

Effects of seasonality, socioeconomic status, and dentist density on online searches regarding toothache: An infodemiological Google Trends analysis

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Abstract

Aim: This study aimed to determine the nature of internet searches regarding toothache in Türkiye, to identify sub-region differences and seasonality effects, and to examine the effects of dentist density and socioeconomic differences.

Methodology: The Google Trends service was used to evaluate online search queries regarding toothache in Türkiye over the previous five years. Queries and topics related to toothache and sub-regional differences in search results were examined, and seasonal differences were identified from a constructed time series using decomposition analysis. Sub-regional cities were categorized by socioeconomic status and dentist density, and the relationship of these predictor variables with the searches was examined using linear regression analysis. The significance level was determined as 5%.

Results: The most searched terms and topics were mostly focused on how to deal with toothache at home. Seasonal differences were observed in searches, with April and the months of summer the most searched periods and with search queries decreasing during the winter months. Searches were greater in sub-regional cities characterized by lower socioeconomic status and lower densities of dentists.

Conclusion: Online searches of public sources regarding toothache are increasing, and individuals use infodemiological information in place of professional advice when suffering from toothache, turning more to online tools under conditions and during periods when it is difficult to access a dentist.

Keywords: Google Trend analysis, infodemiology, oral health, seasonality, toothache

Introduction

Toothache is a common condition characterized by unpleasant symptoms and a negative emotional experience, which significantly reduce quality of life, and it is one of the major reasons for people attending dental offices (1). Toothache has many odontogenic and non-odontogenic etiological factors. Orofacial pain due to disorders in dentoalveolar and related structures is the main source of toothache, but myofascial pains, temporomandibular joint pains, and other pains caused by problems in the cranial nerve can also be perceived as toothaches (2). The most important etiological factors of dental pain are dental caries, traumatic injuries, and periodontal diseases (3). The primary source that people suffering from toothache use for information about the cause of the pain, the procedures they can use to relieve it, and professional instructions and treatment protocols is the internet, which offers new avenues for patients seeking pain relief (4). Thus, especially in cases of chronic pain, people may consult self-care methods instead of receiving professional treatment (5). The breadth of internet penetration and its increased use has produced an information revolution and made the internet a major source of information (5). Medical information can be obtained online quickly, reliably, and cost-free (1). It is logical in the field of medicine to use official data to plan precautions and health plans and to understand the actual incidence of diseases, but accessing the necessary statistics can be time-consuming and costly (5).

Online queries can serve as a surrogate measure for awareness of the existence of diseases (3). Based on the latest information in Türkiye, it has been reported that the rate of households with access to the Internet is 95.5%, and the rate of individuals using the Internet is 87.1% (Household Information Technologies Usage Survey, 2023, TUIK). The popularization of smartphones has enabled people to inquire about their condition online before visiting clinics when they feel abnormal changes and symptoms in their bodies (6). Huge amounts of data are created by systematically structuring the queries people search on the web, which is such a widely used area (4). Much more comprehensive data can be obtained this way than by surveys or institutional documentation (7). Such large data sets are characterized by veracity, value, volatility, validity, volume, variety, variability, and velocity and have ideal forecasting capabilities (8). Big data analysis generated by the interactions of internet users can be useful in explaining the public attitudes of different societies toward resolving dental symptoms themselves (9).

Among search engines worldwide, Google is the most preferred (91.58%) (<https://gs.statcounter.com/search-engine-market-share>, September 2022 - September 2023). Google Trends (GT) is a service that presents the volume of queries made about a specific term or topic searched on Google in a specific period and location within a few seconds. This free online portal service was developed in

2004 and archives all searches since that year and presents them to the user. It prevents artificial increases by eliminating the same queries from the same device in a recent period. GT analysis is considered an optimum analyzer to determine public interest in a health problem and detect changes in human behavior, eliminating the difficulties in accessing such large-scale data (8, 10). Periodic collection and the anonymous nature of real-time data provide methodological standardization, eliminate biases, and create cost efficiency (9).

After the introduction of the GT service, many medical studies have made comparisons with real data (10). There are strong correlations between GT searches and general health conditions (9). It is considered an effective method in the detection, prediction, and documentation of diseases or patient complaints (7). The information obtained with this methodological approach is reliable and has excellent data stability (10). Dental problems affect personal and individual life and reduce the quality of life (2). Many topics and queries have been analyzed in different geographies and sub-regions with GT analysis in dentistry such as dental caries (9,10), bruxism (11), molar incisor hypomineralization (12), the effect of COVID-19 restrictions on toothache (13), dental anesthesia (14), antibiotic use for dental pain (15), home remedy products for toothache (16), cracked teeth (17), amalgam filling (18), peri-implantitis (19) and pediatric dental problems (20).

Previously, some studies have been conducted via Google search for toothache in different parts of the world (4, 9). There is an increasing interest every year among Internet users in searching this topic (4, 13). Search engines, social media platforms, such as Twitter, and other web-based tools and resources on toothache deepen the understanding of patients' web-based behavior, as well as their behavioral changes (8). Information on seasonal differences in toothache is limited. It is questionable whether toothache shows seasonal differences and in which periods it is more common. This study aimed to investigate whether toothache changes seasonally in Türkiye, as well as examined the change in the number of Google searches for toothache, according to the socioeconomic status and the number of patients per dentist in the provinces.

Materials and Methods

In this study, the phrase "toothache" was searched throughout Türkiye under the "health" category on Google Trends on October 1, 2023 (<https://trends.google.com/trends/>). The "health" category was chosen, as the goal of the study was to examine sources strictly within the field of health. "Toothache" was used as the search term, and the monthly variation in relative search volume (RSV), the value indicating the popularity of the term, was determined. Numerical data were retrieved as comma-separated values (CSV). In RSV scores, the most searched period in the relevant query is expressed as 100, and

other numerical data are calculated according to this value, varying between 0 and 100. A period and geographical region with an RSV of 50 indicates that half of the searches were made in the most observed period or region. A RSV of 0 indicates that there are not enough searches that have been made for this term.

First, the term “toothache” was searched, with the search period ranging from 2004, the earliest year from which Google Trends data is available, until October 1, 2023 (Figure 1). However, a linear positive correlation was observed over time due to the increase in internet usage each year compared to the first few years ($R^2 = 0.92$). It was also observed in the autocorrelation and partial autocorrelation functions graph that the series was non-stationary and displayed a rising trend (Fig. 1). A stationary time series was observed in the queries of the last five years (Fig. 2). To eliminate pseudo-seasonal increases that were created by the time trend, information analysis was conducted only on the data from the last five years (October 2018-September 2023).

The findings from searching the phrase “toothache” over the last five-year period were as follows:

1. The most relevant and increasing queries about toothache: The most relevant queries about toothaches are the ones that people who were searching for the query term (“toothache”) were also searching for. Increasing queries are the queries for which the search frequency has recently increased by the greatest amount. While there is RSV in the relevant queries, there are only terms without RSV in the increasing queries.

2. Interest by subregion: This shows the popularity of the search term throughout the specified period in the 81 provinces of Türkiye. The values are obtained as RSV, with the highest value being 100. The population differences between the subregions do not affect the popularity of the search term, as each value is calculated by comparing the relevant search in each subregion to all the searches in its respective province.
3. The predictive effects of the provinces’ socio-economic development scores on Google searches for “toothache” according to the Socio-Economic Development Ranking Research of Provinces and Regions (SEGE, 2017): According to this index, there are six sublevels in each subregion according to its socio-economic development levels. These range from the most developed provinces in the first level to the least developed provinces in the sixth level.
4. The predictive effects of the number of dentists per 100,000 people on the Google search for “toothache”: The provinces are ranked in four separate categories according to this statistic. These include over 45, 36-45, 30-35, and under 35.
5. Time series of “toothache” over the last five years.
6. The effects of seasonality on “toothache” searches.

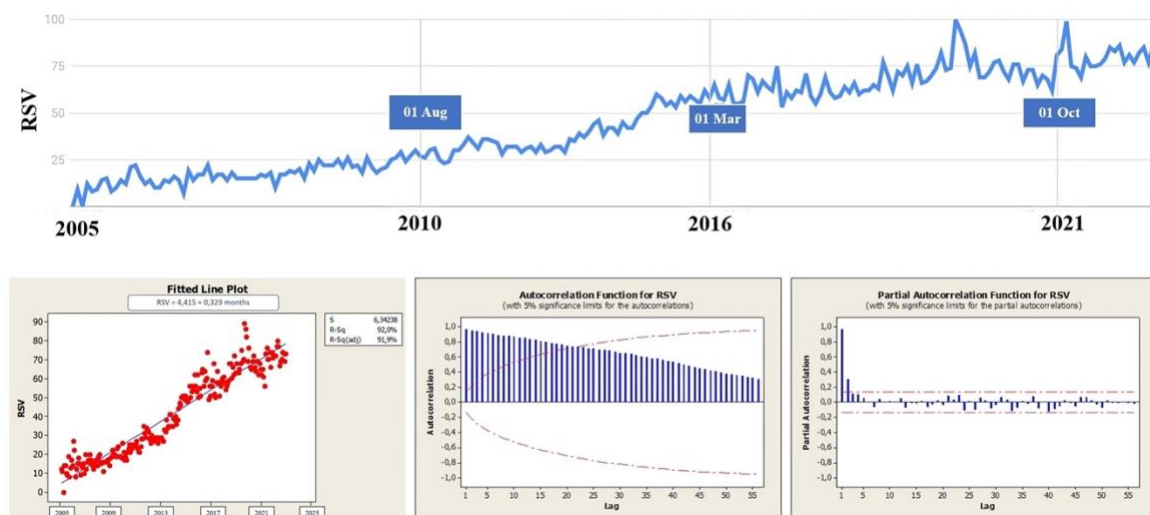


Figure 1. Toothache time series graph, regression graph, autocorrelation, and partial autocorrelation function graphs in Türkiye according to Google Trend data between 2005 and 2023 (There is a clear increasing trend in this period. It is understood that the series is not stationary).

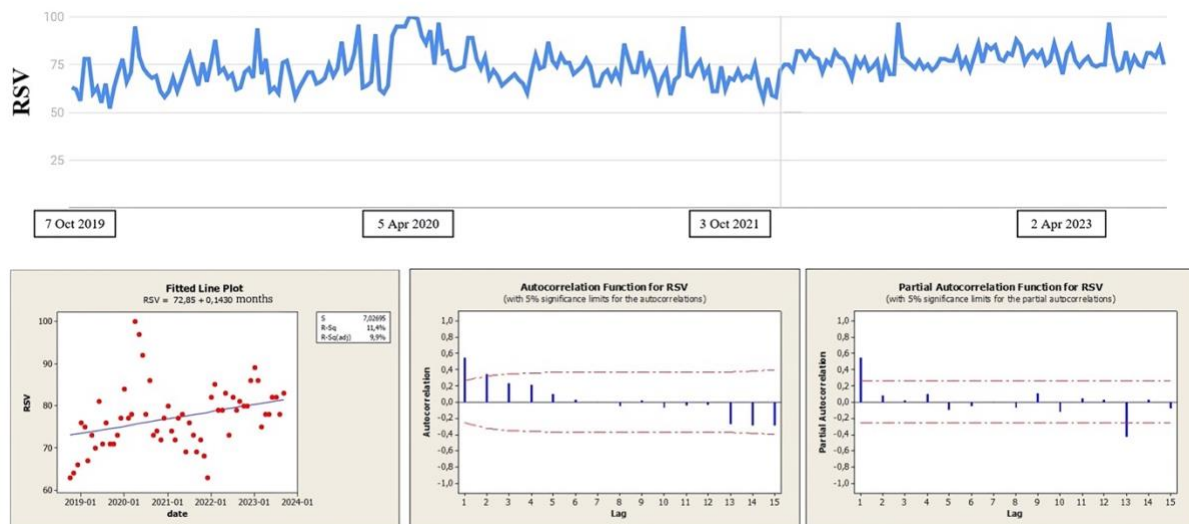


Figure 2. Time series, regression, autocorrelation, and partial autocorrelation graphs on the toothache query in Türkiye for the last five years (October 2018-September 2023) in Google Trend data (It seems that this series is more stationary).

Statistical analysis

Monthly RSV scores, the socioeconomic status of the provinces, and dentists per 100,000 people were entered into the Minitab statistical program (Minitab Inc., State College, PA, US), and statistical analyses were carried out using this program.

The additive model type was preferred in the decomposition analysis to evaluate seasonality's effect in the time series. A linear regression model was established for the predictive effects of socioeconomic development and the number of dentists/patients of the subregions on the toothache search query. The statistical significance level was set at 0.05.

Results

Most relevant and increasing queries

The most frequently searched queries by users regarding toothache, their RSV scores, and those queries that have recently increased are listed in Table 1. The relevant searches with the highest scores were about toothache solutions (spelling errors or differences were counted as separate queries by the Google Trend service). Increasing queries focused on whether painkillers, antibiotics, and home remedy products relieve toothaches.

Interest by subregion

Table 2 presents the 10 cities with the highest and lowest RSV for toothaches in the subregion. Regional differences were observed regarding toothaches.

Predictive effects of socioeconomic development levels and dentist density of subregions on toothache searches

Table 3 summarizes the linear regression model statistics in which the socio-development levels and the number of dentists per 100,000 people in each province are predictive factors for toothache RSV scores.

Both predictor variables had statistically significant effects on Google searches ($p < 0.05$).

The rate of Google searches increased significantly in areas with low dentist density and low socioeconomic levels ($p < 0.05$).

Toothache time series

Figure 2 shows the time series chart of the toothache queries in Türkiye over the last five years. The explanatory variance of the time series was 11.4%.

Toothache seasonality

Toothache searches, seasonal indices, detrended data by season, percent variation by season, and residuals by season graphs of the last five years are shown in Figure 3.

According to the seasonal index, searches decreased in the winter months of December, January, and February and increased in April, May, and the summer months (except June).

The RSV peak was in April 2020, when restrictions and quarantines for the Covid-19 pandemic were most intense.

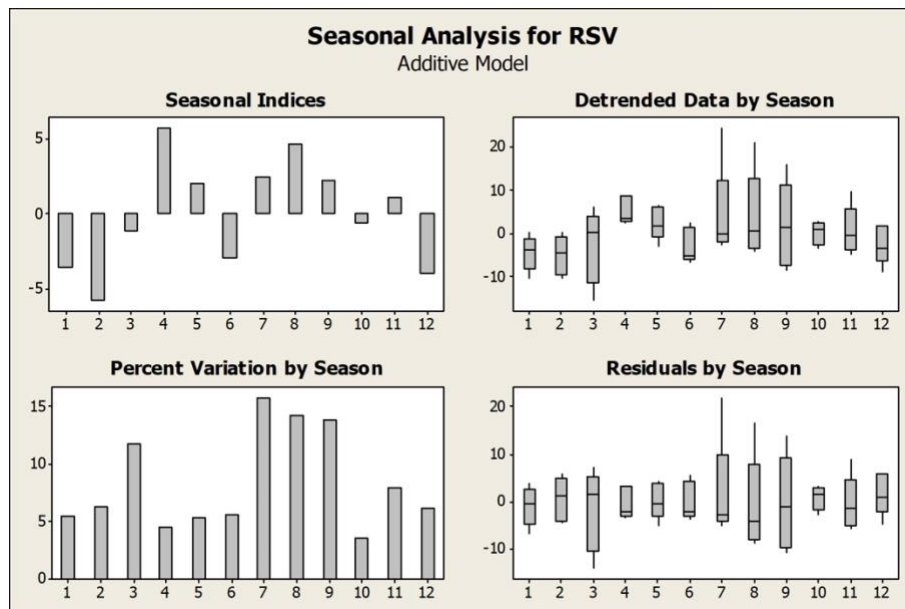


Figure 3. Graphs of seasonal analyses for toothache searches in Türkiye for the last five years, according to Google Trend analysis. It is observed that most searches were made in April and the summer months. The lowest number of searches were made during the winter months

Table 1. The most searched and recently increasing queries related to toothache (RSV scores are for relevant queries)

	Related queries (most relevant)	RSV	Most increasing queries
1	For toothache	100	How to relieve toothache in children
2	what is good for toothache?	73	Is smoking good for toothache
3	What is good for toothache?	71	Tylenol
4	Toothache	63	Is Dichloron good for toothache
5	For toothache	16	Is Amoklavin good for toothache
6	How to relieve toothache	9	Is Etol fort good for toothache
7	Tooth painkiller	9	Is Dolorex used for toothache
8	What is good for toothache?	7	How to relieve irritating toothache
9	Wisdom tooth	6	Black pepper is good for toothache
10	Toothache, typo	6	What is good for toothache in children
11	Good for toothache	6	What to do for child toothache
12	Toothache prayer	5	What is good for throbbing toothache
13	Prayer for toothache	5	Is Dolorex good for toothache
14	Solution to toothache	4	Is Parol good for toothache
15	What is good for toothache at home?	4	Is Apranax good for toothache
16	Toothache painkiller	4	Is Arveles good for toothache
17	What is good for toothache?	4	Is clove oil good for toothache
18	What relieves toothache?	4	Is garlic good for toothache
19	Wisdom tooth pain	4	Is Majezik good for toothache
20	Medicine for toothache	4	Toothache that does not sleep
21	Painkiller for toothache	4	Is Aferin good for toothache
22	Painkiller for tooth	3	Is De forte good for toothache
23	Tooth decay	3	Is clove good for toothache
24	Medicine for toothache	3	Is Minoset good for toothache
25	Wisdom tooth	3	Is raki good for toothache

RSV: Relative Search Volume

Table 2. The 10 provinces with the highest and lowest relative search volume scores according to sub-regional searches

Highest		Lowest	
City	RSV	City	RSV
Hakkâri	100	Trabzon	48
Şırnak	92	Muğla	49
Ağrı	90	İstanbul	50
Muş	86	Ankara	51
Bitlis	85	Antalya	51
Kars	82	İzmir	54
Iğdır	81	Yalova	54
Çankırı	76	Çanakkale	55
Adıyaman	76	Rize	55
Bingöl	76	Denizli	57

RSV: Relative Search Volume

Table 3. Linear regression model of the total number of dentists per 100,000 people and the socioeconomic development ranking of the provinces on toothache RSV scores

R ² =0.456	Unstandardized Coeff.		t	P	95% CI for B	
	B	SE			Lower	Upper
(Constant)	51.15	2.05	24.93	<0.00	47.07	55.24
Total Number of Dentists per 100,000 People	2.48	1.01	2.46	0.02	0.47	4.49
Socioeconomic Development Ranking of Provinces	2.48	0.67	3.71	<0.00	1.15	3.80

SE: standard error; CI: Confidence Interval, Coeff: Coefficients.

Discussion

The collection and analysis of information obtained from the internet fall within the infodemiology scope. This differs from conventional epidemiological studies because it includes internet users with mild to moderate pain or who select self-care by refraining from visiting the dentist (8). GT analysis has become a popular methodology. In a systematic review, 40 GT analysis studies in the field of health were reported in 2016, compared to only two in 2009 (8). Internet platforms contain comprehensive information about dental pain self-medication, urgent dental care, alternative treatments, and patients' first reactions to this information (20).

Examination of the time-series graph of toothache between 2004 and 2023 reveals a constantly increasing trend. While the increase in digital penetration and the constant increase in the numbers of both individuals and households accessing the internet represent the main reasons for this trend, the increase in the use of the internet as an information source should also be recognized as an influencing factor.

Harorlı and Harorlı were the first to apply GT analysis to the field of dentistry in 2014, when their

pioneering study compared five dental terms (1). They found that worldwide queries concerning the terms "toothache," "gum disease," "tooth decay," "oral cancer," and "wisdom teeth" were mostly related to pain. However, the fact that they limited their search to only studies published in the English language led to a lack of data from many countries around the world. Still, after their study, the number of infodemiological studies conducted on dental problems increased. For instance, in a recent systematic review by Gupta et al. (21), toothache following oral maxillofacial surgery and oral cancer was identified as the third most commonly searched topic in terms of online information seeking regarding oral health.

Dental caries is known to be one of the most common chronic diseases as well as the most important predisposing factor for toothache. It is significantly affected by social-behavioral and socioeconomic conditions. In a GT study wherein the 22 most common types of pains in the body were investigated worldwide, the most frequently searched types were headache, abdominal pain, and back pain (5). Moreover, toothache was the ninth most commonly searched term. However, with regard to toothache-related searches, Türkiye ranked third after Indonesia and the Philippines.

One of the main aims of the present study was to examine the seasonal effects of toothache in Türkiye. The methods used to determine the seasonality and its effect in the GT analysis were the examination of visual evidence and detection of peak periods (8). Additionally, seasonality analysis can be performed using the time-series analysis and least squares methods (8). Determining the periodic increase in dental diseases and identifying which types of complaints are more frequently made to clinics during which periods can help with planning annual leave (10). Previous studies have reported a significant increase in inquiries concerning toothache in December and January (4). This increase was interpreted as a consequence of increased stress, disproportionate alcohol use, family conflicts, loneliness, and exacerbated mental health problems due to Christmas festivities (4). In a study that evaluated interest in tooth decay, which is a major cause of toothache, in eight different countries via GT analysis, no difference was observed based on the month in India and Italy. The lowest search interest was found in the third quarter of the year (July-September) in northern hemisphere countries such as France, the USA, and the UK, whereas the lowest search interest was found in the first quarter of the year (January-March) in southern hemisphere countries such as Brazil (10). The researchers emphasized that these periods coincide with the summer period in the relevant locations, when people typically travel for vacation purposes and change their routines. They posited that during these periods, people care less about dental diseases and neglect their oral health habits. By contrast, in a study on toothache in 10 South American countries, no seasonal changes were observed in relation to the toothache-related searches in most countries (9). In Türkiye, toothache was searched on Google the most in April and the summer months, which differs from the global trend of lower search values during the winter months.

The peak periods were April 2020, May 2020, and June 2020, January 2023, and December 2022, respectively. While normally the winter months show lower values, the reason for the increase in these periods is that dental offices are closed or have limited patient care during the COVID-19 pandemic, which has led patients to postpone dental problems and investigate self-care treatments (2,3). In addition, quarantine and restrictions imposed by the state prevented patients from accessing the dentist. This finding is also observed in other populations (2, 3, 13). A 33% increase in toothache queries was reported after COVID-19 restrictions and bans began in Türkiye (13). The Internet is a tool that individuals use to relieve toothache (5, 13). For this reason, individuals want to cope with the pain themselves using medications, home remedies, and over-the-counter drugs (4). In this way, antibiotic use also increases (15). The most common searches related to toothache in Türkiye are solutions to toothache. What is good for toothache, painkillers, and medications are frequently searched queries.

It is known that the prevalence of tooth caries is more prevalent in deprived populations (10). Toothache

is affected by socioeconomic indicators such as education level and family income (22). In low socioeconomic societies, the risk of developing tooth caries and, as a result, toothache increases due to inadequate healthcare systems, low salaries, low frequency of visits to the dentist, and low number of dentists (9). It has been reported that in places where the density of dentists is higher, access to the dentist is easier and RSV scores decrease, indicating that people's care-seeking behavior has changed (2, 3). In addition, increasing urban population density is negatively correlated with online searches, which is another factor that increases contact with a dentist (2). In the current study, the most frequently searched sub-regions were those with the lowest socio-economic aspects and the lowest density of dentists. In the regression analysis, it was observed that both variables significantly affected the searches.

In this study, it is a limitation that only Google is included in the analysis of internet users' searches. Additionally, the demographic characteristics of individuals are not fully known. Another limitation of GT analysis is that the rate can increase when the same individual searches more than once. Although the program processes only one of the recent queries made with the same device, it cannot distinguish between queries made by the same person via mobile phone, work, and home internet.

Conclusion

When Internet users in Türkiye suffer from toothache, search queries mostly focus on pain relief. Regional differences were observed. The decrease in socioeconomic level and the density of dentists accounted for increased Internet searches. Toothache search queries showed seasonal differences, with decreases during the winter months.

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