

# Seasonality of cellulitis: evidence from Google Trends

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**Introduction:** According to our clinical experience, cellulitis is common in summer; however, very few studies have mentioned this trend.

**Methods:** Using Google Trends, we analyzed the monthly data of Google searches for “cellulitis” from 31 countries on 6 continents.

**Results:** Seasonality explained 34%–92% of the variability in search volume, with peaks occurring in summer months.

**Conclusion:** The analyses offered new insights into the epidemiology of cellulitis on national and international scales. Clinical data are needed to validate the Internet search data.

**Keywords:** cellulitis, Internet search, seasonality

## Introduction

Cellulitis is a common bacterial infection involving the skin and its underlying connective tissue, manifesting symptoms of redness, pain, and lymphangitis. According to our clinical experience, cellulitis is more common in summer; yet very few studies in the publicly available literature have mentioned its seasonal variation.<sup>1</sup>

As Internet availability and use has increased worldwide, Internet-based search engines have become an important source for health information for people from all walks of life.<sup>2</sup> Analyzing data on search behaviors and other online resources, in turn, provides a new approach for detection and monitoring of diseases and symptoms.<sup>3</sup> This method is especially suitable for studying time-varying patterns of health conditions and has already been successfully applied to influenza, ankle swelling, mental illness, and sleep disorders.<sup>4–7</sup> Herein we describe the use of such an approach to examine the seasonal variation of the public's interest in cellulitis, as measured by the volume of Internet searches in Google.

## Methods

Google Trends (<http://www.google.com/trends>), provided by Google Inc., is a publicly available data service that shows the relative number of searches globally or within a particular region for a specific search term. The numbers are scaled in a range of 0–100, based on the proportion of overall searches that the queried term represents. Using Google Trends, we obtained monthly data from January 2004 to December 2016 for the search term “cellulitis”. After exclusion of countries with unavailable data or showing no regular pattern over time (Figure S1), a total of 31 countries were included in the analyses.

The monthly data were plotted according to time for each of the 31 countries and regression analysis was performed using GraphPad Prism 7 (GraphPad Software Inc., La Jolla, CA, USA). The regression analysis was carried out with a seasonal model, as described previously,<sup>5,8</sup> consisting of a straight line function and a sinusoid function as follows:

$$\text{Search\_volume} = \text{intercept} + \text{slope} \times \text{time} + \text{amplitude} \times \sin(2\pi \times \text{time}/12 + \text{phase shift})$$

The null hypothesis model was the best-fit straight line for search data over time. Then, a sum-of-squares *F* test was used to compare the two models and a *P* value was calculated for the difference in fit. In 23 countries, the data in the early years did not fit well. Thus, only the data in the latter years was suitable for the analysis.

## Results

The seasonal model fitted better to the data than the null model in the 31 countries included in this study ( $P = 0.013 \sim <0.0001$ ; Table 1). Seasonality explained 34%–92% of the variability in search volume (Table 1). In the northern hemisphere, the search volume peaked in mid-April to mid-July, while in the southern hemisphere it peaked in October to January (Figure 1). Geographically nearby countries usually shared similar peak months of search volume. The peak months were around May in continental Europe, at the end of June in the UK and Ireland, at the beginning of June in Israel and Turkey, close to the beginning of July in the USA and Canada, and around November in South America.

## Discussion

The present study examined the seasonal variation of the public's interest in cellulitis worldwide by using Google Internet search data. In accordance with our hypothesis, the results demonstrated a significant seasonality of this interest with peaks in summer for the 31 countries from 6 continents examined.

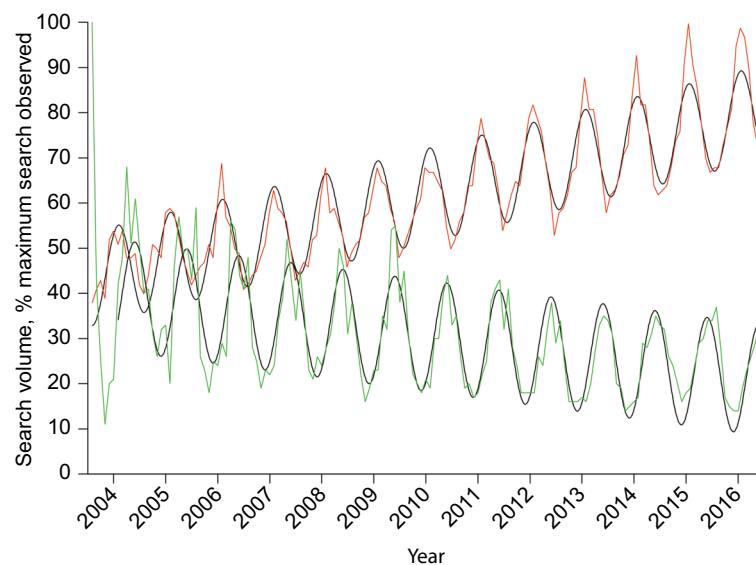
To date, only one epidemiology study has mentioned the seasonality of cellulitis.<sup>1</sup> That study used data collected from a medical insurance database involving 8 USA states and found that the incidence of cellulitis was 1.32 times higher during the summer months than during the winter months.<sup>1</sup> By analyzing Google search data from throughout the USA, we found a similar trend, in that cellulitis attracted more public interest during the summer months than during the winter months in each year from 2004 to 2016.

**Table 1** Fit of a sinusoid model against Google Trends Internet search volume for cellulitis in 31 countries

Country	R <sup>2</sup>	P-value	Peak month	Time range
<b>Northern hemisphere</b>				
USA	0.92	<0.0001	7.1	2004–2016
Spain	0.85	<0.0001	5.2	2004–2016
UK	0.84	<0.0001	6.8	2004–2016
Poland	0.80	<0.0001	4.5	2007–2016
France	0.80	<0.0001	4.8	2004–2016
Belgium	0.75	<0.0001	5.2	2008–2016
Mexico	0.71	<0.0001	5.7	2004–2016
Canada	0.70	<0.0001	6.7	2007–2016
Greece	0.69	<0.0001	5.0	2011–2016
Netherland	0.66	<0.0001	5.3	2004–2016
Switzerland	0.64	<0.0001	5.0	2011–2016
Germany	0.60	<0.0001	5.8	2012–2016
Germany	0.56	<0.0001	5.2	2005–2010
Ireland	0.59	<0.0001	6.8	2008–2016
Israel	0.57	<0.0001	6.1	2011–2016
Portugal	0.55	<0.0001	5.2	2012–2016
Romania	0.52	<0.0001	5.3	2011–2016
Turkey	0.52	<0.0001	6.0	2012–2016
Austria	0.51	<0.0001	5.0	2004–2016
Italy	0.49	<0.0001	5.4	2007–2016
Puerto Rico	0.44	0.0002	6.2	2013–2016
Hungary	0.42	0.0013	4.9	2012–2016
Thailand	0.38	<0.0001	7.6	2012–2016
Denmark	0.35	<0.0001	5.5	2010–2016
<b>Southern hemisphere</b>				
Australia	0.82	<0.0001	1.1	2007–2016
Argentina	0.79	<0.0001	10.9	mid-2004–2016
Brazil	0.74	<0.0001	11.3	2005–2016
Chile	0.68	<0.0001	11.8	2007–2016
Uruguay	0.55	<0.0001	10.9	2004–2016
Peru	0.49	<0.0001	1.3	2008–2016
Paraguay	0.41	<0.0001	11.8	2012–2016
South Africa	0.34	<0.0001	1.3	2011–2016

**Notes:** *P* value was calculated using a sum-of-squares *F*-test comparing the sinusoid model with a straight line model; *R*<sup>2</sup> represents the proportion of variation in the search volume explained by the model.

The lower extremities represent the most frequent sites of cellulitis.<sup>9</sup> Several analyses have shown that a disruption of the cutaneous barrier, such as in the common conditions of leg ulcer, wound, toe-web intertrigo, dermatosis, athlete's foot, and leg edema, is an important risk factor for developing cellulitis of the leg.<sup>10,11</sup> Hot weather, sweating, moisture, insect bites, and skin exposure may make these conditions more common and/or severe during the summer season. For example, some lines of evidence indicate that a warmer climate tends to aggravate venous ulcers of the leg and a rainy season facilitates outbreaks of chronic leg



**Figure 1** Google Trends Internet search volume for cellulitis in the USA and Argentina from January 2004 to December 2016.

**Notes:** The red line represents search volume in the USA; the green line represents search volume in Argentina; the black lines are the best-fit sinusoid.

ulcers, as shown particularly in tropical areas.<sup>12,13</sup> In shoe-wearing populations, interdigital athlete's foot is mainly a seasonal disease, with peaks in hot weather.<sup>14</sup> Itch, sunburn, erythema multiforme and many skin diseases caused by organisms also favor warmer weather.<sup>15,16</sup> And, a recent analysis found that public interest in ankle swelling, as measured as Google search volume, is highly seasonal, with peaks in summer in the USA and Australia.<sup>5</sup> Altogether, these trends may help us to understand why cellulitis is more common in summer.

In this electronic search study of trends of interest, the seasonality of public interest in cellulitis was able to be determined for 31 countries from 6 continents, suggesting that it is a global phenomenon. The seasonality trend detected (i.e. summer) may also exist in the countries that were not included in the analysis; small population, low level of Internet availability and use, small market share of Google, and differences in search language and queries may have obscured the detection of seasonal trend for these countries. The impact of Internet availability and use can be supported by the fact that for most of the 31 countries that showed seasonal variation the search volume was very irregular in the early years and up to the later years when the seasonal trend became obvious. By repeating this study in languages other than English and with search engines other than Google, the seasonality may be detected in more countries. For example, no regular pattern of search volume for cellulitis was found for China using Google Trend, but a significant seasonal trend (with peaks in summer) was detected using search data from

Baidu (Figure S2), a Chinese search engine that accounts for the vast majority of Chinese Internet users.

Besides the ability to cover a large geographic area, the strengths of this study also include the long time-range of observation, observations above and below the equator, and observations of geographically nearby countries. Mexico and Peru seem to be exceptions, as the regions within each representing the search peaks were at a relatively long distance from those within the proximal countries (for Mexico compared with the USA and Canada; Peru compared with other countries of South America). However, when the geographic distribution of the population for each of these countries is considered, the trends fall back in line.

This study has several limitations that need to be considered when interpreting the results. First, the study revealed the seasonal trend of public interest in cellulitis, but not the seasonal trend of cellulitis itself. Besides the suspicion of cellulitis or receiving a clinical diagnosis, news reports, academic conferences, medical courses, and any other information about cellulitis may also excite one's interest in it. Moreover, the individual performing the search is not necessarily the one suffering from the disease. Clinical data are needed to validate the Internet search data from this study. Second, although most of the Internet searches are performed using Google, data from other search engines should be analyzed if possible, especially for regions where Google is not popular. Third, the demographic characteristics were not available for the users who were performing the search. Thus, important covariates that may affect the

development of cellulitis or search behaviors could not be assessed.

## Conclusion

In summary, using Google Trends we demonstrated that the public's interest in cellulitis exhibits significant seasonal variability, with peaks in summer. Clinical data are needed to validate the Internet search data and further research is indicated to clarify the mechanisms underlying seasonal patterns of cellulitis.

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## Author contributions

All authors contributed toward data analysis, drafting and revising the paper and agree to be accountable for all aspects of the work.

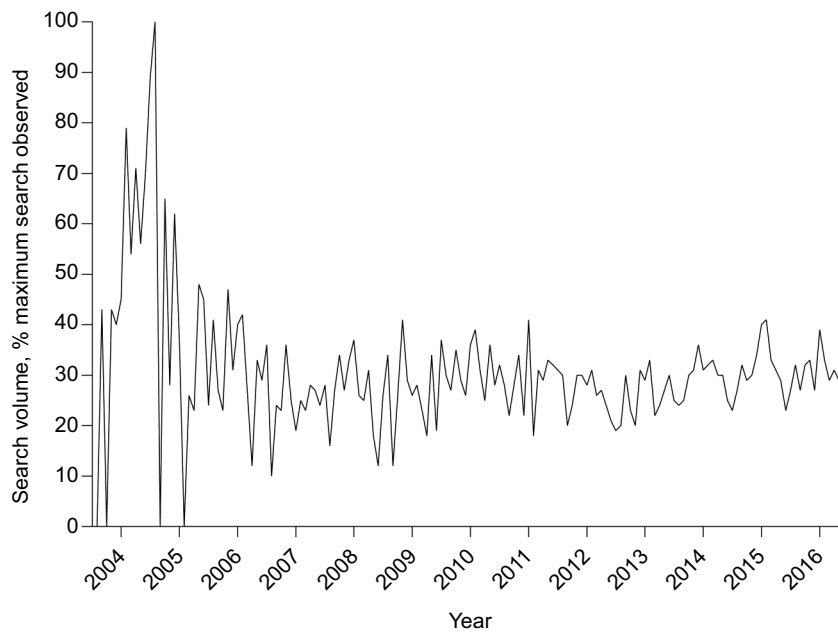
## Disclosure

The authors report no conflicts of interest in this work.

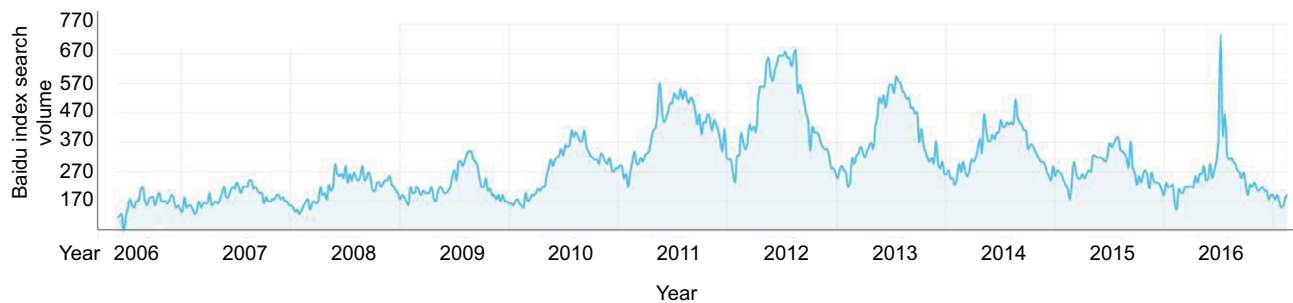
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## Supplementary materials



**Figure S1** Google Trends Internet search volume for cellulitis in a country which does not show any regular pattern (Puerto Rico from January 2004 to December 2016).



**Figure S2** Baidu Index Internet search volume for cellulitis in China from June 1, 2006 to March 1, 2017.

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