

Internet Search Engine Queries of Common Causes of Blindness and Low Vision in the United States



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- **PURPOSE:** To characterize Internet search engine patterns of American Internet users for common causes of blindness and low vision.
- **DESIGN:** A retrospective cross-sectional study.
- **METHODS:** Retrospective analysis with publicly available Google trends data from January 1, 2004, to January 1, 2020, using Google search engine. Patient population: Random sample of US and worldwide Internet users who searched for information on the topics of cataract, macular degeneration, glaucoma, diabetic retinopathy, and near-sightedness using the Google search engine. Main outcome measures: Percentage of searches related to disease and treatment education for each condition.
- **RESULTS:** Cataract searches most commonly pertain to treatment education (72.3%) and disease education (23.6%). Glaucoma, macular degeneration, and near-sightedness searches more commonly pertained to disease education (69.5%, 64.0%, 50.4% respectively) than treatment education (18.4%, 17.9%, 10.7% respectively). Diabetic retinopathy searches related to other diseases (41.5%), followed by disease education (33.5%) and treatment education (8.2%). Mean relative search frequency (RSF) values for queries were 66.7 ± 13.3 , 58.6 ± 6.2 , 33.3 ± 6.7 , 29.2 ± 6.5 , and 8.6 ± 1.4 for cataract, glaucoma, near-sightedness, diabetic retinopathy, and macular degeneration, respectively, with all pairwise comparisons yielding statistically significant values ($P < .001$). RSF was found to be fairly well correlated with North American blindness prevalence by condition ($r^2 = 0.5898$).
- **CONCLUSION:** The search results of American Internet search users yield information on disease basics or treatment education for the disease. The most commonly searched queries for each condition yield different types of information with cataract queries presenting more commonly with treatment information. These results may inform future patient education practices. (Am J

Ophthalmol 2021;222:373–381. © 2020 Elsevier Inc. All rights reserved.)

INTERNET SEARCH ENGINES SUCH AS GOOGLE, BING, AND others are becoming prominent sources of health care information for many patients. A recent news report noted that Google receives about 70,000 health-related searches per minute.¹ Search engines are a unique source of health information for patients because they empower those with Internet access to find information quickly and for free. They also allow individuals to search for specific aspects of a given topic such as more information on their condition and information on treatment options and, thus, are powerful tools for educating patients.

Search engines and the data that emerge from them are useful tools from the clinical perspective because they not only serve as a source of education for many health care professionals, but also they provide data on how patients and the general public interact with health topics. Previous studies in other areas of health care have demonstrated the value of search engines as a tracker of seasonal trends of diseases such as Swine flu ($\mu = 0.047 \pm 0.028$, $r^2 = 0.86$) and the influenza outbreak (GARMA model, forecast confidence 83%, $P = .0005$).^{2,3} Furthermore, retrospective studies have shown that suicide search queries are associated with suicide rates in the United Kingdom for individuals aged 25-34 years ($\rho = 0.848$; $P = .002$) and Italy ($\rho = 0.482$, P value $< .001$).^{4,5}

Google Trends (<https://google.com/trends>) is a publicly available tool reporting search trends of the search engine Google that is based on a sample of Google searches in a given geographic location and time period.⁶ Rather than reporting total search volume, Google Trends provides data in terms of the relative popularity of a given search term divided by the total included search terms as varied by time and geography. These data, represented as the relative search frequency (RSF) value, ranges from 0 to 100, with 100 representing the peak RSF of all terms included in a search. Google Trends also reports top related queries and rising searches. The peak RSF (value of 100) or max search volume can occur at any one time point within the searched time frame and reported values at other time points are based on a relative comparison to that value. For example, the value of 50 at a given time

Accepted for publication Sep 24, 2020.

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point means that the term is half as popular as the number of searches for the time point with the greatest volume of searches within the specified search period. Top related searches refer to the most frequent queried phrases related to the given entered term, but the related query does not necessarily have the originally entered term. Rising searches are terms related to the queried keyword or phrase that have the most significant growth in volume in the searched time period. Search topics are a group of terms that share the same concept in any language whereas the search term shows matches for all terms in the query based on the language used to query.⁷ Search topics are predetermined and named by the Google algorithm and include searches on a topic while considering words with similar meaning (eg, near-sightedness vs myopia), misspellings, different languages, and minor search variations (eg, near-sightedness vs near sighted).

There has been a fair amount of research examining how patients utilize search engines in relation to general public interest, health outcomes, and health behaviors in other fields of medicine, but there has been scant research done examining how search engine queries are used in the field of ophthalmology. One study compared trends of the search term LASIK in Google between January 2007 to January 2011 and found the topic to have waning interest among the general public in the United States, India, and the United Kingdom (−40%, −24%, −22%).⁸ More recently, research has established that Google search trends may correlate with seasonal allergic conjunctivitis within the United States ($\rho = 0.44$, 95% confidence interval 0.24–0.60; $P < .001$) and be indicative of potential candidate conjunctivitis epidemics worldwide ($P < .001$).^{9,10} Notwithstanding, little is known about how the general public uses search engines to understand common causes of vision loss and blindness such as myopia, cataract, glaucoma, age-related macular degeneration, and diabetic retinopathy. The goal of this research is to elucidate the search trends of American Internet search users for these vision-impairing conditions. Understanding Internet search engine trends can inform the ophthalmic community and practitioners what topics within each condition are of greatest importance to the typical Internet search user and may indicate areas where providers can better educate their patients. The hypothesis for this study is that cataract is the most commonly searched cause of vision loss on the Internet considering its high prevalence.

METHODS

A RETROSPECTIVE STUDY WAS CONDUCTED WITH PUBLICLY available Google Trends data (<https://google.com/trends>, Mountain View, California, USA). This study was exempt from IRB approval because of the public nature of the data set. Informed consent was not required due to the

retrospective nature and the IRB exempt status of this study. All study procedures adhere to the Declaration of Helsinki and all federal and state laws. Google Trends data were selected as the data source because of data accessibility and popularity of Google as a search engine owning approximately 85% of market share (as of November 2019).

As stated in the introduction, the RSF data point in the data set that represents the highest number of searches for the most popular search of all chosen terms for a given time point (eg, month for this paper) within the searched time period is normalized to the value of 100. All other data points are normalized proportionally to this point. For example, a data point that represents 25% fewer searches than the peak data point will be represented by a number of 75. Consequently, these scores can be treated as data points that proxies the actual volume of searches because they are all standardized to the same peak data point, which is the highest number of searches for the most popular search of all chosen terms.

The “checklist for documentation of Google Trends” has been used to report search methods to promote reproducibility.¹¹ Trends reported are of US-based queries utilizing 5 common causes of low vision and blindness, with near-sightedness being included as a proxy for refractive errors.¹² The search frequency for the topics “cataract,” “glaucoma,” “near-sightedness,” “diabetic retinopathy,” and “macular degeneration” were compared. Searching by topic allows for the inclusion of searches of different languages. In a preliminary search, other related terms (eg, macular degeneration vs age-related macular degeneration) were compared to determine the search term most commonly used. Monthly RSF of each term was assessed between January 1, 2004, to January 1, 2020, to encapsulate yearly search pattern data from the onset of Google collecting and reporting this information. A regression model was fitted for each disease with the RSF value serving as the dependent variable and time in months being the independent variable.

To determine if Internet relative search frequencies were associated with disease prevalence, the Google trends data collected for each condition was plotted against prevalence data for each condition from the International Agency for the Prevention of Blindness (IAPB) Vision Atlas (<http://atlas.iapb.org/>, London, United Kingdom). The vision atlas reports condition-inducing blindness and severe/moderate vision loss prevalence for North America among other global burden of disease regions. Blindness is defined as visual acuity $<3/60$ in the better eye and moderate and severe visual impairment is defined as visual acuity $<6/18$ to $\geq 3/60$. Prevalence data are reported for the years 2005, 2010, 2015, and 2020. Consequently, the Google Trends average relative Internet search frequencies for the calendar years 2005, 2010, 2015, and 2019 were compared respectively for blindness prevalence and severe/moderate vision loss prevalence.

To analyze specific search trends, 2 graders searched in an incognito Google window for the top 25 related queries of search terms “cataract,” “glaucoma,” “myopia,” “diabetic

TABLE 1. Total 16-Year (2004-2020) RSF Average and Percent Change in Queries in the United States Based on Average RSF in the 2004 and 2019 Calendar Years

	16-year RSF Average	2004 Average RSF	2019 Average RSF	Percent Change	P Value
Cataract	66.7 ± 13.3	57.33	95.16	66.0	< .001
Glaucoma	58.6 ± 6.2	67.58	64.83	-4.1	.260
Near-sightedness	33.3 ± 6.7	27.25	41.08	50.7	< .001
Diabetic retinopathy	29.2 ± 6.5	10.25	10.83	5.6	.28
Macular degeneration	8.6 ± 1.4	43.5	28.75	-33.9	< .001

P values in the table are between the 2004 and 2019 calendar year RSF averages. Statistical comparison among the 16-year averages for all conditions yielded a P value <.001. Bold indicates significant P-value.

retinopathy,” and “macular degeneration” and categorized the searches based on the top-most (first appearing) search result into one of the following predetermined classifications: disease education, treatment education, other health information including general eye searches and other diseases, professional inquiry (eg, *International Classification of Diseases [ICD] codes*), and miscellaneous. Using the first-appearing search term considered the time challenges of searching for many terms in this study and private browsing (incognito) webpage was used to minimize personalization of search results based on previous user activity. These related search queries are commonly inputted phrases into Google that the Google algorithm identified as being commonly searched within the context of the original query inputted into Google Trends. Myopia was used as Google Trends demonstrated that it was the most common specific search term used in the topic of near-sightedness. The respective RSF values of each query were summed based on its category and organized as a percentage of the total summed RSF values of all top 25 queried topics. This can be done because all RSF scores are proportional to their original search totals. Although data on rising trends are also available, the study authors elected to not analyze these data because these values are not standardized to a common number of searches.

- **STATISTICAL ANALYSIS:** Data were analyzed with R Studio (version 1.1.463; Boston, Massachusetts, USA). RSF values among disease types were plotted with linear regression and compared with independent t test or 1-way analysis of variance with Tukey honestly significant difference for multiple comparisons. A statistical significance value of 0.05 was used. Strength of regression was assessed with coefficient of determination. Percentages are reported for top search queries by category for each disease, and a Cohen kappa statistic was performed to determine intergrader agreement.

RESULTS

- **SEARCH VOLUME TRENDS:** A total of 193 monthly RSF data points were collected from January 1, 2004, to January

1, 2020, for each disease in a US search. Mean RSF values were 66.7 ± 13.3 for cataract, 58.6 ± 6.2 for glaucoma, 33.3 ± 6.7 for near-sightedness, 29.2 ± 6.5 for diabetic retinopathy, and 8.6 ± 1.4 for macular degeneration with all pairwise comparisons yielding statistically significant values (P < .001) (Table 1). The average RSF percentage change, or the percentage change between the average RSF of calendar years 2004 and 2019 in the United States, was 66.0% (P < .001) for cataract, -4.1% (P = .260) for glaucoma, 50.7% (P < .001) for near-sightedness, 5.6% (P = .28) for diabetic retinopathy, and -33.9% (P < .001) for macular degeneration (Table 1). Linear regression (Figure 1) yielded US RSF value rate of change per month of 0.0068, 0.0034, 0.0002, less than -0.0001, and -0.0025 for cataract, near-sightedness, glaucoma, diabetic retinopathy, and macular degeneration, respectively.

- **SEARCH QUERY CLASSIFICATIONS:** For the top search queries, the summed RSF among US searches were 907, 949, 636, 606, and 288 for myopia, diabetic retinopathy, macular degeneration, glaucoma, and cataract respectively. Out of 125 websites classified, initial 2 grader agreement for category classification was 94.4% (P < .001). The most common search query category for cataract was treatment education (72.3%) followed by disease education (23.6%) (Figure 2). Disease education was the most commonly searched category for glaucoma (69.5%), macular degeneration (64.0%) with treatment education being the second most common category (18.4% and 17.9% for glaucoma and macular degeneration respectively). Myopia queries most commonly pertained to disease education (50.4%), other disease searches (29.4%), and treatment education (10.7%). Diabetic retinopathy queries most commonly related to other diseases (41.5%) followed by disease education (33.5%).

Table 2 lists the 4 most common search terms that users searched by condition and classification category. Notably, other diseases searched in conjunction with diabetic retinopathy include diabetes, diabetic neuropathy, and edema. Myopia most commonly examined for various definitions and disease basics via searches such as “myopia definition” and “what is myopia.” Cataract treatment education

Relative Frequency Score by Disease Type United States

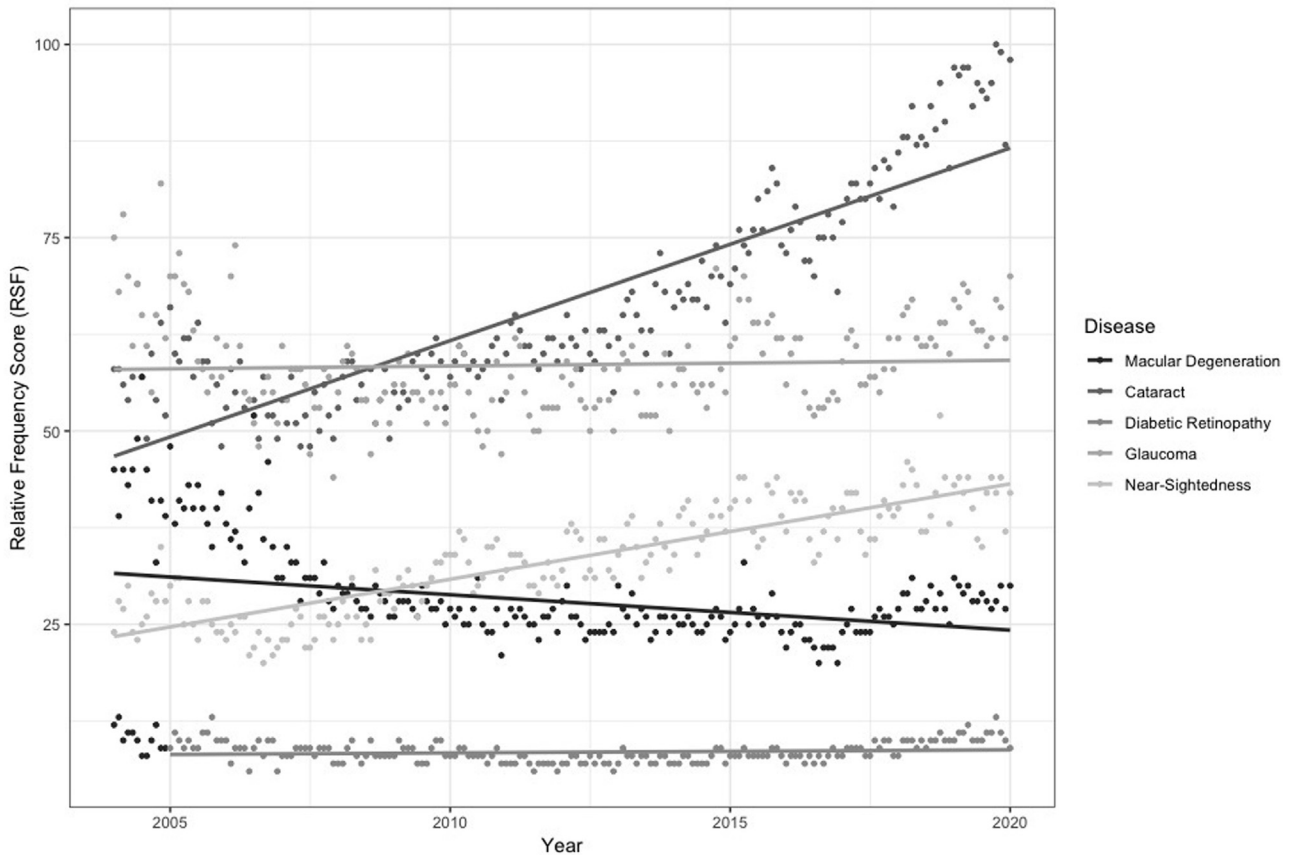


FIGURE 1. Monthly relative search frequency (RSFs) scores of Google Searches from January 1, 2004, to January 1, 2020, are shown. The United States RSF rate of change per month determined by linear regression was highest in cataract (0.0068 RSF points/month), followed by near-sightedness (0.0034 points/month), glaucoma (0.0002 points/month), diabetic retinopathy (less than 0.0001 points/month), and macular degeneration (−0.0025 points/month).

queries focused on information related to cataract surgery. Medical searches typically related to ICD-10 codes.

• **SEARCH VOLUME COMPARISON AGAINST DISEASE PREVALENCE:** The IAPB vision atlas North American crude blindness prevalence for each condition was plotted against calendar year RSF frequency values with a regression slope of $y = 1624.4x + 61981$ for conditions causing visual blindness with an R^2 of 0.5898. (Figure 3). For the plot comparing North American crude severe moderate vision loss prevalence, the regression slope was $y = -1181.8x + 1.0 \times 10^6$ with an R^2 of 0.0005.

DISCUSSION

INTERNET SEARCH ENGINES ARE A POWERFUL TOOL FOR PATIENTS and the general public to become better informed about ophthalmic conditions. The data indicate that the results of American Internet user queries most commonly

lead to information on treatment and disease education, but the categorical breakdown of queries differs depending on the disease. For example, treatment education results and information on cataract surgery more commonly appear in cataract queries. Comparatively, basic disease information more frequently appears in queries on macular degeneration, myopia, and glaucoma. Moreover, search results for diabetic retinopathy often present information in the context of diabetes as more information can be learned about an ocular condition and the underlying cause. Although these study results yield information on what search information appears based on queries, the study authors do not know if the information that Internet queries present is the intended information the search user wanted. Furthermore, it is unclear if these queries generally occur before or after possible conversations with a provider, so it is uncertain if these searches are performed proactively by a patient or in response to a provider conversation. The study results are informative because they provide general insight into what type of information the most common search engine queries yield. If individuals search for

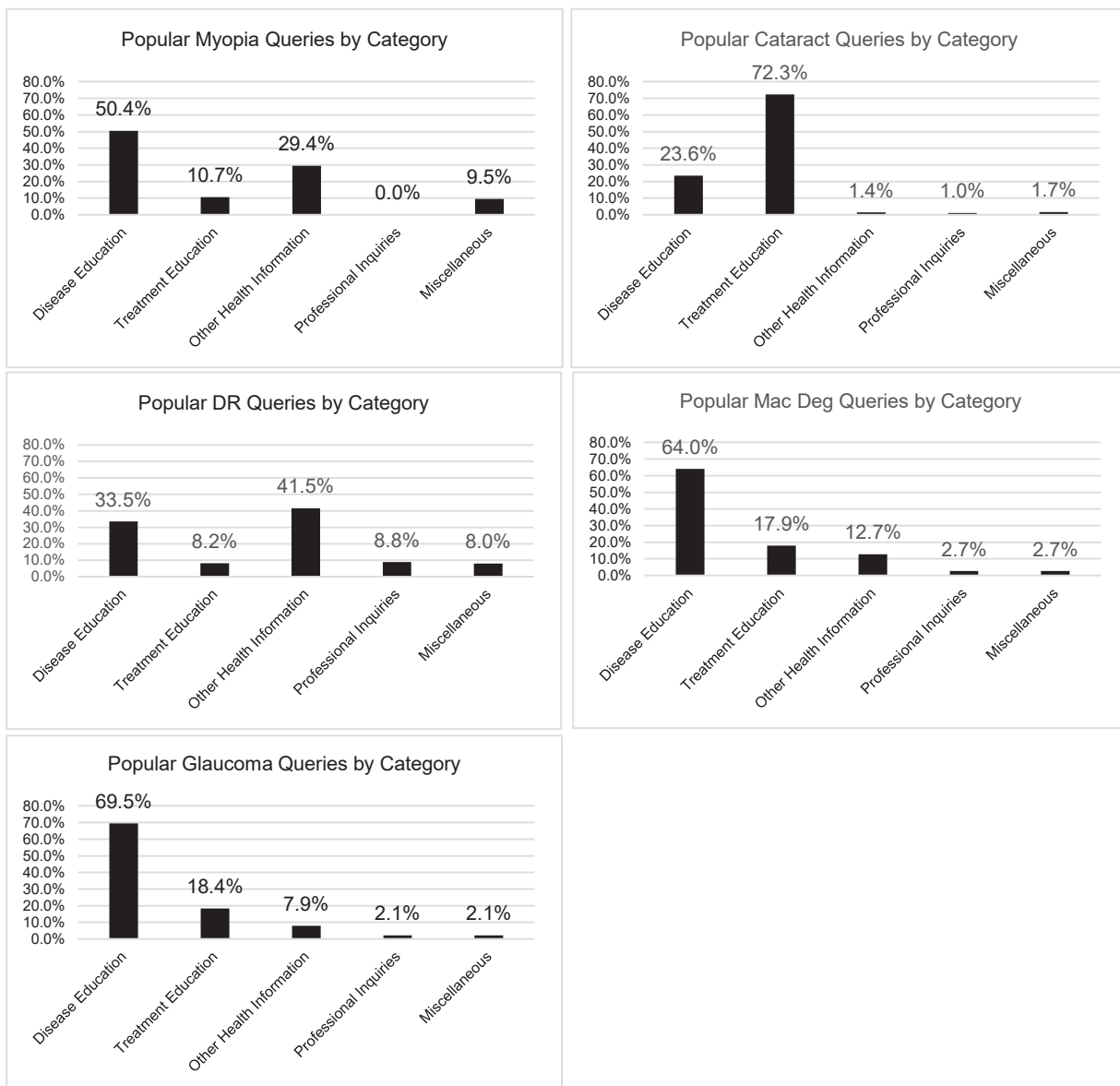


FIGURE 2. Classification of queries by disease and category. Percentages of related queries for each condition based on an average of summed RSF values with the categories disease education, treatment education, other health information, professional inquiries, and miscellaneous is shown. Related queries were classified by the first appearing website with the search term. DR = diabetic retinopathy, Mac Deg = macular degeneration, RSF = relative search frequency.

information preemptively, these study results can provide a general idea into the type of information patients and the general public are accessing. If individuals search for the information after a provider conversation, then this study may provide insight into how the Internet is supplementing conversations patients are having with providers, regardless of whether or not the information patients actually want is accessible.

Based on the results, cataract and glaucoma are the most commonly searched conditions in the United States among those studied. The *P* value of $<.001$ for United States queries indicates that the total search volume was different for each

condition over the 16-year time period. One possible contributor to these results is Internet accessibility. Cataract and glaucoma are diseases that affect the population at large whereas diabetes and consequently, diabetic retinopathy have a racial and socioeconomic status component that contributes to disease disparities.¹³ It has been well established that Internet usage varies based on socioeconomic status.¹⁴ Disease severity, average age of afflicted individuals, and public perception of a disease may also influence the general public's desire to use search engines as well.

Cataract was a unique condition in this study in that it was the only condition where queries that yielded

TABLE 2. Summary of Common Related Search Terms Found in Each Category: The Top 4 Related Search Queries for Each Condition by Category

Top 4 Searches by Category for Common Causes of Blindness and Low Vision within the United States					
	Disease Education	Treatment Education	Alternative Eye Information	Medical Searches	Other
Cataract	1. eye cataract 2. cataracts 3. what is cataract 4. cataract vision	1. cataract surgery 2. after cataract surgery 3. eye surgery 4. eye cataract surgery	1. glaucoma	1. icd 10 cataract	1. cataract falls
Diabetic retinopathy	1. proliferative retinopathy 2. diabetic retinopathy symptoms 3. diabetic retinopathy vision 4. what is diabetic retinopathy	1. diabetic retinopathy treatment 2. treatment for diabetic retinopathy	1. diabetes 2. neuropathy 3. diabetic neuropathy 4. edema	1. diabetic retinopathy icd 10 2. icd 10 code for diabetic retinopathy	1. proliferative
Glaucoma	1. glaucoma eye 2. glaucoma symptoms 3. angle glaucoma 4. what is glaucoma	1. glaucoma surgery 2. glaucoma treatment 3. glaucoma drops 4. glaucoma eye drops	1. cataracts 2. eye drops 3. cataract	1. glaucoma icd 10	1. glaucoma dogs
Amd	1. eye degeneration 2. wet macular degeneration 3. macular degeneration vision 4. what is macular degeneration	1. macular degeneration test 2. macular degeneration vitamins 3. treatment for macular degeneration 4. macular degeneration surgery	1. glaucoma 2. retina 3. cataracts 4. cataract	1. macular degeneration icd 10	1. amd
Myopia	1. myopia definition 2. what is myopia 3. myopia hyperopia 4. myopia astigmatism	1. myopia glasses 2. myopia 3. surgery 4. Lasik	1. eye 2. hyperopia 3. astigmatism 4. presbyopia	None applicable	1. marketing myopia 2. myopia hunt 3. myopia hunt club

Categories without 4 searches are limited to the number of relevant searches.

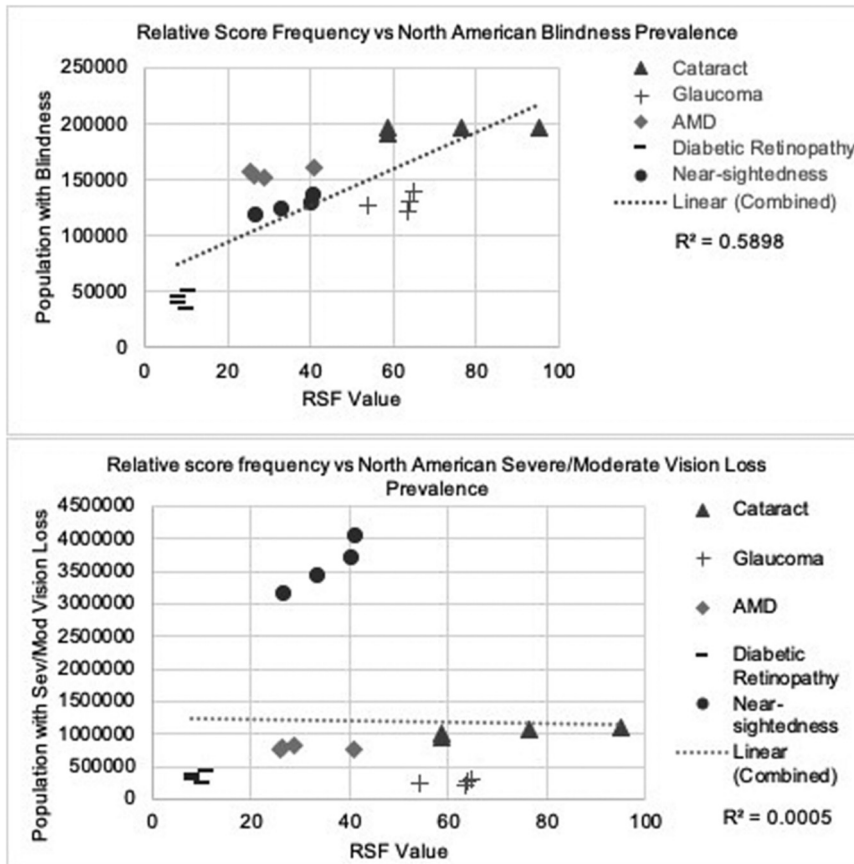


FIGURE 3. Plot of relative search frequency (RSF) scores vs IAPB Atlas prevalence of North American blindness (top) and prevalence of North American severe and moderate vision loss (bottom) is shown. Best fit lines and respective R^2 values are shown. Blindness is defined as visual acuity $< 3/60$ in the better eye and moderate and severe visual impairment defined as visual acuity $< 6/18$ to $\geq 3/60$. Sev/Mod = severe/moderate vision loss.

information on treatment education were most common. The concept of cataract surgery—the main treatment option for cataract—may be worrisome for many patients. Although it is unknown if users are inputting queries intended to provide information on cataract surgery, the majority of queries for cataract yield results related to cataract surgery, indicating that Internet users are receiving information on this procedure. This can help providers who offer cataract surgery because these results suggest that the Internet is presenting information on cataract surgery to many individuals and, thus, providers may want to tailor conversations about cataract to focus on cataract surgery information to augment or clarify information that patients may later encounter on the Internet.

Although it cannot be determined by what volume the searches of each disease are increasing or decreasing, some notable perspectives can be provided on the relative search volume. Compared to more common conditions, the greatest search topic in this study, cataract, is 11.5 times less searched than diabetes in the United States during this 16-year period. Furthermore, cancer is searched 19 times

more frequently in the United States compared with cataract. Of note, some conditions see noticeable differences in search volume among the 2004 calendar year vs the 2019 calendar. For example, cataract and near-sightedness saw a positive 66.0% and 50.7% difference, respectively, and macular degeneration saw a negative 33.9% difference in queries between the 2004 and 2019 calendar years. Although it is unknown why these trends are occurring, these data may provide an indication that there is a greater interest and potential education on the conditions of cataract and nearsightedness via the Internet relative to macular degeneration.

It is potentially notable that IAPB atlas data on the prevalence of condition-attributable blindness is fairly well correlated against Google relative search frequencies ($R^2 = 0.5898$). This may indicate some potential for Internet search volume as a monitor of disease frequency. Nevertheless, the data appear to be much weaker when considered against the prevalence of condition-attributable severe/moderate vision loss ($R^2 = 0.0005$). One contributory factor to this outcome may be that

IAPB atlas reports vision loss prevalence for all causes of refractive errors, whereas the study team elected to use myopia as a representative condition of refractive errors due to Google Trends not offering a comprehensive refractive error search topic. An additional limitation of this comparison is that Google Trends data for the United States was compared against the prevalence of North American global burden of disease region from IAPB atlas data, which includes Canada. A lack of reliable year-to-year data source of disease statistics for these ocular conditions limits this study's ability to explore predictive capabilities of Internet searches for disease, but the IAPB vision atlas data permits for fairly useful analysis considering that the majority of individuals included in the count are likely to be American because of country population differences.

Many studies have proposed that search Internet queries are highly associated with disease incidence.^{15,16} This study does not examine disease incidence for these conditions because of limited data availability, but the authors suspect that disease incidence may be more strongly associated with search volumes than prevalence. Nonetheless, the conditions examined in this study are much less likely to experience notable changes of year-to-year incidence unlike conditions such as syphilis and dengue, where incidence can vary more frequently year to year. As a result, Internet search engine trends may be adequately indicative of disease prevalence, especially considering that some conditions such as cataract can take years of progression before treatment is pursued and more educational interest exists.

This study adds to the literature that explores the role that the Internet is playing within ophthalmic care and health care broadly. Over the past 20 years, the Internet has emerged as a powerful tool for educating patients and the general public on health. This has been useful because patients are now able to have more informed discussions with their physicians and make decisions with more knowledge. Consequently, this study provides a lens into the type of information common queries related to these conditions are yielding, which may help providers better tailor their physician-patient interactions based on virtual information that is accessible to the patient. For example, an ophthalmologist can focus on diabetes in addition to the diabetic retinopathy when discussing disease education and management with patients because numerous Internet queries present this information. Furthermore, ophthalmologists can strive to present educational overviews on the basics of macular degeneration and glaucoma as Internet queries are presenting this information.

Broadly, the Internet can be an educational source for providers about the information patients may be receiving on a health topic. Although the information available on the Internet has generally been limited to educational purposes because of legal considerations, the potential of the Internet to transform ophthalmic care and health care

goes beyond education. From serving as a medium through which physician-patient communication can occur to emerging as a potential reservoir of data on behavioral trends that can influence health outcomes, the potential of Internet-based research is vast.

One unique feature of the Internet that was not accessible to patients previously is the ease of access to the most up-to-date information. Providers and researchers are now able to share the latest best practices and research efficiently now. Although up-to-date information is more easily accessible now, this does not necessarily mean that providers are engaging in current best practices or that patients are engaging and cooperating with reliable information. The need for accurate information on the Internet is imperative as a recent study indicated that 73% of subjects who had technology wanted online glaucoma information, but only 14% of patients had been directed to online resources by physicians.¹⁷ It is unclear what physician preferences are in regard to recommending Internet informational resources, but physicians are likely reluctant to recommend sources that have not been thoroughly vetted by experts for information accuracy. Henceforth, future studies may examine information needs that patients have and develop reliable, accessible Internet sources to address those needs.

Although the Internet may be a valuable source for information as it is inexpensive and easily accessible, the accuracy of the information offered is not always well verified. Some studies have explored this and have found Internet information to be suboptimal. For example, a recent study by Kloosterboer and colleagues evaluated 11 websites for information on diabetic retinopathy, and the average quality score was 55.76 points out of a possible 104 points based on the study team's questionnaire.¹⁸ A study of YouTube videos on patient education for cataract surgery rated the usefulness of the videos as a 2.28 on a scale of 14.¹⁹ Although the Internet provides easily accessible information, trained clinicians are the best source for trusted information that can be individually tailored for a given individual's situation. Considering flaws in online information, clinicians should strive to be the primary source of education for individuals rather than the Internet.

A number of limitations must be acknowledged for this study. Most notably, the values reported in this study are relative measures and do not reflect the actual volume of searches by individuals of the public. Furthermore, Google is one of many available search engines for patients, and thus, searches on Google may not reflect search patterns on other search engines such as Bing and Yahoo!. Nonetheless, Google can be considered as a strong proxy for the general public interest in these diseases considering that Google is the most commonly used search engine in the United States.²⁰ The categorization of top search queries is limited to only the top 25 related search terms, and consequently, some applicable search queries are not included in the data. Lastly, there are also limited

capabilities to discern search patterns by health care professionals vs patients or other interested parties.

Future studies can examine Internet query trends with a broader subset of ophthalmic conditions. Moreover, addi-

tional studies can explore how information obtained from the Internet influences provider practice patterns and patient behaviors.

FINANCIAL SUPPORT: THE AUTHORS REPORT NO FUNDING SOURCES OR CONFLICTS OF INTEREST RELATED TO THIS research. Financial Disclosures: AXC reports grants from the National Institutes of Health and Research to Prevent Blindness. RPS reports personal fees from Genentech/Roche, personal fees from Alcon/Novartis, grants from Apellis and Graybug, personal fees from Zeiss, personal fees from Bausch + Lomb, personal fees from Ophthea, personal fees from Regeneron Pharmaceuticals, Inc. The other authors indicate no financial support or conflicts of interest. All authors attest that they meet the current ICMJE criteria for authorship.

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