Understanding urologic scientific publication patterns and general public interests on stone disease: lessons learned from big data platforms

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Abstract

Purpose To analyse patterns of stone disease online information-seeking behaviours in the United States and to correlate with urological literature publication aspects.

Methods To compare Relative Search Volume (RSV) among different twelve preselected urologic keywords we chose “United States” as country and “01/01/2009–31/12/2018” as time range on Google Trends (GT). We defined “ureteroscopy” as a reference and compared RSV against it for each term. RSV was adjusted and normalized in a scale 0–100. Trend presence was evaluated by Mann–Kendall Test and magnitude by Sen’s Slope Estimator (SS). Weather influence on RSV was also investigated by comparison of the ten hottest versus ten coldest states. Pearson correlation analysis was performed between number of Pubmed publications and RSV for each term over time.

Results We found an upward tendency ($p < 0.01$) for most terms. Higher temporal trends were seen for “kidney stone” (SS = 0.36), “kidney pain” (SS = 0.39) and “tamsulosin” (SS = 0.21). Technical treatment terms had little search volumes and no increasing trend. States with hotter weather showed higher mean RSV for “kidney stone” than colder ones. There was little correlation between GT and Pubmed for most terms, with the exception of “kidney stone” ($R = 0.89; p < 0.01$), “URS” ($R = 0.81; p < 0.01$), and “laser lithotripsy” ($R = 0.74; p = 0.01$).

Conclusion There was a significant increase in online search for medical information related to stone disease. Citizens tend to look for generic terms related to symptoms or the disease itself. States with hotter weather show higher RSV than colder states. There is a discrepancy between public and medical community medical terms.

Keywords Google Trends · Lithiasis · Health · Public Interest · Epidemiology · Pubmed

Abbreviations

GT Google Trends
PCNL Percutaneous Nephrolithotomy
RSV Relative Search Volume

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s00345-020-03477-5) contains supplementary material, which is available to authorized users.

Introduction

Urinary lithiasis is a common disease with an approximated prevalence of 7–12% around the world [1, 2]. Over the past 15 years, the prevalence of urinary stone disease has nearly doubled in United States (US) [3]. Medical expulsive therapy, ureteroscopy (URS), percutaneous nephrolithotomy (PCNL) and extracorporeal shockwave lithotripsy (SWL) are the most common treatment modalities for kidney and ureteral stones [4, 5]. A shift from open to less-invasive
techniques was seen in the last decades and as a consequence, the dedicated medical literature increased [6].

As stone disease burden ascents, online internet search for information regarding the theme upsurges globally. The United States (US) is the fourth largest country in the world by land area with over 312 million internet users as of 2018, being one of the largest online markets worldwide. In 2019, just ten percent of US adults reported that they did not use the internet [7]. Just recently, online strategies and internet trend search gathering tools have been developed to provide useful information for monitoring global and regional health seeking behaviour patterns, epidemiology, aetiology and treatment of various medical conditions, including urolithiasis [8]. Google Trends (GT) is one of the most important of these tools, in which internet queries are catalogued and this indexed information is available to the public. The big data database provided by GT can reveal patterns in health information-seeking behaviour on a population level, allowing development of target information to the public [8, 9].

The main purpose of this study was to analyse patterns of stone disease information-seeking behaviours in the US to understand how patients look for reliable information in this matter. Second, we aimed to study the influence of weather on online search patterns to trace a parallel with stone disease incidence. Finally, we aimed to compare the GT findings to the urological literature publication aspects.

Methods

Data Interpretation

Google Trends is a web service offered by Google Inc. that keeps track of online keywords interest according to country or region over a selected time period. In addition, the search of distinguish terms in different regions can be compared simultaneously. Data are downloaded from the web in “.csv” format and adjusted as follows: search results are proportionate to the time and location of a query; each data point is divided by the total absolute searches of the geography and time range it represents, to compare relative popularity. Otherwise places with the most search volume would always be ranked highest. The resulting numbers are then scaled on a range of 0–100 based on a topic’s proportion to all searches on all topics.

Google’s normalized trends data are the most useful parameter for storytelling, i.e., when we look at a topic search interest over time, we are looking at that interest as a proportion of all searches on all topics on Google at that time and location [10]. Therefore, GT provides a Relative Search Volume (RSV) which is a sampled estimate of a particular query share according to location and time normalized by the highest query of the period in a 1–100 scale. Up to five multiple terms analysis is allowed for query comparison.

Data collection and processing

Google trends

To compare RSV among different urologic keywords, we have used “United States” as country, “01/01/2009–31/12/2018” as time–range, “All Categories” as category and “Web Search” as type of search.

English terms were first selected after a recent study which explored their popularity [8]. A more comprehensive assessment of expressions was included and the final keywords for each term were chosen by an expert based on multiple attempts until one was found to capture the greatest RSV for the period.

To compare more than GT’s limit of five words in the US, we defined “lithotripsy” as a reference and downloaded RSV comparisons against it for each term. We then adjusted the RSV numbers by the reference and normalized them by the highest RSV for the period in a scale 0–100.

The final selection included the following twelve keywords: “kidney stone”;“renal stone”;“kidney stone surgery”;“renal colic”;“kidney pain”;“ureteroscopy”;“extracorporeal shockwave lithotripsy”;“percutaneous nephrolithotomy”;“tamsulosin”;“kidney stent”;“lithotripsy”;“laser lithotripsy”.

To compare trends among different US states from 2009 to 2018, we have downloaded yearly RSV by “sub-region” for the term with the highest RSV on the previous analysis, i.e. “kidney stone”. For comparison, the states were further divided in two groups according to temperature and weather estimates:

- Ten hottest states: Florida, Hawaii, Louisiana, Texas, Georgia, Mississippi, Alabama, South Carolina, Arkansas, Arizona;
- Ten coldest states: Alaska, North Dakota, Maine, Minnesota, Wyoming, Montana, Vermont, Wisconsin, New Hampshire, Michigan.

Pubmed

The number of studies published on the online medical search database was downloaded from Pubmed service using the advanced tool with the same twelve terms selected for Google Trends in the ‘Title’ filter. We have included publications in the same 2009–2018 range. The absolute number of publications per year was considered in the analysis.
**Statistical analysis**

Trend presence was evaluated using the Mann–Kendall test and magnitude was estimated using the Sen’s Slope Estimator (SS). Both of them apply to non-parametric data and were used to evaluate trends for Pubmed and GT over time.

Correlation analysis was done using Pearson method, which is the standard method used by Google in Correlate Service, to address correlations between Pubmed and GT data.

GT comparison between groups of states was done with T Test (normal distribution). Continuous data were detailed as mean and standard deviation. Statistical analysis was done in R version 3.5.1. Significance was set at \( p < 0.05 \).

**Results**

**Temporal Trends on Google**

Year trend analysis revealed an upward trend \( (p < 0.01) \) in most of the researched terms as described in Table 1a. Figure 1a depicts the data in regard to Google Trend RSV in the US. Higher temporal trends were seen for “kidney Stone”, “kidney pain” and “tamsulosin”, “Tamsulosin” had an expressive search volume in 2018 (RSV = 30.70) compared to other terms with a tenfold increase over the ten-year period analysis (2009 RSV = 3.07). Interestingly, “renal colic” and “renal stone” had low search volumes.

Treatment terms which demanded more knowledge of medical vocabulary as “SWL”, “laser lithotripsy”, and “PCNL” had little search volumes and no increasing trend, remaining low in public interest during the ten-year analysis. The most looked-up terms related to surgical procedures were “lithotripsy” and “kidney stent”. “Kidney stent” had a significant increase in search trend over time and had a relevant search volume in 2018 (RSV = 4.97; \( S = 0.02; p < 0.01 \)).

**Pubmed publication patterns**

The number of publications varied considerably yearly for each included term. Figure 1b depicts the volume of publications for each term per year. The expressions with the highest number of publications per year were “lithotripsy” (183.4), “PCNL” (176.9), and “URS” (79.3). On the contrary, the expressions with the lowest number of publications were “kidney pain” (0.46) and “kidney stone surgery” (0.8).

In regard to the temporal trend among publication patterns (Table 1b; Fig. 1b), there was a significant increase in studies with the respective words in the title: “PCNL”, “URS”, “lithotripsy”, “kidney stone”, “laser lithotripsy”, “renal colic”, and “renal stone”. Other terms had no significant increase over time.

**Correlation analysis**

The volumes of publications on Pubmed and RSV on Google are demonstrated in Supplementary Fig. 1 in a 0–100 scale to allow for visual comparison in regard to volume relevance. Not only the volume was different for most terms but also the temporal trend line. There was a significant strong positive correlation for the terms “kidney stone”, “URS”, and “laser lithotripsy”. For all other terms, there was no significant correlation.

Specifically, for GT data, medical knowledge content as “Extracorporeal Shockwave Lithotripsy”, “Percutaneous Nephrolithotomy”, “Lithotripsy” had lower correlation with popular terms as “Kidney Pain” or “Kidney Stone”. A more generic

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**Table 1** Temporal Trend measured by Mann–Kendall Sen’s Slope Estimator (SS) for Google Trend enquiry (a) and PubMed data (b); C—Correlation between databases

| Query                        | A—Google Trends | B—PubMed       | C—Correlation |
|------------------------------|-----------------|----------------|---------------|
|                              | SS  | \( p \)-value | SS  | \( p \)-value (R) | \( p \)-value |
| Kidney stone                 | 0.37 | < 0.01       | 4.71 | < 0.01       | 0.89 | < 0.01 |
| Kidney pain                  | 0.40 | < 0.01       | 0.00 | 0.12         | 0.41 | 0.24 |
| Renal stone                  | 0.00 | < 0.01       | 1.50 | < 0.01       | 0.43 | 0.21 |
| Tamsulosin                   | 0.21 | < 0.01       | 0.63 | 0.78         | 0.43 | 0.21 |
| Renal Colic                  | 0.00 | 0.10         | 2.67 | 0.03         | 0.11 | 0.75 |
| Kidney stone surgery         | 0.02 | < 0.01       | 0.16 | 0.06         | 0.43 | 0.21 |
| PCNL                         | 0.00 | 0.27         | 16.17 | < 0.01       | 0.02 | 0.96 |
| URS                          | 0.01 | < 0.01       | 8.85 | < 0.01       | 0.81 | < 0.01 |
| SWL                          | 0.00 | 0.30         | 0.33 | 0.78         | 0.13 | 0.72 |
| Laser lithotripsy            | 0.00 | < 0.01       | 3.00 | 0.01         | 0.74 | 0.01 |
| Lithotripsy                  | 0.00 | < 0.01       | 5.25 | 0.03         | 0.54 | 0.10 |
| Kidney stent                 | 0.02 | < 0.01       | 1.00 | 0.47         | 0.42 | 0.22 |

Values in bold indicate significance

PCNL Percutaneous nephrolithotomy, URS Ureteroscopy, SWL Extracorporeal shockwave lithotripsy

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surgical term, “Kidney Stone Surgery”, had higher correlation as compared to the treatments above mentioned. More common and popular terms as “Kidney Stent” and “Tamsulosin” were highly correlated with “Kidney Pain” and “Kidney Stone” (Supplementary Fig. 2—the correlation is positive when there is a blue circle matching the terms in left column and upper row; when the color is more intense and the circle larger, the correlation is higher; the red circle is interpreted as no correlation between terms).

Weather influence on online search patterns

There was an eminent tendency towards higher RSV for the term “kidney stone” in the hottest states when compared to the ten coldest American states (Supplementary Fig. 3 and Supplementary Table 1). That greater public interest on the GT search for “kidney stone” achieved significance in the years 2010, 2011, 2015 and 2017. In the remainder years, a marginal difference was seen.

Discussion

This is the first study to investigate in a standardized manner with strict statistical analysis on the information-seeking patterns related to stone disease on Google Trends. In our study, we could notice a remarkable increase in interest of the patients in regard to medical information related to kidney stones in the United States.

The Google Trend platform cannot compare searching patterns of patients naive for stone treatment with those who have already been instructed in a urologic visit. Although we cannot assume the order in which an individual look for the terms online, the relative volume of search and temporal trend allow for some suppositions. Citizens probably start their research using terms that describe their symptoms or the disease itself, e.g. “kidney pain” and “kidney stone”. Interestingly, “renal stone” and “renal colic” had low public interest, which demonstrate...
a cultural language preference of the name “kidney” over 
“renal”. After looking for those terms, they possibly seek 
for information concerning existing clinical and surgi-
cal treatments, e.g. “tamsulosin”, “lithotripsy”, “kidney 
stent” or “kidney stone surgery”. Online search volume 
for technical terms as “PCNL”, “URS”, SWL” and “laser 
lithotripsy” was very low. This is the first study to compare 
population online search behaviour with medical publica-
tion patterns. Noteworthy, our results clarify that there is 
a mismatch between urologic community publications on 
Pubmed and general information-seeking comportment. 
This highlights the need for a shift on media planning to 
better educate our patients who seek for information to 
make informed decision about their own health.

It is reasonable to think that there is also a significant 
number of patients that search for stone disease informa-
tion already after their first kidney stone event or surgery. 
Renal colic is an emergency situation where the patient has 
to be rapidly assisted without the opportunity to seek for 
information prior to initial management. The terms “Kidney 
stent” was the fifth in total search volume and may reflect a 
post-operative information-seeking pattern. “Tamsulosin” 
showed expressive RSV in 2018. In total RSV, it was the 
third term and a significant increase was seen between 2009 
and 2018 which may reflect the interest in medical man-
agement an individual might start or was already put on. 
Notably, tamsulosin is a medication used for other urologic 
disorders, e.g. benign prostatic hyperplasia, and is still con-
sidered an off-label drug for stone disease. Therefore, data 
must be analyzed critically.

Dreher and colleagues [8] have recently queried the 
Google Trends platform using terminology related to 
kidney stone surgical intervention in English within the 
United States from November 2011 through August 2017. 
They found “kidney stone surgery” as the most common 
term in comparison to “PCNL”, “SWL”, “URS” and “laser 
lithotripsy”.

The authors stated that research trends for the 
expression “kidney stone surgery” remained fairly constant 
over the six-year period and was more looked for in the 
states of Tennessee, Indiana, Ohio, Michigan and North 
Carolina. Likewise, they found that specific treatment modalities 
yielded similar search trends over time but were queried at 
a lower frequency than the term “kidney stone surgery”. 
A common aspect to our study is the fact we have also found 
that specific surgical technical terms are indeed not relevant 
in regard to search volume. Nonetheless, we found that the 
search interest for “kidney stone surgery” increased over 
time and the negative results they had might be explained 
by the shorter period of time included in their study. If we 
look at our Fig. 1A, the variation of RSV for “kidney stone 
surgery” was not so pronounced between 2011 and 2017. 
Second, and more importantly, the lack of a formal statisti-
cal analysis is the main drawback of their investigation. One 
cannot assume just by looking at the graphic that there was 
no tendency in one direction or another. Finally, the authors 
did not investigate terms related to the disease itself and 
symptomatology, which we found to be the most important 
terminologies addressed by the population.

Forecasting epidemiology is considered an indispensa-
ble science when dealing with diseases of high prevalence 
or burden to the population medically and economically. 
Kapitány-Fövény et al. [11] investigated if measuring online 
activity could be used as a promising tool for forecasting 
frequent infectious diseases and found a good correlation between the 
reported weekly case numbers of Lyme disease and search 
volume on GT. However, it was not completely accurate, and 
the authors believe that this new instrument could have a role 
in improving the traditional epidemiological surveillance 
models instead of replacing it. Verma et al. [12] studied the 
temporal correlation between GT and Integrated Disease 
Surveillance Programme data to determine if it was feasible 
to use online data for prediction of outbreaks or epidemics. 
A significant temporal association was observed, and the 
authors found a high correlation for Chikungunya and Den-
gue fever in the studied regions, while Malaria and Enteric 
fever had a moderate correlation, all preceding factual epi-
demic outbreak in 2 to 3 weeks. In that same sense, Unsal et 
[13] showed the potential utility of the GT database 
as a resource for epidemiologic monitoring on epistaxis and 
for the identification of at-risk populations. More recently, 
in face of the coronavirus 19 pandemic, Husnayain et al. 
[14] retrieved GT data for the specific locations of Taiwan. 
The authors found high-to-moderate correlations between 
GT RSV and infected cases in several regions and con-
cluded that GT could potentially define the proper timing 
and site for performing risk communication strategies to the 
population.

The capability of GT in predicting high incidence periods 
of stone disease is yet to be determined. Given the high bur-
den of the disease in regard to severity of symptoms, days 
lost of work, and economic expenditure, advancing with 
such investigation would be reasonable. Our analysis showed 
an increased interest in stone-related terms. By evaluating 
the weather influence on online search measured by GT, 
we could for the first time demonstrate that US states with 
hotter weather had a significant higher interest on the term 
“kidney stone” than colder states. The higher incidence of 
stone-related events in the US stone-belt [15] allied with our 
findings suggest that information-seeking behaviour follows 
stone disease prevalence, and this might be used for preven-
tion and population counselling strategies.

The utility of GT use for prevention campaigns has also 
been investigated. Hopkins et al. [16] evaluated trends in US 
surveys for sunscreen, sunburn, skin cancer, and melanoma 
and their relationships with melanoma outcomes. They 
found that terms “sunscreen,” “sunburn,” “skin cancer,”
and “melanoma” were all significantly correlated but “sunscreen” and “sunburn” had the greatest correlation. Therefore, the authors suggested that online skin cancer prevention campaigns should focus on the search terms “sunburn” and “sunscreen”, given the decreasing online searches for skin cancer and melanoma, and because “sunscreen” searches were higher in areas with greater melanoma incidence. Similar prevention campaigns could be created and released prior the historical periods of increased stone-related events for any particular region of the country. Nationwide, “kidney stone” and “kidney pain” are the most indicated terms. For a particular city or state, a specific analysis might be performed to narrow key terms for that region on a determined moment.

We must acknowledge that internet use might be impacted by several factors. Of those, the grade of country development might play an important role. Interestingly, recent data show data even in underdeveloped nations, the internet access is expressive and democratic when a dictatorship government is not in place. As an example, according the Statista Research Department [17], of the nearly 210 million individuals in Brazil in 2016, 140 million were active internet users. Brazil was the largest internet market in Latin America and the fourth largest internet market in the world when considering the number of internet users. Also, our study included only US data where more than 90% of individuals actively access the internet. The 10% remaining are not embodied by GT numbers.

The knowledge gained with this study allows for elaboration of target content to patients seeking for information and for planning of public strategies to educate the population nationwide. Initially, prevention campaigns might focus on those keywords with greater search volumes and its effectiveness could be monitored by continuously in the same online platform. Sequentially, patient counselling and education upon specific medical terms and treatments could be performed more efficiently, allowing for a more shared-decision approach. Finally, prediction models for stone disease occurrence are a line of investigation. They could be added to the climate influence patterns confirmed by our report to increase outbreaks forecast.

Conclusion

There was a significant increase in online search for medical information related to stone disease in the US in the last decade. States with hotter weather show higher search volumes of stone-related terms than colder states. Citizens tend to look for terms related to symptoms and the disease itself. Medical management and kidney stent are expressions of particular interest to patients, while technical expressions of urologic procedures are not. Technical terms are the most expressive among stone-related scientific publications on Pubmed, highlighting the discrepancy between terminologies on both databases.

Author contributions GSM: manuscript design and conception, KVMF: manuscript design and conception, FLN: statistical analysis, FCMT: manuscript design and conception, AD: manuscript design and review, FCV: manuscript conception and review, CAB: statistical analysis, MS: manuscript design, WCN: manuscript review, EM: manuscript design and review.

Funding None.

Availability of data and material All analysed data available if necessary.

Compliance with ethical standards

Conflict of interest All authors declare that they have no conflict of interest.

Ethics approval Not necessary – online data analysis.

Consent to participate Not necessary – online data analysis.

Consent for publication Approved.

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