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Research Article

# Internet Search Trend Analysis Tools Provide Insight into Skin Disease Healthcare Utilization

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**Abstract**

**Background:** About eight million adults search online for health information each day in the United States; the majority start their search at a search engine. In recent years, search engine query data has emerged as a potentially reliable source of epidemiological data. In the field of dermatology, there is a paucity of data indicating which types of provider's patients seek for care. Knowledge of such trends would be an important gauge of dermatologists' impact on skin diseases.

**Objective:** We sought to determine whether Web-based search queries could provide insight into trends in skin disease healthcare utilization.

**Methods:** We catalogued diseases treated by dermatologists, then performed Google Trends queries for each condition alongside dermatology and other pre-specified non-dermatologist providers(s), to determine whether conditions would correlate with searches for dermatology or non-dermatologist providers.

**Results:** Overall, the majority of skin conditions searched for did not trend with searches for dermatology.

**Limitations:** It is unknown whether the same individuals are searching for both diseases and providers.

**Conclusion:** Our findings underscore the importance of future education of the public regarding the role of the dermatologist in the management of certain skin conditions.

## INTRODUCTION

An estimated eight million adults search online for health information each day in the United States (U.S.), and 66% begin their internet session at a search engine. [1] In 2008, search engine queries began to emerge as a reliable source of population-based health information when a leading search engine provider, Google, demonstrated that queries for influenza-related symptoms could predict an influenza outbreak one to two weeks faster than the Centers for Disease Control and Prevention surveillance data [2,3]. Recently, Schuster et al. demonstrated that search engine query data accurately predicted trends in pharmaceutical revenues and Medicare utilization in several U.S. metropolitan areas [4]. These examples underscore the potential utility for search engine analysis tools in identifying, and possibly predicting, healthcare trends. These tools are available to the public in various formats: Google Trends (GT) (google.com/trends), Google Flu Trends (google.com/flutrends), Google Dengue Trends (google.org/denguetrends) and the related Google Correlate (google.com/trends/correlate). Of these, GT seems to be the most versatile tool available at this time for generation of epidemiological analyses, including infectious diseases and the occurrence of kidney stones [2,3,5].

The scope of skin disease is broad, and there is often overlap between dermatologists and non-dermatologist providers in the diagnosis and treatment of conditions of the hair, skin, and nails. For example, a recent study which analyzed population-based data from the National Psoriasis Foundation reported that patients seek treatment for psoriasis from dermatologists, rheumatologists, internists, family practitioners, and other medical providers [6]. In the realm of cosmetic dermatology, plastic surgeons and other non-dermatology physicians performed the majority of ambulatory cosmetic dermatologic procedures from 1995 to 2010, with just one-third being performed by dermatologists [7]. For some dermatologic conditions such as melasma, there is a paucity of data indicating which specialist patients seek for care. Supply constraints in dermatology, along

with economic, geographic, and psychosocial elements may all play a role in skincare-seeking patterns [6,8]. It is our opinion that knowledge of such trends, and how they have changed over time, would be an important gauge of dermatologists' impact on skin diseases. We postulate that Google search queries could provide insight into consumer trends for skin-directed health care utilization among providers. Thus, we analyzed GT query data for a wide array of skin diseases to compare their correlation with queries for dermatologists and other non-dermatologist providers. Specifically, we sought to determine if searches for specific skin disease(s) correlate more with dermatologists or non-dermatologists.

## METHODS

### Data Collection using GT Technology

We catalogued 47 dermatologic conditions thought to sample from the scope of dermatology (Table 1) and selected non-dermatologist providers likely to care for each condition. Then, we

**Table 1:**

| Skin disease-related search term | Correlation with Dermatology* | Non-dermatologist provider(s)◊ | Correlation with non-dermatologist provider§ |
|---|---|---|---|
| *Blistering diseases* | | | |
| Blisters | 0.7615 | P, I | 0.5313 |
| Pemphigoid ("bullous pemphigoid" + pemphigoid) | 0.4300 | R | 0.2218 |
| Pemphigus (pemphigus + "pemphigus vulgaris") | 0.0829 | R | -0.0466 |
| *Connective Tissue Diseases* | | | |
| Lupus | 0.1381 | R | 0.2145 |
| Scleroderma | 0.1323 | R | -0.0212 |
| Morphea | 0.1886 | R | -0.2316 |
| *Cosmetic* | | | |
| Botox | 0.3611 | A, PS | 0.2700 |
| Fillers (juvederm+restylane+radiesse+sculptra) | 0.4177 | A, VS | 0.3292 |
| Sclerotherapy ("vericose vein treatment"+"varicose veins"+sclerotherapy) | 0.6378 | PS, VS | 0.3204 |
| Dermabrasion | 0.3909 | PS, A | 0.1491 |
| "Laser hair removal" | 0.1776 | PS, A | 0.3257 |
| Laser skin resurface ("laser skin resurfacing"+"laser peel"+"co2 laser resurfacing"+"erbium laser resurfacing"+"fraxel laser resurfacing") | 0.0828 | PS, A | 0.1537 |
| *Follicular Disorders* | | | |
| Acne (acne+"acne treatment") | 0.8909 | A | 0.6130 |
| Rosacea (rosacea+"rosacea treatment") | 0.0120 | I | -0.0119 |
| Hair loss ("hair loss"+"hair loss treatment"+alopecia) | 0.2011 | PS | 0.1359 |
| *Granulomatous Disease* | | | |
| "Granuloma Annulare" | 0.4824 | R | 0.2885 |
| Sarcoidosis (sarcoid+sarcoidosis) | 0.0435 | R | -0.0501 |
| *Infectious Disease* | | | |
| Bed bugs ("bed bugs"+"bed bug bites") | 0.7663 | P, I, F | 0.7188 |
| HFMD ("hand foot mouth"+"hand foot mouth disease") | 0.1870 | P, F | 0.0399 |
| Leprosy (leprosy+"leprosy symptoms") | 0.0561 | P, I, F | -0.0223 |
| Lyme Disease ("lyme disease"+"lyme disease rash") | 0.2935 | P, I, F | 0.0768 |
| Mites ("mites"-animal+"mite infestation"-animal) | 0.4025 | P, I, F | 0.1863 |
| Scabies ("scabies rash"+scabies) | 0.7033 | P, I, F | 0.6703 |
| Shingles ("herpes zoster"+zoster+"shingles"-roof) | 0.6168 | I, F | 0.4325 |
| Syphilis (syphilis+"syphilis rash") | 0.3267 | I, F | 0.1810 |
| Warts (warts+"skin warts"+"warts treatment") | 0.0391 | P, I, F | -0.0082 |
| *Miscellaneous* | | | |
| Rash (rash+"skin rash") | 0.8724 | P, I, F | 0.6690 |
| Spider Bite ("spider bite"+"spider bite rash") | 0.5333 | P, I, F | 0.3336 |
| "Stretch marks" | 0.8971 | PS | 0.3976 |
| *Neoplasms* | | | |
| Cyst | 0.8847 | P, I, F | 0.8018 |
| Keloids(keloids+"keloid scar"+"keloid treatment"+"keloid removal") | 0.3732 | PS | 0.3352 |
| Melanoma (melanoma+"melanoma signs"+"melanoma symptoms"+"malignant melanoma") | 0.0094 | Onc | 0.4785 |
| Mole ("mole"-animal-rat-chemistry-recipe-food) | 0.3625 | PS | 0.0391 |
| Skin Cancer ("skin cancer"+"skin cancer signs"+"skin cancer symptoms") | 0.1021 | I | -0.1746 |
| Skin growth ("skin growth"+"skin tumor") | 0.1482 | PS | -0.114 |
| Sun spots ("skin sun spots"+"sun spots") | 0.0060 | PS | -0.0658 |
| Sun damage ("sun damage"+"sun damaged skin"+"sun damage treatment") | 0.3877 | PS | 0.1064 |
| *Papulosquamous Disorders* | | | |
| Eczema ("dry skin"+eczema+"eczema treatment") | 0.6641 | P, I, F | 0.6429 |
| Lichen planus | 0.1306 | I | 0.0149 |
| Poison Ivy ("poison ivy"+"poison ivy rash"+"poison ivy treatment") | 0.3836 | P, I, F | 0.1522 |

| | | | |
|---|---|---|---|
| Psoriasis (psoriasis+"psoriasis treatment") | 0.5208 | R | 0.5071 |
| Seborrheic dermatitis (seborrhea+seborrheic+"seborrheic dermatitis") | 0.5618 | P, I, F | 0.5386 |
| *Pediatric Skin Diseases* | | | |
| Birth mark("birth mark"+"birthmark"+"birth mark removal") | 0.2307 | P, PS | 0.2627 |
| Hemangioma ("strawberry hemangioma"+hemangioma+"hemangioma removal") | 0.1715 | P, PS | 0.1275 |
| Kawasaki Disease ("kawasaki disease"+"kawasaki disease rash"+"kawasaki rash"+"kawasaki disease symptoms") | 0.1018 | P, Card | 0.1045 |
| *Pigmentary Disorders* | | | |
| Melasma (melasma+"pregnancy skin darkening") | 0.4208 | Ob, PS | 0.1470 |
| Vitiligo (vitiligo+"vitiligo treatment") | 0.2082 | PS | 0.0897 |
| *Ulcerative Skin Disorders* | | | |
| Foot ulcer ("foot ulcer" +"skin ulcer" +"foot ulcer treatment") | -0.0076 | I, Po | 0.7559 |

*Search terms used: dermatology + dermatologist.

◊ The following search terms were used for non-dermatologist specialists: Aesthetician +esthetician (A); Cardiology+ cardiologist (Card), "Family doctor" +"family practice" +"family practice doctor" (F); "Internal medicine" +internist (I); Obstetrics+ obstetrician+ gynecology+ gynecologist (Ob); Oncology+ oncologist (Onc); Pediatrics +Pediatrician (P); "Plastic surgery" +"plastic surgeon" (PS); Podiatry +Podiatrist (Po); Rheumatology +Rheumatologist (R), "Vascular surgery"+ "Vascular surgeon" (VS)

§Correlations represent the search terms for non-dermatologist specialists with highest correlation among all non-dermatology specialists queried for comparison.

performed GT queries for each condition alongside dermatology and each pre-specified non-dermatologist provider(s). We obtained weekly GT query data from January 2004 to June 2013 within the United States.

All query outputs from GT are normalized by dividing a data set by its largest variable to allow for comparisons between variables. To increase sensitivity for detection of future changes in search volume index (SVI), GT also divides by an unrelated and common Web search query. Normalization also factors out the effect of a larger population on SVI. For such purposes, GT uses Internet protocol addresses from server logs to establish the origin of Web-based queries.

After normalization, GT scales the result for each query entry relative to its average search volume over the time period selected. GT displays a relative SVI graph based on a fraction of total Google Web searches over a specified period of time and extrapolates the data to estimate total search volume. This information is currently updated daily. Users may enter up to five individual queries and limit searches to certain locations, as well as apply category filters such as "Health" or "Finance." For users logged in to a Google account (available to Internet users at no cost), the results of GT queries can be downloaded as a comma-separated value file for subsequent statistical analysis (Figure 1) [3].

The use of symbols removes ambiguity in GT searches. For example, an addition (+) sign combines searches whereas a subtraction (-) excludes searches. For example, a GT query for "shingles– roof" includes queries for shingles but excludes queries that include roof, thereby increasing the likelihood that the query refers to herpes zoster rather than home repair or construction-related queries. A quotation mark will restrict the query to Google searches with words in that order. The specific queries used in this study can be found in Table 1.

### Statistical Analysis

For each queried skin condition, Pearson correlation coefficient analyses were performed to determine the correlation between queries for each skin condition and queries for particular providers (dermatology versus non-dermatologist providers). Specifically, we sought to determine whether search trends for each condition would correlate ($R > 0.50$) with searches for "dermatology" and not correlate ($R < 0.50$) with queries for an alternative non-dermatologist provider(s), or vice versa. For calculation, weekly GT relative query values for all skin-related conditions were compared to weekly GT relative query values for dermatology and non-dermatologist providers. Weekly data from January 2004 to June 2013 was analyzed as a whole, and subsequently divided into four-year increments (2004 to 2008 and 2009 to 2013) to see whether correlations, if present, had changed over time. The correlation values obtained were subsequently entered into a cluster analysis to explore the statistical relationship, if any, between Web-based searches for a condition and particular provider(s).

## RESULTS

Table 1 lists the correlation among queries for each skin condition and queries for particular providers from 2004 to 2013. If multiple non-dermatologist providers were used for comparison, the R-value of the highest correlating provider was listed in Table 1 and used for subsequent statistical analysis. Table 2 lists those queries for skin conditions which correlated ($R > 0.50$) with searches for "dermatology" and did not correlate ($R < 0.50$) with queries for an alternative non-dermatologist provider, and vice versa, for each of the three time periods analyzed (2004-13, 2004-8, 2009-13). Overall, the majority of queried skin conditions for did not trend with searches for dermatology. Searches for six of the skin conditions (blisters, cyst, rash, shingles, spider bite, and stretch marks) correlated with searches for dermatology over two time periods, 2004-2008 and 2009-2013 ($R > 0.50$ with searches for dermatology and $R < 0.50$ with searches for alternative non-dermatologist providers). The number of searches for skin conditions that correlated with dermatology more than doubled between 2004-2008 and 2009-2013, while the number of searches for skin conditions that correlated with non-dermatologist providers remained stable over time.

Multiple clustering analysis algorithms were applied to the data sets, including k-means and single linkage with docking to detect outliers. Each clustering algorithm demonstrated

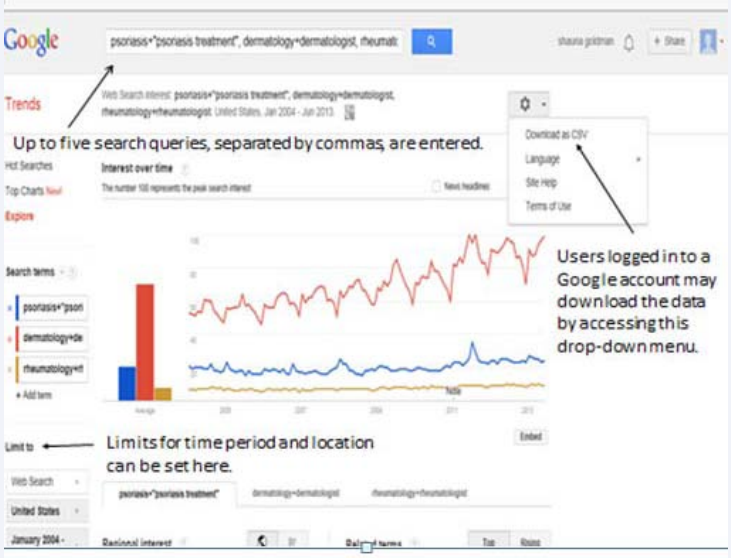


**Figure 1**

**Table 2:**

| 2004-2013 | | 2004-2008 | | 2009-2013 | |
|---|---|---|---|---|---|
| ***Queries that correlated with dermatology**** | ***Queries that correlated with non-dermatologist provider**** | ***Queries that correlated with dermatology*** | ***Queries that correlated with non-dermatologist provider*** | ***Queries that correlated with dermatology*** | ***Queries that correlated with non-dermatologist provider*** |
| Sclerotherapy | Foot ulcer | Blisters | Laser hair removal | Blisters | Foot ulcer |
| Shingles | | Cyst | Dermabrasion | Cyst | Seborrheic dermatitis |
| Spider bite | | Rash | | Rash | |
| Stretch marks | | Shingles | | Shingles | |
| | | Spider bite | | Spider bite | |
| | | Stretch marks | | Stretch marks | |
| | | | | Hand, Foot and Mouth Disease | |
| | | | | Keloids | |
| | | | | Lyme Disease | |
| | | | | Laser hair removal | |
| | | | | Mites | |
| | | | | Poison Ivy | |
| | | | | Sclerotherapy | |
| | | | | Warts | |

** R>0.5 for dermatology, R<0.5 for alternative non-dermatologist provider; ** R>0.5 for non-dermatologist provider, R<0.5 for dermatology*

substantially different clusters such that overall, our analysis failed to reveal statistically significant distinctions between queries for particular groups of skin conditions, such as follicular or pigmentary disorders, and either dermatology or non-dermatologist providers.

Despite the lack of groups of skin disorders to cluster with particular specialties, results for individual skin-related conditions were noteworthy. For example, Web-based searches for "skin rashes" were highly associated with dermatology throughout the time course included in the study (R = 0.72, 0.81 for 04-08 and 09-13 respectively). Also, bed bugs were highly associated (R = 0.76) with dermatology and non-dermatologist providers (family medicine and pediatrics) prior to 2010. After 2010, however, queries for bed bugs failed to associate as strongly (R = 0.40) with queries for dermatologists or non-dermatologist providers. Analysis of queries for the following conditions demonstrated an increased association with queries for dermatology over the course of this study: acne, blister, cysts, mites, scleroderma, stretch marks, warts, and herpes zoster.

## DISCUSSION

Currently, there is a demand for skin disease-related care in the U.S. that is being increasingly met by non-dermatologists [9]. The treatment approach to common skin conditions can differ

significantly depending on the physician provider, which may result in decreased quality of care received by these patients [10,11]. GT is a potential useful source of population-based healthcare data capable of accurately and expeditiously gauging patient health care utilization [2,3]. Our data supports that GT query analysis is a potentially useful tool for evaluating searching behaviors related to skin disease and skin-directed healthcare.

The cluster analysis data failed to reveal meaningful clusters between groups of skin conditions and dermatology or non-dermatologist providers. These results suggest that people performing Web-based searches for information related to particular types of skin disease are not searching chronologically for particular providers. These findings indicate the importance of future education of the public regarding the role of the dermatologist. The finding that queries for skin rash were associated with dermatology throughout the course of the study indicates that there is public awareness of the role of the dermatologist in the treatment of this condition. Moreover, the increased association between queries for dermatology and queries for acne, blister, cyst, mites, scleroderma, stretch marks, warts, and herpes zoster over the study period may indicate that public knowledge of the role of the dermatologist in these areas has increased over the previous decade. Interestingly, searches for six of the skin conditions (blisters, cyst, rash, shingles, spider bite, and stretch marks) correlated with searches for dermatology over two time periods, 2004-2008 and 2009-2013, but not over the 2004-2013 time period. This is a point for further investigation and highlights the need for further analysis of the search trends over extended periods of time.

As noted above, the application of the clustering algorithm suggests interesting associations for several of the Web-based queries included in this study. Whereas Web-based queries for bed bugs are associated with dermatology and non-dermatologist providers prior to 2010, this association was lost in the following years. This change is most likely a result of the spike in SVI for bed bugs in late 2010, which reflected the epidemic of bed bugs in the New York City area as described by news headlines during that time period. It would not be expected that this spike in interest was due to patients searching for care of a condition and, more likely, reflect increased public interest in the epidemic.

It is important to note the limitations of our study and those inherent to use of the GT tool. Most importantly, the demographics of search engine users (sex, age, ethnicity, medical history, socioeconomic status, or other relevant factors) are not available. This limitation might be adjudicated in the future as social media devices extend their products for searching, such as Face book's Graph Search®. Also, search algorithms are not available to researchers for modification, and thus, it is not possible to know if correspondent search indices are generated from the same user group. Further, data extraction from GT is largely dependent on user-generated search terms, and thus, more relevant and correlated terms may not be recognized for analysis. Nonetheless, the substantial, and near real-time, data available through Google is a potentially useful analysis tool worthy of further exploration.

We have demonstrated how search query data can provide insight into healthcare utilization trends for skin disease and explored whether the trends differ by provider. The treatment approach and quality of care may substantially differ among those providing care for skin disease, [10,11] and thus an understanding of patient health seeking behavior can help gauge areas that need improved patient education regarding the role of the dermatologist.

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