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Public interest in Invisalign in developed and developing countries: A Google Trends analysis

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Abstract

Objective: To investigate long-term changes and possible seasonal variations in Google search volumes related to Invisalign in developed and developing countries.

Design: Cross-sectional, Google search-based study.

Methods: Google Trends (GT) was accessed to retrieve the Relative Search Volume (RSV) of Google queries related to the search term 'Invisalign' in 10 countries selected on the basis of population size, Internet usage and socioeconomic criteria between 1 January 2004 and 30 June 2021. The countries examined were the following: Australia, Brazil, Italy, Mexico, Philippines, Saudi Arabia, Spain, Thailand, UK and USA. By applying the time series decomposition method, the trend component and the seasonal variation were identified.

Results: Overall, RSVs regarding Invisalign have increased significantly in all countries with the developed countries outperforming developing countries throughout most of the observation period. There was no meaningful pattern when the trends were compared either on a monthly or quarterly basis. Similar peaks and valleys were found in Australia - Brazil, UK - USA, Italy - Spain and Saudi Arabia - Philippines - Thailand.

Conclusions: Public interest in online information for Invisalign has grown significantly over the years across countries of diverse socioeconomic and cultural backgrounds while seasonal patterns were observed in the related Google searches. Seasonal fluctuations seemed to follow the academic calendar. The study results may have direct implications on practice management and professional development.

Keywords

Invisalign, clear aligner therapy, Google Trends, Internet

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Introduction

Clear aligner therapy (CAT) has gained wide acceptance in clinical orthodontics over the years (Miles at al., 2020). CAT systems account for 15% of the existing orthodontic appliances market, with Invisalign holding an estimated 10% market share (Tindera, 2018). Align Technology (2021), the manufacturer of Invisalign (Align Technology, Inc., San Jose, CA, USA) recently announced to have reached 10.2 million cases, including 2.6 million teenage patients, along with a network of 200,000 cooperating practitioners. Web studies have confirmed the intense public interest in Invisalign in terms of online engagement,

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interaction and search volume (Livas et al., 2018; Sycinska-Dziarnowska et al., 2021; Ustdal and Guney, 2020).

As increasingly more individuals seek information on the Internet for health-related decisions before accessing healthcare services (Montemurro et al., 2015), and mainly through a general search engine (Fox, 2006), it is likely that such searches will be initiated on a massively visited platform such as Google Search, simply known as Google (Google LLC, Alphabet, Mountain View, CA, USA). Google processes, on average, more than 40,000 search queries every second, which corresponds to over 3.5 billion searches per day and 1.2 trillion searches per year worldwide (Mavragani et al., 2018).

Analysis of Web search data using Google Trends (GT), a freely accessibly online portal that surveys and ranks the online popularity of search terms and topics, may provide valuable insights into human behaviour and needs (Internet World Stats, 2021). More specifically, GT performs custom searches adjusted by geographic location (worldwide or distinct countries), time frame (last hour/4 hours/day/7 days/30 days/90 days or custom time range starting from 2004), categories (including arts and entertainment, beauty and fitness, business and industrial, finance, health and science among others) and search type (image, news, Google shopping, YouTube). In this perspective, leveraging data from health information queries in Google may enable healthcare policymakers and providers to be compatible with emerging population trends and demands (Shen et al., 2020).

With the exception of the spring lockdown in 2020 due to the COVID-19 pandemic, Invisalign queries in the Google search engine increased steadily globally between 2016 and 2021 as indicated by GT data (Sycinska-Dziarnowska et al., 2021). However, online health-related search behaviour may differ between users from developed and developing countries due to discrepancies in social, economic, cultural and psychological backgrounds (Cruvinel et al., 2019). Therefore, the aims of the present study were to investigate the long-term changes in the interest levels of Google users related to Invisalign among countries with socioeconomic and cultural disparities as well as possible seasonal effects.

Methods

GT search

On 30 June 2021, GT was accessed to retrieve the Relative Search Volume (RSV) of Google queries related to the search term 'Invisalign' in 10 developed and developing countries between 1 January 2004 and 30 June 2021. The particular starting date was selected to measure the relative popularity of Invisalign searches from the first day GT data became publicly available. To expand search results on Google, the default settings for categories and search type, i.e. 'All categories' and 'Web search', respectively, were selected.

RSV

By typing a search term or topic, GT generates a graph that illustrates the monthly variation of the relative popularity of the given search query (RSV). For this reason, each data point is divided by the total searches of the geography and time range it represents. The resulting RSV numbers are scaled on a range of 0–100 indicating low to peak search activity (Trends Help, 2021). GT datasets can be downloaded in comma-separated values (CSV) format.

Country selection

Based on the classification of developed/developing countries (United Nations, 2019), population (Worldometer, 2020) and Internet penetration data (Internet World Stats, 2020). Ten countries were included in the study: Australia, Brazil, Italy, Mexico, Philippines, Saudi Arabia, Spain, Thailand, UK and USA. To facilitate comparison in RSVs between countries, population size and Internet penetration rate criteria for inclusion were applied, i.e. $>$25,000,000 inhabitants and $>$65%, respectively (Lotto et al., 2017). Furthermore, the current list of countries aimed to reflect a balanced representation of geographical regions providing a comprehensive assessment of Web metrics. A summary of country variable values is displayed in Table 1.

As this study involved free accessible, non-identifiable Internet traffic data and neither animals nor humans, no ethical approval was required.

Statistical analysis

Time series analysis is a popular method for describing changes over time in a sequence of observations (Donatelli et al., 2022; Lee et al., 2017; Lim et al., 2017). By applying the time series decomposition method, the trend component and the seasonal variation were identified and graphically presented. To compare RSVs among the 10 countries over the years, linear regression analysis and the Student-Newman-Keuls (SNK) test for multiple comparisons were conducted. The SNK test is one of the most widely used multiple comparison tests, known to have a better power than the Tukey test and the Scheffe test (Zolman 1993), and holds the familywise error rate to alpha (Type I error). All of the statistical analyses were performed using Language R version 4.2.1 (R Foundation for Statistical Computing, Vienna, Austria).

Results

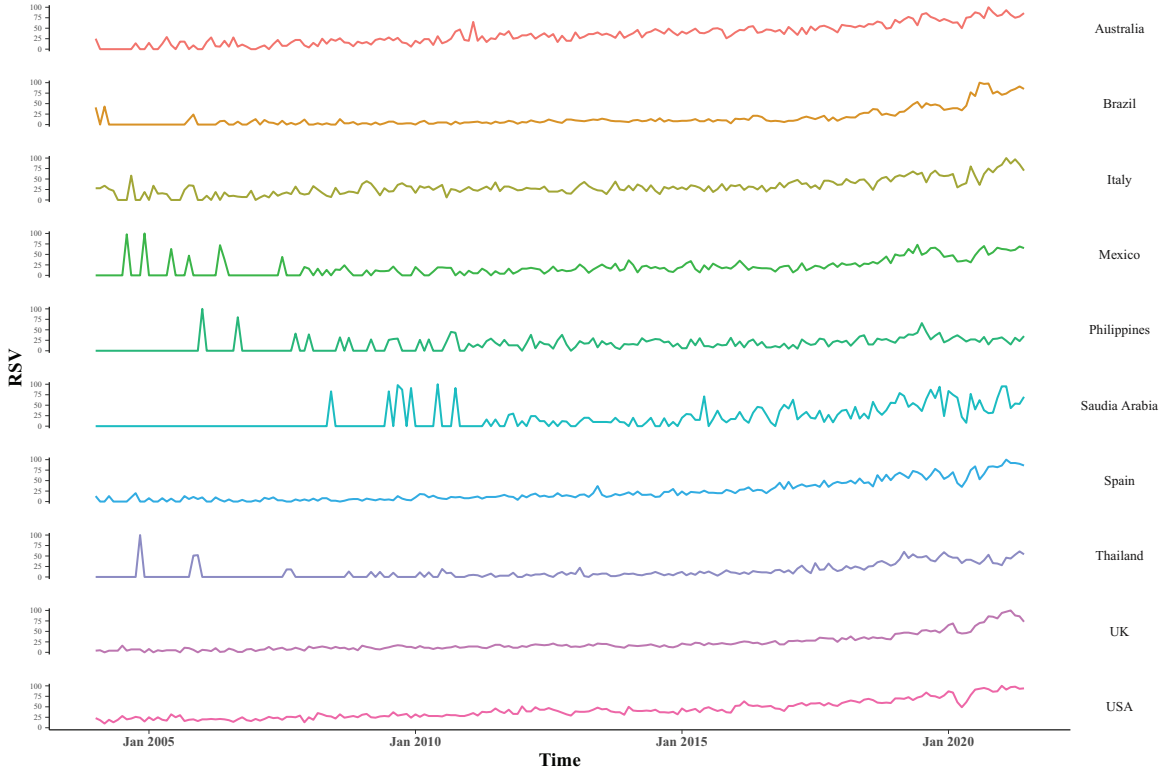
Overall, RSVs have increased over the years (Figures 1 and 2). Time series decomposition identified a trend component indicating RSV increase in all countries.

Among the 10 countries, developed countries demonstrated significantly higher RSVs than developing countries

Table 1. Classification, populations and Internet penetration rates of the countries included in the study.

Country variables			
Country	Country classification	Population	Internet penetration (%)
Australia	Developed	25,499,884	67.7
Brazil	Developing	212,559,417	70.7
Italy	Developed	60,641,826	92.5
Mexico	Developing	128,932,753	66.5
Philippines	Developing	109,581,078	72.1
Saudi Arabia	Developing	34,813,871	91.5
Spain	Developed	46,754,778	92.5
Thailand	Developing	69,799,978	81.7
UK	Developed	67,886,011	94.9
USA	Developed	331,002,651	89.0

Figure 1. Changes of Invisalign Relative Search Volume per month in each country examined during January 2004 to June 2021.



($P < 0.01$) (Tables 2 and 3). For example, USA, Australia and Italy showed higher RSVs than the Philippines, Brazil and Thailand (Figure 3). However, fairly recently, the developing countries displayed higher RSVs than the developed countries (Figure 4). Nevertheless, a slight decline in RSVs was observed after January 2020 in Mexico, the Philippines, Saudi Arabia and Thailand (Figure 5).

There was no meaningful pattern when the trends were compared either on a monthly or quarterly basis. Seasonal variations were different among most of the examined

Figure 2. Changes of Invisalign Relative Search Volume per year in each country examined during January 2004 to June 2021.

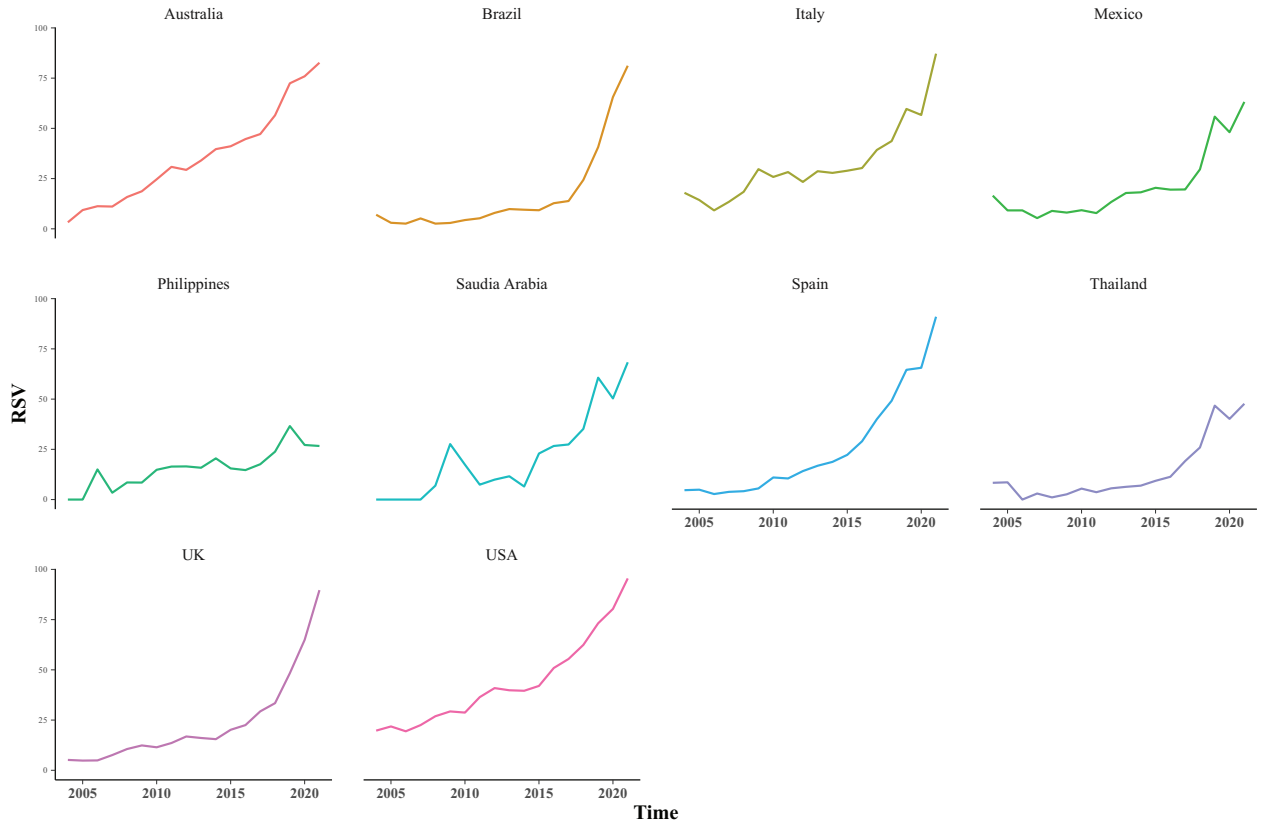


Table 2. Global test results by applying multiple linear regression model.

	Coefficient	Standard Error	*P*
Developing vs developed countries	1569.9	269.9	<0.0001
Year	3.5	0.1	<0.0001
Interaction effect	–0.8	0.1	<0.0001

countries. Similarities in the seasonal variation were observed in pairs or a small group of countries. Specifically, similar peaks and valleys were found in Australia - Brazil, UK - USA, Italy - Spain, and Saudi Arabia - Philippines - Thailand (Figure 6).

Discussion

In general, the present study demonstrated the high popularity of Invisalign and the public's need for relevant information across countries regardless of socioeconomic conditions. Developed countries exhibited significantly higher RSVs but developing countries have surpassed developed countries in that respect in recent years. These results may imply the extensive demand for Invisalign in socioeconomically advantaged countries and, at the same time, the great growth potential in disadvantaged countries despite the less optimal starting interest levels. The minor decrease in Internet users' searches observed in four out of five developing countries after January 2020 may be attributed to the tightened social restrictions and lockdown measures in fear of COVID-19 spread that affected more severely the economies of less-privileged countries than higher-income countries (Gottlieb et al., 2021). This might be the case for Mexico, the Philippines and Thailand, which present the lowest adjusted per national income per capital in the 10-country list of the study (The World Bank, 2021). A more significant decline in online interest for Invisalign and braces-associated terms has been reported by a recent GT-based study (Sycinska-Dziarnowska et al., 2021).

Table 3. SNK multiple comparisons among the 10 countries ($P < 0.01$).

Country	Mean RSV	SNK groups
USA	42.1	a
Australia	34.7	b
Italy	30.8	b
Spain	23.6	c
UK	21.9	c
Mexico	19.9	cd
Saudi Arabia	19.7	cd
Philippines	15.3	de
Brazil	15.3	de
Thailand	13.0	e

RSV, relative search volume; SNK, Student-Newman-Keuls.

Nevertheless, overlapping of the search results due to the selected keywords in that study might have inflated the magnitude of the change in Google search traffic (Livas and Delli, 2021).

Hypothetically, the study implications may be generalised to all CAT systems, seeing that Invisalign has been found to be the most frequently used search term for orthodontic clear aligners in the Google search engine (Ustdal and Guney, 2020). Thus, training on CAT procedures in dental school curricula and orthodontic residency programmes needs to be reinforced to keep up with the rising global interest. At the practice level, continuous professional development in this treatment method will help practitioners upgrade clinical skills according to the latest advances and run profitable offices. Given the utility of behavioural research in planning and improving person-centred care (Cruvinel et al., 2019), the current findings may point out the need for health insurance companies to revise their reimbursement policies to cover CAT costs in a wider range of plans.

In spite of the fact that adult orthodontics is becoming more common, practice revenues are still largely driven by adolescent patients (McIver, 2016). In this context, the similarities in seasonal variation observed here might be closely related to the academic calendar of each country as the heights of these peaks seem to coincide with the summer and winter school vacations. Comparable seasonality patterns have been previously identified in the number and age distribution of patients seeking orthodontic treatment and orthognathic surgery with the younger ones, likely students, visiting orthodontic settings during their summer and winter breaks (Lee et al., 2020; Lim et al., 2017). Likewise, a small-scale study in dental and orthodontic practices in the United States revealed that new patient flow may be expected at the end of summer when families are getting settled for the new school year (McIver, 2016.) With respect to the sales seasonality trends during the winter months, an uptick in orthodontic revenues can occur in December and January,

Figure 3. Boxplot of Relative Search Volumes displayed by the 10 countries.

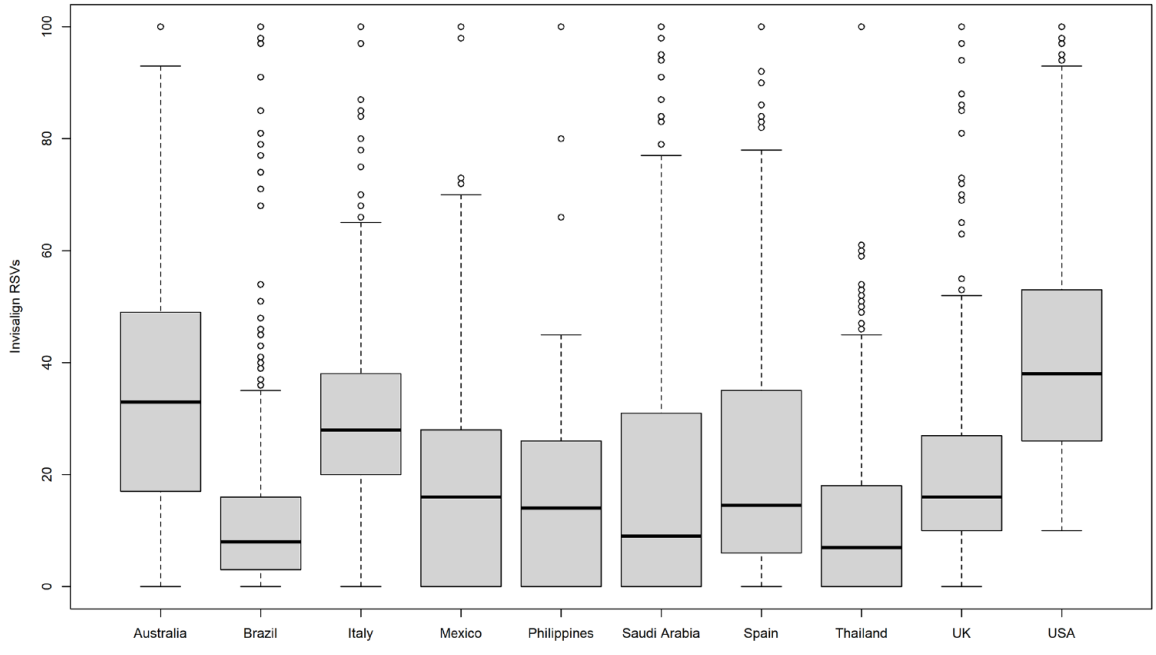


Figure 4. Changes of Invisalign Relative Search Volumes in developed and developing countries during the observation period.

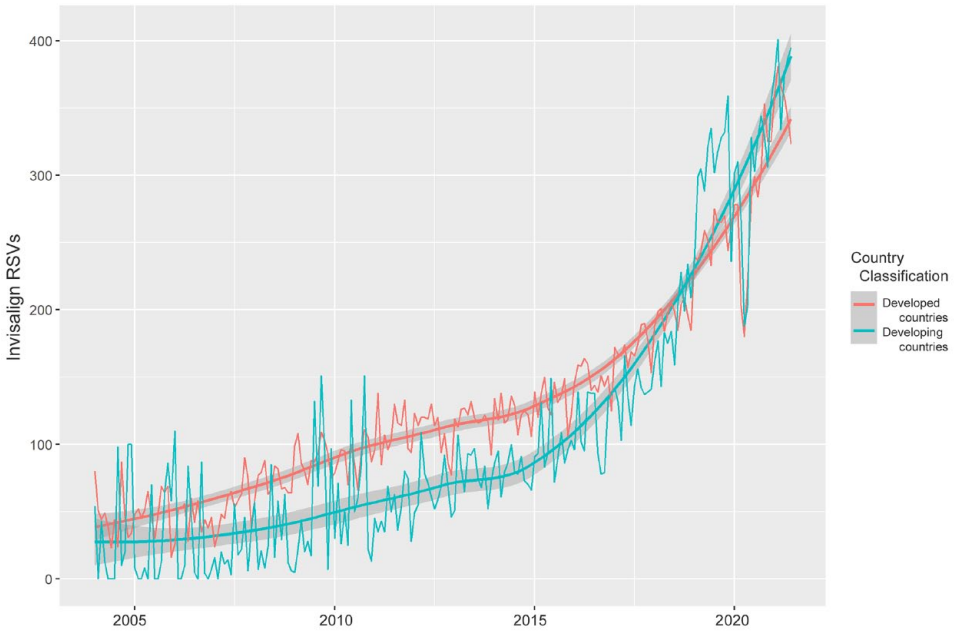


Figure 5. Trend component in Invisalign Relative Search Volume in each country examined in the study.

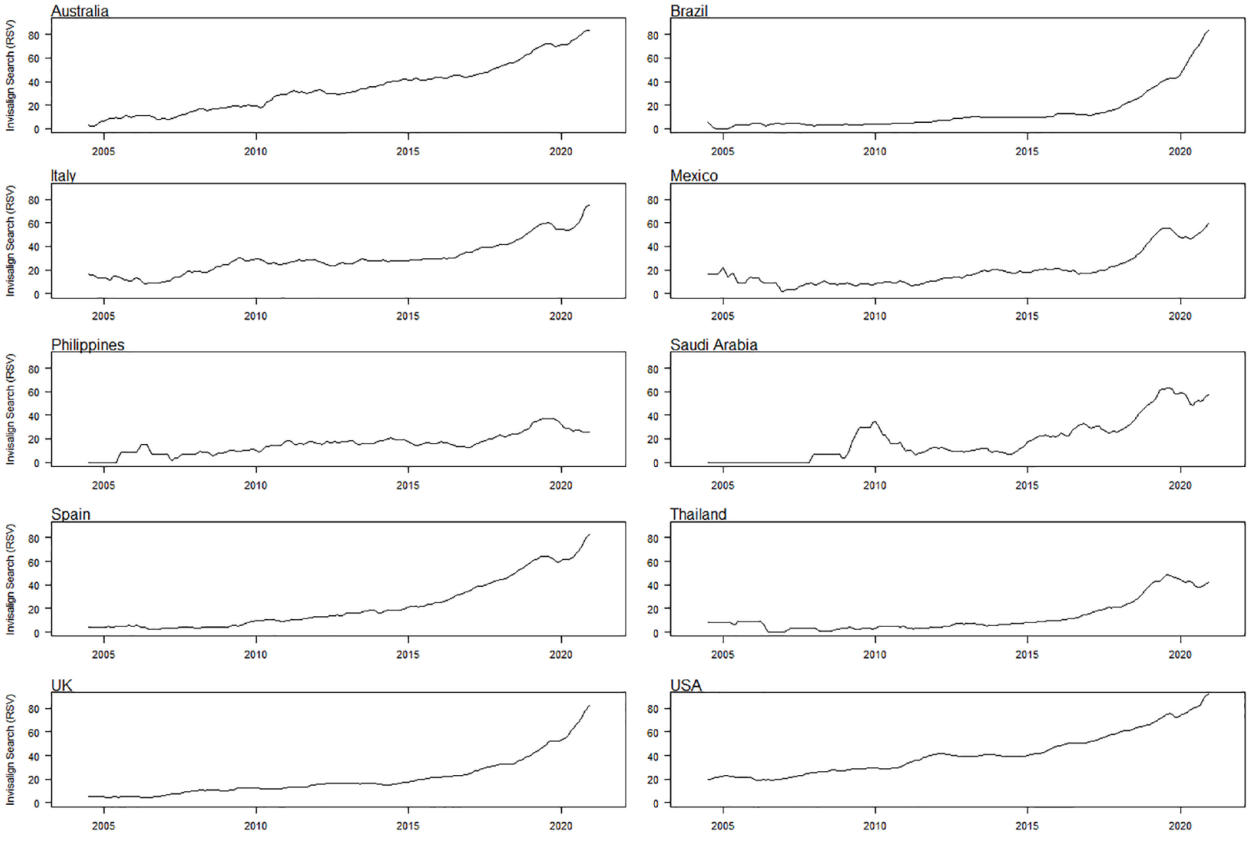
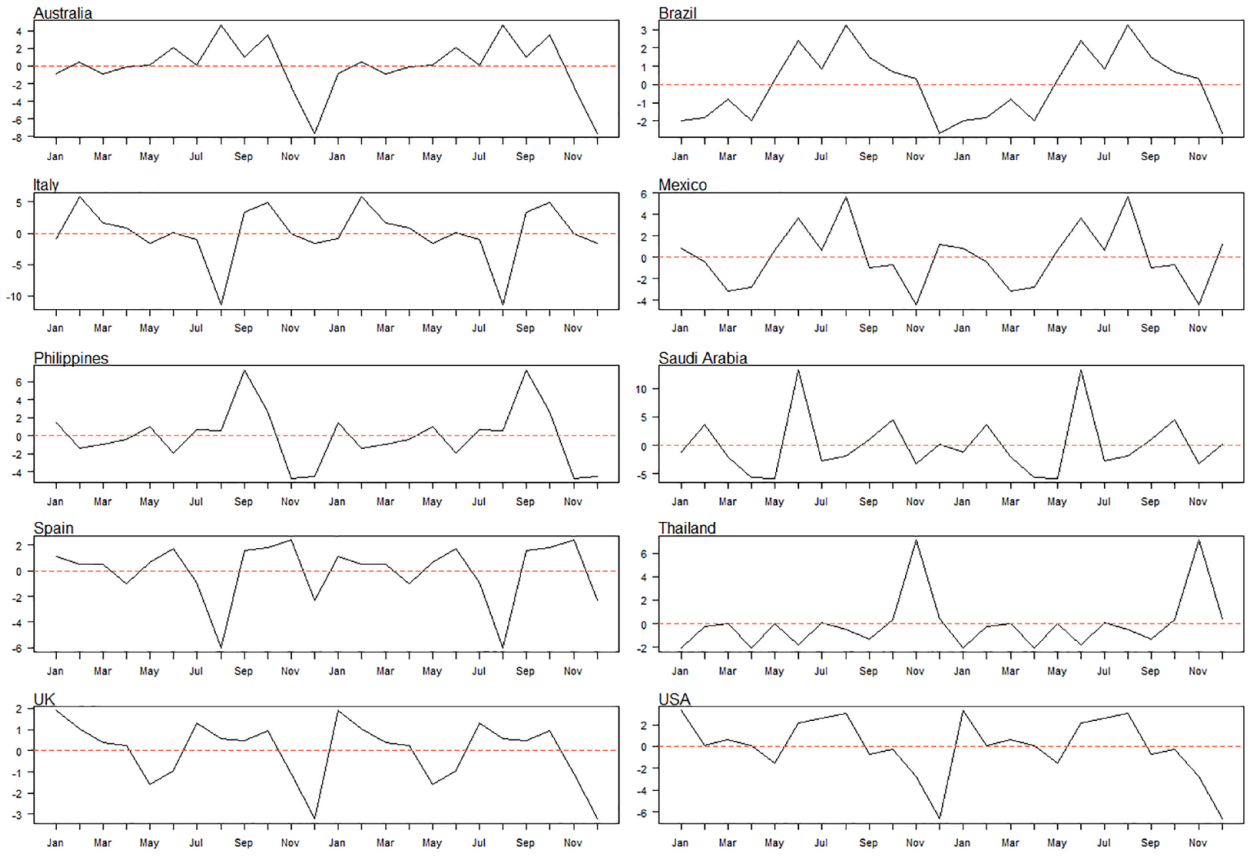


Figure 6. Seasonal variation in Invisalign Relative Search Volume in each country examined in the study.



probably due to patients trying to take advantage of expiring or new orthodontic insurance benefits (McIver, 2016).

The advantages and disadvantages of the study are mainly related to the GT tool itself. Users' characteristics and intentions cannot be identified, while the exact mechanisms employed by Google to generate and analyse search data are not known (Nuti et al., 2014). By definition, GT does not capture total Internet traffic but, still, it refers to 92.26% of the available search engines (Alex, 2021). On the positive side, GT is considered the prevailing behaviour analytics tool using Web-based search datasets. It allows anonymous and objective real-time data collection decreasing the reporting bias observed in surveys, as well as methodological standardisation for inter-study comparison (Lotto et al., 2017). To the authors' knowledge, this is the first study in orthodontics to combine GT and time series analysis. By eliminating the noise within the time series data, time series analysis can disclose more information than a cursory observation of data (Lim et al., 2017). Finally, and in view of the problematic reporting of methodology in GT literature, the recommended checklist for the documentation of search strategy by Nuti et al. (2014) was adopted in this investigation to strengthen replicability of the results.

Understanding sales seasonality enables practitioners to decide effectively about when to undertake hiring, capital improvements and to ease the anxiety caused by predictable fluctuations in practice revenues (McIver, 2016). Nonetheless, it needs to be acknowledged that seeking information on the Internet is not necessarily translated directly into a practice visit but may indicate personal intention to undergo treatment with Invisalign in the future or interest in treatment details for family members or friends. Thus, it will be beneficial to investigate sales seasonality in orthodontic practices in developed and developing countries in combination with GT-based data regarding CAT systems and other treatment techniques.

Conclusion

- In general, the volumes of Google search queries related to Invisalign increased significantly across developed and developing countries indicating the high demand of the public for relevant information.
- Developed countries exhibited significantly higher interest levels in Invisalign compared to developing countries for the majority of the observation period.

- Similar seasonality patterns in online seeking behaviour were observed between specific countries with the fluctuations following the academic calendar.
- Processing of GT data may be useful in the strategic planning of the orthodontic practice and provision of services focused on individual needs.

Declaration of conflicting interests

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