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ORIGINAL ARTICLE

The use of Google Trends and Twitter data as a tool for evaluating public interest in hyaluronic acid eyelid filler

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Abstract

Background: Google Trends and the Twitter Academic Research Product Tract (TARPT) are free, online tools that can be used to evaluate public interest in plastic surgery procedures.

Aim: To evaluate the correlation between online public interest in hyaluronic acid eyelid filler on two popular web platforms (Google and Twitter) and hyaluronic acid filler procedure volumes in the United States.

Methods: The Google Trends database and the TARPT tool were used to calculate the number of annual Google searches and Twitter tweets, respectively, related to 10 search terms associated with hyaluronic acid eyelid filler injections from January 2010 to December 2020. Annual procedure volumes for hyaluronic acid filler injections were obtained from the American Society of Plastic Surgery (ASPS). Univariate linear regression was used to correlate Google searches to ASPS procedure volumes and Twitter tweet volumes to ASPS procedure volumes.

Results: Significant positive correlations were found between Google Trends data and ASPS procedure volumes for 8/10 search terms and between Twitter tweet volumes and ASPS procedure volumes for 6/10 search terms, respectively. Online public interest in eyelid filler related search terms increased significantly over time according to an exponential model ($p < 0.0001$).

Conclusions: We observed statistically significant positive associations between public interest related to eyelid filler on two online platforms, Google and Twitter, and hyaluronic acid soft tissue filler procedure volumes. The Google Trends and TARPT databases represent free information sources for surgeons that may be used to inform marketing and advertising decisions and to anticipate patient inquiries during the patient encounter.

Relevance for patients: Information provided by the Google Trends and TARPT tools can be used by surgeons to (1) inform marketing and advertising strategies and (2) gain insight into which procedures patients are researching during a given time period, preparing them to best address the evolving needs of patients.

Keywords: Google Trends; hyaluronic acid; eyelid; filler; twitter; public interest

1. Introduction

The prevalence of soft tissue minimally-invasive cosmetic procedures is rising, with more than 3,000,000 soft tissue filler injections reported in 2020 in the United States.[1] Of the more than 3,000,000 soft tissue filler minimally-invasive procedures performed last year according to American Society of Plastic Surgery (ASPS) data, more than 75% of the procedures were hyaluronic acid filler injections. Since the first hyaluronic acid-based filler was approved for use in the United States, the number of hyaluronic acid filler injections per year has risen tremendously, suggesting increasing public interest.[2] Public interest in many cosmetic procedures, including filler, may be driven by high profile media coverage, with celebrity endorsements by "influencers" often leading to increased procedure volumes.[3,4] Providing hyaluronic acid filler injections can also be very lucrative for surgeons, which may help account for its rising popularity.[5] While the exponential rise in revenue associated with minimally invasive procedures such as soft tissue fillers suggests increased public interest in hyaluronic acid filler, public interest in hyaluronic acid filler has not been previously quantified.[6,7]

Internet search traffic data is one mechanism that can be used to quantify public interest in novel treatments such as hyaluronic acid filler. Google Trends is a free, open-source tool that is used to track the frequency with which search terms are entered into the Google search engine, with custom analyses based on time-period and geographic location. Previous research indicates that Google Trends data describing public interest in various surgical and nonsurgical procedures ranging from knee arthroplasty to rhinoplasty have correlated with actual healthcare utilization.[8–15] However, the relationship between Google Trends data and hyaluronic acid eyelid filler injections has not been previously studied.

More than half of all plastic surgery patients utilize social media outlets to gather information before selecting their surgeon.[16] As such, social media data also has the potential to quantify public interest in medical procedures such as eyelid filler injections. Twitter is one common social media platform that patients may use as an information source when researching various cosmetic surgeries. In recent years, Twitter has risen in popularity, with more than 70 million daily users in the United States.

Additionally, Twitter users are, on average, older than users of other people social media platforms Instagram and Snapchat, with more than half of users between the ages of 35 and 65, the prime age demographic for plastic surgeons hoping to market aesthetic procedures.[17]

Recently, Twitter launched a new feature called the Twitter Academic Research Product Track (TARPT) database. The TARPT tool is free for academic researchers, intuitive, and offers access to the full archive of tweets since Twitter's inception in 2006.[18] The TARPT tool can be used to provide insight on what the public is tweeting about, with the potential to generate reports analyzing tweets related to a certain keyword or hashtag, such as #eyelidfiller. Given the increased use of Twitter in plastic surgery [4-6], we believe that the TARPT database may represent an informative and accessible tool that can be used to gauge the public's interest in various plastic surgery procedures. Furthermore, two prior studies have demonstrated the utility of the TARPT tool in tracking public interest in various surgical and cosmetic procedures by correlating tweet volumes with procedure volumes.[19,20] However, the relationship between tweets related to hyaluronic acid filler and procedure volumes remains unclear.

As such, the purpose of our study is to evaluate the correlations between online public interest data from two distinct data sources (the Google Trends database and the TARPT tool) and hyaluronic acid filler procedure volumes in the United States. We also assessed whether public interest in eyelid filler displayed temporal, seasonal, or income-related trends. Describing these correlations and the potential utility of both the Google Trends and TARPT tools to gauge public interest in hyaluronic acid filler may assist surgeons to inform marketing strategies and to aid in patient outreach efforts.

2. Methods

2.1 Google Trends

The Google Trends tool generated customizable analyses based on search term, time-period, and geographic location. After the search term was entered into Google Trends and the appropriate temporal and geographic constraints specified, Google Trends generated visuals and outputs that reflected the volume of a given search term relative to peak popularity within the defined time-period, which was assigned a value of 100. The data were presented as relative search volume (RSV), which is computed as the percentage of searches of a term in a location during a specific time period. An RSV value of 100 indicated the largest ratio between searches for a specific topic and the total amount of Google queries. A value of 0 indicated that at the specified time point, the proportion of queries for the search term was less than 1% of its peak RSV. [21] The following filters were utilized in the Google Trends tool: Search Term: [Search Term of Interest], Time Period: [January 1, 2010 - December 31, 2020], Geographic Location: [United States]. The search was conducted on April 4, 2021.

2.2 Twitter academic research product track

We used the "Full Archive Tweet Count" component of the TARPT tool to assess trends in tweet volume over time. We customized tweet analyses by search term, time-period, and geographic location. After the appropriate search term was entered into the TARPT tool and specific temporal and geographic parameters were specified, the TARPT tool generated a report demonstrating the frequency with which the given search term or keyword appeared in a tweet over the temporal parameters specified. For our study parameters, we generated a database of daily tweet totals in the United States for all search terms of interest from January 1, 2010 to December 31, 2020. We generated the database on May 5, 2021. Similar to two prior studies which utilized the TARPT tool, tweet volumes for all years after 2010 (2011-2020) were adjusted to account for growth in Twitter users and number of tweets per day.[19,20] We divided tweet

volumes provided by the TARPT tool for each year after 2010 by a factor equivalent to the ratio of the total number of tweets on the Twitter platform during the respective calendar year divided by the total number of tweets in 2010 in order to standardize tweet volumes over the study period. Adjusted tweet volumes were subsequently used in our statistical analyses.

2.3 Search term selection

Ten search terms related to hyaluronic acid eyelid filler were selected based on prior literature and the "related queries" feature of the Google Trends tool, which provides information about which search terms people most frequently use when searching for information related to eyelid filler.[11] Search terms selected included both technical and colloquial terms. All search terms can be observed in Table 1.

2.4 Case volumes

We retrieved annual case volumes for hyaluronic acid filler injections in the United States from the American Society of Plastic Surgeons (ASPS) via their annual statistics reports from 2010 to 2020.[1] We used the years 2010-2020 as temporal parameters for the study because tweet volumes increased drastically in 2010, indicating increased utilization of Twitter by the public.[17]

2.5 Statistical analysis

We used univariate linear regression to determine the correlation between (1) Google search volumes and ASPS procedure volumes and (2) Twitter tweet volumes and ASPS procedure volumes for each of the 10 search terms included in our study. We also utilized Google Trends data to generate growth models describing changing public interest in eyelid filler and to evaluate potential income-related and monthly trends in public interest in eyelid filler in the United States. A $p < 0.05$ was used to determine significance.

3. Results

3.1 Correlation of Google Trends search volumes/Twitter tweet volumes and annual procedure volumes in the United States

Univariate linear regression of Google Trends data from 2010 to 2020 compared with ASPS procedure volumes demonstrated statistically significant positive correlations for eight of the ten search terms included in this study. The search terms with a significant positive correlation included the following: "Juvederm" ($R^2 = 0.681$, $p = 0.0103$), "Restylane" ($R^2 = 0.621$, $p = 0.0123$), "Eye Filler" ($R^2 = 0.742$, $p = 0.0054$), "Under Eye Filler" ($R^2 = 0.713$, $p = 0.0162$), "Tear Trough Filler" ($R^2 = 0.661$, $p = 0.0159$), "Eye Filler Cost" ($R^2 = 0.688$, $p = 0.0032$), "Lower Lid Filler" ($R^2 = 0.843$, $p < 0.0001$), and "Eyelid Filler" ($R^2 = 0.742$, $p = 0.0007$) (Table 2).

Univariate linear regression of Twitter data from 2010 to 2020 compared with ASPS procedure volumes demonstrated statistically significant positive correlations for six of the ten search terms included in this study. The search terms with a significant positive correlation included the following: "Juvederm" ($R^2 = 0.442$, $p = 0.0257$), "Eye Filler" ($R^2 = 0.649$, $p = 0.0045$), "Under Eye Filler" ($R^2 = 0.461$, $p = 0.0210$), "Eye Filler Cost" ($R^2 = 0.419$, $p = 0.0310$), "Lower Lid Filler" ($R^2 = 0.723$, $p < 0.0001$), and "Eyelid Filler" ($R^2 = 0.841$, $p < 0.0001$) (Table 2).

3.2 Temporal trends - Google Search volumes

Search volumes for Google search terms with a statistically significant positive correlation to case volumes consistently increased throughout the study period from January 2010 to December 2020. The exponential model was determined to have the strongest measure of accuracy to describe changing public interest over time, with a mean absolute percentage error of 12.2% and a R^2 of 0.9163 (Figure 1). Public interest in eyelid filler related search terms increased significantly over time (all models $p < 0.0001$) and peaked in August 2020, after an initial dip in public interest at the beginning of the COVID-19 pandemic.

3.3 Income-related trends

Google search volume trends in the five highest income states showed more rapid growth in interest in eyelid filler than in the five lowest income states (Figure 2).

3.4 Monthly trends

Greatest Google search interest in eyelid filler was observed in the months of August (+10.91% relative to annual mean), July (+8.43%), and September (+7.32%). Decreased public interest was observed in January (-8.16%), February (-5.49%), and December (-2.34%) (Figure 3).

4. Discussion

Our study assessed public interest in eyelid filler using both the Google Trends and the TARPT databases. The results of our study demonstrated a statistically significant increase in public interest in eyelid filler over time, according to both Google search trends and Twitter tweet volumes. When analyzing the correlation between Google search trends and hyaluronic acid filler injections in the United States, eight out of ten search terms demonstrated a statistically significant positive correlation: "Juvederm", "Restylane", "Eye Filler", "Under Eye Filler", "Tear Trough Filler", "Eye Filler Cost", "Lower Lid Filler", and "Eyelid Filler". When analyzing the correlation between Twitter tweet volumes and hyaluronic acid filler injections, six out of ten search terms demonstrated a statistically significant positive correlation: "Juvederm", "Eye Filler", "Under Eye Filler", "Eye Filler Cost", "Lower Lid Filler", and "Eyelid Filler". As patients increasingly rely on the internet for information about oculoplastic and other plastic surgery procedures, tech-savvy surgeons can utilize free, intuitive databases such as Google Trends and the TARPT tool to anticipate trends in public interest to inform both marketing and advertising strategies and expectations for patient inquiries.

Although previous research with the Google Trends tool has shown significant positive correlations between Google search trends and healthcare utilization in the past, there is limited information on the association between tweet volumes and procedure volumes, with only two studies previously utilizing data from the TARPT database. [8–12,19,20,22] Our results reveal significant positive correlations between Google searches and procedure volumes for 80% of search terms related to eyelid filler and significant positive correlations between Twitter tweet volumes and procedure volumes for 60% of search terms related to eyelid filler, demonstrating the potential utility of both the Google Trends database and the TARPT tool to inform public interest in eyelid filler. Disparities in the number of statistically significant positive correlations observed when comparing the Google Trends and TARPT databases likely stems from the varying purposes of the Google and Twitter platforms. Google operates as a search engine that patients can use to retrieve information on eyelid filler, while Twitter functions not as

a search engine but rather a medium for users to share their thoughts on various topics and engage in conversations with other Twitter users. Despite varying correlations observed when comparing the Google Trends and TARPT tools, our results demonstrate that both the Google Trends and TARPT tools can be utilized by surgeons to inform marketing decisions.

With regards to the Google Trends tool, strong positive correlations between google searches related to eyelid filler and procedure volumes suggest that patients are often using online search engines such as Google to learn more about filler prior to their treatment. This hypothesis aligns with previous research which suggests that nearly 75% of people seeking information about plastic surgery procedures relied on the internet as their main source of information.[23] As such, surgeons who are able to maximize search engine optimization after initial Google queries by patients are more likely to be able to recruit patients into their practice. Examples of easy-to-implement techniques that can be used to improve search engine optimization include picking relevant and effective keywords, creating a short title for each webpage, using keywords throughout webpages, and providing hyperlinks to strategically link relevant sources of information throughout the webpage.[24]

In addition to investing resources in search engine optimization to drive potential patients to their websites, surgeons must consider the elements of a quality website preferred by patients once they are redirected to the surgeon's unique website after their initial Google search. A survey by Walden et al.[25] revealed that the most powerful influence on choice of surgeon for breast augmentation was the plastic surgeon's website. It is imperative that surgeons designing their own websites emulate best practices regarding website navigation, graphical representation, organization, content utility, simplicity, and readability that have been proven to increase user engagement in the past.[26] The results of our study reveal strong positive correlations between Google searches related to eyelid filler and actual utilization by the public. As such, surgeons who can maximize their online visibility via search engine optimization strategies and strong website design may be able to better convert online public interest in eyelid filler into patient inquiries and ultimately greater procedure volumes.

The results of our study further illustrate the potential utility of the TARPT tool in driving marketing decisions. Twitter currently represents a largely untapped resource for plastic surgeons hoping to market their services, with an analysis of the return on investment for various marketing strategies used by plastic surgery practices revealing a greater return on investment when utilizing social media platforms such as Twitter, Instagram, and Facebook when compared with Google search engine optimization among start-up practices.[27] As such, surgeons with a strong twitter presence and an ability to utilize the TARPT tool may recognize trends in Twitter activity regarding various procedures that can prove advantageous when recruiting new patients.

Seasonal and income-related trends describing public interest in eyelid filler may help inform marketing decisions and advertising budgets. Notably, public interest in filler showed a pattern of greater public interest in the summer months of June, July, and August and decreased public interest in the winter months of December, January, and February. These results align with a recent study of online public interest in rhinoplasty which also saw greatest public interest in the summer months of June and July.[4] Additionally, in the United States, public interest in lid fillers increased at a greater rate in the five highest-income states than in the five lowest-income states. Income-related trends observed in our study are likely related to the steep expense of cosmetic eyelid surgery, which is approximated to be more than $4000 according to the American Society of Plastic Surgeons.[28] The seasonal and income-related trends observed in our studies can help surgeons to guide their marketing decisions, with our results revealing greater public interest in filler in the summer months and in high-income states. Demonstrating a strong online presence during these time periods may help to enhance the effectiveness of online marketing campaigns.

Previous research has demonstrated the strong impact that high profile plastic surgery related media coverage can have on public interest in cosmetic procedures, and our study results align with these findings.[12,13,16,22,29,30] When analyzing Google search data regarding the months with the highest increases in public interest in lid filler, there were only three months during the entirety of the study period in which

there was greater than 15% increase in public interest (as measured by Google Trends relative search volume) compared to the prior month. All three of these instances may be attributed in part to high profile media events. In January 2018, Kate Perry announced to her nearly 75 million Instagram followers that she had received eyelid filler injections to treat "dark circles under the eyes".[31] A 15.1% increase in Google searches related to lid filler was observed during the same month compared to the prior month, December 2017. In March 2019, a month which demonstrated a 16.2% increase in Google searches related to filler compared to the prior month, Vanderpump Rules' television star Lala Kent announced to her more than 1 million Instagram followers that she had received tear trough filler injections, generating headlines in several popular media outlets including *Bravo*, *The US Sun*, and *The List*.[32–34] Finally, in May 2020, which showed a 19% increase in public interest in filler compared to the previous month, an article titled "12 Celebrities Who've Spoken Out About Fillers" was published describing filler experiences of celebrities such as Kylie Jenner, Kim Kardashian West, Chrissy Teigen, Courtney Cox, Gwyenth Paltrow, and Heidi Montag.[35] Our findings of increased public interest in filler associated with celebrity endorsements and/or high profile media coverage on the topic suggests that surgeons seeking to market their own services should capitalize on high profile media coverage related to filler and enhance marketing and search engine optimization during these time periods, when patients are most likely to search for filler-related information online.

There are limitations to our study. First, both the Google Trends database and the TARPT tool provide limited demographic information about their daily users. As such, we cannot be certain that Google and Twitter users are reflective of the United States population. However, previous research reveals that the age range of most cosmetic surgery patients (30-54) is similar to the average age of Twitter users (ages 25-34 and 35-49) and that Google owns approximately 86% of the search engine market share, so it is likely that users of both Google and Twitter are representative of the population of potential patients.[36,37] Another limitation is that there may be search terms related to eyelid filler that were not included in our study. While we used the "related queries" feature of the Google Trends tool to help

define our search terms of interest, other technical and colloquial terms related to eyelid filler besides the 10 that were selected for inclusion may not have been captured in our study. Finally, the case volumes we obtained from the American Society of Plastic Surgery annual reports are subject to potential bias because not all cosmetic procedures are reported to the ASPS during a given year. However, ASPS case volumes have been used in prior studies evaluating the correlation between online search trends and case volumes in the past, and with no centralized oculoplastics data set containing information about annual procedure volumes, the ASPS case volumes for hyaluronic acid filler injections served as the best available barometer of national public interest in eyelid filler.[12,13,22] Finally, with Twitter's recent sale to Elon Musk, it is unclear whether or not public usage of the platform will change, which could impact Twitter's utility as a marketing tool.

Conclusions

In conclusion, our study reveals statistically significant positive associations between public interest related to eyelid filler on two online platforms, Google and Twitter, and hyaluronic acid filler procedure volumes. We also identified seasonal and income-related trends in public interest in eyelid filler and connected large increases in public interest in lid filler on internet platforms to high profile media coverage and celebrity endorsements. Our results may be utilized by plastic surgeons when creating marketing strategies and to aid in patient outreach efforts. Surgeons who maintain a strong Twitter presence and effectively monitor trends in online engagement for eyelid filler and other plastic surgery procedures can use the information provided by the Google Trends and TARPT tools to (1) inform marketing and advertising strategies and (2) gain insight into which procedures patients are researching during a given time period, preparing them to best address the evolving needs of patients.

Conflict of interest

The authors declare no conflicts of interest.

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Figures and tables

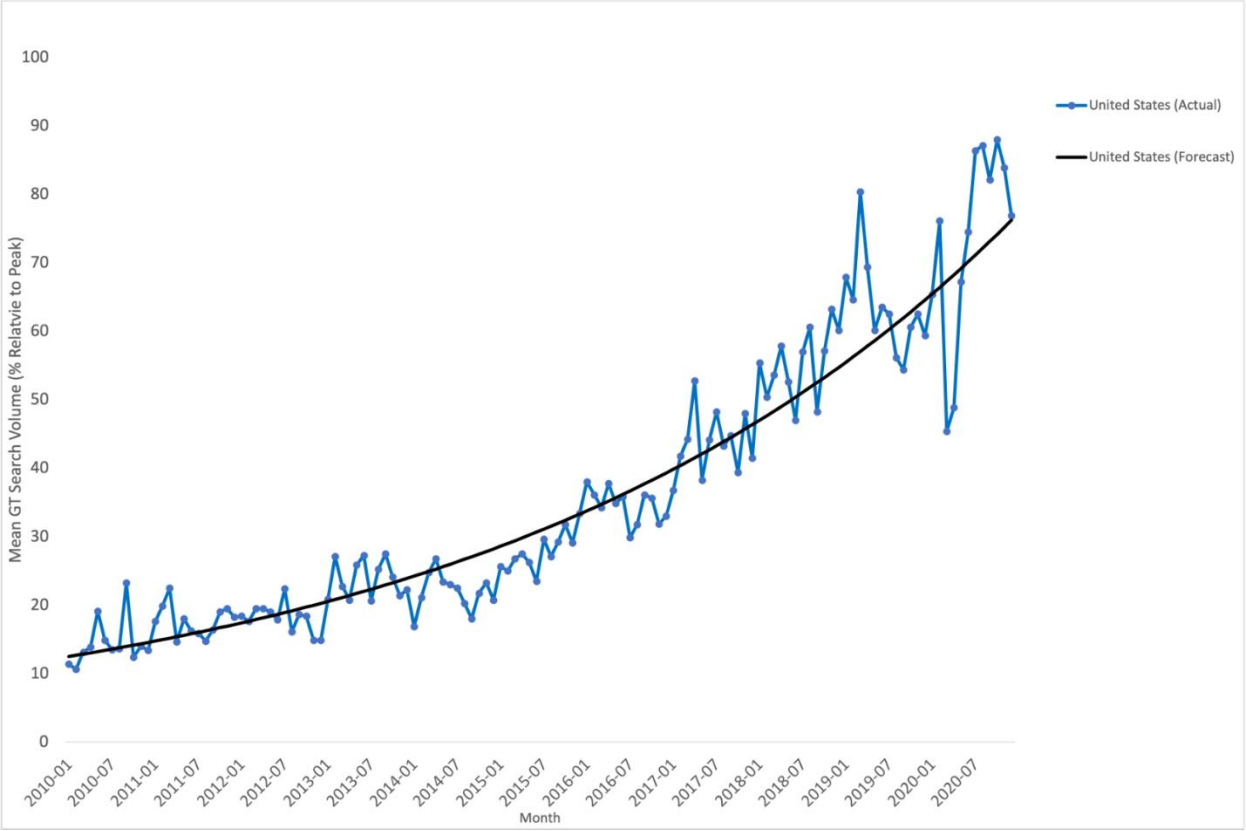

Figure 1: Exponential trend model representing public interest in eyelid filler, 2010-2010.

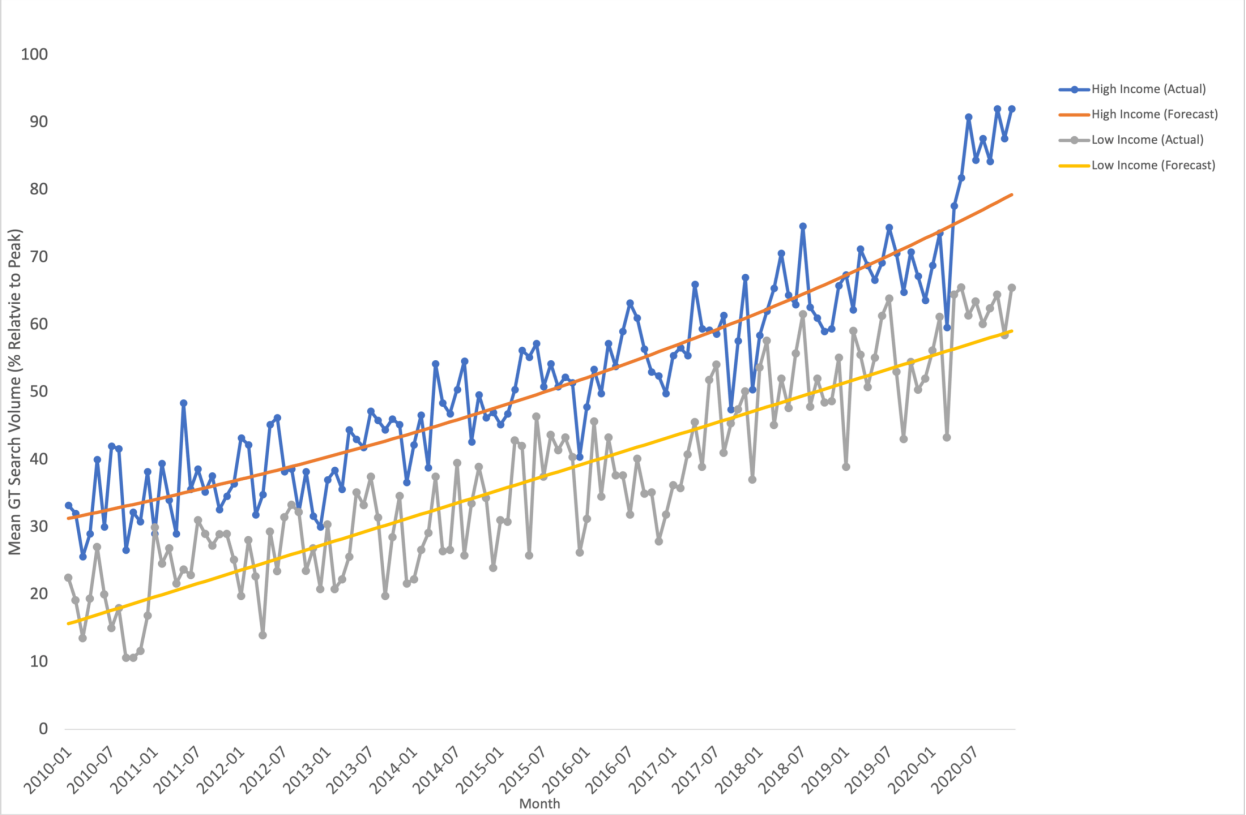

Figure 2: Exponential and linear trend models demonstrating public interest in eyelid filler in high-income and low-income states, respectively.

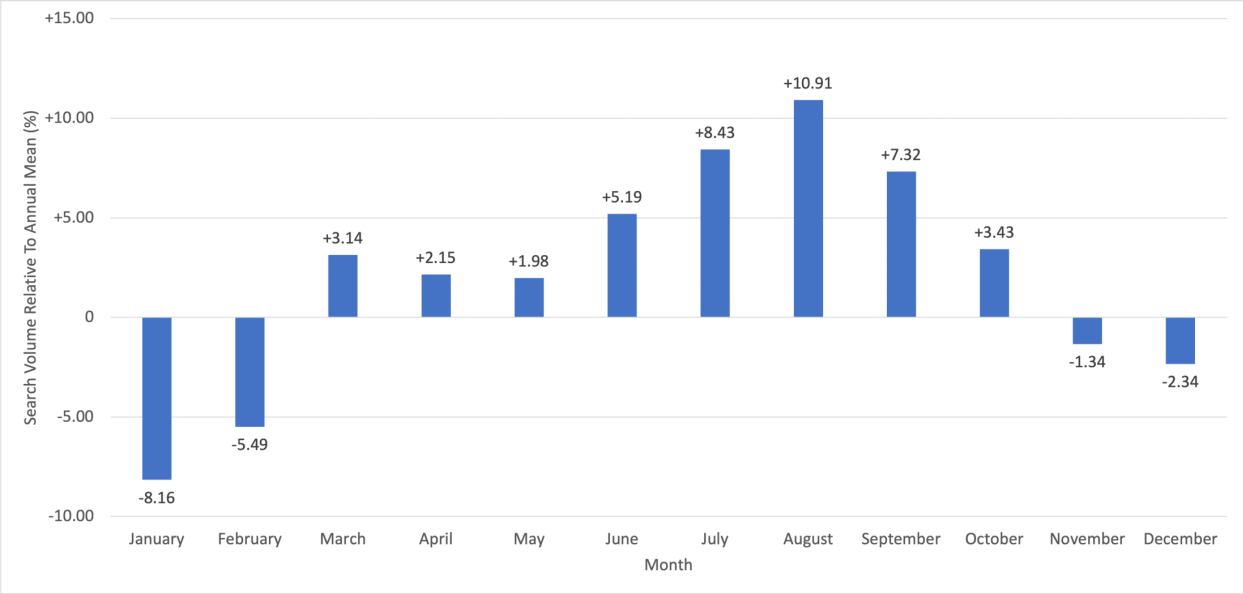

Figure 3: Monthly trends in Google interest related to eyelid filler, January 2010 to December 2020.

Table 1: Search terms related to hyaluronic acid eyelid filler.

Hyaluronic Acid Eye Filler
Hyaluronic Acid Eye Injection
Juvederm
Restylane
Eye Filler
Under Eye Filler
Tear Trough Filler
Eye Filler Cost
Lower Lid Filler
Eyelid Filler

Table 2: Correlation of Google Trends search volumes/Twitter tweet volumes and procedure volumes

Search Term	GT Coefficient (95% CI)	GT R^2	GT *P*	Twitter Coefficient (95% CI)	Twitter R^2	Twitter *P*
Hyaluronic Acid Eye Filler	37595.8 (5365.4, 69826.2)	0.436	0.0269	169.2 (-3.8, 342.1)	0.361	0.1010
Hyaluronic Acid Eye Injection	32688.9 (-21677.5, 87055.4)	0.171	0.2070	37.9 (-277.3, 353.3)	0.008	0.0791
Juvederm	39143.8 (23408.5, 54879.1)	0.681	**0.0103**	59.2 (9.0, 109.3)	0.442	**0.0257**
Restylane	25052.2 (16865.3, 33239.1)	0.621	**0.0123**	-49.7 (-183.9, 84.6)	0.072	0.4240
Eye Filler	18103.3 (12052.8, 24153.8)	0.742	**0.0054**	9.7 (3.9, 15.6)	0.649	**0.0045**
Under Eye Filler	16737.8 (10691.5, 22783.9)	0.713	**0.0162**	125.4 (23.4, 227.4)	0.461	**0.0210**
Tear Trough Filler	18089.7 (11507.5, 24672.0)	0.661	**0.0159**	3.7 (-26.6, 34.2)	0.011	0.7860
Eye Filler Cost	20338.4 (12898.2, 27778.6)	0.688	**0.0032**	209.5 (23.6, 395.3)	0.419	**0.0310**
Lower Lid Filler	25129.2 (16877.8, 33380.6)	0.843	**<0.0001**	211.6 (159.6, 263.6)	0.723	**<0.0001**
Eyelid Filler	32813.9 (18214.2, 47413.6)	0.742	**0.0007**	4.8 (3.3, 6.3)	0.841	**<0.0001**