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Contextualizing Breast Implant Removal Patterns with Google Trends: Big Data Applications in Surgical Demand

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Background: The demand for breast implant removal (BIR) has increased substantially in recent years. This study leveraged large datasets available through Google Trends to understand how changes in public perception could be influencing surgical demand, both geographically and temporally.

Methods: Using Google Trends, we extracted relative search volume for BIR-related search terms in the United States from 2006 to 2019. A network of related search terms was established using pairwise correlative analysis. Terms were assessed for correlation with national BIR case volume based on annual reports provided by the American Society of Plastic Surgeons. A surgical demand index for BIR was created on a state-by-state basis.

Results: A network of internally correlated BIR search terms was found. Search volumes for such terms, including "explant" [$\rho = 0.912$], "breast implant removal" [$\rho = 0.596$], "breast implant illness" [$\rho = 0.820$], "BII" [$\rho = 0.600$], and "ALCL" [$\rho = 0.895$] ($P < 0.05$), were found to be positively correlated with national BIR case volume, whereas "breast augmentation" [$\rho = -0.596$] ($P < 0.05$) was negatively correlated. Our 2019 BIR surgical demand index revealed that Nevada, Arizona, and Louisiana were the states with the highest BIR demand per capita.

Conclusions: Google Trends is a powerful tool for tracking public interest and subsequently, online health information seeking behavior. There are clear networks of related Google search terms that are correlated with actual BIR surgical volume. Understanding the online health queries patients have can help physicians better understand the factors driving patient decision-making. *(Plast Reconstr Surg Glob Open 2022;10:e4005; doi: 10.1097/GOX.0000000000004005; Published online 5 January 2022.)*

INTRODUCTION

Breast augmentation remains one of most popular procedures in the field of plastic surgery, with 313,735 cases reported by the American Society of Plastic Surgeons (ASPS) in 2018 alone.[1] In recent years, however, breast implant removal (BIR) case volume has increased,[2] and the safety of silicone-based implants has come under public and academic scrutiny.[3,4] For example, the recall of BIOCELL textured breast implants in 2019 garnered substantial public interest in complications such as breast implant associated anaplastic large cell lymphoma (BIA-ALCL).[5,6] Likewise, breast implant illness (BII), a controversial and nebulously defined constellation of systemic symptoms, has emerged as an important patient concern. These changes, in part, have been associated with the growing usage of social media by patients to both share their experiences and seek out health information.[7] Although these platforms can serve as an important source of peer-to-peer support,[8] the quality of information is variable and may be misleading.[9] Large data analysis can therefore

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play an important role in this space by helping physicians identify and address patient-related concerns and health-seeking behavior.

Google Trends (GT) (Google Inc., Mountain View, Calif.) is an open-access tool that provides aggregated, unfiltered relative search volume (RSV) in a temporal and geographic fashion for specified search terms. Given Google's 87.69% capture of the search engine market,[10] researchers have successfully used GT to assess public interest in topics such as breast implant recall and BIA-ALCL.[5] Changes in public interest can have a critical impact on surgical demand for procedures such as BIR, which have been shown to be performed by patient request in upwards of 22% of tissue expander and implant removal cases.[11] As such, GT surgical demand analysis is both warranted and insightful in the context of BIR.

A recent GT analysis performed by our team investigated potential contributing factors driving the aforementioned changes in BIR demand. Our data suggested that targeted search terms could have correlative value when assessing surgical demand (in press). In this study, we expanded upon our preliminary findings through a multipronged analysis of public interest in BIR. We identified a network of related search terms associated with BIR and determined which terms were most strongly correlated with BIR case volume. Additionally, we constructed a state-by-state demand index to identify states with the highest BIR demand on a per capita basis. This large data set analysis unpacks components of BIR public interest that are difficult to investigate objectively in a healthcare setting, where patients may feel hesitant to fully express their concerns.

Takeaways

Question: How is public perception of breast implant removal changing, and how are these changes influencing surgical demand?

Findings: There exists a network of internally correlated BIR search terms. Search volumes for terms including "explant," "breast implant removal," "breast implant illness," "BII," and "ALCL" were positively correlated with national BIR case volume, whereas "breast augmentation" was negatively correlated. Nevada, Arizona, and Louisiana were the states with the highest BIR demand per capita in 2019.

Meaning: Google Trends can clarify the online health queries patients have, helping physicians better understand the factors driving patient decision-making.

METHODS

2006–2019 surgical volumes for reconstructive and augmentation BIR cases were extracted from the ASPS annual reports. Total BIR case volume was defined as the sum of reconstructive and augmentation BIR case volumes. Data processing was performed in the software environment R (R Foundation for Statistical Computing, Vienna, Austria).

GT was used as an index for public interest, providing normalized Google search volumes for defined search queries from 2006 to 2019. Initial term inclusion was determined by sourcing potential motivating factors for BIR from relevant patient-centered outcome studies,[3,12,13] topical product recall statements,[14] and other studies that utilized GT to investigate related changes.[5] Additional related queries were added based on GT generated search suggestions. Relevant queries in this analysis included "breast implant removal," "explant," "breast implant illness," "BII," "breast augmentation," "breast reduction," "breast implant recall," "ALCL," and "ALCL lymphoma" from 2006 to 2019. Additionally, RSV was collected for negative controls that comprised cosmetic procedures outside of the BIR space. This included the terms "cheek implant," "liposuction," and "facelift."

A correlation matrix was constructed using pairwise Spearman's rank-order correlation on a term-by-term basis for the 2006–2019 GT data. Spearman's rank-order correlation is a nonparametric measure of both the magnitude and direction of association between two variables. RSV for each query was also assessed for correlation with ASPS annual reported BIR procedures via Spearman's rank-order correlation.

For relevant geographic displays, a correction factor was applied for heatmap scaling. GT normalizes RSV across state boundaries (for a given year) or between years (for a given geographical designation), but not both simultaneously. Therefore, state-by-state data for each year (2006–2019) in the supplemental video was multiplied by a correction factor for the given year, to account for the temporal increase in RSV. (**See Video [online],** which displays longitudinal interest profiles for "breast augmentation" and "breast implant removal" by state in the United States, from 2006 to 2019.) This correction factor was defined as $[(\text{Correction Factor})_{year} = (\text{United States RSV})_{year}/100]$ and can be found in Supplemental Digital Content 1 and 2. (**See Table 1, Supplemental Digital Content 1**, which displays the correction factors used to generate the breast implant removal heatmap seen in Supplemental Video. **http://links.lww.com/PRSGO/B875**.) (**See Table 2, Supplemental Digital Content 2**, which displays the correction factors used to generate the breast augmentation heatmap seen in the supplemental video. **http://links.lww.com/PRSGO/B876**.)

A BIR surgical demand index was created on a state-by-state basis for 2019. BIR surgical demand was defined as [RSV/(# of active plastic surgeons per 10,000 individuals)], as described previously by Blau et al.[15] RSV was generated by GT for the basketed query "breast implant removal + explant" for 2019; this returned RSV for searches in 2019, including either "breast implant removal" or "explants," generating a more comprehensive demand index. Surgeon and population data were collected from ASPS and the US Census Bureau 2019 reports, respectively. Data analysis and visualization was conducted in MATLAB (MathWorks Inc., Natick, Mass.) and R, respectively.

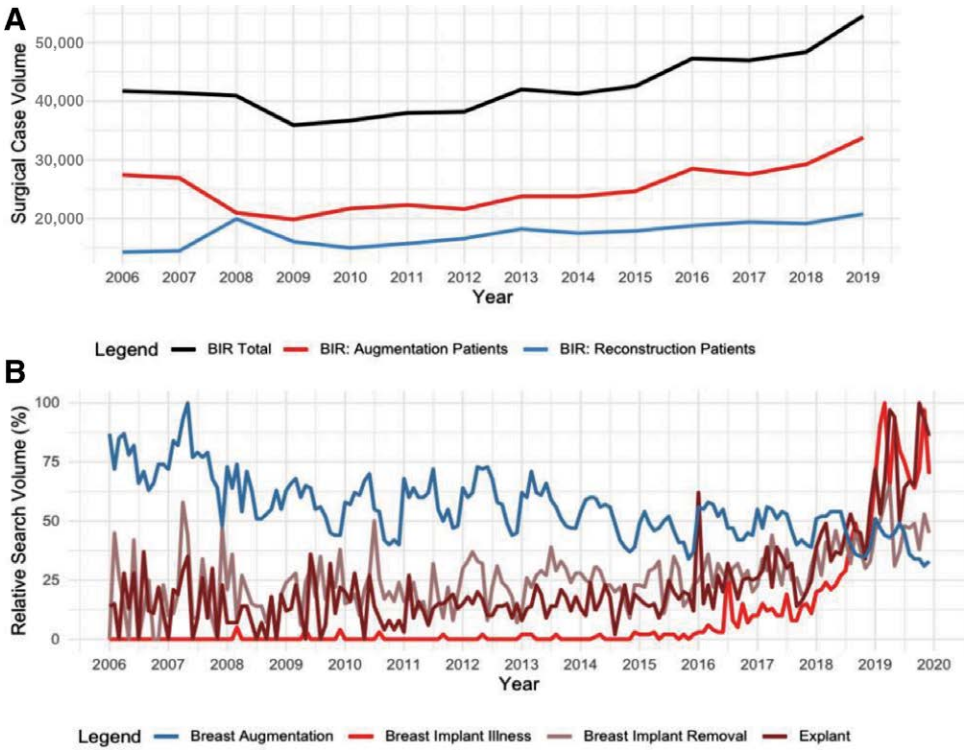

Fig. 1. Case volume trends. A, 2006-2019 Case volume for breast implant removal (augmentation, reconstruction, and total) as reported by ASPS. B, 2006-2019 Google Trends relative search volume for related terms.

RESULTS

Analysis of breast implant removal (BIR) case volumes from 2006 through 2019 on a year-by-year basis demonstrated a total increase of 30.7%. Patients with prior primary augmentations saw a 23% increase in BIR, and patients with prior implant-based reconstruction had a 31.3% increase in removal (Fig. 1A). In addition, longitudinal analysis of Google search interest in the same time period revealed increasing interest in "breast implant illness," "breast implant removal," and "explant" with a decreasing interest in "breast augmentation" (Fig. 1B).

BIR-related search queries included in our study demonstrated moderately strong pairwise correlations, suggesting a network of related search terms (Fig. 2). The term "breast implant removal" was significantly correlated to the terms "explant" [$\rho = 0.554$], "breast implant illness" [$\rho = 0.512$], "breast implant recall" [$\rho = 0.373$], "ALCL" [$\rho = 0.347$], "BII" [$\rho = 0.284$], and "ALCL lymphoma [$\rho = 0.283$]" ($P < 0.001$). For "breast augmentation," there were significant negative correlations with "breast implant illness" [$\rho = -0.532$], "breast implant recall" [$\rho = -0.425$], "BII" [$\rho = -0.384$], and "explant" [$\rho = -0.337$] ($P < 0.001$). A full list of pairwise correlations for "breast implant removal" and "breast augmentation" is provided (Table 1).

Several of these BIR-related search queries also demonstrated significant correlations with actual case volume of BIR reported by ASPS. This included the queries "explant" ($\rho = 0.912$, $P < 0.0001$), "breast implant removal" $\rho = 0.895$, $P < 0.0001$), "breast implant illness" ($\rho = 0.820$, $P < 0.001$), "BII" ($\rho = 0.600$, $P < 0.05$), "ALCL" ($\rho = 0.596$, $P < 0.05$), and "breast augmentation" ($\rho = -0.574$, $P < 0.05$) (Table 2). In addition, RSV for the

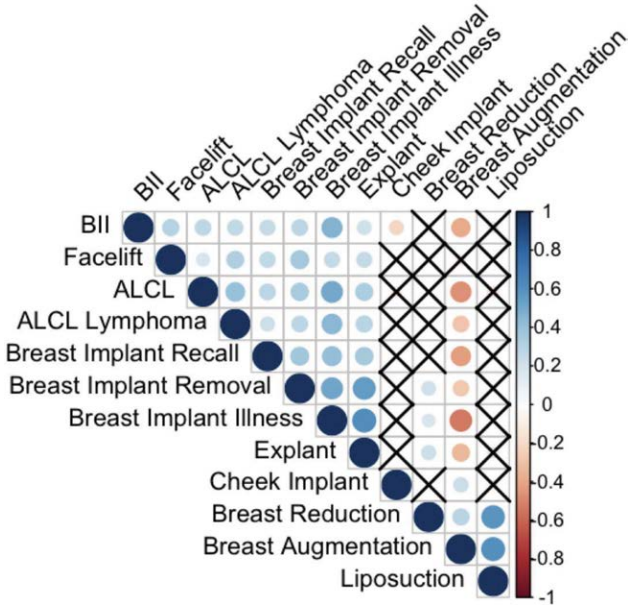

Fig. 2. Correlogram for BIR-related terms and three unrelated plastic surgery terms ("liposuction," "facelift," and "cheek implant"). "X" marks nonsignificant pairwise comparisons ($P > 0.05$). The red to blue gradient display represents correlation outputs ranging from −1 to 1, respectively.

Table 1. Pairwise GT Search Queries for "Breast Implant Removal" and "Breast Augmentation"

Query 1:	Query 2:	ρ (Correlation Coefficient)	*P* (Pearson's)
"Breast implant removal"	"Explant"	0.554	6.66E-15
"Breast implant removal"	"Breast implant illness"	0.512	1.28E-12
"Breast implant removal"	"Breast implant recall"	0.373	6.25E-07
"Breast implant removal"	"ALCL"	0.347	4.10E-06
"Breast implant removal"	"BII"	0.284	0.000192
"Breast implant removal"	"ALCL lymphoma"	0.283	0.000190
"Breast implant removal"	"Breast reduction"	0.216	0.00488
"Breast implant removal"	"Liposuction"	0.0633	0.415
"Breast implant removal"	"Facelift"	0.369	8.59E-07
"Breast implant removal"	"Cheek implant"	−0.0414	0.594
"Breast augmentation"	"Breast implant illness"	−0.532	1.13E-13
"Breast augmentation"	"Explant"	−0.337	7.89E-06
"Breast augmentation"	"Breast implant recall"	−0.425	9.25E-09
"Breast augmentation"	"BII"	−0.384	2.73E-07
"Breast augmentation"	"Liposuction"	0.601	2.20E-16
"Breast augmentation"	"Breast reduction"	0.296	9.66E-05
"Breast augmentation"	"Cheek implant"	0.231	0.00263
"Breast augmentation"	"Breast implant removal"	0.216	0.00488

ASPS cosmetic procedures unrelated to BIR demonstrated no significant correlation with BIR case volume; this included "cheek implant," "liposuction," and "facelift."

The geographical distribution of search interest for BIR from 2006 to 2019 also demonstrated increasing interest in BIR not limited to a particular geographical designation, paralleled with decreasing interest in breast augmentation across the country (**See Video [online],** which displays longitudinal interest profiles for "breast augmentation" and "breast implant removal" by state in the United States, from 2006 to 2019). 2019 GT geospatial analysis demonstrated that search interest for the basketed term "breast implant removal + explant" was clustered in 22 hotspot states; in comparison, the remaining US states were shown to have negligible relative search interest in BIR. From our indexed surgical demand analysis, an approximately five-fold difference was noted between Nevada and New York, the hotspot states with the most and least BIR surgical demand respectively (Table 3, Fig. 3).

DISCUSSION

It is vitally important to consider factors driving patient behavior and market demand outside of the direct influence of clinicians. Although physicians can frequently help establish the choice architecture to better inform patients, there are still subversive environmental influences that can impact patient decision-making.[16] Outside of the clinic, social media platforms and the associated health information seeking behaviors can result in a disproportionate response to uncommon but alarming events such as implant side effects.[7,9]

Large data analysis using tools like GT can help providers better identify patient concerns that directly correlate with surgical demand. Google search volume data are unsolicited and anonymous, reducing a source of potential bias felt by patients who may want to conform to physician expectations.[16,17]

Our previous study highlighted a 235% increase in "breast implant removal" and 527% increase in "explant" RSVs, respectively, from 2006 to 2019 (in press). In addition, we found that search terms such as "breast implant illness" and "ALCL" were queries and/or topics related to BIR that demonstrated similar increases in interest (in press). Indeed, mainstream and social media have

Table 2. GT Search Queries and Surgical Volume Ranked by ρ and Significance

Query:	ρ (Correlation Coefficient)	*P* (Pearson's)
Explant	0.912	1.31e-5*
Breast implant removal	0.895	2.11e-5*
Breast implant illness	0.820	0.000325*
BII	0.600	0.0262*
ALCL	0.596	0.0275*
Breast augmentation	−0.574	0.0350*
ALCL lymphoma	0.411	0.146
Breast reduction	0.336	0.240
Cheek implant	−0.257	0.374
Liposuction	0.209	0.473
Breast implant recall	0.139	0.635
Facelift	−0.125	0.669

Table 3. The 22 Hotspot States for Interest in Breast Implant Removal in 2019, Ranked by Surgical Demand Index

State	Surgical Demand Index for BIR	BIR RSV	No. ASPS Surgeons	State Population	Surgical Density (Surgeons/ 10k People)
Nevada	769.231	90	36	30,80156	0.117
Arizona	568.182	100	128	7,278,717	0.176
Louisiana	513.333	77	70	4,648,794	0.15
Tennessee	503.817	66	90	6,829,174	0.131
Washington	428.571	54	96	7,614,893	0.126
South Carolina	411.765	56	70	5,148,714	0.136
Colorado	402.878	56	80	5,758,736	0.139
Florida	401.914	84	449	21,477,737	0.209
North Carolina	385.185	52	142	10,488,084	0.135
Texas	385.093	62	467	28,995,881	0.161
Missouri	372.263	51	84	6,137,428	0.137
California	367.021	69	742	39,512,223	0.188
Georgia	331.081	49	157	10,617,423	0.148
Ohio	328.767	48	171	11,689,100	0.146
Michigan	297.101	41	138	9,986,857	0.138
Massachusetts	276.074	45	112	6,892,503	0.163
Illinois	239.264	39	207	12,671,821	0.163
Pennsylvania	231.250	37	205	12,801,989	0.16
Maryland	195.313	50	155	6,045,680	0.256
Virginia	178.947	34	162	8,535,519	0.19
New Jersey	174.312	38	194	8,882,190	0.218
New York	153.846	36	456	19,453,561	0.234

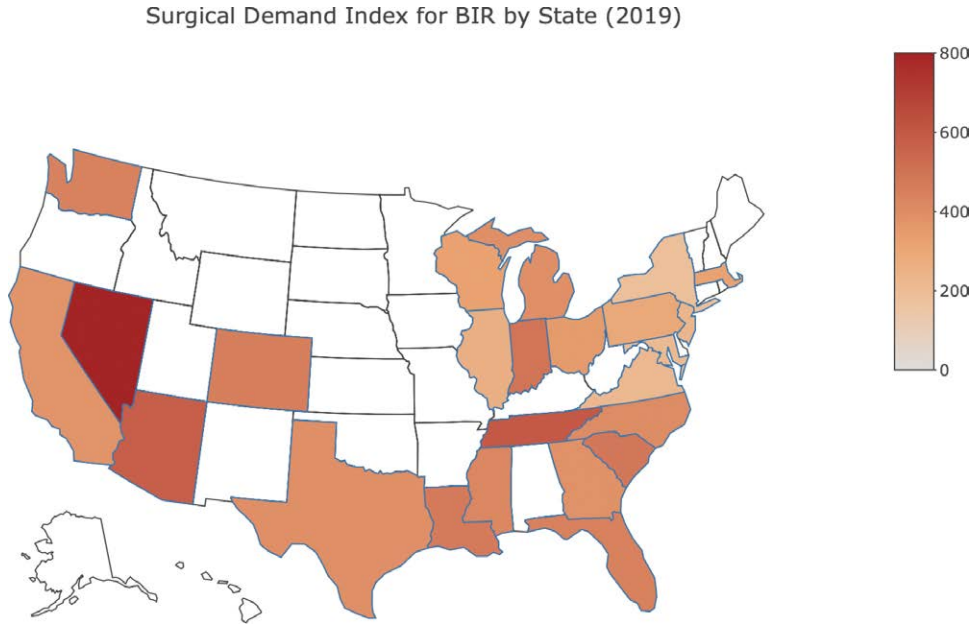

Fig. 3. Distribution of BIR surgical demand index in 2019, for the 22 hotspot states identified by GT. BIR surgical demand index was defined as (BIR RSV)/(# of active plastic surgeons per 10,000 individuals).

facilitated discussion regarding BII and associated symptoms, despite a lack of consensus in scientific literature.[9,18] In our current analysis, it has become clear that these topics significantly correlate with changes in BIR case volume and demand, as previously shown in Table 2.

Our correlogram in Figure 2 demonstrates that BIR-related search terms are not independent entities but instead form a network of interconnected concerns. Particularly with the advent of targeted advertising, a Google search for a particular healthcare query or phenomenon is no longer an isolated event.[19] Instead, it draws internet users' attention to related topics that may further intensify their initial concerns. We identified a network of queries that reflect patient concerns, possibly driving recent trends in BIR; as demonstrated in Table 2, the majority of these terms were found to be significantly correlated with BIR case volume.

Visual display of BIR and breast augmentation interest from 2006 to 2019, as in **Video 1**, shows increased interest in BIR that should be recognized. A large driver of this increased interest may be attributed to patient dissatisfaction. Upwards of 22% of cases in tissue expander and implant removal patients have been shown to be elective,[11] and 17% have been attributed to negative publicity, perhaps surrounding topics including BII and ALCL.[20,21] Such large margins demonstrate how dependent the implant market can be on public sentiment.

Our findings are most relevant to the areas of high BIR surgical demand identified in our study, such as Nevada, Arizona, and Louisiana. Although Nevada and Arizona were not identified to be hotspot states for BIR in 2006, they now represent the first and second highest surgical demand for BIR, respectively, as shown in Table 3. Our findings regarding patient concerns can be used to equip surgeons in areas of high demand with information to better support their patient populations.

LIMITATIONS

There are limitations unique to this type of analysis. GT only captures the search data for individuals with internet access who use Google as their primary search engine. However, given Google's market capture of 87.69% of the search engine market[10] for the estimated 313 million Americans with internet,[22] it is likely that the sampled data capture the majority of BIR patients. Even still, particularly focused search terms may return a low RSV that can be difficult to interpret. For instance, the scope of Google searches cannot be narrowed from "breast implant removal" to "tissue expander breast implant removal" without compromising data set quality. The time frame of this study was also restricted by data availability from GT, the US Census Bureau, and ASPS. On this note, the number of ASPS plastic surgeons per state is publicly available and a useful proxy for the number of active plastic surgeons per state, but these two parameters are not identical. Lastly, correlated search terms cannot be mistaken as definitive causes for BIR trends. Instead, they serve to provide an insight into the social pulse surrounding these trends.

CONCLUSIONS

In conclusion, GT can be used as a powerful tool to understand BIR trends by providing large data sets acquired outside of the healthcare setting. Our results demonstrate that many BIR-related concerns such as BII and ALCL are correlated with each other. Furthermore, for the vast majority of these terms, there exists a significant correlation between Google search volume and surgical case volume for BIR. This demonstrates how Google search interest can be related to and used to assess surgical demand. It is also clear from our large data analysis that overall public interest in BIR has risen dramatically in

recent years. It is therefore critical that healthcare providers, particularly in areas of high BIR surgical demand, be cognizant of these major movements in the field.

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