DOI:10.34084/bshr.1990753 e-ISSN 2587-1641

Journal of Biotechnology and Strategic Health Research

Araştırma Makalesi /Research Article

http://dergipark.org.tr/tr/pub/bshr

Temporal Trends in Online Search Interest in Dental Implant Treatment in Türkiye: A Google Trends–Based Infodemiology Study

Türkiye'de Dental İmplant Tedavisine Yönelik Çevrim İçi Arama İlgisinin Zamansal Eğilimleri: Google Trends Tabanlı Bir İnfodemiyoloji Çalışması

Saim Yanık, Mehmet Emrah Polat, Şeğmus Özdemir

Harran University, Faculty of Dentistry, Department of Oral and Maxillofacial Surgery, Şanlıurfa, Türkiye

ORCID ID: Saim Yanık: https://orcid.org/0000-0002-1229-2982, Mehmet Emrah Polat: https://orcid.org/0000-0002-3249-1997, Şeğmus Özdemir: https://orcid.org/0009-0009-3610-8826

***Sorumlu Yazar / Corresponding Author:** Şeğmus Özdemir **e-posta / e-mail:** ozdemirsegmus2023@harran.edu.tr

Geliş Tarihi / Received : 09-07-2026 **Kabul Tarihi / Accepted:** 16-07-2026 **Yayın Tarihi / Online Published:** 31-08-2026

Yanık S, Polat ME, Özdemir Ş. Temporal Trends in Online Search Interest in Dental Implant Treatment in Türkiye: A Google Trends–Based Infodemiology Study., J Biotechnol and Strategic Health Res. 2026;10(2):99-111

Abstract

Aim This study evaluated long-term trends in online search interest in dental implant treatment in Türkiye, level and slope changes around March 2020, and associations with year-on-year changes in the Consumer Price Index (CPI).

Materials and Methods Monthly relative search volume (RSV) data for five implant-related terms were obtained from Google Trends. Data from 2004–2025 were used for visual assessment and 2014–2025 for inference. Trends were evaluated using linear regression with Newey–West heteroskedasticity- and autocorrelation-consistent (HAC) standard errors and the Mann–Kendall test. Changes around March 2020 were examined using segmented regression. CPI–RSV associations were assessed using Spearman and time-adjusted partial Spearman correlations with Benjamini–Hochberg false discovery rate (FDR) correction.

Results All terms showed significant positive trends during 2014–2025 (all HAC $p < 0.001$); "implant diş" had the highest mean RSV and largest increase. Most terms showed no significant immediate level or slope changes. "Diş implantı" showed an immediate level decrease ($\beta_2 = -1.366$; $p < 0.001$) followed by a positive slope change ($\beta_3 = 0.0256$; $p < 0.001$), whereas "implant fiyat" showed a negative slope change ($\beta_3 = -0.0474$; $p = 0.028$). The positive unadjusted CPI–RSV associations weakened after time adjustment; only "implant diş" remained significant after FDR correction ($\rho = 0.335$; $q < 0.001$).

Conclusions Online search interest in dental implant treatment increased during 2014–2025, with patterns varying by terminology. Heterogeneous changes around March 2020 and attenuation of CPI associations after time adjustment underscore the importance of accounting for secular trends when interpreting online search behavior.

Keywords Dental İmplants, İnformation Seeking Behavior, İnternet, İnflation Economic, Regression Analysis

Öz

Amaç *Bu çalışma, Türkiye'de dental implant tedavisine yönelik çevrim içi arama ilgisinin uzun dönemli eğilimlerini, Mart 2020 çevresindeki düzey ve eğim değişikliklerini ve yıllık Tüketici Fiyat Endeksi (TÜFE) değişim oranlarıyla ilişkilerini değerlendirdi.*

Gereç ve Yöntem *İmplantla ilişkili beş terime ait aylık göreli arama hacmi (RSV) verileri Google Trends'ten elde edildi. 2004–2025 verileri görsel değerlendirmede, 2014–2025 verileri çıkarımsal analizlerde kullanıldı. Eğilimler, Newey–West değişen varyans ve otokorelasyon tutarlı (HAC) standart hatalara dayalı doğrusal regresyon ve Mann–Kendall testiyle değerlendirildi. Mart 2020 çevresindeki değişiklikler segmentli regresyonla incelendi. TÜFE–RSV ilişkileri Spearman ve zamana göre düzeltilmiş parsiyel Spearman korelasyonlarıyla değerlendirildi; Benjamini–Hochberg yanlış keşif oranı (FDR) düzeltmesi uygulandı.*

Bulgular *Tüm terimler 2014–2025 döneminde anlamlı pozitif eğilim gösterdi (tüm HAC $p < 0,001$); "implant diş" en yüksek ortalama RSV ve en büyük artışı sergiledi. Çoğu terimde anlamlı ani düzey veya eğim değişikliği saptanmadı. "Diş implantı" ani düzey azalması ($\beta_2 = -1,366$; $p < 0,001$) ve ardından pozitif eğim değişikliği ($\beta_3 = 0,0256$; $p < 0,001$) gösterirken, "implant fiyat" negatif eğim değişikliği gösterdi ($\beta_3 = -0,0474$; $p = 0,028$). Pozitif düzeltilmemiş TÜFE–RSV ilişkileri zamana göre düzeltme sonrasında zayıfladı; FDR düzeltmesinden sonra yalnızca "implant diş" anlamlı kaldı ($\rho = 0,335$; $q < 0,001$).*

Sonuç *Türkiye'de dental implant tedavisine yönelik çevrim içi arama ilgisi 2014–2025 döneminde arttı ve örüntüler terminolojiye göre farklılaştı. Mart 2020 çevresindeki heterojen değişiklikler ve zamana göre düzeltme sonrasında TÜFE ilişkilerinin zayıflaması, çevrim içi arama davranışları yorumlanırken seküler eğilimlerin dikkate alınmasının önemini göstermektedir.*

Anahtar Kelimeler *Dental Implantlar, Bilgi Arama Davranışı, Internet, Ekonomik Enflasyon, Regresyon Analizi*

INTRODUCTION

Dental implant therapy is currently regarded as one of the most predictable and reliable treatment modalities for the rehabilitation of partial and complete tooth loss. Since the establishment of the concept of osseointegration, advances in implant surface technologies, surgical and prosthetic protocols, and digital workflows have substantially improved the clinical outcomes and long-term predictability of implant-based rehabilitation[1].

Systematic reviews and long-term clinical studies have demonstrated high survival rates for dental implants and favorable long-term clinical outcomes[2]. Consistent with these findings, epidemiological evidence indicates that the prevalence of dental implant use has increased markedly in recent years and is expected to continue rising in the future[3].

Alongside the growing use of dental implant therapy, patients' informational needs and the sources they consult when seeking treatment-related information have become increasingly important. Studies conducted across different populations have shown considerable variation in public knowledge of dental implants, reliance on diverse information sources, and a persistent need for further information among a substantial proportion of individuals[4-6]. The internet is now widely used to obtain health-related information[7]. A nationally representative study from Türkiye likewise identified the internet as the most frequently used source of health information[8]. Online health information seeking has evolved beyond a purely informational activity and has become an important component associated with health-related decision-making, treatment preferences, and patterns of healthcare utilization[7].

Digital data generated through internet use have contributed to the emergence of infodemiology and infoveillance, fields concerned with investigating population-level patterns of health-related information-seeking behavior[9]. Within this framework, the analysis of online health data can provide indirect insights into public interest, awareness, and information needs concerning specific health topics[9]. Google Trends has consequently become a widely used tool in infodemiological research because it provides normalized measures of relative search volume across time and geographic regions for specified search queries[10,11]. Nevertheless, interpretation of Google Trends data requires careful consideration of several methodological constraints, including their relative and normalized nature, sensitivity to search-term selection and data-retrieval procedures, and the absence of information on user characteristics or underlying search intent[12-14].

Google Trends data are increasingly being used to investigate population-level online information-seeking behavior across a range of dental and oral-health topics[15-18]. Although a growing body of research has examined the temporal patterns of online information seeking in relation to broader societal and economic factors, studies jointly addressing the COVID-19 pandemic and subsequent economic conditions in this context remain limited[19].

Accordingly, this study aimed to evaluate long-term trends in online search interest in dental implant treatment in Türkiye using Google Trends data. Data from January 2004 to December 2025 were used to visually characterize the overall temporal pattern, whereas the January 2014–December 2025 period, which provided more continuous monthly observations, was used for inferential statistical analyses. In addition, changes in level and slope around the March 2020 breakpoint and associations between search patterns and inflation indicators were explored. These analyses were not intended to estimate causal effects but rather to characterize temporal changes and patterns of co-variation between the variables examined.

MATERIALS AND METHODS

Study Design

This retrospective, ecological, observational study used an infodemiological framework to evaluate temporal changes

in online information-seeking behavior related to dental implant treatment in Türkiye. Long-term search trends from January 2004 through December 2025 were examined using relative search volume (RSV) data obtained from Google Trends. Inferential statistical analyses were restricted to the period from January 2014 through December 2025, during which zero RSV values attributable to low search volume were substantially less frequent. Changes in level and slope around the March 2020 breakpoint, as well as associations with year-on-year CPI change rates in Türkiye, were additionally explored. The study was designed and reported in accordance with methodological recommendations for health research using Google Trends data [10,11].

Data Sources

Two data sources were used: Google Trends (Google LLC, Mountain View, CA, USA) and monthly Consumer Price Index (CPI) data produced by the Turkish Statistical Institute (TurkStat), retrieved through the Electronic Data Delivery System (EVDS) of the Central Bank of the Republic of Türkiye.

Google Trends normalizes Google search activity within a specified geographic region and time interval and reports it as relative search volume (RSV) on a scale from 0 to 100. RSV values do not represent absolute search counts; rather, they reflect relative search interest within the selected geographic, temporal, and comparative framework. To represent macroeconomic conditions, year-on-year CPI change rates (%) were used. These data are reported monthly and indicate the percentage change in prices relative to the corresponding month of the preceding year.

Accordingly, RSV values were not interpreted as actual search counts or as proxies for treatment demand; they were used solely to assess temporal variation in relative online search interest within the predefined query framework.

Google Trends Data Collection

Google Trends data were accessed on July 5, 2026. All queries were conducted with Türkiye specified as the geographic region. The "Search term" option was used for all queries rather than the "Topic" option, thereby focusing the analysis on relative search interest in the exact expressions entered by users.

The following filters were applied during data retrieval:

- Region: Türkiye
- Search type: Web Search
- Category: Health
- Time range: January 2004–December 2025
- Temporal resolution: Monthly

The following five search terms were included:

- "diş implantı"
- "implant diş"
- "dental implant"
- "implant fiyat"
- "implant tedavisi"

All five terms were entered simultaneously within a single comparative Google Trends query. This approach ensured that RSV values for all terms were normalized within the same temporal, geographic, categorical, and comparative framework.

Selection of Search Terms

Search terms were selected with reference to previously published Google Trends–based dental research and to the range of expressions that may be used in Türkiye when searching online for information related to dental implant treatment. The selection strategy was designed to capture commonly used public expressions, technical and treatment-oriented terminology, and a cost-related query reflecting the economic dimension of treatment.

Accordingly, "implant diş" and "diş implantı" were included as expressions reflecting everyday usage, "dental

implant" as a technical term, "implant tedavisi" as a treatment-oriented query, and "implant fiyat" as a cost-oriented query. Multiple search expressions were evaluated together to reduce potential terminology-selection bias associated with reliance on a single keyword. The search terms were retained in their original form throughout the manuscript because they represent the exact expressions entered in Google Trends.

Data Preprocessing

Before analysis, monthly RSV data obtained from Google Trends were assessed for data integrity, missing observations, and temporal continuity. All observations from January 2004 through December 2025 were retained for visual assessment of long-term trends.

Preliminary inspection revealed substantial data sparsity during 2004–2013, consistent with low search volumes. During this period, the proportion of zero RSV values ranged from 25.0% to 89.2% across search terms, and the longest consecutive runs of zero observations ranged from 11 to 54 months. By contrast, during 2014–2025, zero RSV values accounted for 0% to 2.1% of observations, and no consecutive run of zeros exceeded one month. Therefore, the primary statistical analyses were restricted to January 2014–December 2025, a period characterized by more continuous and comparable monthly observations. The inferential analysis period thus comprised 144 monthly observations.

To assess the stability of data retrieval, the Google Trends query was repeated while holding constant the five search terms, geographic region, category, search type, and time interval. Across all 264 monthly observations from January 2004 through December 2025, RSV values for each of the five search terms were identical between the initial and repeated data extractions.

Study Variables

The primary outcome variables were the monthly RSV values provided by Google Trends for each of the five search terms.

The explanatory and grouping variables evaluated in the analyses were the sequential monthly time index, year-on-year CPI change rate (%), and March 2020 breakpoint indicators used in the segmented regression analysis.

For the pandemic-related time-series analysis, March 2020 was prespecified as the breakpoint. The study period was accordingly coded as pre-pandemic (January 2014–February 2020; n=74 months) and post-pandemic (March 2020–December 2025; n=70 months). This coding was used within the segmented regression model to estimate the immediate level change at the breakpoint and the change in slope thereafter; it was not intended to estimate an independent or causal effect of the pandemic.

Statistical Analysis

Statistical analyses were performed using jamovi (version 2.7; The jamovi project, Sydney, Australia) and Python (version 3.12.13; Python Software Foundation). Descriptive statistics, linear regression, and unadjusted Spearman rank correlations were conducted in jamovi. Time-adjusted partial Spearman correlations, Mann–Kendall tests, Sen's slope analyses, Newey–West analyses with heteroskedasticity- and autocorrelation-consistent (HAC) standard errors, and segmented linear regression were performed in Python 3.12.13; HAC and segmented regression models were implemented using statsmodels 0.14.6.

Descriptive statistics included n, mean, standard deviation, median, minimum, and maximum. For each search term, temporal trends were evaluated by simple linear regression with sequential month as the independent variable and monthly RSV as the dependent variable; β, R^2, confidence intervals, and p values were reported. Because monthly observations may be serially dependent, inference was recalculated using Newey–West heteroskedasticity- and autocorrelation-consistent standard errors [20]. The

primary lag length was 12 months, with 3- and 6-month lags examined as sensitivity analyses. Mann–Kendall tests and Sen's slope estimates provided complementary non-parametric assessments of trend direction and magnitude. Level and slope changes around March 2020 were assessed using segmented linear regression. Models included sequential month for the pre-breakpoint slope (β_1), a post-breakpoint indicator for the immediate level change (β_2), and post-breakpoint time for the slope change (β_3). The total post-breakpoint slope ($\beta_1+\beta_3$) was evaluated by linear hypothesis testing. Confidence intervals and p values used Newey–West HAC standard errors with a 12-month lag. The analysis characterized structural changes around the breakpoint and was not interpreted as estimating an independent causal effect of the pandemic.

Associations between monthly RSV and year-on-year CPI change rates were explored using Spearman correlations. Because both variables could share long-term temporal trends, partial Spearman correlations controlling for the sequential monthly time index were also calculated. Crude and time-adjusted associations were reported as ρ. Benjamini–Hochberg false discovery rate (FDR) correction was applied to the five time-adjusted tests, with p and q values reported. These analyses were interpreted as patterns of co-variation rather than causal or independent economic effects. All tests were two-sided, with $p < 0.05$ considered statistically significant.

Ethics Statement

This study exclusively used publicly available, aggregated, and non-identifiable data obtained from Google Trends and official macroeconomic data produced by the Turkish Statistical Institute and accessed through the Electronic Data Delivery System of the Central Bank of the Republic of Türkiye. No human participants, biological specimens, patient records, or personal health information were included. Therefore, institutional ethics committee approval and informed consent were not required, as the study did not involve human participants, patient records, or identifiable personal data.

RESULTS

Descriptive Findings

Descriptive statistics for the Google Trends data covering 2014–2025 are presented (Table 1). Among the five search terms examined, "implant diş" had the highest mean relative search volume (RSV) (51.0 ± 17.9), followed by "implant tedavisi" (5.50 ± 1.32), "dental implant" (4.21 ± 1.48), "implant fiyat" (3.24 ± 1.84), and "diş implantı" (2.83 ± 1.15). The term "implant diş" also had the highest median RSV and ranged from 21 to 100 over the study period. Maximum RSV values for the remaining terms ranged from 6 to 12 (Table 1).

Table 1. Descriptive statistics of relative search volume (RSV) values for Google Trends search terms during 2014–2025.

Search term	n	Mean ± SD	Median	Min–Max
implant diş	144	51.0 ± 17.9	49	21–100
dental implant	144	4.21 ± 1.48	4	2–9
diş implantı	144	2.83 ± 1.15	3	0–6
implant tedavisi	144	5.50 ± 1.32	5	2–8
implant fiyat	144	3.24 ± 1.84	3	0–12

SD: standard deviation; RSV: relative search volume.

The monthly trajectories of the search terms from 2004 to 2025 are shown (Figure 1). Some series exhibited sparse and intermittent RSV observations during the earlier years, whereas search patterns became more continuous after 2014.

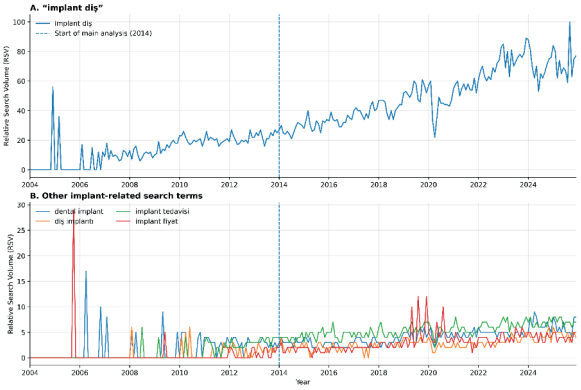

Figure 1. *Monthly relative search volume (RSV) trends for implant-related Google Trends search terms in Türkiye from January 2004 to December 2025. Panel A shows "implant diş," and Panel B shows the other four search terms ("dental implant," "diş implantı," "implant tedavisi," and "implant fiyat"). The vertical dashed line indicates the start of the main inferential analysis period in January 2014.*

Temporal Trend Analysis

Temporal changes in the search terms during 2014–2025 were evaluated using linear regression analysis (Table 2). Confidence intervals and p values were calculated using Newey–West HAC standard errors to account for potential serial correlation and heteroskedasticity in the monthly time-series data. Statistically significant positive linear trends were identified for all search terms examined (HAC $p < 0.001$ for all analyses). The largest slope coefficient was observed for "implant diş" ($\beta = 0.385$; HAC 95% CI: 0.335–0.434; $R^2 = 0.804$). R^2 values for the remaining search terms ranged from 0.253 to 0.570. All positive trends remained statistically significant under alternative HAC specifications with lag lengths of 3 and 6 months.

Table 2. Linear trend analysis of Google Trends search terms during 2014–2025.

Search term	β (slope)	HAC 95% CI	R^2	HAC p
implant diş	0.385	0.335–0.434	0.804	< 0.001
dental implant	0.0268	0.0203–0.0334	0.570	< 0.001
diş implantı	0.0181	0.0124–0.0238	0.428	< 0.001
implant tedavisi	0.0231	0.0203–0.0259	0.532	< 0.001
implant fiyat	0.0222	0.0159–0.0286	0.253	< 0.001

β: linear regression slope coefficient, representing the mean monthly change in relative search volume (RSV); R^2: coefficient of determination; CI: confidence interval; HAC: heteroskedasticity- and autocorrelation-consistent standard errors. Confidence intervals and p values were calculated using the Newey–West/HAC method with a lag length of 12 months.

Mann–Kendall Trend Analysis

To complement the linear regression findings, temporal trends in the search terms were further evaluated using the Mann–Kendall trend test (Table 3). Statistically significant positive monotonic trends were identified for all search terms examined ($p < 0.001$ for all analyses). The highest Kendall's τ coefficient was observed for "implant diş" ($\tau = 0.753$), followed by "dental implant" ($\tau = 0.608$), "implant tedavisi" ($\tau = 0.592$), "implant fiyat" ($\tau = 0.569$), and "diş implantı" ($\tau = 0.521$). Sen's slope estimates were positive for all search terms, with the largest monthly increase observed for "implant diş" (0.382 RSV/month) (Table 3).

Table 3. Mann–Kendall trend test and Sen's slope estimates for Google Trends search terms during 2014–2025

Search term	Kendall's τ	Sen's slope (RSV/month)	p
implant diş	0.753	0.382	< 0.001
dental implant	0.608	0.024	< 0.001
diş implantı	0.521	0.016	< 0.001
implant tedavisi	0.592	0.022	< 0.001
implant fiyat	0.569	0.021	< 0.001

τ: Kendall's tau coefficient. Sen's slope: median monthly change over time (RSV/month).

Level and Slope Changes Around the March 2020 Breakpoint

Changes in level and slope around the March 2020 breakpoint were evaluated using segmented linear regression while accounting for the underlying long-term temporal trend. Newey–West HAC standard errors were used to address potential heteroskedasticity and serial correlation in the monthly time-series data (Table 4). Although pre-breakpoint slopes were positive and statistically significant for "implant diş," "dental implant," and "implant tedavisi," none of these terms showed a significant immediate level change at the March 2020 breakpoint or a significant post-breakpoint change in slope. Nevertheless, the total post-breakpoint slopes remained positive and statistically significant for all three terms (all $p < 0.001$).

In contrast, "diş implantı" showed a significant immediate decrease in level at the March 2020 breakpoint ($\beta_2 = -1.366$; 95% CI: −1.873 to −0.859; $p < 0.001$), followed by a significant positive change in slope after the breakpoint ($\beta_3 = 0.0256$; 95% CI: 0.0134–0.0379; $p < 0.001$). The total post-breakpoint slope for this term was also positive and statistically significant ($\beta_1 + \beta_3 = 0.0455$ RSV/month; $p < 0.001$).

For "implant fiyat," the pre-breakpoint slope was positive and statistically significant ($\beta_1 = 0.0509$; $p = 0.0035$); however, a significant negative change in slope was observed after the breakpoint ($\beta_3 = -0.0474$; 95% CI: −0.0897 to −0.0051; $p = 0.028$). The resulting total post-breakpoint slope was not statistically significant ($\beta_1 + \beta_3 = 0.0036$ RSV/month; $p = 0.706$). The observed RSV series and fitted trends from the segmented regression models for all five search terms are presented (Figure 2).

Table 4. Segmented regression results based on the March 2020 breakpoint

Search term	β_1 (95% CI)	β_2 (95% CI)	β_3 (95% CI)	Post-breakpoint slope ($\beta_1+\beta_3$)	R^2
implant diş	0.407 (0.330–0.484)***	−5.904 (−17.073–5.264)	0.081 (−0.133–0.294)	0.488***	0.813
dental implant	0.024 (0.004–0.044)*	−0.371 (−1.440–0.697)	0.014 (−0.008–0.035)	0.038***	0.583
diş implantı	0.020 (0.009–0.030)***	−1.366 (−1.873–−0.859)***	0.026 (0.013–0.038)***	0.046***	0.561
implant tedavisi	0.028 (0.017–0.039)***	−0.779 (−1.644–0.085)	0.007 (−0.005–0.019)	0.035***	0.556
implant fiyat	0.051 (0.017–0.085)**	−0.555 (−2.255–1.144)	−0.047 (−0.090–−0.005)*	0.004	0.333

Note. β_1: monthly pre-breakpoint slope; β_2: immediate level change at the March 2020 breakpoint; β_3: post-breakpoint change in slope; post-breakpoint slope: $\beta_1+\beta_3$; CI: confidence interval; HAC: heteroskedasticity- and autocorrelation-consistent standard errors. Confidence intervals and p values were calculated using the Newey–West/HAC method with a lag length of 12 months. *p < 0.05; **p < 0.01; ***p < 0.001.

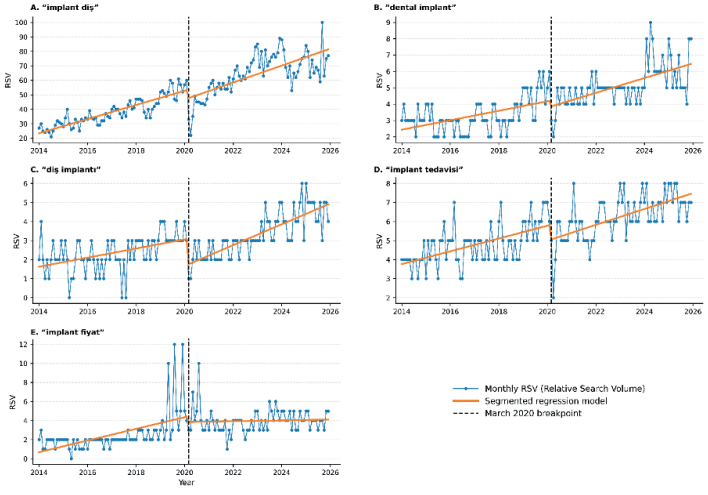

Figure 2. Segmented regression of monthly relative search volume (RSV) for five implant-related Google Trends search terms during 2014–2025. The vertical dashed line indicates the March 2020 breakpoint, and fitted lines show the pre- and post-breakpoint trends for each search term.

Association Between Inflation and Search Trends

Associations between Google Trends relative search volume (RSV) and year-on-year Consumer Price Index (CPI) change rates were initially evaluated using Spearman rank correlation analysis. In the unadjusted analyses, year-on-year CPI change rates were positively and statistically significantly correlated with RSV for all search terms examined ($p < 0.001$ for all analyses). The strongest unadjusted correlation was observed for "implant diş" ($\rho = 0.862$).

However, partial Spearman correlation analyses controlling for the sequential monthly time index showed substantial attenuation of these associations. After adjustment for time, the positive association between year-on-year CPI change and "implant diş" remained evident ($\rho = 0.335$; $p < 0.001$) and retained statistical significance after Benjamini–Hochberg false discovery rate correction ($q < 0.001$). For "dental implant," the very weak positive association was nominally significant before multiple-testing correction ($\rho = 0.165$; $p = 0.048$) but did not remain significant after FDR adjustment ($q = 0.121$). No significant time-adjusted associations were identified for "diş implantı" ($\rho = 0.012$; $p = 0.888$), "implant tedavisi" ($\rho = -0.029$; $p = 0.732$), or "implant fiyat" ($\rho = -0.038$; $p = 0.650$); all corresponding q values were 0.888 (Table 5).

DISCUSSION

This study evaluated online search behavior related to dental implant treatment in Türkiye using long-term Google Trends data and jointly examined temporal trends, changes in level and slope around the March 2020 breakpoint, and associations with macroeconomic indicators. Significant increasing trends were observed for all search terms examined, with "implant diş" showing the highest relative search volume. Segmented regression analyses indicated that changes around March 2020 were not homogeneous across search terms: while most terms showed no significant level or slope change, "diş implantı" exhibited an immediate decrease followed by an increase in slope, whereas "implant fiyat" showed a post-breakpoint deceleration in slope. The positive unadjusted associations observed between year-on-year CPI change and RSV were substantially attenuated, or disappeared for most terms, after controlling for the monthly time index. These findings indicate that temporal and macroeconomic associations in online search behavior should be interpreted with careful attention to underlying secular trends.

Google Trends has become a widely used tool in infodemiology and digital epidemiology for assessing population-level health-related information-seeking behavior. Its ability to provide near real-time data, reflect large-scale user activity, and track long-term temporal patterns offers important advantages, particularly in public health research[9-12]. However, the relative nature of Google Trends data and their sensitivity to search-term selection and data-retrieval procedures require that findings derived from this platform be interpreted within their methodological limitations [13,14]. In this context, the confirmation of temporal trends not only by linear regression but also by the

Table 5. Unadjusted and time-adjusted associations between year-on-year CPI change rates and Google Trends relative search volumes during 2014–2025.

Search term	Unadjusted Spearman ρ	p	Partial Spearman ρ*	p	FDR-BH q
implant diş	0.862	< 0.001	0.335	< 0.001	< 0.001
dental implant	0.730	< 0.001	0.165	0.048	0.121
diş implantı	0.571	< 0.001	0.012	0.888	0.888
implant tedavisi	0.642	< 0.001	−0.029	0.732	0.888
implant fiyat	0.631	< 0.001	−0.038	0.650	0.888

ρ: Spearman rank correlation coefficient; CPI: Consumer Price Index; RSV: relative search volume. *Partial Spearman correlations were calculated while controlling for the sequential monthly time index. FDR-BH q: false discovery rate-adjusted q value obtained using the Benjamini–Hochberg procedure. FDR correction was applied to the five time-adjusted partial correlation tests.

nonparametric Mann–Kendall test may be considered an important methodological feature supporting the robustness of the present findings.

The significant positive temporal trends observed across all search terms indicate an overall increase in online interest in dental implant treatment in Türkiye over the past decade. This finding is in line with the study by Shen et al., who reported an approximately 1.9-fold increase in global search interest for the term "dental implants" between 2004 and 2019 in an analysis of online search trends related to oral and maxillofacial surgery[21]. In parallel, Elani et al. reported a marked increase in the prevalence of dental implant use in the United States over time, whereas Buser et al. emphasized that high success rates, advances in digital technologies, and increasing esthetic expectations have positioned implant therapy as a core rehabilitative modality in contemporary dentistry[1,3]. Although Elani et al. evaluated actual implant utilization, whereas the present study examined population-level online information-seeking behavior, the concordant direction of these trends may reflect broader increases in the societal visibility and uptake of implant therapy. This interpretation is further supported by previous evidence showing a marked increase in online health information seeking in recent years[7]. In addition, previous research has shown that individuals may use the internet to obtain information about health conditions and treatment options both before and after clinical consultations[22].

Differences Across Search Terms

One of the notable findings of this study was that "implant diş" consistently showed the highest relative search volume among the five terms examined. By contrast, the more technical term "dental implant" and the treatment- and cost-oriented expressions "implant tedavisi" and "implant fiyat" generated substantially lower search volumes. This pattern suggests that individuals seeking health-related information online may favor expressions used in everyday language over formal scientific terminology. Google Trends studies in oral health have demonstrated that alternative search expressions representing the same or related clinical concepts can generate markedly different relative search volumes. Previous Google Trends research in oral health has shown that alternative query formulations for related oral-health concepts may yield different search patterns[15].

The importance of search-term selection in Google Trends research has long been recognized, as the choice of terminology can directly influence study findings. Carneiro and Mylonakis noted that users may search for the same health concept using different query formulations depending on educational, cultural, and linguistic characteristics, underscoring the importance of selecting appropriate search queries[23]. Nuti et al. and Mavragani and Ochoa cautioned that the use of terms that do not adequately reflect real-world search behavior may yield misleading results and recommended evaluating alternative search expressions where appropriate[10,11]. Consistent with this approach, the inclusion of both technical terminology and expressions commonly used by the public in the present study enabled a broader assessment of online interest in dental implant treatment.

Comparable observations have been reported in other areas of dentistry. Sycińska-Dziarnowska et al. demonstrated that online search interest in clear aligner therapy varied over time and across countries, while Google Trends studies conducted in Türkiye have examined search patterns related to a range of dental topics[16,18,24]. Sabitha et al. examined online search patterns for several oral-health terms, including dental implant, and reported variation in search interest across digital platforms and geographic regions25. More recently, Akay and Erkan Akay evaluated online search trends concerning treatment options and preferences for dental care in the context of toothache in Türkiye[26].

The predominance of "implant diş" in the present analy-

sis is consistent with previous evidence that online search patterns are sensitive to the wording of search queries and further underscores the importance of considering the language used by the intended audience in online health communication. Accordingly, population-oriented digital health strategies may benefit from incorporating not only scientific terminology but also expressions commonly used in everyday language, potentially improving the reach and effectiveness of health communication.

Online Search Patterns Around the March 2020 Breakpoint

Segmented regression revealed a more nuanced pattern than would be apparent from a simple distributional comparison of the periods before and after the pandemic. For "implant diş," "dental implant," and "implant tedavisi," no significant immediate level changes at the March 2020 breakpoint or significant post-breakpoint changes in slope were identified. Rather, the positive trends already present before March 2020 continued thereafter. Consequently, the higher RSV levels observed in subsequent years should not be attributed directly to the pandemic.

In contrast, "diş implantı" exhibited an immediate decrease in level at the March 2020 breakpoint followed by a significant increase in slope. This pattern may be compatible with a more rapid recovery or reorientation after a short-term disruption at the onset of the pandemic; however, because Google Trends data provide no information on the motivations underlying searches, such a mechanism cannot be directly established. Fluctuations in online search activity associated with restricted access to healthcare services and the postponement of elective treatment during the pandemic have also been reported in other dental contexts[27,28].

For "implant fiyat," the positive pre-breakpoint slope slowed significantly after March 2020, and the total post-breakpoint slope was no longer statistically significant. This finding suggests that cost-oriented search behavior may have followed a temporal pattern distinct from that of broader implant-related interest. Nevertheless, the present study design cannot disentangle whether this change was attributable to economic conditions, the pandemic, shifts in search terminology, or other concurrent factors.

Previous studies have reported changes in online search interest in dental topics such as orthodontics and toothache during the COVID-19 period[27,28]. The present findings, however, indicate that pandemic-related temporal patterns were not homogeneous across implant-related search terms. Therefore, rather than relying solely on simple comparisons of mean or median search levels before and after the pandemic, it is important to account for pre-existing secular trends and serial dependence. The observed findings characterize structural changes around the March 2020 breakpoint and should not be interpreted as evidence of an independent or causal effect of the pandemic.

Association Between CPI and Online Search Trends

Unadjusted analyses showed positive correlations between year-on-year CPI change rates and RSV for all terms, but these associations weakened substantially after controlling for the sequential monthly time index. After FDR correction, only "implant diş" remained significant; "dental implant" did not survive correction, and the remaining terms were non-significant. Thus, much of the crude association may reflect concurrent temporal patterns rather than an independent economic relationship.

Few studies have examined dental implant search behavior alongside macroeconomic indicators. In Türkiye, Taşkaldıran and Meşeli evaluated "gum bleeding" searches in relation to gross domestic product, population, illiteracy, and dental attendance but found no significant correlations[29]. The present findings further show that apparent economic associations can change markedly after accounting for shared temporal trends.

Economic context remains relevant because dental-care preferences and willingness to pay vary with income, socioeconomic status, insurance coverage, out-of-pocket expenditure, and treatment costs[30,31]. Alqutub et al. identified financial burden as a prominent reason for not choosing implant treatment, while Najafi Shahkoohi et al. linked willingness to pay with socioeconomic circumstances and cost. Neither study, however, established effects on online search interest. İyilikci reported declining "implant" search interest during an economic downturn in Türkiye19, although direct comparison is limited by differences in periods, terms, and analytical frameworks.

The cost-oriented term "implant fiyat" illustrates this complexity: its positive crude CPI–RSV correlation disappeared after time adjustment. This argues against a simple economic mechanism, although a monthly time index cannot capture nonlinear macroeconomic dynamics. CPI–RSV associations should therefore remain exploratory and non-causal. Future studies integrating procedure volumes, treatment costs, income, and broader macroeconomic indicators may better clarify these relationships.

Strengths and Limitations of the Study

A major strength of this 12-year study is its use of complementary methods to evaluate implant-related online search behavior in Türkiye. Linear regression and Mann–Kendall testing characterized trends, segmented regression with HAC-robust inference assessed changes around March 2020, and time-adjusted partial correlations examined whether crude CPI associations persisted after accounting for the monthly trend.

Several limitations should be acknowledged. Google Trends captures only Google searches and reports normalized RSV rather than absolute search counts, user numbers, or individual-level characteristics[10,11,14]. Use of the "Health" category may have excluded relevant searches assigned elsewhere, and the keyword strategy did not include every possible formulation, including variants without Turkish diacritics or misspellings. The selected terms therefore cannot represent all implant-related information seeking.

RSV reflects information-seeking behavior, not clinical utilization or treatment demand; increasing searches do not imply proportional increases in implant procedures. Correlations likewise represent co-variation rather than causation and should be interpreted alongside clinical and epidemiological evidence[10,11,19]. Although segmented regression accounted for the pre-existing linear trend, a single March 2020 breakpoint and linear segments cannot disentangle concurrent economic, societal, technological, or healthcare changes or fully capture delayed and nonlinear dynamics. The observed structural changes should not be interpreted as causal pandemic effects.

Google Trends also has sampling and data-generation limitations[13]. Repeated retrieval with identical parameters yielded exactly the same monthly RSV values, supporting dataset stability but not absolute reproducibility across retrieval dates or query conditions; algorithmic opacity and limited information on sampled queries remain concerns[13,14]. Finally, the analysis was restricted to Türkiye, and representativeness may vary with internet access, Google use, and geography[12,14]. Multinational studies integrating procedure volumes, treatment costs, and additional economic indicators are warranted.

CONCLUSION

This study demonstrated that online search interest in dental implant treatment in Türkiye increased across all five search terms examined between 2014 and 2025, with search patterns varying according to the terminology used. Segmented regression analyses identified no significant level or slope changes around March 2020 for most terms; however, "diş implantı" showed an immediate decline followed by an increase in slope, whereas "implant fiyat" exhibited a post-breakpoint deceleration in slope. Accordingly, higher search interest in subsequent years should not

be interpreted as evidence of a uniform pandemic-related effect. The substantial attenuation of the positive unadjusted associations between CPI and RSV after controlling for time further suggests that these relationships may be influenced by shared temporal trends. Google Trends may serve as a complementary tool for monitoring long-term changes in online information-seeking behavior related to dental implant treatment; however, because search data do not directly reflect actual treatment demand or clinical procedure volumes, future research should integrate such data with indicators of clinical utilization and other population-level measures.

Ethical Approval

This study exclusively used publicly available, aggregated, and non-identifiable data obtained from Google Trends and official macroeconomic data produced by the Turkish Statistical Institute and accessed through the Electronic Data Delivery System of the Central Bank of the Republic of Türkiye. No human participants, biological specimens, patient records, or personal health information were included. Therefore, institutional ethics committee approval and informed consent were not required, as the study did not involve human participants, patient records, or identifiable personal data.

Peer-review

Externally and internally peer-reviewed.

Authorship Contributions

Concept: S.Y., M.E.P., Ş.Ö., Design: S.Y., M.E.P., Ş.Ö., Data Collection or Processing: S.Y., Analysis or Interpretation: S.Y., M.E.P., Ş.Ö., Literature Search: S.Y., M.E.P., Ş.Ö., Writing: S.Y., M.E.P., Ş.Ö.

Conflict of Interest

The authors declare no conflicts of interest.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Data Availability

The data used in this study were obtained from publicly available Google Trends data and official Consumer Price Index data produced by the Turkish Statistical Institute and accessed through the Electronic Data Delivery System of the Central Bank of the Republic of Türkiye. The processed dataset is available from the corresponding author upon reasonable request.

References

1. Buser D, Sennerby L, De Bruyn H. Modern implant dentistry based on osseointegration: 50 years of progress, current trends and open questions. Periodontol 2000. 2017;73(1):7-21. doi:10.1111/prd.12185.
2. Howe MS, Keys W, Richards D. Long-term (10-year) dental implant survival: a systematic review and sensitivity meta-analysis. J Dent. 2019;84:9-21. doi:10.1016/j.jdent.2019.03.008.
3. Elani HW, Starr JR, Da Silva JD, et al. Trends in dental implant use in the U.S., 1999-2016, and projections to 2026. J Dent Res. 2018;97(13):1424-1430. doi:10.1177/0022034518792567.
4. Tepper G, Haas R, Mailath G, et al. Representative marketing-oriented study on implants in the Austrian population. I. Level of information, sources of information and need for patient information. Clin Oral Implants Res. 2003;14(5):621-633. doi:10.1034/j.1600-0501.2003.00916.x.
5. Pommer B, Zechner W, Watzak G, et al. Progress and trends in patients' mindset on dental implants. I: Level of information, sources of information and need for patient information. Clin Oral Implants Res. 2011;22(2):223-229. doi:10.1111/j.1600-0501.2010.02035.x.
6. Tomruk CÖ, Özkurt-Kayahan Z, Şençift K. Patients' knowledge and awareness of dental implants in a Turkish subpopulation. J Adv Prosthodont. 2014;6(2):133-137. doi:10.4047/jap.2014.6.2.133.
7. Jia X, Pang Y, Liu LS. Online health information seeking behavior: a systematic review. Healthcare (Basel). 2021;9(12):1740. doi:10.3390/healthcare9121740.
8. Özkan S, Tüzün H, Uğraş Dikmen A, et al. The relationship between health literacy level and media used as a source of health-related information. Health Lit Res Pract. 2021;5(2):e109-e117. doi:10.3928/24748307-20210330-01.
9. Eysenbach G. Infodemiology: the epidemiology of (mis)information. Am J Med. 2002;113(9):763-765. doi:10.1016/S0002-9343(02)01473-0.
10. Nuti SV, Wayda B, Ranasinghe I, et al. The use of Google Trends in health care research: a systematic review. PLoS One. 2014;9(10):e109583. doi:10.1371/journal.pone.0109583.
11. Mavragani A, Ochoa G. Google Trends in infodemiology and infoveillance: methodology framework. JMIR Public Health Surveill. 2019;5(2):e13439. doi:10.2196/13439.
12. Arora VS, McKee M, Stuckler D. Google Trends: opportunities and limitations in health and health policy research. Health Policy. 2019;123(3):338-341. doi:10.1016/j.healthpol.2019.01.001.
13. Rovetta A. Reliability of Google Trends: analysis of the limits and potential of web infoveillance during COVID-19 pandemic and for future research. Front Res Metr Anal. 2021;6:670226. doi:10.3389/frma.2021.670226.
14. Alibudbud R. Google Trends for health research: its advantages, application, methodological considerations, and limitations in psychiatric and mental health infodemiology. Front Big Data. 2023;6:1132764. doi:10.3389/fdata.2023.1132764.
15. Patthi B, Kumar JK, Singla A, et al. Global search trends of oral problems using Google Trends from 2004 to 2016: an exploratory analysis. J Clin Diagn Res. 2017;11(9):ZC12-ZC16. doi:10.7860/JCDR/2017/26658.10564.
16. Sarı ÖF, Büyükçavuş MH, Kale B, et al. Türkiye'de ortodonti ile ilgili internet verilerinin değerlendirilmesi: bir Google Trends analizi. Aydın Dental Journal. 2022;8(1):10-25. doi:10.17932/IAU.DENTAL.2015.009/dental_v08i1002.
17. Kanmodi KK, Abolade O, Amzat J, et al. Analysis of global search and research interests on dentists using infoveillance and bibliometric approaches. Oral. 2023;3:11-30. doi:10.3390/oral3010002.
18. Fidan M, Olgar İE. Türkiye'de diş hekimliği ile ilgili internet verilerinin Google Trends ile değerlendirilmesi: metodolojik çalışma. Turkiye Klinikleri Journal of Dental Sciences. 2023;29(4):605-612. doi:10.5336/dentalsci.2023-97357.
19. İyilikci B. Effects of the pandemic and economic crisis on public search trends related to oral and maxillofacial surgery in Türkiye: a Google Trends time-series analysis (2020-2025). BMC Oral Health. 2026;26:503. doi:10.1186/s12903-026-07878-7.
20. Newey WK, West KD. A simple, positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix. Econometrica. 1987;55(3):703-708. doi:10.2307/1913610.
21. Shen JK, Every J, Morrison SD, et al. Global interest in oral and maxillofacial surgery: analysis of Google Trends data. J Oral Maxillofac Surg. 2020;78(9):1484-1491. doi:10.1016/j.joms.2020.05.017.
22. McMullan M. Patients using the Internet to obtain health information: how this affects the patient-health professional relationship. Patient Educ Couns. 2006;63(1-2):24-28. doi:10.1016/j.pec.2005.10.006.
23. Carneiro HA, Mylonakis E. Google Trends: a web-based tool for real-time surveillance of disease outbreaks. Clin Infect Dis. 2009;49(10):1557-1564. doi:10.1086/630200.
24. Sycińska-Dziarnowska M, Szyszka-Sommerfeld L, Woźniak K, et al. Predicting interest in orthodontic aligners: a Google Trends data analysis. Int J Environ Res Public Health. 2022;19(5):3105. doi:10.3390/ijerph19053105.
25. Sabitha V, Santhoshi P, Ganesh R, et al. Analysis of interest of Google users (Web, Google Image, and YouTube search) on oral health information among South Indian states. Journal of Academy of Dental Education. 2024;10(1):15-19. doi:10.25259/JADE_62_2023.
26. Akay A, Erkan Akay S. Evaluation of treatment and dentist options for patients with toothache in Turkey using Google Trends. HRU International Journal of Dentistry and Oral Research. 2025;5(1):20-23. doi:10.61139/ijdor.1588499.
27. Sycińska-Dziarnowska M, Bielawska-Victorini H, Budzyńska A, et al. The implications of the COVID-19 pandemic on the interest in orthodontic treatment and perspectives for the future: real-time surveillance using Google Trends. Int J Environ Res Public Health. 2021;18(11):5647. doi:10.3390/ijerph18115647.
28. Güneş G, Sadık E, Ünal Erzurumlu Z. "Dr. Google, I have a toothache"—assessment of the impact of COVID-19 pandemic on toothache-related internet searches with Google Trends data. Current Research in Dental Sciences. 2025;35(2):117-120. doi:10.17567/currresdentsci.1416263.
29. Taşkaldıran ES, Meşeli SE. An infodemiological study on Google search trends for "gum bleeding": demographic, economic, and temporal perspectives. European Annals of Dental Sciences. 2023;50(3):133-137. doi:10.52037/eads.2023.0030.
30. Alqutub AW, Nassar AA, Alzahrani AA, et al. Factors affecting demand for dental implant treatment: a population-based study in the Western Region of Saudi Arabia. Open Dent J. 2025;19:e18742106370233. doi:10.2174/0118742106370233250306074925.
31. Najafi Shahkoohi A, Alipour V, Arabloo J, et al. Patient preferences and willingness to pay for dental services: a systematic review. BMC Oral Health. 2025;25:227. doi:10.1186/s12903-025-05520-6.