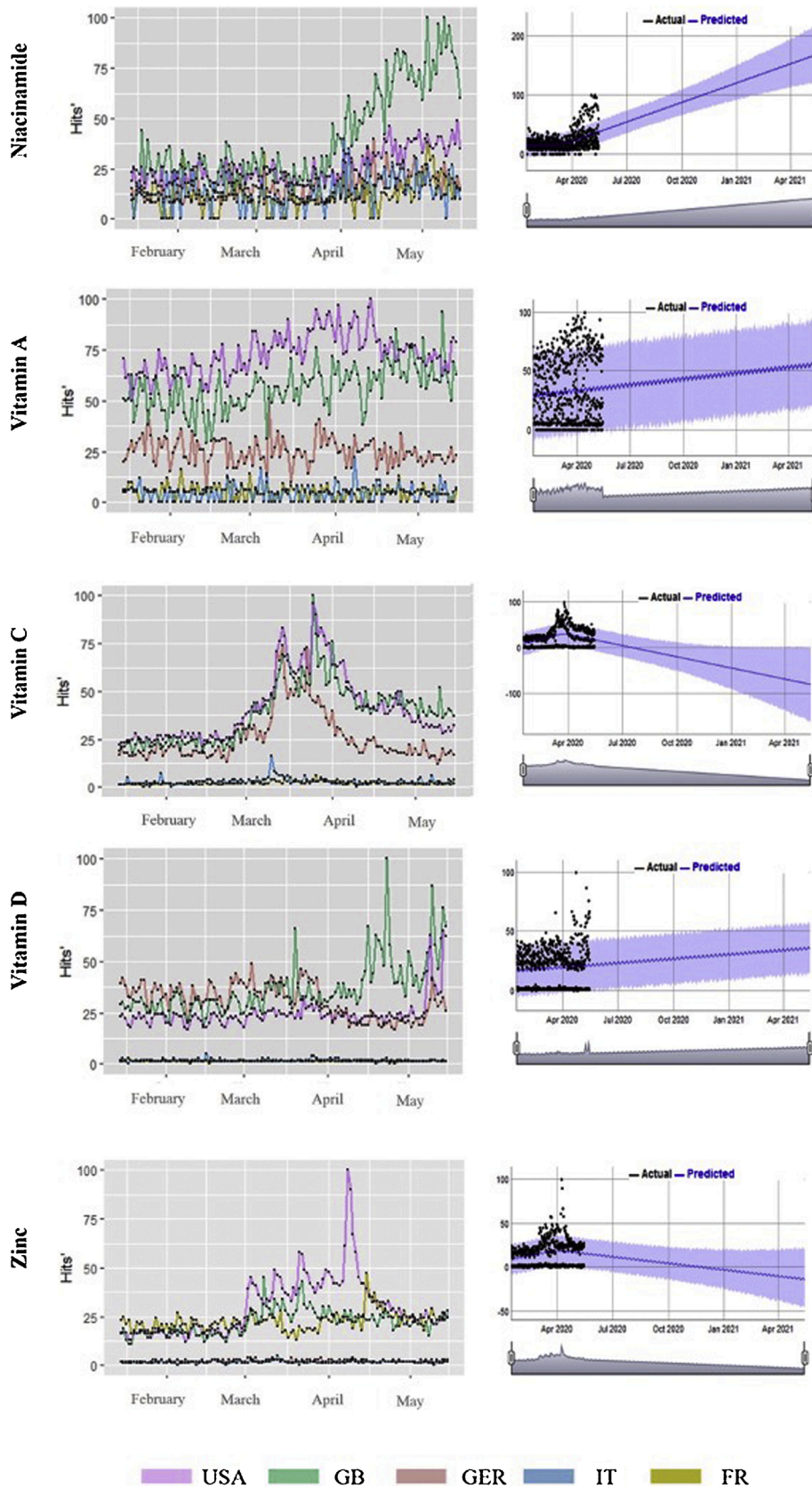


Fig. 4. The search curves of vitamins & minerals group across the USA, GB, Germany, Italy, and France during the period of January 15–May 15 2020. Both actual and predicted search curves also present.

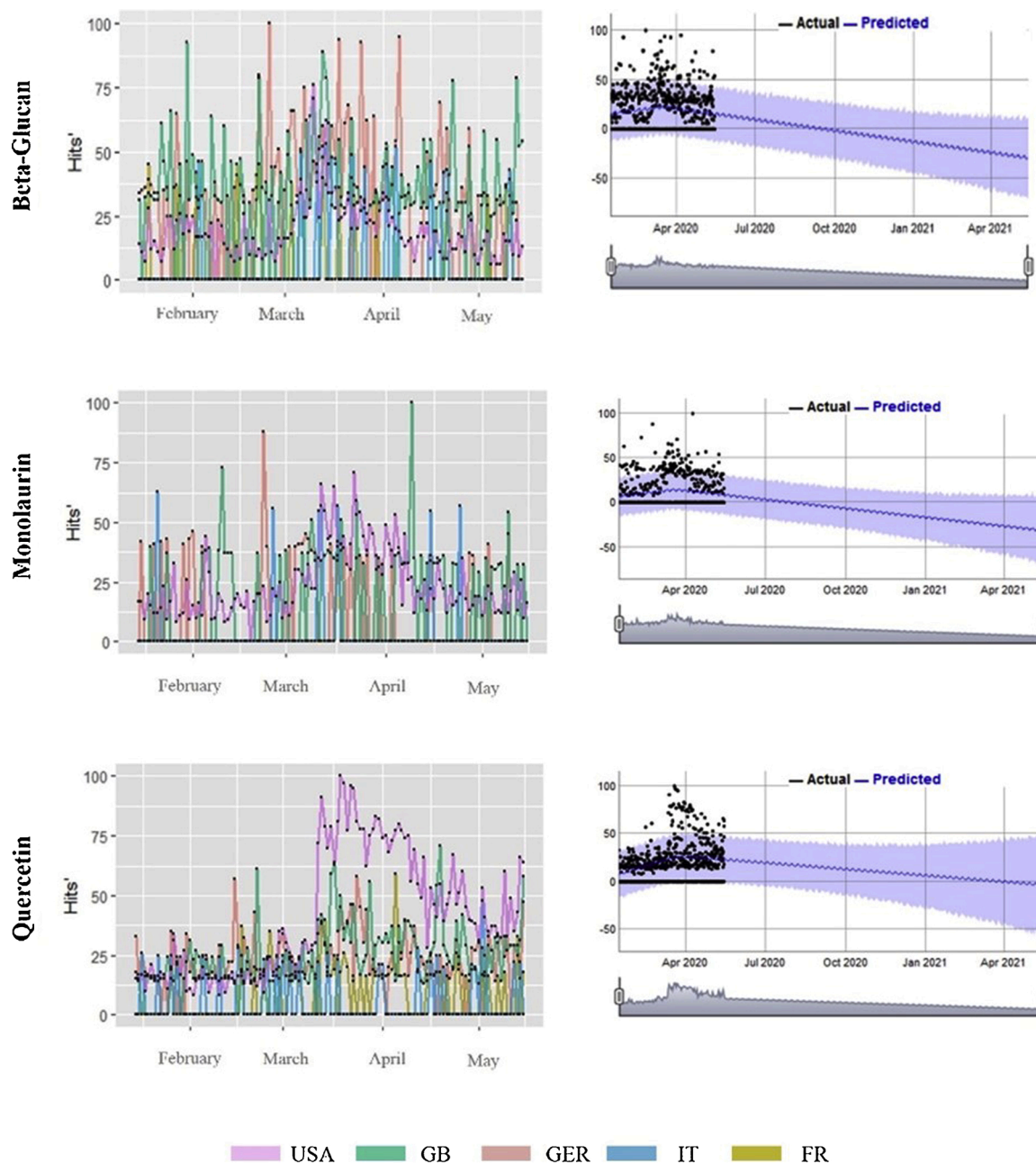


Fig. 5. The search curves of other supplements across the USA, GB, Germany, Italy, and France during the period of January 15–May 15 2020. Both actual and predicted search curves also present.

4. Discussion

The strong positive correlation between the RSV values of the “coronavirus” and “immunity” keywords indicated that the public had an interest in finding ways to achieve “strong immunity against COVID-19 infection,” as individuals searched for ways to optimize immune system function to combat COVID-19. The correlation results for various foods and supplements searched for during the outbreak (Table 1) support this possibility.

In the herbs & herbal supplements group, it has determined that keywords were differentially searched based on the country in which an individual resided. These geographic differences may be associated with the habitat of a given plant, traditional medical knowledge or regional beliefs, national news stories in the media and/or on the internet, relevant scientific studies, and the sales potential of the commercial product in a given country. Consistent with the search profile of

coronavirus, the actual search trends of various herbs and herbal supplements initially increased, then decreased within the defined search period, suggesting the terms may have been searched in relation to the outbreak.

The potential relationships between the novel coronavirus and “acerola”,<sup>27</sup> “andrographis”,<sup>28</sup> “astragalus”,<sup>29</sup> “cinchona”,<sup>30</sup> “echinacea”,<sup>31</sup> “elderberry”,<sup>32</sup> “goldenseal”,<sup>33</sup> “mullein”,<sup>34</sup> and “oregano oil”<sup>35</sup> are summarized in Table 2. Although, in general, the antiviral, anti-inflammatory, and immunomodulatory effects of these plants have been described in the literature,<sup>29,35,36</sup> a limited number of studies have investigated the protective effects of these herbs & herbal supplements against COVID-19, and any protective role these plants may have is currently hypothetical.

The actual RSV graphs of the “black seed” and “propolis” keywords exhibit huge peaks within the search period. The reason for the elevated trends in the search queries for these terms may be related to their



**Table 2**

The potential effects of popular herbs &amp; herbal supplements, vitamins, minerals and other supplements on the COVID-19 infection.

Category	Keywords	The Potential Relationship Between Coronavirus Pandemic and Herbs/Foods/Supplements	References
Herbs & Herbal Supplements	Acerola	It has the high content of ascorbic acid and phytonutrients.	Parakash and Baskaran, 2018
	Andrographis	Andrographolide from <i>Andrographis paniculata</i> has been defined as a potential inhibitor of the main protease of SARS-CoV-2.	Enmozhi et al., 2020
	Astragalus	It has antiviral, anti-inflammatory and immune regulation.	Yang et al., 2020
	Cinchona	Quinine which derived from the cinchona bark, is highly effective against the malaria and the efficacy of the chloroquine on the coronavirus has been discussed.	Touret and de Lamballerie, 2020
	Echinacea	Echinacea is a source of potent antivirals for respiratory virus infections. Therefore, it was hypothesized that it can be antiviral agent for the coronavirus.	Hensel et al., 2020
	Elderberry (Sambucus Nigra)	Elderberry is known as an immune supporting herb and the polyphenols of <i>Sambucus</i> have antiviral activity.	Weng et al., 2019
	Goldenseal	Goldenseal has potential role in immune-modulatory effect.	Clement-Kruzel et al, 2008
	Mullein	Mullein uses for the treatment of inflammatory diseases, asthma, coughs, diarrhea and other pulmonary problems.	Turker and Camper, 2002
	Oregano Oil	It has antiviral efficacy against human norovirus.	Gilling et al, 2014
	Niacinamide	B vitamins supplementation can play role in strong immune system.	Villaruz-Sulit and Cabaluna, 2020
Vitamins & Minerals	Vitamin A	Retinoids have strength immunomodulatory, antiviral and anti-inflammatory properties.	Trasino, 2020
	Vitamin C	It was hypothesized that high dose intravenous Vitamin C can be beneficial for coronavirus patients in the early period.	Carr, 2020; Wilkinson, 2020.
	Vitamin D	Vitamin D supplementation could reduce risk of influenza and coronavirus infections related deaths.	Grant et al., 2020
	Zinc	Zinc level has a critical importance for the antiviral immune response.	Read et al., 2019
	Beta Glucan	Beta glucan extracts have <i>in vitro</i> immunomodulatory and pulmonary cytoprotective effects.	Murphy et al, 2020
Other Supplements	Monolaurin	Coconut oil and its components such as monolaurin, have potential impacts and safe antiviral agents against the coronavirus infections.	Dayrit FM, Newport, MT, 2020
	Quercetin	Quercetin has health-improving effect, anti-viral and anti-inflammatory activity. It is also studied in an experimental, synergistic therapy with Vitamin C for the treatment of COVID-19	Colunga Biancatelli et al., 2020

potential antiviral effects as well as personal interests in these natural products.<sup>37,38</sup> However, there is no evidence that the consumption of black seed or propolis offers any protection from SARS-CoV-2 infection in humans. Therefore, more studies are required to elucidate the therapeutic effects of black seed and propolis on COVID-19.

In the functional foods group, the use of the keywords “garlic,” “ginger” and “lemon” was higher in actual and predicted search queries than searches for the same terms before the start of the COVID-19 pandemic. A possible explanation for the increased search trends for the functional foods group may be related to their antiviral, antibacterial, anti-inflammatory, and immunomodulatory properties, and their vitamin and mineral contents. However, the British Dietetic Association previously confirmed that is not possible to “turbocharge” one’s immune system through dietary intake alone.<sup>39</sup> In addition, the WHO has reported that no special foods or supplements can prevent or cure new COVID-19 infections.<sup>40</sup> In particular, the WHO has discredited claims that garlic can improve COVID-19 resistance.<sup>41</sup> Therefore, the public should be well-educated about the false claims related to the consumption of these food products through the use of appropriate tools.

The effects of various vitamins and minerals on COVID-19 infections have been investigated in several studies since the beginning of the outbreak.<sup>9,10,42</sup> Each of these studies differed with respect to the search trends; these included differences in the terms used based on the country, the peak status, and the search period. For instance, the high peak for the terms “vitamin C” and “vitamin D” could be related to their therapeutic potential against SARS-CoV-2 infection.<sup>10,42,43</sup> The timing of the peak of these search terms may be associated with the timing of COVID-19-related searches, the number of cases, and the timing of the publication of related articles and news story broadcasts on the internet and other media outlets.

It is known that vitamin A has immunomodulatory, antiviral, and anti-inflammatory properties,<sup>44</sup> and the frequency of searches for it has increased little-by-little. This can be explained by the fact that it is not directly related to the novel coronavirus. Although there is a lack of scientific evidence for the efficacy of niacinamide and zinc on COVID-19 in that period, both have been highly searched by Google users in GB and the USA, respectively. This increasing trend could be associated

with some advertisements on popular web sites and the immunomodulator functions of these vitamins and minerals.<sup>45,46</sup>

The potential effects of beta-glucan,<sup>47</sup> monolaurin,<sup>48</sup> and quercetin<sup>49</sup> on COVID-19 are summarized in Table 2. The changes in search trends for these keywords were similar to those of the herbs & herbal supplements group, as was the motivation to seek out information on these products. In addition, social media and commercial advertisements can contribute to changes in Google search trends.

Both the correlation analysis and the findings based on tool sets in the R programming language confirmed that Google users in the USA and GB displayed more potential interest in herbs, foods products, and supplements during the search period than did those of Germany, Italy, and France. Regional eating habits, regional CAMs, the number of COVID-19 cases, and national news in the media and on the internet could influence the herb-, food-, and supplement-related search queries. Generally, the search trends of keywords exhibited similar RSV values as those of “coronavirus” and “COVID-19,” suggesting searches for these terms could be related to the pandemic conditions.

This study provided a model to help estimate the search trends for other time periods based on the search parameters. However, search trends are dynamic and can be affected by external factors such as the publication of new scientific studies, statements released by authorities, and novel discoveries. All of these factors could impact the predictions. Nevertheless, the predicted search trends are of vital importance, as they contribute to the identification and modulation of sources of false information, which could help the public in future periods.

Several limitations should be taken into consideration when interpreting the results of this study. Firstly, the detailed analyses were performed based on Google searches from only five countries (the USA, the UK/GB, Germany, Italy, and France). However, Google searches about complementary medicine frequently appear in African and Asian countries due to their cultures’ continued use of traditional medicine and the lack of modern medical tools, including medicines and vaccines. Therefore, the study’s results cannot completely reflect the pandemic’s effect on the global public interest in herbs, foods and dietary supplements. Secondly, the language of the searched keywords was English, and most of the countries included in the study were English-speaking,

although the names of certain herbs and other supplements were universal. However, functional foods, vitamins, and minerals could be searched by members of the public in non-English languages; for example, German in Germany, Italian in Italy, and French in France. Therefore, especially for the functional foods category, the data in our study may be less representative of these countries. Lastly, all searches performed during the outbreak period do not necessarily mean that they were conducted to find information to protect against the virus. It is not known whether the changes in the trends of the Google searches were a result on the pandemic or simply for scientific purposes or general interests.

This is a comprehensive study to evaluate both actual and predicted Google search trends related to B-B CAM therapies during the pandemic. Although there was no scientific evidence that COVID-19 affected the GT of some keywords, their RSV values did increase during the pandemic, possibly in relation to news media, popular web sites, and personal interests. Thus, our results contribute to the estimates of public interest in false beliefs and fake cures.

GT can be a beneficial tool to determine the general interest in dietary supplements.<sup>50</sup> During the COVID-19 pandemic, people are likely to be generally anxious and want to alleviate their concerns by taking additional protective measures. This behavior may contribute to the increased number of searches related to the use of supplements and the consumption of certain foods. However, we observed that the initial increase in the number of search queries using some keywords tended to decrease again after a certain period of time during the pandemic. Moreover, the “coronavirus” and “COVID-19” search trends exhibited a similar profile. A possible reason for this could be that people acclimatize to pandemic conditions over time and can give up searching for new pandemic-related information on the internet. In addition, scientific studies, official statements released by authorities, and news in the media may have played a role in changing people’s behavior pertaining to Google searches for information about dietary supplements and functional foods to protect against SARS-CoV-2 infection. Therefore, the public should be well-educated to protect themselves during the COVID-19 pandemic via the use of appropriate tools and information provided by national and/or international public health authorities.

#### Author contributions

E.G. designed and conducted the study, analyzed the data and wrote the manuscript. O.C. designed the study and analyzed the data in R program and I.K.C. designed and conducted the study. All authors contribute to discussion of the results, and approval of the final version of paper.

#### Role of the funding source

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

#### Declaration of Competing Interest

The authors report no declarations of interest.

#### Acknowledgements

We thanks to health professions who combat with coronavirus pandemic.

#### Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.ctim.2021.102682>.

#### References

- Wang C, Horby PW, Hayden FG, Gao GF. A novel coronavirus outbreak of global health concern. *Lancet*. 2020;395(10223):470–473. [https://doi.org/10.1016/S0140-6736\(20\)30185-9](https://doi.org/10.1016/S0140-6736(20)30185-9).
- WHO/Europe | Coronavirus disease (COVID-19) outbreak - WHO announces COVID-19 outbreak a pandemic; 2020. Accessed May 31 <http://www.euro.who.int/en/health-topics/health-emergencies/coronavirus-covid-19/news/news/2020/3/who-announces-covid-19-outbreak-a-pandemic>.
- Coronavirus; 2020. Accessed May 31 <https://www.who.int/health-topics/coronavirus#tab=tab.1>.
- Signorelli C, Fara GM. Covid-19: hygiene and public health to the front. *Acta Biomed*. 2020;91:7–8. <https://doi.org/10.23750/abm.v91i13-S.9507>.
- Calder PC, Carr AC, Gombart AF, Eggersdorfer M. Optimal nutritional status for a well-functioning immune system is an important factor to protect against viral infections. *Nutrients*. 2020;12(4):1–10. <https://doi.org/10.3390/nu12041181>.
- Muscogiuri G, Barrea L, Savastano S, Colao A. Nutritional recommendations for CoVID-19 quarantine. *Eur J Clin Nutr*. 2020:10–11. <https://doi.org/10.1038/s41430-020-0635-2>. Published online.
- Di Renzo L, Merra G, Esposito E, De Lorenzo A. Are probiotics effective adjuvant therapeutic choice in patients with COVID-19? *Eur Rev Med Pharmacol Sci*. 2020;24(8):4062–4063. <https://doi.org/10.26355/eurrev.202004.20977>.
- Messina G, Polito R, Monda V, et al. Functional role of dietary intervention to improve the outcome of COVID-19: a hypothesis of work. *Int J Mol Sci*. 2020;21(9). <https://doi.org/10.3390/ijms21093104>.
- Hemilä H, Chalker E. Vitamin C as a possible therapy for COVID-19. *Infect Chemother*; 2020. Published online May 15, 2020. Accessed June 2, 2020 <http://www.ncbi.nlm.nih.gov/pubmed/32410417>.
- Grant WB, Lahore H, McDonnell SL, et al. Evidence that vitamin D supplementation could reduce risk of influenza and covid-19 infections and deaths. *Nutrients*. 2020;12(4):1–19. <https://doi.org/10.3390/nu12040988>.
- Links between coronavirus, nutrition and the immune system | World Cancer Research Fund International; 2020. Accessed May 31 <https://www.wcrf.org/int/blog/articles/2020/04/links-between-coronavirus-nutrition-and-immune-system>.
- Dietary supplement sales skyrocket during coronavirus pandemic | Nutritional Outlook; 2020. Accessed June 1 <https://www.nutritionaloutlook.com/trends-business/dietary-supplement-sales-skyrocket-during-coronavirus-pandemic>.
- Coronavirus update: F.D.A. And FTC warn seven companies selling fraudulent products that claim to treat or prevent COVID-19 | FDA; 2020. Accessed June 8 <https://www.fda.gov/news-events/press-announcements/coronavirus-update-fda-and-ftc-warn-seven-companies-selling-fraudulent-products-claim-treat-or>.
- Higgins TS, Wu AW, Sharma D, Illing EA, Rubel K, Ting JY. Correlations of online search engine trends with coronavirus disease (COVID-19) incidence: infodemiology study (Preprint). *JMIR Public Heal Surveill*. 2020;6. <https://doi.org/10.2196/19702>.
- Hong Y-R, Lawrence J, Williams Jr D, Mainous III A. Population-level interest and telehealth capacity of US hospitals in response to COVID-19: cross-sectional analysis of google search and national hospital survey data. *JMIR Public Heal Surveill*. 2020;6(2). <https://doi.org/10.2196/18961>. e18961.
- Caputi TL, Ayers JW, Dredze M, Suplina N, Burd-Sharps S. Collateral crises of gun preparation and the COVID-19 pandemic: an infodemiology study. *JMIR Public Heal Surveill*. 2020;6:1–8. <https://doi.org/10.2196/19369>.
- Strzelecki A. The second worldwide wave of interest in coronavirus since the COVID-19 outbreaks in South Korea, Italy and Iran: a Google Trends study. *Brain Behav Immun*. 2021. <https://doi.org/10.1016/j.bbi.2020.04.042>. Published online 2020.
- Yuan X, Xu J, Hussain S, Wang H, Gao N, Zhang L. Trends and prediction in daily new cases and deaths of COVID-19 in the United States: an internet search-interest based model. *Explor Res Hypothesis Med*. 2020:1–6. <https://doi.org/10.14218/erhm.2020.00023>.
- Hu D, Lou X, Xu Z, et al. More effective strategies are required to strengthen public awareness of COVID-19: evidence from Google Trends. *J Glob Health*. 2020;10(1):011003. <https://doi.org/10.7189/jogh.10.011003>.
- Cervellin G, Comelli I, Lippi G. Is Google Trends a reliable tool for digital epidemiology? Insights from different clinical settings. *J Epidemiol Glob Health*. 2017; 7(3):185–189. <https://doi.org/10.1016/j.jegh.2017.06.001>.
- Worldometer. Coronavirus cases. Worldometer; 2021. <https://doi.org/10.1101/2020.01.23.20018549v2>.
- Natural medicines - food, herbs & supplements; 2020. Accessed July 17 <https://naturalmedicines.therapeuticresearch.com/databases/food,-herbs-supplements.aspx>.
- Koithan M. Introducing complementary and alternative therapies. *J Nurse Pract*. 2009;5(1):18–20. <https://doi.org/10.1016/j.nurpra.2008.10.012>.
- Coronavirus update (live): 76,167,173 cases and 1,684,482 deaths from COVID-19 virus pandemic - Worldometer; 2020. Accessed December 19 <https://www.worldometers.info/coronavirus/>.
- R: The R project for statistical computing; 2020. Accessed December 19 <https://www.r-project.org/>.
- Taylor S. Letham B. Package ‘prophet’. Accessed July 20; 2020. <https://cran.r-project.org/web/packages/prophet/prophet.pdf>.
- Prakash A, Baskaran R, Acerola, an untapped functional superfruit: a review on latest frontiers. *J Food Sci Technol*. 2018;55(9):3373–3384. <https://doi.org/10.1007/s13197-018-3309-5>.
- Enmozhi SK, Raja K, Sebastine I, Joseph J. Andrographolide as a potential inhibitor of SARS-CoV-2 main protease: an in silico approach. *J Biomol Struct Dyn*. 2020:1–10. <https://doi.org/10.1080/07391102.2020.1760136>. Published online April 24.
- Yang Y, Islam MS, Wang J, Li Y, Chen X. Traditional Chinese medicine in the treatment of patients infected with 2019-new coronavirus (SARS-CoV-2): a review

- and perspective. *Int J Biol Sci.* 2020;16(10):1708–1717. <https://doi.org/10.7150/ijbs.45538>.
- 30 Touret F, de Lamballerie X. Of chloroquine and COVID-19. *Antiviral Res.* 2020;177. <https://doi.org/10.1016/j.antiviral.2020.104762>.
  - 31 Hensel A, Bauer R, Heinrich M, et al. Challenges at the time of COVID-19: opportunities and innovations in antivirals from nature. *Planta Med.* 2020;86(10):659–664. <https://doi.org/10.1055/a-1177-4396>.
  - 32 Weng JR, Lin CS, Lai HC, et al. Antiviral activity of Sambucus Formosana Nakai ethanol extract and related phenolic acid constituents against human coronavirus NL63. *Virus Res.* 2019;273:197767. <https://doi.org/10.1016/j.virusres.2019.197767>.
  - 33 Clement-Kruzel S, Hwang SA, Kruzel MC, Dasgupta A, Actor JK. Immune modulation of macrophage pro-inflammatory response by goldenseal and Astragalus extracts. *J Med Food.* 2008;11(3):493–498. <https://doi.org/10.1089/jmf.2008.0044>.
  - 34 Turker AU, Camper ND. Biological activity of common mullein, a medicinal plant. *J Ethnopharmacol.* 2002;82(2-3):117–125. [https://doi.org/10.1016/S0378-8741\(02\)00186-1](https://doi.org/10.1016/S0378-8741(02)00186-1).
  - 35 Gilling DH, Kitajima M, Torrey JR, Bright KR. Antiviral efficacy and mechanisms of action of oregano essential oil and its primary component carvacrol against murine norovirus. *J Appl Microbiol.* 2014;116(5):1149–1163. <https://doi.org/10.1111/jam.12453>.
  - 36 Hudson J, Vimalanathan S. Echinacea—a source of potent antivirals for respiratory virus infections. *Pharmaceuticals.* 2011;4(7):1019–1031. <https://doi.org/10.3390/ph4071019>.
  - 37 Idrees M, Khan S, Memon NH, Zhang Z. Effect of the phytochemical agents against the SARS-CoV and selected some of them for application to COVID-19: a mini-review. *Curr Pharm Biotechnol.* 2020;21. <https://doi.org/10.2174/1389201021666200703201458>.
  - 38 Zahra FT, Saleem S, Imran M, Ghazal A, Arshad U. *The SARS-CoV-2 pandemic and the role of honey and its products as an emerging therapeutic regime: a review.* 36. 2020.
  - 39 *COVID-19 / coronavirus - advice for the general public;* 2020. Accessed May 31 <https://www.bda.uk.com/resource/covid-19-corona-virus-advice-for-the-general-public.html>.
  - 40 *#HealthyAtHome - Healthy Diet;* 2020. Accessed July 27 <https://www.who.int/campaigns/connecting-the-world-to-combat-coronavirus/healthyathome/healthyathome—healthy-diet>.
  - 41 *Mythbusters;* 2020. Accessed July 27 <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public/myth-busters#garlic>.
  - 42 Carr AC. A new clinical trial to test high-dose vitamin C in patients with COVID-19. *Crit Care.* 2020;24(1):133. <https://doi.org/10.1186/s13054-020-02851-4>.
  - 43 Wilkinson E. RECOVERY trial: The UK covid-19 study resetting expectations for clinical trials. *BMJ.* 2020;369. <https://doi.org/10.1136/bmj.m1626>.
  - 44 Trasino SE. A role for retinoids in the treatment of COVID-19? *Clin Exp Pharmacol Physiol.* 2020. <https://doi.org/10.1111/1440-1681.13354>. Published online.
  - 45 Theodore Cabaluna I. *Should B Vitamins be used in the treatment of COVID-19?* 2021. <https://doi.org/10.1002/14651858.CD004905.pub5>.
  - 46 Read SA, Obeid S, Ahlenstiel C, Ahlenstiel G. *The role of zinc in antiviral immunity.* 2021. <https://doi.org/10.1093/advances/nmz013>.
  - 47 Murphy EJ, Masterson C, Rezoagli E, et al.  $\beta$ -Glucan extracts from the same edible shiitake mushroom *Lentinus edodes* produce differential in-vitro immunomodulatory and pulmonary cytoprotective effects — implications for coronavirus disease (COVID-19) immunotherapies. *Sci Total Environ.* 2020;732:139330. <https://doi.org/10.1016/j.scitotenv.2020.139330>.
  - 48] Dayrit FM, Newport M. *The potential of coconut oil and its derivatives as effective and safe antiviral agents against the novel coronavirus (nCoV-2019)* |. Accessed July 21. Ateneo de Manila University; 2020. <https://ateneo.edu/ls/sose/sose/news/research/potential-coconut-oil-and-its-derivatives-effective-and-safe-antiviral>.
  - 49 Colunga Biancatelli RML, Berrill M, Catravas JD, Marik PE. Quercetin and vitamin C: an experimental, synergistic therapy for the prevention and treatment of SARS-CoV-2 related disease (COVID-19). *Front Immunol.* 2020;11:1451. <https://doi.org/10.3389/fimmu.2020.01451>.
  - 50 Kamiński M, Kregielska-Narozna M, Bogdański P. Determination of the popularity of dietary supplements using google search rankings. *Nutrients.* 2020;12(4). <https://doi.org/10.3390/nu12040908>.