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Can the levels of toothache-related interests of Google and YouTube users differ between developed and developing countries over the years?

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Background: The preferences of Web users can be influenced by distinct factors of populations, such as the ability of obtaining, processing, and understanding health information adequately. In this sense, hypothetically, source-based patterns of health-related Web searches might differ between individuals from developed and developing countries, due to their educational backgrounds. This study aimed to determine the trends of toothache-related searches performed on *Google Search* and *YouTube,* regarding differences between developed and developing countries. **Methods:** This longitudinal study analyzed computational metadata on toothache-related interests of Internet users. *Google Trends* was accessed to obtain the monthly variation of relative search volume (RSV) of the topic "Toothache-Disease" on *Google* (G) and *YouTube* (YT) through 2008 to 2017. Autocorrelation and partial autocorrelation plots, ARIMA models, Kruskal-Wallis, Dunn's and T tests were performed for evaluating trends, 12-month forecasts and the differences of annual ratios of YT/G searches between developed and developing countries, respectively ($P<0.05$). **Results:** Uptrends of RSVs were observed in both country groups over time, although 12-month forecasts tended to plateau. The volumes of searches were larger in developed countries, becoming closer to those observed in developing countries in last years. Independently of country groups, the ratios YT/G remained relatively constant throughout the period, indicating a greater interest in toothache-related information available on *Google*. **Conclusion:** In conclusion, toothache-related searches from *Google* and *YouTube* increased during the last decade. The preferences of Web users seemed to be influenced by the differences found in the availability and penetration of the Internet, and education levels between developed and developing countries.

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Abstract

Background: The preferences of Web users can be influenced by distinct factors of populations, such as the ability of obtaining, processing, and understanding health information adequately. In this sense, hypothetically, source-based patterns of health-related Web searches might differ between individuals from developed and developing countries, due to their educational backgrounds. This study aimed to determine the trends of toothache-related searches performed on *Google Search* and *YouTube,* regarding differences between developed and developing countries.

Methods: This longitudinal study analyzed computational metadata on toothache-related interests of Internet users. *Google Trends* was accessed to obtain the monthly variation of relative search volume (RSV) of the topic "Toothache-Disease" on *Google* (G) and *YouTube* (YT) through 2008 to 2017. Autocorrelation and partial autocorrelation plots, ARIMA models, Kruskal-Wallis, Dunn's and T tests were performed for evaluating trends, 12-month forecasts and the differences of annual ratios of YT/G searches between developed and developing countries, respectively ($P<0.05$).

Results: Uptrends of RSVs were observed in both country groups over time, although 12-month forecasts tended to plateau. The volumes of searches were larger in developed countries, becoming closer to those observed in developing countries in last years. Independently of country groups, the ratios YT/G remained relatively constant throughout the period, indicating a greater interest in toothache-related information available on *Google*.

Conclusion: In conclusion, toothache-related searches from *Google* and *YouTube* increased during the last decade. The preferences of Web users seemed to be influenced by the differences found in the availability and penetration of the Internet, and education levels between developed and developing countries.

Introduction

The spreading of communication and information technologies (ICTs) stimulated individuals in seeking alternatives to their health demands, and consequently, contributed to the development of a participatory care model, characterized by an increasingly interest of people in sharing the decisions about their own conditions with health professionals (Moerenhout, Devisch, & Cornelis, 2018; Phanareth et al., 2018). In this sense, it is noteworthy that most Internet users are interested in health-related topics retrieved by digital platforms (Aguirre et al., 2018), such as search engine tools, video-sharing websites, and social media (Hansen et al., 2018; Atkinson, Saperstein, & Pleis, 2009).

In this context, we previously demonstrated a high interest of Internet users on toothache-related issues, with the aim of achieving self-resolution of dental pain through the frequent use of alternative methods, such as painkillers and home remedies (Cohen et al., 2009; Ahlwardt et al., 2014; Lotto et al., 2017). Unfortunately, oral diseases continue to be extremely prevalent among distinct populations, contributing to the onset of painful symptoms in dental tissues and adjacent

structures (Pitts et al., 2011; Cohen et al., 2008; Peres et al. 2010). These conditions affect preferably social deprived groups, most commonly found in developing countries (Santiago, Valença, & Vettore, 2013; da Cunha et al., 2017).

The preferences of Web users can be influenced by distinct factors of populations, such as the ability of obtaining, processing, and understanding health information adequately (Levin-Zamir & Bertschi, 2018). Frequently, participants of Web-based computer-tailored preventive programs report their preference on video contents instead of texts, considering their usefulness, involvement, and attractiveness (Walthouwer et al., 2015). With a similar way of reasoning, people access video-sharing platforms as open sources of health information (Madathil et al., 2015), expecting to find contents with minimum correctness and clear presentation about their questions (Azer et al., 2013; Sahin et al., 2018). In this scenario, *YouTube* presents the highest popularity among streaming services, achieving 1.5 billion users and more than 2 billion views per day worldwide (Statista, 2018).

In this sense, hypothetically, source-based patterns of health-related Web searches might differ between individuals from developed and developing countries, due to their educational backgrounds (Cruvinel et al., 2018; Cruvinel et al., 2017). To our knowledge, there is no evidence comparing the volume of searches on oral health obtained from video platforms and Web search engines in different populations.

Therefore, this study aimed to determine the trends of toothache-related searches performed by Internet users on *Google Search* and *YouTube,* regarding developed and developing countries. The null hypothesis was that the levels of toothache-related interests would have no differences between country groups over time (H_0).

Materials & Methods

Study design

This retrospective longitudinal study analyzed computational metadata on toothache-related interests of Internet users. *Google Trends* was accessed to obtain the monthly variation of the relative search volume (RSV) of the topic "Toothache-Disease" on *Google Search* (G) and *YouTube* (YT) from developed and developing countries through 2008 to 2017. The trends, 12-month forecasts and annual ratios of YT/G searches were determined and compared between both country groups.

Country groups

Ten countries were divided in two groups, according to their socioeconomic development levels. The countries must have more than 15 million inhabitants and >50% of Internet penetration, being localized in different geographic global regions. Developed countries were composed by Australia, Chile, Japan, United Kingdom, and United States, while developing countries were composed by Brazil, Mexico, Russia, Saudi Arabia and South Africa. To avoid bias related to the selection and comparability of countries, both groups were statistically similar in relation to burden of untreated dental caries in permanent teeth, characterized by toothache (Institute for Health Metrics and Evaluation, 2018).

Relative search volume (RSV)

The platform *Google Trends* was used for data collection. It depicts results of the monthly variation of RSVs of specific queries, ranging from 0 to 100. These values represent the normalized ratio of search volume of a particular keyword by the overall searches detected in a given time, considering the maximum value of the curve as RSV=100. Also, results presented by *Google Trends* can be filtered by location, time, category, and source of information, with the availability of determination of RSVs of popular issues by topics related to predefined and automatic algorithms.

On August 27, 2018, the volume of data related to the topic "Toothache-Disease" was determined according to the activity of *Google* and *YouTube* users, through January 2008 to December 2017.

Data analysis

Data were analyzed with the Statistical Package for Social Sciences (version 22.0; SPSS, Chicago, IL, USA), as follows:

1. RSV trends: the curves of observed RSV values were analyzed heuristically. The trends of toothache-related time series were also checked by autocorrelation (ACF) and partial autocorrelation (PACF) plots.
2. Forecasting models: data collected until December 2017 were applied to construct 12-month forecasts for toothache-related RSV values. For that, autoregressive integrated moving average (ARIMA) models were chosen by the lowest values of normalized Bayesian information criteria (Normalized BIC), among curves without a significant residual autocorrelation (Ljung–Box test).
3. Comparisons between time series: since fitted values of *Google*- and *YouTube*-based RSVs were normally and homogeneously distributed (Kolmogorov-Smirnov and Levene tests), T independent test was applied to compare the curves from developed and developing countries
4. Ratio YT/G: were obtained and compared, since the ratios between *YouTube* and *Google* searches were not normally and homogeneously distributed (Kolmogorov-Smirnov and Levene tests), they were compared using Kruskal-Wallis and Dunn's test, considering country groups and different years.

For all statistical analysis, P values < 0.05 were considered significant.

Results

RSV trends

Heuristically, RSVs up trended in both platforms and country groups over time (Fig. 1). However, it was not possible to establish conclusive trends using ACF and PACF analyses (Fig. 2), with the detection of a significant negative autocorrelation in *Google* searches performed in developed countries (lag 2), and a significant positive autocorrelation in *Google* searches performed in developing countries (lag 1).

Forecasting models

Table 1 summarizes adequacy measures and parameter estimation of forecasting models for toothache-related RSV values. The excellent adequacy of ARIMA models was demonstrated by low values of normalized BIC (2.42-4.19). The curves of observed and fitted values of ARIMA

models are showed in Fig. 3. Twelve-month forecasts tended to plateau, independently of the source of information and country groups.

Comparisons between time series

The percentages of increments of *Google*- and *YouTube*-based searches were respectively 146.9% and 156.1% for developed countries, and 288% and 273.3% for developing countries. The means of *Google*-based searches on toothache were significantly higher than those of *YouTube*-based searches in developed (68.02 *vs.* 19.12) and developing countries (54.73 *vs.* 13.81). Comparing the last five years, these significant differences were maintained only in relation to *Google*-based searches; however, search volumes of the last two years were similar between both groups, whereas *YouTube*-based searches returned to be significantly higher in developed countries in 2017 (Table 2).

Ratio between Google and YouTube searches (YT/G)

The volume of *Google*-based searches was higher than that observed in *YouTube* between 2008 and 2017. Additionally, there was no statistical difference between the ratios of YT/G searches over time, considering both country groups (Fig. 4).

Discussion

These findings indicate that volumes of toothache-related searches increased through 2008-2017, with differences between developed and developing countries. The volumes of *Google*- and *YouTube*-based searches were larger in developed countries, although these differences were reduced in last years. This finding was observable when considering *YouTube*-based searches in the period between 2013 and 2016. Additionally, the volume of *Google*-based searches performed in developing countries exceeded that observed in developed ones in 2017, without significant statistical difference. Also, the ratios YT/G remained constant over the years, independently of country groups. To our knowledge, this is the first study that compared the interests of *Google* and *YouTube* users in toothache-related information according to socioeconomic development levels of countries.

The accentuated growth of toothache-related interests observed in developing countries in the last years can be explained by the notorious increase of their Internet penetration. This phenomenon can be explained by three main factors: the rapid expansion of digital infrastructure, the popularization of gadgets, and the decrease of Web access costs (World Bank Group, 2018; Aliance for Afordable Internet, 2018). This process permitted comparisons of people's behaviors from distinct global areas, since a large volume of data was made available (Aliance for Afordable Internet, 2018; Morsy et al., 2018; Brigo, & Trinka, 2015). In this sense, an interesting set of results was detected, as follows: i) the volumes of *Google*-based RSVs were maintained significantly higher in developed countries only until 2015; ii) distinctly, the volumes of *YouTube*-based searches were similar between both groups from 2013 to 2016; iii) in 2017, *YouTube*-based searches returned to be higher in developed countries, as noted in the whole period of time (2008-2017). These findings may be related to the late digital inclusion of developing countries, since netizens are more prone to access health information for solving their

own conditions in comparison to new Internet users, which usually belong to lower socioeconomic groups (Perrin & Bertoni, 2017). In a second time, the lower level of education can influence the preferences of users in relation to Web media, favoring the consumption of videos instead of reading materials (Walthouwer et al., 2015). This pattern could explain the similarities of *YouTube*-based searches between both country groups. Finally, a new *YouTube*-based difference found in the last year of analysis can be related to the mobile access to the Internet, which differs in diffusion, cost and quality according to countries (Fox & Duggan, 2013).

The growing interest in toothache observed in both platforms can be justified by the negative impact of untreated dental caries in permanent teeth on the quality of life of individuals (Institute for Health Metrics and Evaluation, 2018), being related to the self-resolution of oral symptoms (Cruvinel et al., 2019). This behavior is motivated by financial barriers for dental treatment, due to high expenses of private services and insufficient offering of public attendance (Dhama et al., 2016). In these conditions, the use of *YouTube* as a source of health information may be elucidated by two factors. First, the market of this platform is increasing rapidly, with approximately +17% in audience until 2021 (Statista, 2018). Second, *YouTube* video contents favor the potential of learning of its users (Clifton & Mann, 2011; Barry et al., 2016; Shatto & Erwin, 2017).

Some methodological aspects deserve more clarification. Data were collected from *Google Trends* because it enables the comparison of search volumes of specific topics between *Google* and *YouTube*, both leaders in their market segments (Net Market Share, 2018). Also, the selection criteria of countries considered a minimum of population and Internet penetration to provide an adequate amount of data for statistical analysis. For that, the country groups presented similar DALYs indices (data not shown), avoiding the influence of the burden of dental caries on the interpretation of these results. Finally, the geographic diversity of countries intended to minimize the influence of social, cultural and economic factors during these analyses.

These results need to be interpreted with caution. These data are referring exclusively to the activity and behavior of users from two Web platforms, not considering the information of other search engine tools. Additionally, it is not possible to associate socioeconomic characteristics of particular users with their behaviors, since their searches are performed anonymously. Also, this approach can overestimate the activity of netizens, because the impossibility of exclusion of duplicate searches performed by a same person in two or more distinct devices.

Conclusions

In conclusion, toothache-related searches performed on *Google* and *YouTube* increased indistinctly during the last decade. The media preferences of users seemed to be influenced by the differences in the education levels, spreading and availability of the Internet found in developed and developing countries. Therefore, the hypothesis H_0 was rejected. Indeed, the analysis of these computational-based data can subsidize the diffusion of health educational programs and campaigns through most accessible media in accordance with target population.

These actions should be concentrated in minimizing negative effects of ineffective self-management of toothache through digital materials and public alerts, empowering people in making correct and autonomous oral health-related choices.

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Table 1(on next page)

ARIMA model fit statistics

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1

Country group Web platform ARIMA model	Normalized BIC	MAPE	Ljung-Box	Model parts	Lag	Estimate	SE	*p*
Developed Countries								
Google								
(0,1,1)(0,1,1)	2.42	3.91	0.77	MA	Lag 1	0.60	0.07	<0.01
				MA, Seasonal	Lag 1	0.53	0.08	<0.01
Developed Countries								
YouTube								
(0,0,0)(0,0,0)	4.19	113.96	0.83	Constant		13.36	0.70	<0.01
Developing Countries								
Google								
(0,0,0)(1,1,0)	2.89	6.50	0.40	Constant		0.16	0.01	<0.01
				AR, Seasonal	Lag 1	-0.48	0.08	<0.01
Developing Countries								
YouTube								
(0,1,1)(0,0,0)	2.49	32.54	0.52	Constant		0.10	0.01	<0.01
				MA	Lag 1	1.00	0.04	<0.01

2

Table 2(on next page)

Mean of toothache-related searches performed in *Google* and *YouTube* for users from developed and developing countries in different periods

Mean of toothache-related searches performed in *Google* and *YouTube* for users from developed and developing countries in different periods

1

Period	Statistics	*Google* searches		*YouTube* searches	
		Developed countries	**Developing countries**	**Developed countries**	**Developing countries**
Whole period (2008-2017	mean	68.02	54.73	19.12	13.81
	SE	1.63	2.03	1.10	1.00
	df		118		130
	P		<0.001*		0.02*
Last 5 ys. (2013-2017)	mean	83.00	73.45	24.97	20.98
	SE	0.94	1.76	2.08	1.65
	df		59		59
	P		<0.001*		0.13
Last 4 ys. (2014-2017)	mean	85.18	77.57	27.88	22.69
	SE	0.93	1.72	2.43	1.98
	df		47		47
	P		<0.001*		0.10
Last 3 ys. (2015-2017)	mean	86.79	81.05	32.71	26.33
	SE	1.08	1.93	2.80	2.35
	df		35		35
	P		0.01*		0.08
Last 2 ys. (2016-2017)	mean	90.20	87.64	39.59	33.07
	SE	0.93	1.61	3.30	2.57
	df		23		23
	P		0.17		0.13
Last year (2017)	mean	93.41	94.35	49.69	41.25
	SE	0.76	1.22	0.01	0.11
	df		11		11
	P		0.52		<0.001*

2

Figure 1(on next page)

Relative search volume on toothache performed on *Google*

Relative search volume on toothache performed on *Google* from developed (blue line) and developing (green line) countries, and on *YouTube* from developed (red line) countries in and developing (black line) countries.

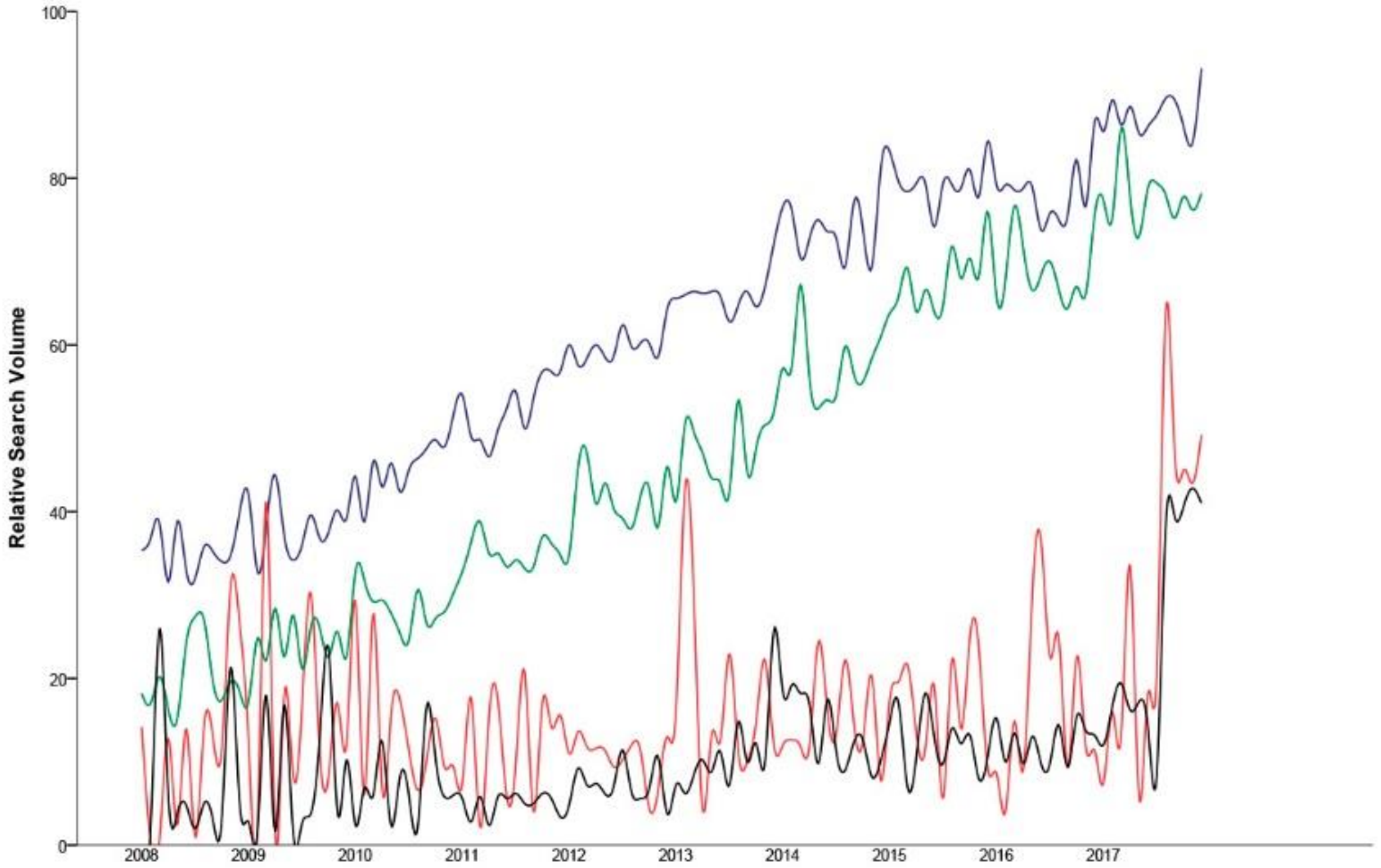

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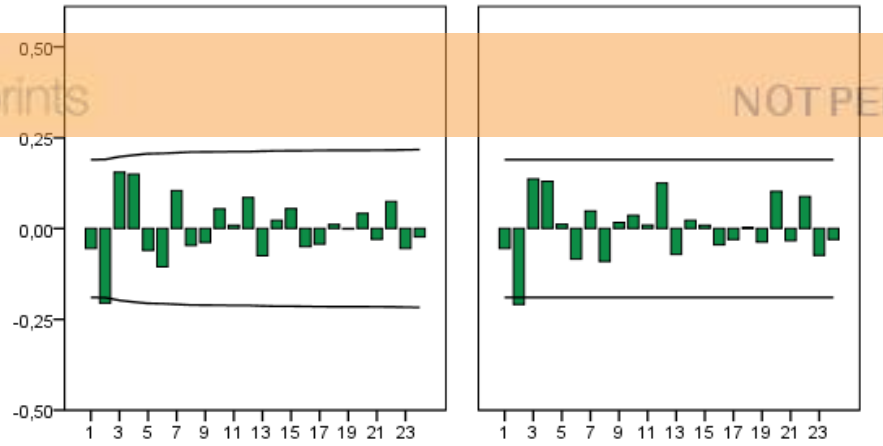
Figure 2(on next page)

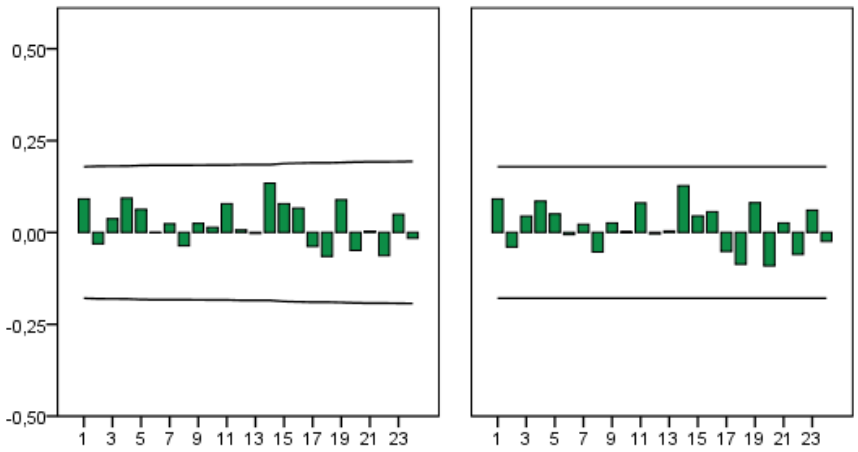
Autocorrelation and partial autocorrelation plots for the monthly variation of RSV toothache

Autocorrelation and partial autocorrelation plots for the monthly variation of RSV toothache: (A) *Google* searches in developed countries, (B) *YouTube* searches in developed countries, (C) *Google* searches in developing countries, (D) *YouTube* searches in developing countries.

A



B



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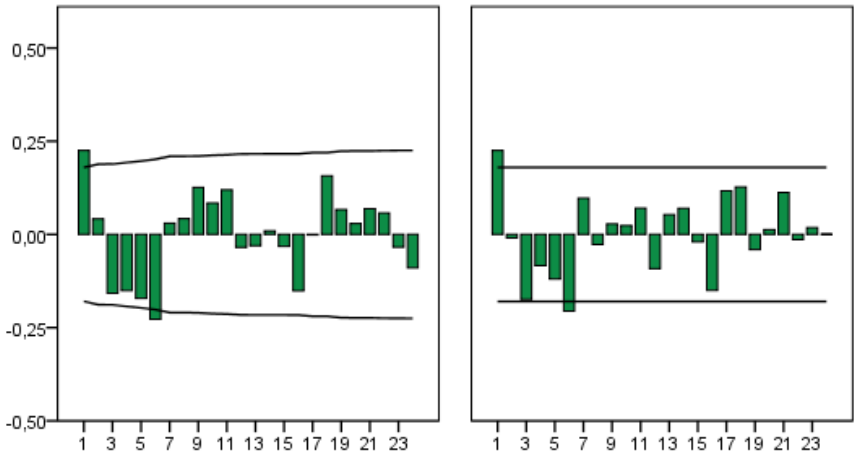

D

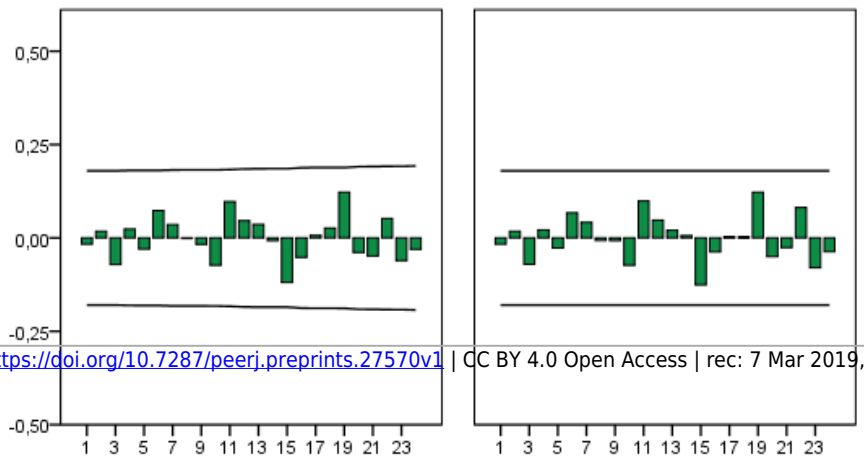

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Figure 3(on next page)

Predictive charts demonstrate the variation of toothache-related RSVs

Predictive charts demonstrate the variation of toothache-related RSVs in developed countries using *Google* (A) and *YouTube* (B), and in developing countries using *Google* (C) and *YouTube* (D). Note that RSVs presented after 2018 represent 12-month predictive values.

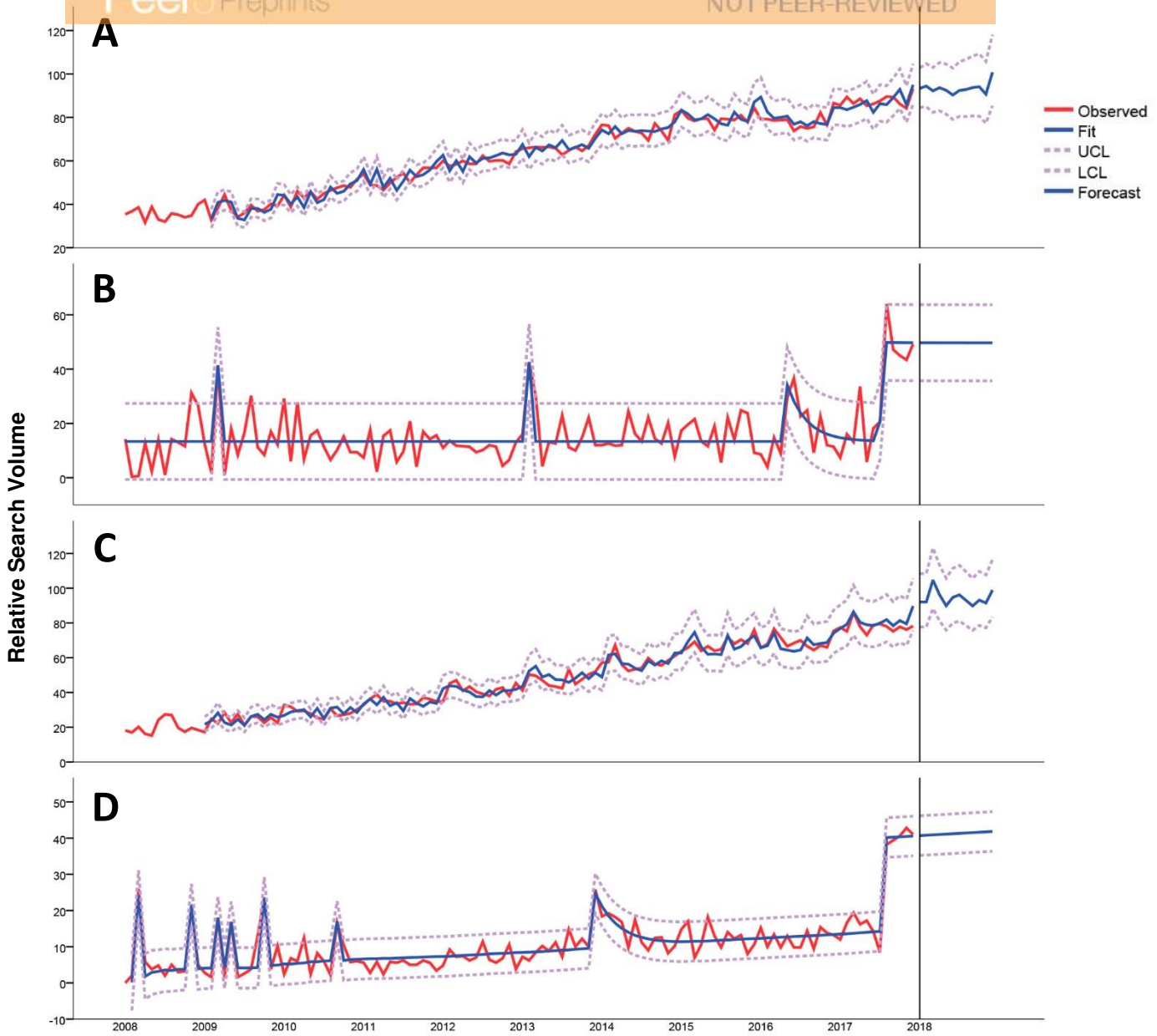

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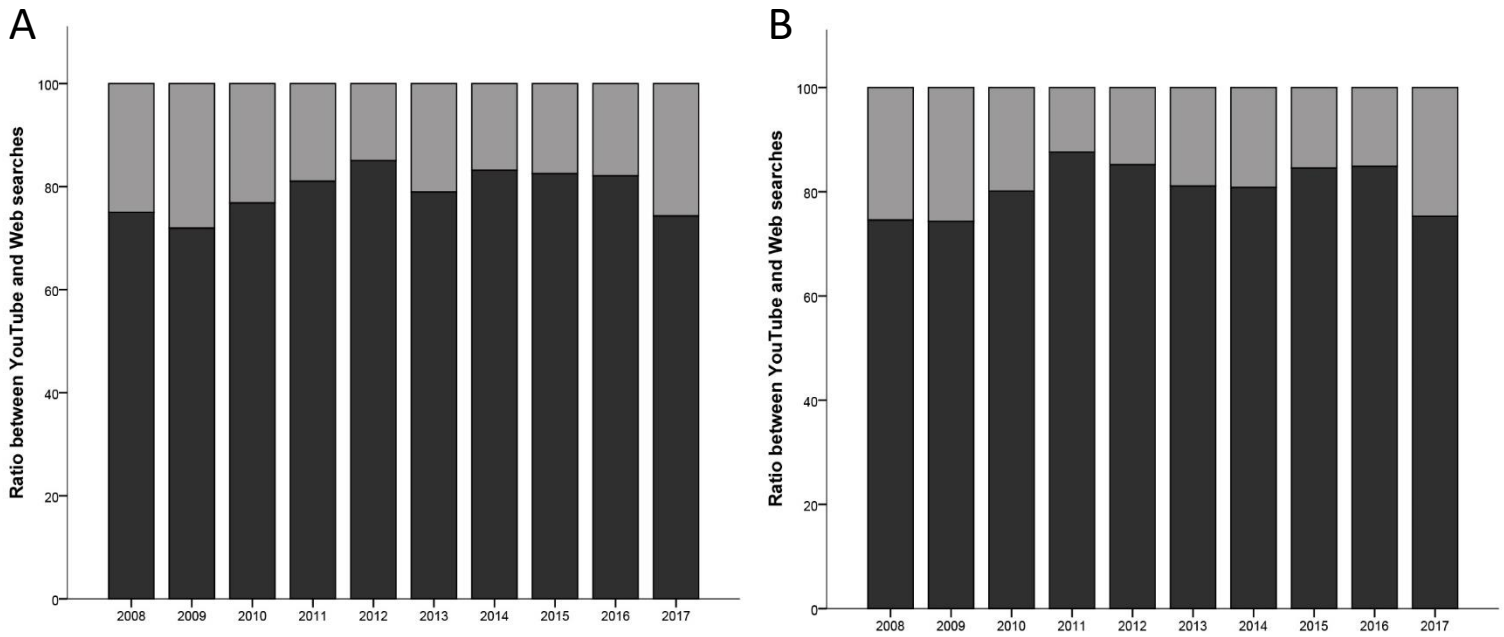
Figure 4(on next page)

Ratio between *YouTube* and *Google* searches

Ratio between *YouTube* and *Google* searches for developed (A) and developing countries (B).



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