Is Google Trends a reliable way to determine digital dental epidemiology?

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Abstract

Aim: Google Trends, which allows Internet users to interact with and search data, can provide in-depth information about new phenomena regarding population and health-related behavior and is a tool that can be accessed free of charge. With the widespread use of dental implants in almost every country in the world today, an increase has also been reported in the prevalence of peri-implantitis (PP), which is a peri-implant disease. The aim of this study is to determine whether the rates of PP that were obtained from previous studies on this disease are in line with the data obtained using Google Trends.

Methodology: Using observational, ecological research, we searched Google Trends for the following query terms: peri implantitis + periimplantitis, to obtain the volume of this Internet search query. The queries were searched within Spain (ES), Germany (DE), the Netherlands (NL), the United Kingdom (UK), and Turkey from January 2010 to December 2019.

Results: An examination of the search results for "peri-implantitis + peri-implantitis" on Google Trends found that the largest numbers of searches for these words were made from the country of ES, and the smallest numbers were made from Turkey. It took two years to make forecasts based on the results, and the study determined that there has been a change in the trends in countries that were searched for these words. Also, the results obtained in previous studies for the prevalence of peri-implantitis were not similar to the data obtained from Google Trends.

Conclusion: We concluded in this study that Google Trends is not a reliable tool for dental epidemiology.

Keywords: google trends, peri-implantitis, forecasting

Introduction

The aesthetic and functional disorders that result from losing teeth have been addressed in recent years through the applications of implants to replace missing teeth. Over the long term, the survival rate of implants inside the mouth has been reported as 97% (1). However, although implants can remain inside the mouth for long periods of time, peri-implant diseases are encountered in the vast majority of cases (2). Peri-implant diseases are divided into two categories: peri-implant mucositis and peri-implantitis. While peri-implant mucositis was initially defined as a disease that was characterized by bleeding on probing and/or suppuration where the inflammatory reaction is observed only in the mucosa, the diagnostic criteria now include bone losses of up to 2 mm in cases where

the initial radiographies of patients are unavailable (3, 4). Peri-implantitis is a disease in which additional bone loss is observed after the clinical findings of bleeding on probing and/or suppuration (4). As in cases involving periodontal diseases, microbial dental plaque is a primary factor in the etiology of peri-implant diseases. In addition to changes in the composition of the plaque that forms on the implants, in areas that are next to the edges of the gums, and in the tissue defenses, it is known that some systemic conditions also increase predisposition to peri-implant diseases (5). The presence of unsuitable occlusal loadings, parafunctional habits such as bruxism in patients, smoking, and histories of having had periodontitis in the past are among other factors that negatively affect the success of implants (6). In patients whom they followed for more than two years, Kordbacheh Changi et al. reported the prevalence of peri-implantitis as being 34% at the patient level and 21% at the implant level (7). Using a randomly selected patient group from the Swedish National Insurance Registry and following them up for nine years, Derks et al. found that 14% of the patients and 8% of the implants were affected by moderate-to-severe peri-implantitis (8). In spite of the high rates of success and survival of the implants, the numbers of implants and individuals with peri-implant diseases are constantly rising (9).

The Internet is rapidly becoming the primary source for health information. Estimations showed that 60-to-100 million people searched for health information online, and most did this at least once a month (10). Indeed, millions of people worldwide are searching online for health-related information every day (11), and this makes Internet searches an important source of information for mass health trends (12–14). In addition, Internet users are able to access vast amounts of information quickly through keyword-based Internet searches (15).

Google (http://www.google.com) is an Internet tool or search engine that was initially designed for defining, organizing, and listing websites that contain material on subjects that are related to one another. Searches on Google Trends present results such as the relative search volumes (RSV) related to different geographical regions for specific periods. RSVs vary between 0 and 100: 0 shows that the interest in the searched topic is low, while 100 indicates that there is intense search activity on the topic. As queries on the Google database may be associated with any identity and/or physical location, as is stated in Google's privacy policy (www.google.com/privacypolicy.html), ethical approval is not required for studies that are conducted using this search information.

With the widespread use of dental implants in almost every country in the world today, an increase has also been reported in the prevalence of peri-implantitis (PP), which is a peri-implant disease (16, 17). This study was conducted to determine the relationship between the numbers of Internet searches for peri-implantitis in various countries and the PP that was determined through studies conducted in these countries. This was done to define the main hypothesis of our study, as well as to establish the direction of the

trend in such searches over the past 10 years and form an estimate of how this trend will change in the next few years.

Materials and Methods

This observational and ecological study was conducted in compliance with the Declaration of Helsinki and the policies of Google. As it was not possible in this study to access information regarding the identities of the individuals who were conducting the Internet searches, as it was in previous studies, no application was made for ethics board approval. The Google Trends tool is found at http://google.com/trends/ and can be used by all Internet users. By visiting this address, users can enter the key phrases they want (e.g., "dental implant") into the search tab and see the RSVs for their desired regions and time intervals.

Study Design

Using the online tool Google Trends, this longitudinal retrospective infodemiological study analyzed the interest in peri-implantitis in different countries between January 2010 and December 2019, through analysis of structured computational data. Search strategies were devised in five distinct languages (English, Chinese, Italian, Portuguese, and French), covering all countries with sufficient relative search volume (RSV) data. There were insufficient RSV data for all languages except English. Therefore, the search was conducted only in English using the query term "peri implantitis + periimplantitis". Trends, including seasonality, in the obtained RSV data were analyzed quantitatively and qualitatively.

Search volume trends

This study used the RSV data of 10-year (2010-2019) worldwide search of the phrases "peri implantitis + periimplantitis" on Google Trends (Fig. 1). While making a search on Google Trends, inclusion of a word within closed quotes is used when it is desired that only that word is seen in the search results. Because some people used phrases like peri-implantitis treatment, peri-implantitis complication, etc. While searching on Google to not include such search results, so we entered the phrase we searched within closed quotes. Additionally, to observe search results better, by considering that some people would write peri implantitis with a space between while searching for peri-implantitis, and some people would use the compound word periimplantitis, we included the phrases 'peri implantitis' and 'periimplantitis'. Putting the symbol + between two phrases while searching on Google Trends reveals the total RSV value of those two phrases.

To be able to make a comparison among countries that search for these phrases most, Google Trends was used. There are empty search boxes on Google Trends for making comparisons. A comparison was made by entering the names of the countries (Spain, Germany,

the Netherlands, the United Kingdom, Turkey) and the desired time interval (2010-2019) into these boxes (Fig. 2), and a CSV file was obtained.

As files obtained in Google Trends are in the CSV format, these need to be converted into the XLS format. For this, we used the website named CVS to XLS.
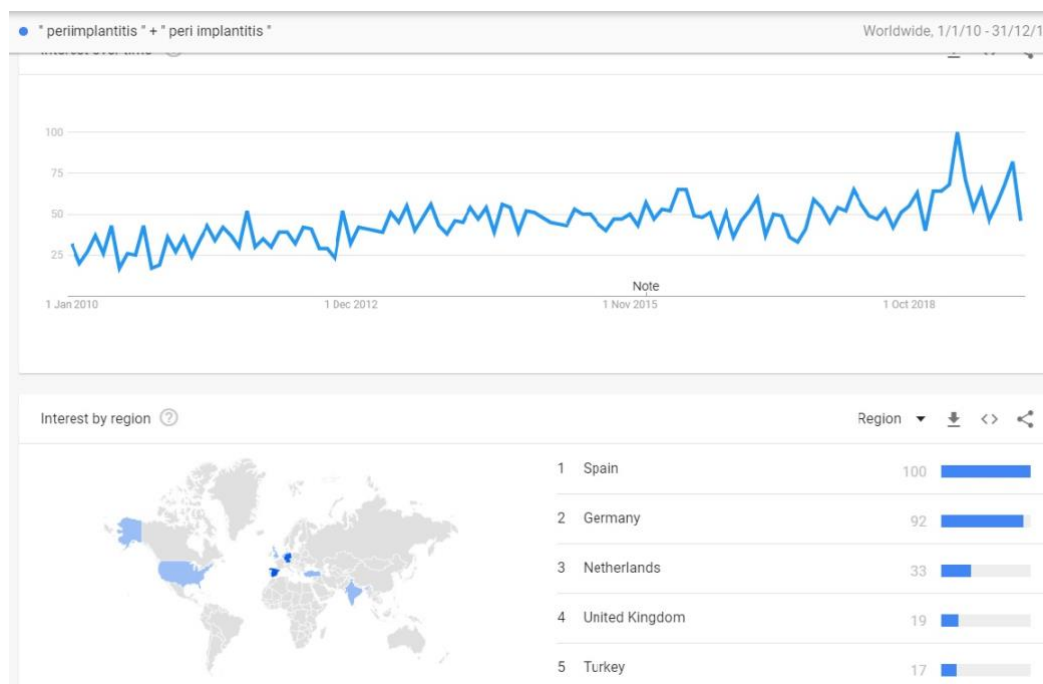

Figure 1. Relative search volume values of [Peri implantitis + peri implantitis] in Google trends (2010-2019)
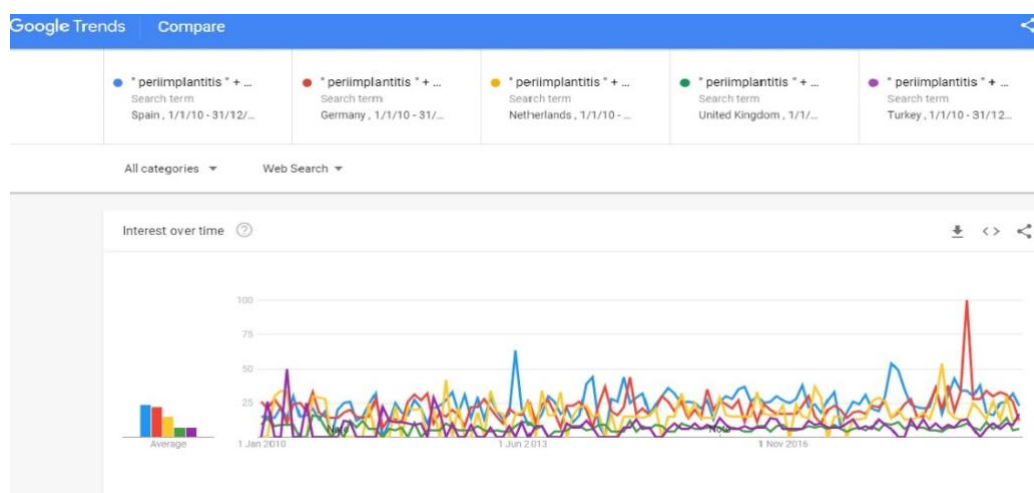

Figure 2. Comparison of the searches of the words [Peri implantitis + peri implantitis] for Spain (ES), Germany (DE), the Netherlands (NL), United Kingdom (UK), and Turkey (TUR) for the years between 2010-2019 in Google Trends

Statistical analysis

The data were analyzed by using the SPSS software version 23.0 (IBM Corp., Armonk, NY, USA). Means, standard deviations (SD), medians, minima-maxima, and percentages were used as descriptive statistics. The normal distribution of the data was tested by using Kolmogorov-Smirnov test. Kruskal-Wallis test was used for intergroup comparisons where the data were not normally distributed. To assess the trends in the time series data for each country, autocorrelation (ACF) and partial autocorrelation (PACF) plots were used. Additionally, curves that were obtained from autoregressive integrated moving average (ARIMA) models were heuristically analyzed to understand the variations in time. By using ARIMA models, predictions were formed for the relevant RSVs for the next 24-month period. As the most suitable model, the models with the lowest normalized Bayesian information criterion (BIC) values were selected. $p < 0.05$ was accepted as statistically significant for all analyses.

Results

According to the search results of the phrases 'Peri implantitis + periimplantitis' on Google Trends, the countries that made the most searches worldwide from 2010 to 2019 were determined as Spain, Germany, the Netherlands, the United Kingdom, and Turkey (Figure 1). The median and min-max values of the RSVs for these countries are shown in Figure 3. Based on the RSV values, it may be stated that the interest in Spain with the highest value (100) in the phrases 'Peri implantitis + periimplantitis' was higher than those in the other countries. The results of the test we conducted to understand whether or not the searches from these countries on 'peri implantitis + periimplantitis' were made in similar time intervals are shown in Table 1. This analysis revealed that the searches made from these countries for 'peri implantitis + periimplantitis' were made in different time intervals, except for those from TUR-UK, which were made in the same time interval.

Data obtained from Google Trends constitute a time series. In time series, there are concepts such as trends, seasonal effects, and stationarity. If we conduct a statistical test like ARIMA on a time series at hand, we obtain information on what kind of a trend that series will follow in the future period. For being able to conduct an ARIMA test on a time series, the series must be stationary or be converted into stationary. In order to understand whether a time series is stationary or not, it is needed to examine ACF and PACF plots. When the ACF and PACF plots of the time series used in this study (Figure 4) were examined, it was seen that the trend was random, it was not affected by any time interval, the autocorrelation coefficients did not go outside the significance limits, and all p values in the conducted Ljung-box test were greater than 0.05 (Table 1), meaning that the time series was stationary.

Using this time series that we obtained from Google Trends, a forecasting test was conducted to make a projection regarding the 2-year period towards the future. According to the results of this test, it was projected that the trend would be similar in the following period for the phrases "peri implantitis + periimplantitis", and the search amounts would continue similarly in comparison to previous years for these countries (Fig. 5).
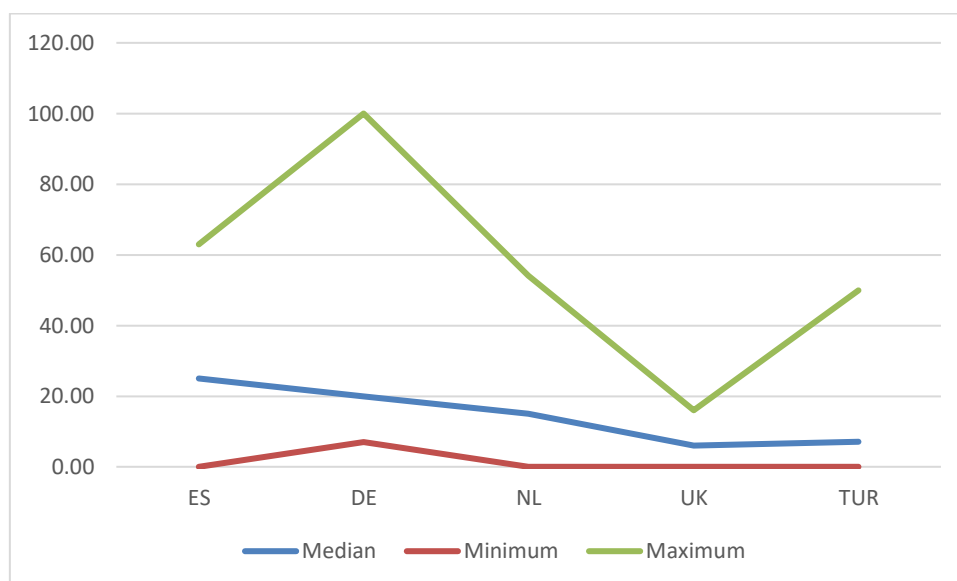

Figure 3. Spain (ES), Germany (DE), the Netherlands (NL), United Kingdom (UK), and Turkey (TUR) for the years between 2010-2019 Median and Min-Max of RSV values.

Table 1. Comparison of similarities of RSV values for Spain (ES), Germany (DE), the Netherlands (NL), United Kingdom (UK), and Turkey (TUR) for the years between 2010-2019

	N	Median	Min	Max	Mean Rank	Test statistics	P value
ES	120	d	0	63	4.25		
DE	120	c	7	100	4.00		
NL	120	b	0	54	3.12	χ^2= 267.165	<0.001
UK	120	a	0	16	1.77		
TUR	120	a	0	50	1.85		

a-d: There is no difference between countries with the same letter, x2: Friedman test statistic
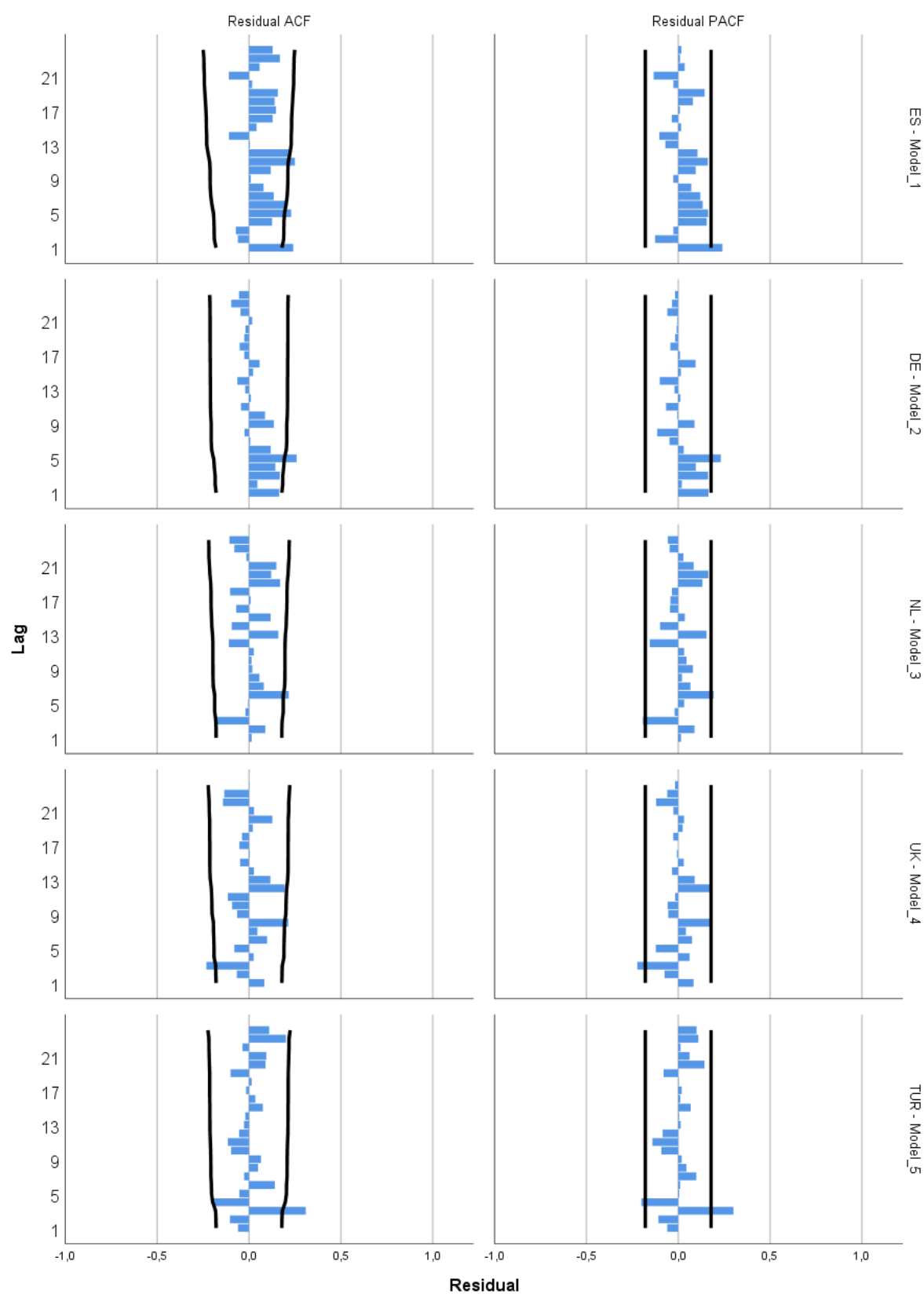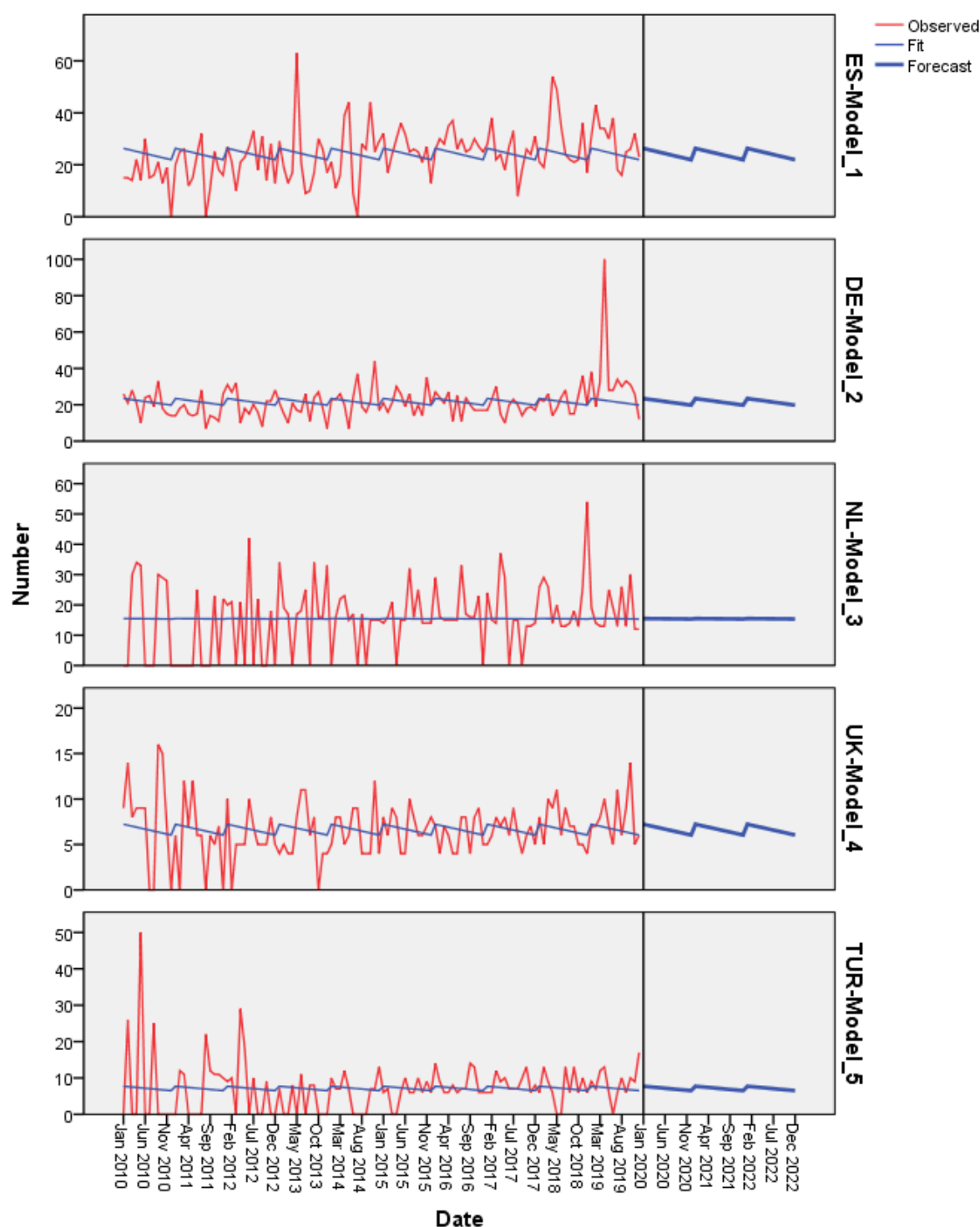
Figure 4. ACF and PACF values

Figure 5. Forecasting result of relative search volume [Peri implantitis + Peri implantitis]

Discussion

Examining the search results of the phrases 'peri implantitis + periimplantitis' on Google Trends, it is seen that the most searches made for these phrases were from the country of ES. Until now, several studies have been conducted to investigate the prevalence of peri-mucositis and peri-implantitis (PP) in 5-20-year implants for various countries on the patient or implant level (8,9,18–22). Considering these studies, it is observed that PP generally varies in the range of 1-63.7% (23,24). Previous studies reported that there is an inverse relationship between peri-implantitis and the usage time of an implant, higher rates of PP are observed in implants that are used for a long time, and PP varies from country to country (25). Matarazzo et al. reported PP to be 39.8% for the Brazilian society and that sex, the number of implants and position (maxilla-

mandible), amount of keratinized gums, and the adhesion form of the prosthetic are effective on the health of the implant (26). Considering the results of studies that have been conducted on the patient level in different countries to detect PP, it is observed that PP was found for ES as 15.1%,(18) 10.3%,(27) 38.8%,(28) and 51%,(29) for DE as 11.2%, (30) 12.9%, (31) and 13.9% (32), for NL as 16.9%(33) for implants under 5-year functional loading and as 29.7% (33) for implants under 10-year functional loading, for UK as 22%(34) and for TUR as 21.7% (35) and 14.5-31.0% (36). Based on previous studies, PP for ES was found to be very high in some studies (28, 29) and very low in some others (27). Although the Google Trends search results on the phrases 'peri implantitis + periimplantitis' seem to be in parallel with the results of studies conducted on PP, the results were not completely consistent. According to the results of this study, it was observed that Google Trends search results were not sufficient to determine the prevalence of peri-implantitis for countries. Based on this result, we also report that there is no relationship between the frequency of a disease being searched on Google and its prevalence.

Many studies have been conducted in the field of health on the prevalence of diseases by using Google Trends (37–40). It is noteworthy that one of such study was on epidemiology (38). In the study, it was reported that Google Trends is insufficient in defining the epidemiology of prevalent or rare diseases, and these data are affected rather by the media than epidemiological data (38).

Time series projection is a significant field of forecasting where the past observations of the same variable are collected and analyzed to develop a model that explains the relationship at the foundation (41). In addition to a current disease such as the COVID-19 pandemic, to project seasonal or future period courses for many diseases from knee injuries to hypothyroidism, forecasting has been carried out in many studies using time series and seasonal or ARIMA models (42–46). For this time series obtained from Google Trends, forecasting was performed by using an ARIMA model. The model revealed as a result of forecasting, and the normalized BIC, Lag, SE, t and P values are shown in Table 2. AS a result of forecasting, it was determined that the change in the search trend that would be observed in these countries in the time series in future years would not be different, and there would be a similar trend to those in previous years.

Table 2. ARIMA Model Fit statistics

Country	ARIMA Model	Normalized BIC	Ljung-Box	Lag	Estimate	SE	t	P value
ES	(0,0,0)(0,0,0)	4.687	0.000	Lag 0	26,726	1,949	13,715	<0.001
					-,398	,265	-1,502	
DE	(0,0,0)(0,0,0)	4.720	0.111	Lag 0	23,774	1,981	12,002	<0.001
					-,329	,269	-1,224	
NL	(0,0,0)(0,0,0)	4.929	0.174	Lag 0	15,520	2,199	7,058	<0.001
					-,013	,299	-,044	
UK	(0,0,0)(0,0,0)	2.310	0.062	Lag 0	7,333	,593	12,356	<0.001
					-,108	,081	-1,335	
TUR	(0,0,0)(0,0,0)	3.993	0.075	Lag 0	7,836	1,377	5,691	<0.001
					-,109	,187	-,585	

Conclusions

Consequently, when people research the complications of a treatment that is popular today, such as dental implants, they encounter peri-implantitis, and they search this term on Google. For this reason, it was concluded that usage of Google Trends is not very suitable for determining PP. It is needed to support this result with other studies to be conducted on this topic in the future.

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References

1. Busenlechner D, Fürhauser R, Haas R, Watzek G, Mailath G, Pommer B. Long-term implant success at the academy for oral implantology: 8-year follow-up and risk factor analysis. J Periodontal Implant Sci. 2014;44(3):102-8. (Crossref)
2. Lindhe J, Meyle J. Peri-implant diseases: Consensus Report of the Sixth European Workshop on Periodontology. In: Journal of Clinical Periodontology. 2008. p. 282-5. (Crossref)
3. Ferreira SD, Silva GLM, Cortelli JR, Costa JE, Costa FO. Prevalence and risk variables for peri-implant disease in Brazilian subjects. J Clin Periodontol. 2006;33(12):929-35. (Crossref)
4. Zitzmann NU, Berglundh T. Definition and prevalence of peri-implant diseases. In: Journal of Clinical Periodontology. 2008. p. 286-91. (Crossref)
5. Meffert RM. Periodontitis vs. peri-implantitis: The same disease? The same treatment? Vol. 7, Critical Reviews in Oral Biology and Medicine. 1996. p. 278-91. (Crossref)
6. Charalampakis G, Rabe P, Leonhardt Å, Dahlén G. A follow-up study of peri-implantitis cases after treatment. J Clin Periodontol. 2011;38(9):864-71. (Crossref)
7. Kordbacheh Changi K, Finkelstein J, Papapanou PN. Peri-implantitis prevalence, incidence rate, and risk factors: A study of electronic health records at a U.S. dental school. Clin Oral Implants Res. 2019;30(4):306-14. (Crossref)
8. Derks J, Schaller D, Håkansson J, Wennström JL, Tomasi C, Berglundh T. Effectiveness of Implant Therapy Analyzed in a Swedish Population: Prevalence of Peri-implantitis. J Dent Res. 2016;95(1):43-9. (Crossref)
9. Koldsland OC, Scheie AA, Aass AM. Prevalence of Peri-Implantitis Related to Severity of the Disease With Different Degrees of Bone Loss. J Periodontol. 2010;81(2):231-8. (Crossref)
10. Cline RJW, Haynes KM. Consumer health information seeking on the internet: The state of the art. Health Educ Res. 2001;16(6):671-92. (Crossref)
11. Johnson HA, Wagner MM, Hogan WR, Chapman W, Olszewski RT, Dowling J, et al. Analysis of Web access logs for surveillance of influenza. Medinfo. 2004;11(Pt 2):1202-6.
12. Eysenbach G. Infodemiology: tracking flu-related searches on the web for syndromic surveillance. AMIA Annu Symp Proc. 2006;244-8.
13. Polgreen PM, Chen Y, Pennock DM, Nelson FD. Using internet searches for influenza surveillance. Clin Infect Dis. 2008;47(11):1443-8. (Crossref)
14. Carneiro HA, Mylonakis E. Google trends: A web-based tool for real-time surveillance of disease outbreaks. Clin Infect Dis. 2009;49(10):1557-64. (Crossref)
15. Brownstein JS, Freifeld CC, Madoff LC. Digital Disease Detection — Harnessing the Web for Public Health Surveillance. Vol. 360, New England Journal of Medicine. 2009. p. 2153-7. (Crossref)
16. Tarnow DP. Increasing Prevalence of Peri-implantitis: How Will We Manage? Vol. 95, Journal of Dental Research. 2016. p. 7-8. (Crossref)
17. Valente NA, Andreana S. Peri-implant disease: What we know and what we need to know. Vol. 46, Journal of Periodontal and Implant Science. 2016. p. 136-51. (Crossref)
18. Aguirre-Zorzano LA, Estefanía-Fresco R, Telletxea O, Bravo M. Prevalence of peri-implant inflammatory disease in patients with a history of periodontal disease who receive supportive periodontal therapy. Clin Oral Implants Res. 2015;26(11):1338-44. (Crossref)
19. Monje A, Wang H-L, Nart J. Association of Preventive Maintenance Therapy Compliance and Peri-Implant Diseases: A Cross-Sectional Study. J Periodontol. 2017;88(10):1030-41. (Crossref)
20. Francetti L, Cavalli N, Taschieri S, Corbella S. Ten years follow-up retrospective study on implant survival rates and prevalence of peri-implantitis in implant-supported full-arch rehabilitations. Clin Oral Implants Res. 2019;30(3):252-60. (Crossref)
21. Rokn A, Aslroosta H, Akbari S, Najafi H, Zayeri F, Hashemi K. Prevalence of peri-implantitis in patients not participating in well-designed supportive periodontal treatments: a cross-sectional study. Clin Oral Implants Res. 2017;28(3):314-9. (Crossref)
22. Tenenbaum H, Bogen O, Séverac F, Elkaim R, Davideau JL, Huck O. Long-term prospective cohort study on dental implants: clinical and microbiological parameters. Clin Oral Implants Res. 2017;28(1):86-94. (Crossref)
23. Renvert S, Aghazadeh A, Hallström H, Persson GR. Factors related to peri-implantitis - a retrospective study. Clin Oral Implants Res. 2014;25(4):522-9. (Crossref)
24. Zetterqvist L, Feldman S, Rotter B, Vincenzi G, Wennström JL, Chierico A, et al. A Prospective, Multicenter, Randomized-Controlled 5-Year Study of Hybrid and Fully Etched Implants for the Incidence of Peri-Implantitis. J Periodontol. 2010;81(4):493-501. (Crossref)
25. Cosgarea R, Sculean A, Shibli JA, Salvi GE. Prevalence of peri-implant diseases-a critical review on the current evidence. Braz Oral Res. 2019;33. (Crossref)
26. Matarazzo F, Sabóia-Gomes R, Alves BES, de Oliveira RP, Araújo MG. Prevalence, extent and severity of peri-implant diseases. A cross-sectional study based on a university setting in Brazil. J Periodontal Res. 2018;53(5):910-5. (Crossref)
27. Canullo L, Peñarrocha-Oltra D, Covani U, Botticelli D, Serino G, Penarrocha M. Clinical and microbiological findings in patients with peri-implantitis: A cross-sectional study. Clin Oral Implants Res. 2016;27(3):376-82. (Crossref)
28. Mir-Mari J, Mir-Orfila P, Figueiredo R, Valmaseda-Castellón E, Gay-Escoda C. Prevalence of peri-implant diseases. A cross-sectional study based on a private practice environment. J Clin Periodontol. 2012;39(5):490-4. (Crossref)
29. Rodrigo D, Sanz-Sánchez I, Figuero E, Llodrá JC, Bravo M, Caffesse RG, et al. Prevalence and risk indicators of peri-implant diseases in Spain. J Clin Periodontol. 2018;45(12):1510-20. (Crossref)
30. Rinke S, Ohl S, Ziebolz D, Lange K, Eickholz P. Prevalence of periimplant disease in partially edentulous patients: A practice-based cross-sectional study. Clin Oral Implants Res. 2011;22(8):826-33. (Crossref)
31. Konstantinidis IK, Kotsakis GA, Gerdes S, Walter MH. Cross-sectional study on the prevalence and risk indicators of peri-implant diseases. Eur J Oral Implantol. 2015;8(1):75-88.
32. Schwarz F, Becker K, Sahm N, Horstkemper T, Rousi K, Becker J. The prevalence of peri-implant diseases for two-piece implants with an internal tube-in-tube connection: a cross-sectional analysis of 512 implants. Clin Oral Implants Res. 2017;28(1):24-8. (Crossref)
33. Meijer HJA, Raghoebar GM, De Waal YCM, Vissink A. Incidence of peri-implant mucositis and peri-implantitis in edentulous patients with an implant-retained mandibular overdenture during a 10-year follow-up period. J Clin Periodontol. 2014;41(12):1178-83. (Crossref)
34. Holland C. Investigation: Combating peri-implant disease. Vol. 220, British dental journal. 2016. p. 48-9. (Crossref)

35. Gunpinar S, Meraci B, Karas M. Analysis of risk indicators for prevalence of peri-implant diseases in Turkish population. Int J Implant Dent. 2020 May;6(1):19. (Crossref)

36. Elemek E, Agrali OB, Kuru B, Kuru L. Peri-implantitis and Severity Level. Eur J Dent. 2020;14(1):24–30. (Crossref)

37. Zuin M, Rigatelli G, Ronco F. Worldwide and European interest in the MitraClip: A Google Trends-based analysis. J Cardiovasc Med. 2020;21(3):246–9. (Crossref)

38. 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):185–9. (Crossref)

39. Husnayain A, Fuad A, Lazuardi L. Correlation between Google Trends on dengue fever and national surveillance report in Indonesia. Glob Health Action. 2019;12(1). (Crossref)

40. Mavragani A, Ochoa G, Tsagarakis KP. Assessing the methods, tools, and statistical approaches in Google trends research: Systematic review. J Med Internet Res. 2018;20(11). (Crossref)

41. BATES JM, GRANGER CWJ. Combination of Forecasts. Oper Res Q. 1969;20(4):451–68. (Crossref)

42. Stübinger J, Schneider L. Epidemiology of Coronavirus COVID-19: Forecasting the Future Incidence in Different Countries. Healthcare. 2020;8(2):99. (Crossref)

43. Petropoulos F, Makridakis S. Forecasting the novel coronavirus COVID-19. PLoS One. 2020;15(3). (Crossref)

44. Kardeş S, Kardeş E. Seasonality of bruxism: evidence from Google Trends. Sleep Breath. 2019;23(2):695–701. (Crossref)

45. Dewan V, Sur H. Using google trends to assess for seasonal variation in knee injuries. J Arthrosc Jt Surg. 2018;5(3):175–8. (Crossref)

46. Ilias I, Alexiou M, Meristoudis G. Is There Seasonality in Hypothyroidism? A Google Trends Pilot Study. Cureus. 2019; (Crossref)