Toothpaste-related interests of Google users from different countries

Bruna DI PROFIO[(a)] (iD)
Matheus LOTTO[(b)] (iD)
Patricia Estefania Ayala AGUIRRE[(b)] (iD)
Cristina Cunha VILLAR[(a)] (iD)
Giuseppe Alexandre ROMITO[(a)] (iD)
Mariana Minatel BRAGA[(c)] (iD)
Thiago CRUVINEL[(b)] (iD)
Cláudio Mendes PANNUTI[(a)] (iD)

[(a)]Universidade de São Paulo – USP, School of Dentistry, Department of Stomatology, São Paulo, SP, Brazil.

[(b)]Universidade de São Paulo – USP, Bauru School of Dentistry, Department of Pediatric Dentistry, Orthodontics, and Public Health, Bauru, SP, Brazil.

[(c)]Universidade de São Paulo – USP, School of Dentistry, Department of Pediatric Dentistry, São Paulo, SP, Brazil.

Corresponding Author:
Cláudio Mendes Pannuti
E-mail: pannuti@usp.br

Abstract: The Internet is a growing source of knowledge and can provide information about oral health. This ecological study aimed to characterize the interests in toothpaste among Google users from different countries. Our hypothesis was that there would be an increase in Google users' interest in information about toothpaste. This retrospective longitudinal ecological study analyzed the toothpaste-related interest of Google users from 10 countries between January 2004 and December 2020. The monthly variation in relative search volume (RSV) and the main related queries were determined using Google Trends. Autoregressive integrated moving average (ARIMA) forecasting models were built to establish the predictive RSV values for toothpaste for an additional 12 months. Autocorrelation plots and the generalized additive model (GAM) were used to diagnose trends and seasonality in RSV curves. Additionally, the influence of social isolation related to the outbreak of COVID-19 was analyzed. Although not detected by autocorrelation function (ACF) and partial autocorrelation function (PACF) analyses, the heuristic analysis showed an increase in the interest in toothpaste-related information in all countries, with a stable trend observed in the 12-month forecasts, except for the increases in the United Kingdom and South Africa. Also, GAM analyses demonstrated a non-significant monthly or quarterly seasonal influence on data. In addition, social isolation during the COVID-19 pandemic did not influence the online information-seeking behavior of Google Search users linked to this topic. We confirmed the hypothesis that the interest of Google Search users in information about toothpaste increased in all of the 10 assessed countries.

Keywords: Consumer Health Information; Internet Use; Dental Informatics; COVID-19; Toothpastes.

Introduction

Dental biofilm is a major etiological agent of dental caries and gingivitis. Thus, the prevention of both diseases depends on daily self-performed mechanical removal of biofilm.[1] Mechanical biofilm control consists of a combination of toothbrushing and interdental plaque removal. However, maintaining the tooth surfaces free of plaque is not an easy task, as it requires high levels of motivation and manual dexterity.[2] Furthermore, optimal biofilm control requires providing the patient with appropriate tools

and correct oral hygiene instructions. Unfortunately, few individuals achieve proper levels of mechanical oral hygiene.[2] Consequently, adjunctive chemical plaque control is indicated to provide additional benefits in reducing plaque and gingivitis.[3] Chemical plaque control consists of the delivery of antiseptics by mouthrinse or toothpaste.[3]

Delivery of chemical agents with toothpaste is the most logical approach to adjunctive chemical plaque control in that the population commonly uses dentifrices during toothbrushing.[1] Furthermore, toothpastes are widely accepted and present a reasonable cost. Toothbrushing with a fluoride toothpaste is one of the most important preventive measures to decrease dental caries.[3] In addition, there is evidence of the benefits of other substances found in toothpastes for the reduction of biofilm and gingivitis, such as triclosan/copolymer, stannous fluoride[4] and dual-zinc plus arginine.[5] Moreover, some products have demonstrated efficacy in root caries reduction,[6] dentin hypersensitivity management,[7] and protection against abrasive or erosive challenges.[8]

Given the wide choice of available products and the controversies about oral hygiene in the media, it is natural for patients to search for the best way to promote their routine oral care.[9] The internet is an important and popular source of health information.[10] Unfortunately, the quality of most websites is poor, mainly because much content is produced by non-dental organizations, which present unreliable information about oral health, associated with no awareness or incentive to include evidence-based information.[11] Low-quality information can mislead patients, who can adhere to unproven or deceptive treatments to the detriment of evidence-based healthcare, thus affecting their safety and quality of life[12] and undermining their trust in dental professionals.[11] In this context, an investigation into oral health searches from various populations may offer insights into the experiences, interests, and behaviors of Internet users when using toothpaste in their daily lives, helping the establishment of oral health communication strategies based on more realistic problems that are not necessarily known

by dentists. Consequently, these strategies would be more able to influence and empower individuals to improve self-care for oral health more effectively. In addition, understanding the health-related interests of internet users may reveal the population's oral health needs and may contribute to public health policy planning.[13,14]

Considering the importance of toothpastes in routine oral health care, the wide range of products offered by the market, and the needs of each population, this study aimed to characterize the interests in toothpastes among Google users from different countries. Our hypothesis was that there would be an increase in Google users' interest in information about toothpaste.

Methodology

Study design

This retrospective longitudinal ecological study analyzed the toothpaste-related computational metadata of 10 countries using Google Trends. We followed the methodology of a previous study concerning the selection of countries based on their population size, the percentage of the population with internet access, and their socioeconomic characteristics.[15] The relative volume search (RSV) and main queries for the topic "toothpaste - subject" from January 2004 to December 2020 were collected and stored on January 22, 2021. The data were analyzed considering (a) search volume trends, (b) the development of forecasting models, (c) seasonality, (d) the most popular related queries, and (e) influence of the COVID-19 outbreak on users' interests. The methodology and data analysis were based on previous dental surveillance studies.[13-16]

Ethics

Considering that federal regulations have established that research using publicly available data does not involve human subjects, this study did not require approval by the Institutional Review Board.

Selection of countries

We selected 10 countries according to the following inclusion criteria: (a) socioeconomic development (50%

developing and 50% developed countries), (b) >50% of Internet penetration rate, (c) more than 15 million inhabitants, and (d) different continents.[13,15,16] The developed countries chosen for data collection were Australia (AUS), Chile (CHL), Japan (JPN), United Kingdom (GBR), and the United States (USA), and the developing countries chosen were Brazil (BRA), Mexico (MEX), Russia (RUS), Saudi Arabia (SAU), and South Africa (ZAF). Countries were used as the independent variable.

Relative search volume (RSV)

The dependent variable of this study is the RSV, which represents the weekly or monthly search volume of a specific query performed by users on Google Search, normalized by the maximum value in a given period (RSV=100). We filtered the metadata by period, source, location, and category. On January 22, 2021, we used the topic "toothpaste - subject" to collect data from the 10 selected countries from January 2004 to December 2020, using the other settings as default (all categories and sources). This topic is the keyword obtained from algorithms developed by Google Trends that filter all keywords linked to the topics of interest.

Main queries

In addition, Google Trends offers a list of the most popular queries used in each country to find information associated with the topic of interest over time. In this sense, the main queries of the topic "toothpaste - subject" were collected, translated, and dichotomized to identify the toothpaste-related subjects.

Data analyses

We used the Statistical Package for Social Sciences software (version 22.0; SPSS, Chicago, USA) to assess data according to the following aspects:

a. **Trends:** The variations over time, expressed by curves generated from Autoregressive Integrated Moving Average (ARIMA), were analyzed heuristically by observing the behavior of fitted value curves. The autocorrelation (ACF) and partial autocorrelation (PACF) plots evaluated the trends of time series for each country.

b. **Seasonality:** The impact of seasonality on the time series was observed using the generalized additive model (GAM) by detrending each curve over the period by its lag-1 difference, with subsequent application of different generalized linear models to examine the impact of monthly and quarterly seasonality on the time series.

c. **Forecasting models:** Twelve-month forecasts were built using ARIMA models based on the lowest values of the standardized Bayesian information criteria (normalized BIC) between curves without significant residual autocorrelation (Ljung-Box test).

d. **COVID-19 pandemic impact:** We analyzed the influence of social isolation associated with the COVID-19 outbreak on users' interests in toothpastes. The quarantine start date was customized for each country[17] and the RSV values from 12 months before and after the outbreak were compared. Depending on normality and homogeneity (Shapiro-Wilk and Levene's tests), the values were compared with Student's t- test (AUS, BRA, CHL, GBR, JPN, MEX, RUS, and USA) or Mann-Whitney test (SAU and ZAF).

For all statistical analyses, values of $p < 0.05$ were considered significant.

RESULTS

Trends

Figure 1 presents the time series of the monthly variation. The heuristic analysis showed an increase in the interest related to toothpaste information in the 10 analyzed countries. Nevertheless, it is not possible to establish a clear trend from ACF and PACF analyses (Figure 2). We detected a significant positive autocorrelation in CHL (lag 17), MEX (lag 12), RUS (lag 17), GBR (lag 6), SAU (lags 7, 8, and 23), ZAF (lag 6), and a positive partial autocorrelation in MEX (lag 7), RUS (lag 17), GBR (lags 6 and 11), SAU (lag 7), and ZAF (lag 13). However, we observed a significant negative autocorrelation in JPN (lag 4), MEX (lags 2, 3, and 9), RUS (lag 5), GBR (lag 9), SAU (lag 13), ZAF (lag 11), and a negative partial autocorrelation in JPN (lag 4), MEX (lags 2, 3, 9,

and 16), RUS (lag 5), USA (lag 14), SAU (lag 13), and ZAF (lag 11).

Seasonality

The variation of the means of monthly detrended RSV values is represented on a heatmap (Figure 3). According to GAM analysis, the data did not show a significant influence of monthly or quarterly seasonality on the interests of Google Search users. The chart shows occasional increases in search volume in January and February for MEX and January for GBR over time, thus indicating a preference of Mexicans

and British people for searching for toothpaste at the start of the years.

Forecasting models

Tables 1 and 2 show the statistics of 12-month forecasting models for toothpaste-related interests. The selected ARIMA models exhibited adequate normalized BIC (3.15–5.36), RMSE (4.65–14.27), and MAPE (6.82–30.86) parameters. The curves generated from this analysis allowed for the observation of trends in the data variation (Figure 1). All countries showed a stable trend in the 12-month forecast.
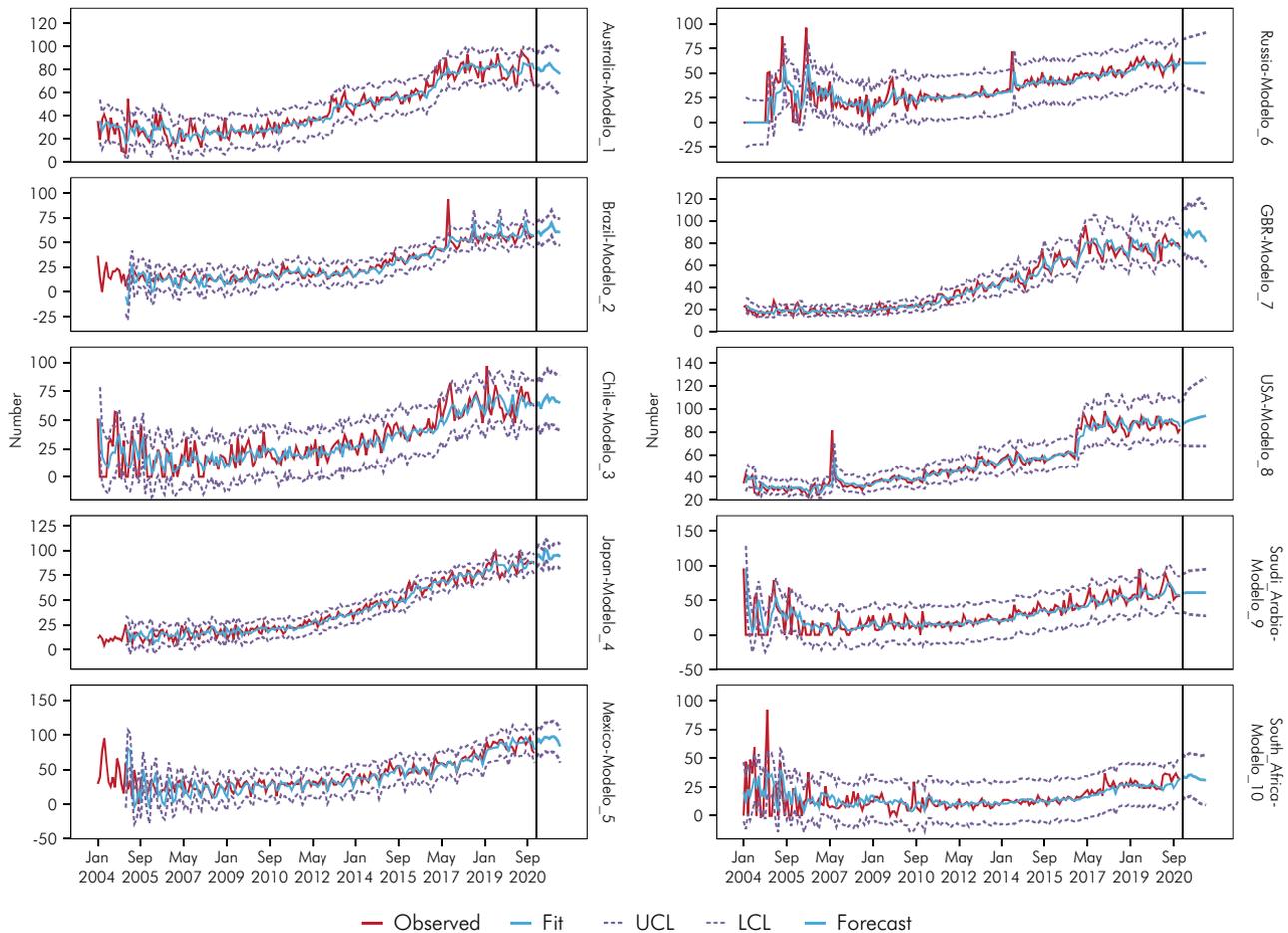
Figure 1. Relative search volume (RSV) time series variation of toothpaste-related online searches and predictive charts for toothpaste-related interests among individuals from Australia (AUS), Chile (CHL), Japan (JPN), United Kingdom (GBR), United States (USA) – developed countries, and from Brazil (BRA), Mexico (MEX), Russia (RUS), Saudi Arabia (SAU), and South Africa (ZAF) – developing countries. The curves for the observed values (red lines), fit and forecast values (blue lines), and upper and lower bound of confidence intervals (violet lines) are depicted from January 2004 through December 2020. Note that RSV values presented after January 2020 (black line) represent 12-month predictive values.

Main queries

The toothpaste-related searches were associated with specific brands or products, including toothpastes for tooth whitening and tooth sensitivity, baby or children's toothpaste, recommendation for the best toothpaste, compounds such as charcoal, bicarbonate, fluoride, or fluoride-free products, homemade and natural toothpaste, abrasive, cooking salt, gingiva, gingivitis, mouth, periodontitis, teeth staining, and gum (Table 3).

COVID-19 pandemic influences

Most countries did not demonstrate a significant difference in toothpaste interests before and after the COVID-19 outbreak , except for the increase in searches in GBR (p = 0.01) and ZAF (p = 0.049) (Table 4).

Discussion

The heuristic analysis of the time series indicated an increase in the interest of internet users in toothpaste between January 2004 and December 2020. This increase may reflect the population's growing autonomy regarding solving their own health problems.[18,19] Health care consumers seek autonomy regarding their health status and consequently invest more time in searching for information.[19] The Internet seems to be the most popular source of information, followed by books and advice from family and friends.[18] All countries showed a stable trend in the 12-month forecast of interests related to toothpaste after the COVID-19 outbreak , which may be explained by different factors, such as the

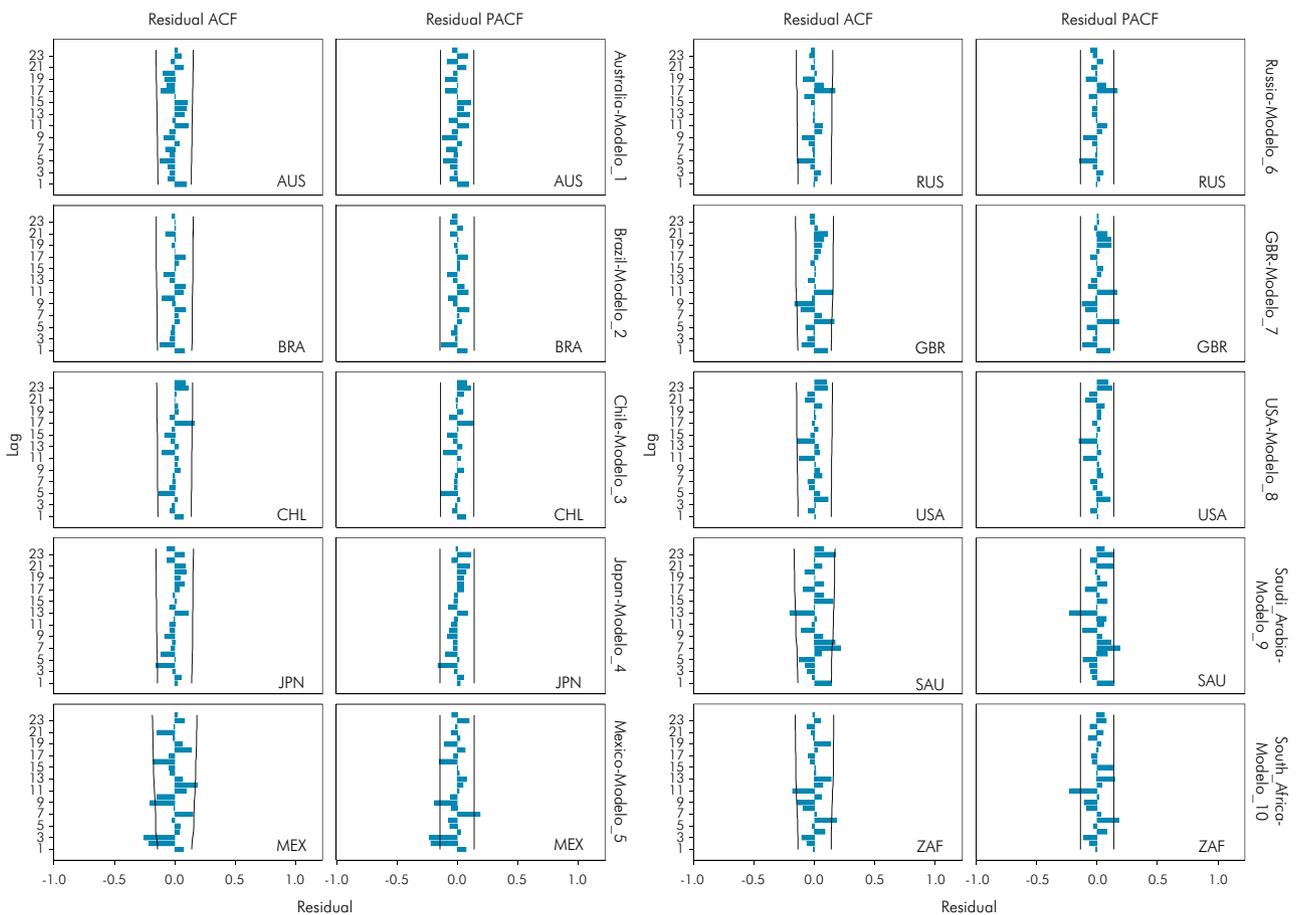**Figure 2.** Autocorrelation (ACF) and partial autocorrelation (PACF) plots for the monthly variation of RSV toothpaste values for Australia (AUS), Chile (CHL), Japan (JPN), United Kingdom (GBR), United States (USA) – developed countries, and for Brazil (BRA), Mexico (MEX), Russia (RUS), Saudi Arabia (SAU), and South Africa (ZAF) – developing countries.
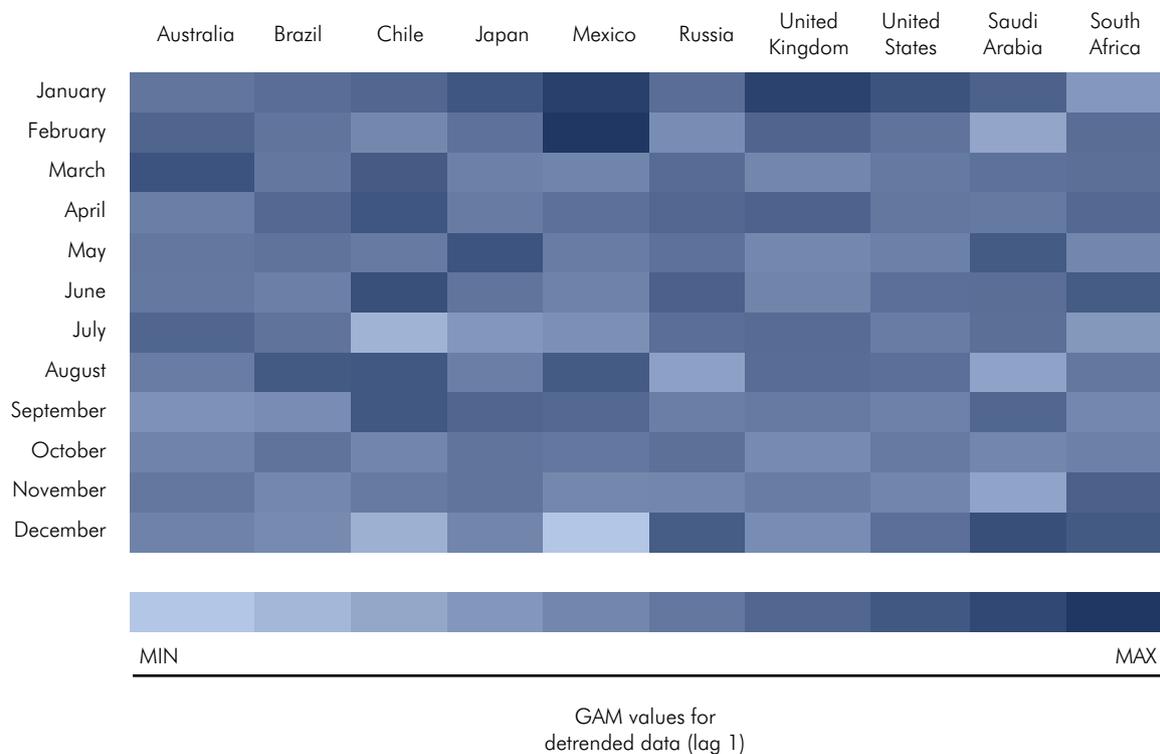
Figure 3. Heatmap showing the variation of predictive generalized additive model (GAM) values for toothpaste-related online searches for Australia (AUS), Chile (CHL), Japan (JPN), United Kingdom (GBR), United States (USA) – developed countries, and for Brazil (BRA), Mexico (MEX), Russia (RUS), Saudi Arabia (SAU), and South Africa (ZAF) – developing countries. Seasonality was estimated by fitting a generalized additive model (GAM) to detrend the Google Trends data (lag-1 difference).

relative deceleration of the increase in interest in toothpaste due to the heightened concerns related to the emergence of the new disease, the possible negligence of oral health self-care during social isolation, and also the previous incorporation of self-management of one's own health into contemporary behavior, leading individuals to become more active in making decisions about their own health.[19] The use of friendly language, videos, and images enables the dissemination of information based on scientific studies in a reliable, adequate, and effective manner and contributes to the acquisition of new knowledge, in the eyes of the internet users and professionals.[20,21] The motivation for searches is multifactorial and may be related to a concern about a specific disease, disease prevention, desire for a healthy lifestyle, curiosity, or even willingness to help others.[22]

Another possible reason for the increase in Internet searches about toothpastes may be related to industry marketing strategies. The growing awareness of the importance of oral health has led to an increase in purchases of dental healthcare products.[23] Patients have limited knowledge about health care, which results in the use of the Internet as a source of information.[24] Searches for an oral health problem may direct specific target audiences toward industry-maintained websites through algorithmic systems,[25] which increases interest in and internet searches for specific brands. In fact, we detected an interest in specific brands from the main terms. Although these searches may provide oral health-related information to the general population, some patients may question or even replace professional guidance with their search results,[18] despite the quality of the information encountered on the Internet. It is also important to point out that searches for information regarding a particular purchase are analyzed from various perspectives. For instance, the consumers' memory

Table 1. ARIMA model fit statistics for toothpaste.

Country, Model	R^2	Normalized BIC*	RMSE**	MAPE§	Ljung-box Statistics	Ljung-box p-value
Australia ARIMA(0,1,1) (1,0,1)	0.24	4.06	7.31	15.61	22.34	0.99
Brazil ARIMA(0,1,1)(0,1,1)	0.47	3.65	6.03	18.09	15.27	0.50
Chile ARIMA(1,1,1)(1,0,0)	0.31	4.89	11.07	25.48	16.36	0.35
Japan ARIMA(0,1,1)(0,1,1)	0.54	3.29	5.04	18.31	14.88	0.53
Mexico ARIMA(0,1,1)(0,1,1)	0.37	4.91	11.31	23.39	62.23	< 0.01***
Russia ARIMA(0,1,2)(0,0,0)	0.22	4.89	11.23	21.71	18.81	0.27
United Kingdom ARIMA(1,1,1)(0,0,0)	0.29	3.15	4.65	9.38	27.69	0.02***
United States ARIMA(1,1,1)(0,0,0)	0.15	3.51	5.58	6.82	14.79	0.54
Saudi Arabia ARIMA(0,1,4)(0,0,0)	0.19	5.36	14.27	25.15	48.38	< 0.01***
South Africa ARIMA(1,0,11)(0,0,0)	0.34	4.68	9.63	30.83	31.78	0.01***

*Normalized Bayesian information criteria; **Root mean square error; ***significant at alpha = 5%

is, in many cases, the starting point of any search for information.[19]

These results suggest an interest in natural products. Similarly, previous studies have detected interest in non-traditional therapies, alternative therapies, and home treatments for toothache on the Internet.[13,16] Natural products provide important contributions to pharmacotherapy and represent an opportunity for the pharmaceutical industry. There is growing consumer interest in natural and sustainable products.[13,16,26] Recently, a boost in the sales of organic toothpastes has been observed. Consequently, the industry has turned its attention to this market, focusing its marketing strategies on campaigns that promote the concept of sustainability and environmental responsibility, such as reducing the consumption of plastic packaging, thus offering an opportunity to promote this segment.[26] Most websites represent sales platforms. Thus, consumers may be misled by false claims about the efficacy of herbal products.[27] These websites do not offer evidence-based information, serving as marketing tools for dissemination and sales, without proof of efficacy. As a result, information from these websites may pose a risk to the population's oral health.

The present study showed there was a high interest in searches for the bleaching effects of activated charcoal, despite the lack of evidence to support its use for this purpose. Likewise, there is no evidence that charcoal-based toothpastes play a role in tooth remineralization or possess antimicrobial properties.[28] On the contrary, there is some evidence that activated charcoal has negative impacts on the topography of dental enamel.[29] Despite these facts, a recent study has identified 36 charcoal-based products, 72% of which had Instagram profiles with numerous followers and high engagement rates. These products are advertised as natural or organic,

Table 2. Parameter estimation of ARIMA models for RSV toothpaste values in different countries.

Country/Parameter	Lag	Estimate	SE*	t	p-value**
Australia					
Difference		1			
MA**	Lag 1	0.73	0.49	15.02	< 0.001
AR***, Seasonal	Lag 1	0.86	0.94	9.16	< 0.001
MA‡, Seasonal	Lag 1	0.69	0.14	4.86	< 0.001
Brazil					
Difference		1			
MA***	Lag 1	0.80	0.46	17.44	< 0.001
Seasonal Difference		1			
MA, Seasonal	Lag 1	0.68	0.65	10.54	< 0.001
Chile					
AR****	Lag 1	0.23	0.82	2.86	0.005
Difference		1			
MA***	Lag 1	0.89	0.39	23.26	< 0.001
AR§, Seasonal	Lag 1	0.36	0.68	5.37	< 0.001
Japan					
Difference		1			
MA***	Lag 1	0.74	0.05	14.95	< 0.001
Seasonal Difference		1			
MA***, Seasonal	Lag 1	0.76	0.06	11.63	< 0.001
Mexico					
Difference		1			
MA***	Lag 1	0.78	0.69	10.88	< 0.001
Seasonal Difference		1			
MA***, Seasonal	Lag 1	0.75	0.06	10.88	< 0.001
Russia					
Difference		1			
MA***	Lag 1	0.50	0.69	7.39	< 0.001
MA***	Lag 2	0.22	0.69	3.28	0.001
United Kingdom					
Difference		1			
MA***	Lag 1	0.72	0.05	14.41	< 0.001
AR, Seasonal	Lag 1	0.97	0.03	27.92	< 0.001
MA***, Seasonal	Lag 1	0.87	0.09	9.10	< 0.001
United States					
Constant		0.01	0.01	2.52	0.012
AR****	Lag 1	0.49	0.09	5.36	< 0.001
Difference		1			
MA***	Lag 1	0.87	0.05	16.19	< 0.001

Continuation					
Saudi Arabia					
Difference		1			
MA***	Lag 1	0.65	0.05	11.51	< 0.001
MA***	Lag 4	0.19	0.05	3.76	< 0.001
South Africa					
Constant		20.91	7.40	2.82	0.005
AR****	Lag 1	0.98	0.02	46.97	< 0.001
MA***	Lag 1	0.87	0.04	18.05	< 0.001
MA***	Lag 5	0.29	0.07	4.02	< 0.001
MA***	Lag 6	-0.43	0.07	-6.05	< 0.001
MA***	Lag 11	0.09	0.04	2.04	0.042

*Standard error; ** significant at alpha = 5%; ***Moving average component; ****Autoregressive component;

free of metals, and with bleaching properties.[30] Moreover, the commercial appeal of celebrities in the promotion of these products associates them with an image of high quality.[31] Digital influencers inadvertently endorse such products on the Instagram platform arguing that these products are natural, as if this would guarantee the safety for use. The aim is to persuade their followers to purchase the so-called natural products, even if they lack scientific evidence of safety and efficacy.[32] The misleading fluoride information on Instagram is mostly commercial and is motivated by social, psychological, and/or financial interests.[33]

Another frequent search topic was related to toothpaste for children. Excessive toothpaste consumption has negative consequences, especially for children. Aggressive and misleading marketing strategies are used in selling fluoride toothpaste to children, while warnings about excessive consumption among youth are downplayed.[34] These marketing strategies may be responsible for the increasing searches for toothpastes for children. Packaging is the main tool used by the industry to attract young consumers.[34] When targeting adults, the marketing campaigns also focus on visual stimuli, considered the most direct and efficient marketing strategy to influence consumption habits.[35]

Easy access to the Internet is stimulating and may bring benefits. However, some internet users may perceive the information overload and the unreliability of the information as disadvantages.[18,22] Moreover, excessive information may lead to misinformation[32] and anxiety.[36] The Internet empowers and engages people in knowing about health issues, alerting and noticing these issues, and the ability to manage and make healthy changes,[10] leading to shared decision-making between health professionals and patients.[37]

It should be, however, mentioned that health information published on the Internet does not provide the users with credible and reliable medical advice.[18] The health information available online is mostly incomplete, outdated, unreliable, and unreasonable from the scientific point of view.[22] Surveillance of digital activity aims to combat scientific misinformation by minimizing the spread of fake news/misinformation/disinformation and promoting the development and implementation of public health information and awareness campaigns.[37]

It was not possible to detect a significant increase in interest in toothpaste-related topics during the COVID-19 outbreak in most of the analyzed countries (AUS, BRA, CHL, JPN, SAU, MEX, RUS, and USA). This finding conflicts with those related to searches about toothache or toothache treatment on Google[38] and Twitter.[39] One possible reason is that during a pandemic, characterized by *infodemic* and excessive information about a disease outbreak,[40] a non-urgent issue can be neglected.

The design of this study has some limitations and the findings need to be interpreted with caution.

Table 3. Toothpaste-related queries and their respective RSV for each country. Terms with RSV = 0 were not considered.

Toothpaste-related interests of Google users from different countries

AUS Queries	RSV	BRA Queries	RSV	CHL Queries	RSV	JPN Queries	RSV	MEX Queries	RSV	RUS Queries	RSV	GBR Queries	RSV	USA Queries	RSV	SAL Queries	RSV	ZAF Queries	RSV
toothpaste	100	toothpaste	100	toothpaste	100	toothpaste	100	toothpaste	100	toothpaste	100	toothpaste	100	toothpaste	100	Paste	100	toothpaste	100
Colgate	7	toothpaste	92	toothpaste	87	tooth	15	toothpastes	58	toothpastes	9	whitening toothpaste	9	best toothpaste	8	Toothpaste	8	colgate	12
colgate toothpaste	7	toothpaste	71	toothpaste	12	toothpaste whitening	14	toothpaste	46	toothpaste	6	best toothpaste	8	whitening toothpaste	7	Toothpaste	7	colgate toothpaste	11
whitening toothpaste	6	toothpaste	12	toothpaste	11	Whitening	14	toothpaste	14	Rocks	8	teeth	8	crest	7	toothpaste	7	whitening toothpaste	9
best toothpaste	5	Colgate	9	toothpaste	10	recommended toothpaste	8	Colgate	8	Rocks toothpaste	5	fluoride toothpaste	5	crest toothpaste	7	Best toothpaste	7	best toothpaste	6
tooth paste	4	toothpaste	6	Colgate	10	dentifrice	6	toothpaste	6	splat	4	fluoride	5	colgate	5	Toothpaste	5	toothpaste pimples	5
fluoride	4	colgate toothpaste	5	whitening toothpaste	5	Toothpaste white	5	Colgate toothpaste	6	whitening toothpaste	4	Colgate	5	charcoal	5	Crest paste	4	fluoride	5
fluoride toothpaste	4	how to make toothpaste	5	vitis toothpaste	5	Toothpaste ranking	5	toothpaste	5	children's toothpaste	3	Colgate toothpaste	4	fluoride toothpaste	5	Whitening toothpaste	3	fluoride toothpaste	5
charcoal toothpaste	4	best toothpaste	5	ap24 toothpaste	5	White toothpaste	4	toothpaste	5	splat paste	3	toothpaste spots	4	fluoride	5	colgate	3	charcoal toothpaste	4
oral b	3	spine toothpaste	5	whitening toothpaste	4	White teeth	4	Water	5	splat toothpaste	3	charcoal toothpaste	4	colgate toothpaste	5	Crest toothpaste	3	sensodyne toothpaste	4
natural toothpaste	2	toothbrush	4	vitis toothpaste	3	toothbrush	3	toothpaste	4	acne toothpaste	2	teeth whitening	2	charcoal toothpaste	4	colgate toothpaste	2	sensodyne	4
oral b toothpaste	2	toothpaste	4	ap 24 toothpaste	2	Fluorine	2	soap	4	splat	2	best whitening toothpaste	2	tooth paste	4	Toothpaste for the face	2	ap24 toothpaste	3
sensodyne	2	glister	3	homemade toothpaste	2	Toothpaste Fluorine	2	how to make toothpaste	4	the best toothpaste	2	teeth whitening toothpaste	2	best whitening toothpaste	3	Sensodyne toothpaste	2	toothpaste on face	2
toothbrush	2	bicarbonate	3	homemade toothpaste ap 24 toothpaste	2	Commercial toothpaste	2	crest	4	buy toothpaste	2	oral b toothpaste	2	toothpaste acne	2	Toothpaste for children	2	aquafresh toothpaste	2
sensodyne toothpaste	2	toothpaste pregnancy test	3	toothpaste dispenser	2	Periodontal disease toothpaste	2	shampoo	3	splat toothpaste	2	oral b	2	baking soda toothpaste	2	Colgate toothpaste	2	ap 24 toothpaste	2
coles toothpaste	2	smile	3	no additional information	3	Periodontal disease	2	how to make toothpaste	3	toothpaste for children	2	tooth paste	2	sensodyne	3	Depurdent toothpaste	2	oral b toothpaste	1

Continue

Continuation

Term	n	Term	n	Term	n	Term	n	Term	n	Term	n	Term	n	Term	n	Term	n	Term	n
teeth whitening	2	oral b	2	no additional information	3	Whiten teeth	3	homemade toothpaste	2	rocs toothpaste	2	sensodyne	2	natural toothpaste	2	Baby toothpaste	2	toothpaste brands	1
teeth whitening toothpaste	2	colgate toothpaste	2	no additional information	3	Toothpaste to whiten teeth	3	homemade toothpaste	2	fluoride-free toothpaste	2	toothbrush	2	sensodyne toothpaste	2	Baby paste	2	meridol toothpaste	1
toothpaste ingredients	2	best toothpaste	2	no additional information	3	Tooth whitening	3	colgate toothpaste	2	toothbrush	2	toothpaste on spots	2	kids toothpaste	2	sensodyne toothpaste	1	ap24 whitening toothpaste	1
how to make toothpaste	2	no additional information	2	no additional information	3	Children toothpaste	3	toothbrush	2	rocs toothpaste	2	sensodyne toothpaste	2	teeth whitening	2	Close-up toothpaste	1		
kids toothpaste	2					Toothpaste to whiten teeth	3	best toothpaste	1	toothpaste president	1	sensitive toothpaste	2	teeth whitening toothpaste	2				
best whitening toothpaste	2					Tooth whitening toothpaste	3	crest toothpaste	1	whitening toothpaste reviews	1	best toothpaste uk	2	how to make toothpaste	2				
						Toothpaste turns white	3	Toothpaste	1	toothpaste for sensitive teeth	1	corsodyl	1	sensitive toothpaste	2				
						Whiten teeth	3	what is toothpaste for	1	fluorine	1			toothpaste ingredients	2				
						Abrasive	3	toothpaste for children	1	toothpaste slime	1								

Table 4. Comparison of the relative search volume (RSV) values between pre-pandemic and crosspandemic periods for all countries. They were compared through Student's t test or Mann-Whitney test, depending on the normality and homogeneity of data.

Country	Student's t test		
	Average (RSV)		p-value
	Pre-pandemic	Cross-pandemic	
Australia	80.16	81.12	0.798
Brazil	55.62	58.89	0.06
Chile	61.43	66.36	0.169
Japan	82.75	87.08	0.145
Mexico	86.17	86.71	0.854
Russia	60	58.32	0.396
United Kingdom	73.52	79.81	0.01*
United States	87.06	86.3	0.631
	Mann-Whitney test		
	Sum of ranks (RSV)		p-value
	Pre-pandemic	Cross-pandemic	
Saudi Arabia	127.5	172.5	0.193
South Africa	116	184	0.049*

* significant at alpha = 5%.

These data refer exclusively to the activity and behavior of users of one web platform (Google Search), without considering information from other search engine tools. Additionally, anonymity makes it impossible to detect characteristics of sex, age, sociodemographic aspects, and educational level of the users. Furthermore, this approach does not rule out the possibility of duplicate searches performed by the same person on two or more devices, and the outcomes may be overestimated. Finally, although the behavior of Internet users suggests a growing interest in oral health self-care surveys, it is not possible to confirm the implementation of corrective measures. The analyses were performed based on a standardized metric. Thus, this approach does not allow direct comparisons between research volumes in different countries. Although promising, the collection and interpretation of a large amount of computational data based on Internet activity do not replace traditional epidemiological methods. However, the anonymous and periodic collection of near real-time data in several distinct countries may contribute to a greater understanding of behavioral data. As such, this information may enable the implementation of specific public oral health policies and oral-care communications based on the population's needs. Along these lines, information monitoring and improvements in oral health literacy may contribute to the reduction of currently existing social and economic barriers.

Conclusion

In support of our hypothesis, the interest of Google Search users in information about toothpaste increased in all of the 10 analyzed countries. However, these trends were not usually influenced by the COVID-19 outbreak. Understanding the interest in health information underscores the importance of further analysis of community concerns and needs, by emphasizing the need for investigations into digital activity and the promotion of health literacy and oral hygiene education policies.

Acknowledgements

References

1. Cota LO, Villar CC, Vettore MV, Campos JR, Amaral GC, Cortelli JR, et al. Periodontal diseases: is it possible to prevent them? A populational and individual approach. Braz Oral Res. 2021 Sep;35 Supp 2:e098. https://doi.org/10.1590/1807-3107bor-2021.vol35.0098

2. Weijden GA, Hioe KP. A systematic review of the effectiveness of self-performed mechanical plaque removal in adults with gingivitis using a manual toothbrush. J Clin Periodontol. 2005;32(s6 Suppl 6):214-28. https://doi.org/10.1111/j.1600-051X.2005.00795.x

3. Jepsen S, Blanco J, Buchalla W, Carvalho JC, Dietrich T, Dörfer C, et al. Prevention and control of dental caries and periodontal diseases at individual and population level: consensus report of group 3 of joint EFP/ORCA workshop on the boundaries between caries and periodontal diseases. J Clin Periodontol. 2017 Mar;44 Suppl 18:S85-93. https://doi.org/10.1111/jcpe.12687

4. Valkenburg C, Van der Weijden FA, Slot DE. Plaque control and reduction of gingivitis: the evidence for dentifrices. Periodontol 2000. 2019 Feb;79(1):221-32. https://doi.org/10.1111/prd.12257

5. Nascimento MM, Alvarez AJ, Huang X, Browngardt C, Jenkins R, Sinhoreti MC, et al. Metabolic Profile of Supragingival Plaque Exposed to Arginine and Fluoride. J Dent Res. 2019 Oct;98(11):1245-52. https://doi.org/10.1177/0022034519869906

6. Maltz M, Alves LS, Zenkner JE. Biofilm control and oral hygiene practices. Monogr Oral Sci. 2017;26:76-82. https://doi.org/10.1159/000479348

7. Martins CC, Riva JJ, Firmino RT, Schünemann HJ. Formulations of desensitizing toothpastes for dentin hypersensitivity: a scoping review. J Appl Oral Sci. 2022 Mar;30:e20210410. https://doi.org/10.1590/1678-7757-2021-0410

8. West NX, Seong J, Hellin N, Eynon H, Barker ML, He T. A clinical study to measure anti-erosion properties of a stabilized stannous fluoride dentifrice relative to a sodium fluoride/triclosan dentifrice. Int J Dent Hyg. 2017 May;15(2):113-9. https://doi.org/10.1111/idh.12159

9. Geisinger ML. Oral hygiene recommendations in the age of Dr Google: an evidence-based approach for dental professionals. Nashville: Dental Academy of Continuing Education; 2021 [cited 2021 Nov 12]. Available from: https://dentalacademyofce.com/courses/4327%2FPDF%2F2104CEDgei.pdf

10. Ramirez AG, Baldwin S, Adeigbe RT, Aguilar RP, Gallion K, Despres C. SaludToday: curating Latino health information for a new generation. J Commun Healthc. 2016;9(1):60-9. https://doi.org/10.1080/17538068.2015.1133790

11. Weintraub JA, Jamison AR, Rozier RG, Atchison KA. Assessing oral health content in nondental professional association websites. J Public Health Dent. 2021 Sep;81(3):240-4. https://doi.org/10.1111/jphd.12441

12. Daraz L, Morrow AS, Ponce OJ, Beuschel B, Farah MH, Katabi A, et al. Can patients trust online health information? A meta-narrative systematic review addressing the quality of health information on the internet. J Gen Intern Med. 2019 Sep;34(9):1884-91. https://doi.org/10.1007/s11606-019-05109-0

13. Lotto M, Ayala Aguirre PE, Rios D, Machado MAAM, Cruvinel AFP, Cruvinel T. Analysis of the interests of Google users on toothache information. PLoS One. 2017 Oct;12(10):e0186059. https://doi.org/10.1371/journal.pone.0186059

14. Cruvinel T, Ayala Aguirre PE, Lotto M, Oliveira TM, Rios D, Cruvinel AFP. Digital behavior surveillance: monitoring dental caries and toothache interests of Google users from developing countries. Oral Dis. 2019 Jan;25(1):339-47. https://doi.org/10.1111/odi.12986

15. Lotto M, Aguirre PE, Strieder AP, Cruvinel AF, Cruvinel T. Levels of toothache-related interests of Google and YouTube users from developed and developing countries over time. PeerJ. 2019 Oct;7:e7706. https://doi.org/10.7717/peerj.7706

16. Strieder AP, Aguirre PE, Lotto M, Cruvinel AF, Cruvinel T. Digital behavior surveillance for monitoring the interests of Google users in amber necklace in different countries. Int J Paediatr Dent. 2019 Sep;29(5):603-14. https://doi.org/10.1111/ipd.12500

17. Hale T, Angrist N, Kira B, Petherick A, Phillips T, Webster S, et al. Variation in Government Responses to COVID-19: version 5.0. BSG Working paper series. Oxford: Blavatnik School of Government; 2020 [cited 2021 Aug 30]. Available from: www.bsg.ox.ac.uk/covidtracker

18. Mukherjee A, Bawden D. Health information seeking in the information society. Health Info Libr J. 2012 Sep;29(3):242-6. https://doi.org/10.1111/j.1471-1842.2012.00997.x

19. Bratucu R, Gheorghe IR, Purcarea RM, Gheorghe CM, Popa Velea O, Purcarea VL. Cause and effect: the linkage between the health information seeking behavior and the online environment: a review. J Med Life. 2014 Sep;7(3):310-6.

20. Corrêa CC, Pauleto AR, Ferrari DV, Berretin-Felix G. Website Babies Portal: development and evaluation of the contents regarding orofacial functions. J Appl Oral Sci. 2013;21(6):581-9. https://doi.org/10.1590/1679-775720130267

21. Maximino LP, Picolini-Pereira MM, Carvalho JL. Telegenetics: application of a tele-education program in genetic syndromes for Brazilian students. J Appl Oral Sci. 2014;22(6):477-83. https://doi.org/10.1590/1678-775720130311

22. Kłak A, Gawińska E, Samoliński B, Raciborski F. Dr Google as the source of health information - the results of pilot qualitative study. Polish Ann Med. 2017;24(2):188-93. https://doi.org/10.1016/j.poamed.2017.02.002

23. Future Markek Insights.The oral care market, 2021. Review and Analysis: Oral Care Market by Product Type - Toothbrush, Toothpaste, Mouthwash, Dental Floss, and Denture Care for 2021 - 2031. Available from: https://www.futuremarketinsights.com/reports/oral-care-market. Accessed 23 June 2021.

24. Naganandini S, Rao R, Kulkarni SB. Survey on the use of the Internet as a source of oral health information among dental patients in Bangalore City, India. Oral Health Prev Dent. 2014;12(2):141-7. https://doi.org/10.3290/j.ohpd.a31218

25. Tan B, Srikant R. Online advertisement, optimization and stochastic networks. IEEE Trans Automat Contr. 2012;57(11):2854-68. https://doi.org/10.1109/TAC.2012.2195810

26. Siripipatthanakul S, Sixl-Daniell K. Strategic management in oral care product market: a case study of Colgate-Palmolive (Thailand) limited of the Creative Commons Attribution License (CC BY 4.0) Int J Trend Sci Res Dev. 2021;5(5):851-65

27. Morris CA, Avorn J. Internet marketing of herbal products. JAMA. 2003 Sep;290(11):1505-9. https://doi.org/10.1001/jama.290.11.1505

28. Franco MC, Uehara J, Meroni BM, Zuttion GS, Cenci MS. The Effect of a Charcoal-based Powder for Enamel Dental Bleaching. Oper Dent. 2020 Nov;45(6):618-23. https://doi.org/10.2341/19-122-L

29. Palandi SD, Kury M, Picolo MZ, Coelho CS, Cavalli V. Effects of activated charcoal powder combined with toothpastes on enamel color change and surface properties. J Esthet Restor Dent. 2020 Dec;32(8):783-90. https://doi.org/10.1111/jerd.12646

30. Bauler LD, Santos CS, Lima GS, Moraes RR. Charcoal-based dentifrices and powders: analyses of product labels, Instagram engagement, and altmetrics. Braz Dent J. 2021;32(2):80-9. https://doi.org/10.1590/0103-6440202104233

31. Byrne A, Whitehead M, Breen S. The naked truth of celebrity endorsement. Br Food J. 2003;105(4/5):288-96. https://doi.org/10.1108/00070700310477086

32. Silva ET, Batista SG, Diogo FS, Tunas IT. Digital Influencers and the advertising of activated charcoal-based powder as a dental whitening agent: an alert to dentists and their patients. Rev Bras Odontol. 2021;78e:1-8.

33. Lotto M, Sá Menezes T, Zakir Hussain I, Tsao SF, Ahmad Butt Z, P Morita P, et al. Characterization of misleading fluoride information on Instagram: an infodemiology study. J Med Internet Res. 2022 May;24(5):e37519. https://doi.org/10.2196/37519

34. Basch CH, Rajan S. Marketing strategies and warning labels on children's toothpaste. J Dent Hyg. 2014 Oct;88(5):316-9.

35. Khandelwal M, Sharma A, Indoria V, Jain V. Sensory marketing: an innovative marketing strategy to sustain in emerging markets. International Journal of Public Sector Performance Management. 2020;6(2):236-45. https://doi.org/10.1504/IJPSPM.2020.106730

36. Starcevic V, Schimmenti A, Billieux J, Berle D. Cyberchondria in the time of the COVID-19 pandemic. Hum Behav Emerg Technol. 2020 Nov; https://doi.org/10.1002/hbe2.233

37. Eysenbach G. Infodemiology and infoveillance: framework for an emerging set of public health informatics methods to analyze search, communication and publication behavior on the Internet. J Med Internet Res. 2009 Mar;11(1):e11. https://doi.org/10.2196/jmir.1157

38. Rizzato VL, Lotto M, Lourenço Neto N, Oliveira TM, Cruvinel T. Digital surveillance: the interests in toothache-related information after the outbreak of COVID-19. Oral Dis. 2021 Aug; https://doi.org/10.1111/odi.14012

39. Oliveira LM, Zanatta FB. Self-reported dental treatment needs during the COVID-19 outbreak in Brazil: an infodemiological study. Braz Oral Res. 2020 Sep;34:e114. https://doi.org/10.1590/1807-3107bor-2020.vol34.0114

40. World Health Organization. Infodemic. Geneva: World Health Organization; 2023 [cited 2021 Mar 23]. Available from: https://www.who.int/health-topics/infodemic#tab=tab_1