



Doctor Google: Correlating internet search trends for epistaxis with metropolitan climates[☆]

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ARTICLE INFO

Keywords:

Epistaxis
Nosebleed
Google Trends
Temperature
Humidity
Barometric pressure
Dew point
Dew point temperature
Google
Weather

ABSTRACT

Objective: Variation in weather patterns is often cited as a risk factor for epistaxis although robust studies investigating specific climate factors are lacking. As society is increasingly utilizing the Internet to learn more about their medical conditions, we explore whether Internet search activity related to epistaxis is influenced by fluctuations in climate.

Methods: Internet search activity for epistaxis-related search terms during 2012–2017 were extracted from Google Trends and localized to six highly populated cities in the US: New York, New York; Los Angeles, California; Chicago, Illinois; Houston, Texas; Philadelphia, Pennsylvania; and Atlanta, Georgia. Data were compared to local average monthly climate data from the National Centers for Environmental Information for the same time period.

Results: Spearman correlations (r) were statistically strongest for dew point temperature ($r_{\text{NewYork}} = -0.82$; $r_{\text{Philadelphia}} = -0.74$; $r_{\text{Chicago}} = -0.65$; $r_{\text{Atlanta}} = -0.49$, $r_{\text{LosAngeles}} = -0.3$). This was followed closely by relative humidity ($r_{\text{NewYork}} = -0.63$; $r_{\text{Philadelphia}} = -0.57$; $r_{\text{LosAngeles}} = -0.44$; $r_{\text{Atlanta}} = -0.42$; $r_{\text{Houston}} = -0.40$) and average temperature ($r_{\text{NewYork}} = -0.8$; $r_{\text{Philadelphia}} = -0.72$; $r_{\text{Chicago}} = -0.62$; $r_{\text{Atlanta}} = -0.45$). Overall, correlations were most significant and predictable for cities with the greatest seasonal climate shifts (New York, Philadelphia, and Chicago). The weakest environmental factor was barometric pressure, which was found to be moderately positive in Atlanta ($r_{\text{barometric}} = 0.31$), Philadelphia ($r_{\text{barometric}} = 0.30$) and New York ($r_{\text{barometric}} = 0.27$).

Conclusions: Google Trends data for epistaxis-related search activity responds closely to climate patterns in most cities studied, thus underscoring the potential utility of Internet search activity data as a resource for epidemiologic study and for the identification of at risk populations.

1. Introduction

Epistaxis is one of the most common complaints seen by otolaryngologists, affecting over 60% of the population in their lifetime and requiring 6% to seek medical attention [1–6]. Epistaxis accounts for 1 in 200 emergency department visits annually in the United States, with

thousands requiring hospital admission [4,7]. Episodes of epistaxis among individuals can oftentimes be attributed to factors such as coagulopathy, acute illness, intranasal pathology, allergic rhinitis, or nasal trauma (picking), and have also been found to have a close relationship with environmental factors [8]. Previous studies have highlighted a strong correlation between climate and incidence of epistaxis, noting an

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<https://doi.org/10.1016/j.amjoto.2019.02.001>

Received 19 November 2018

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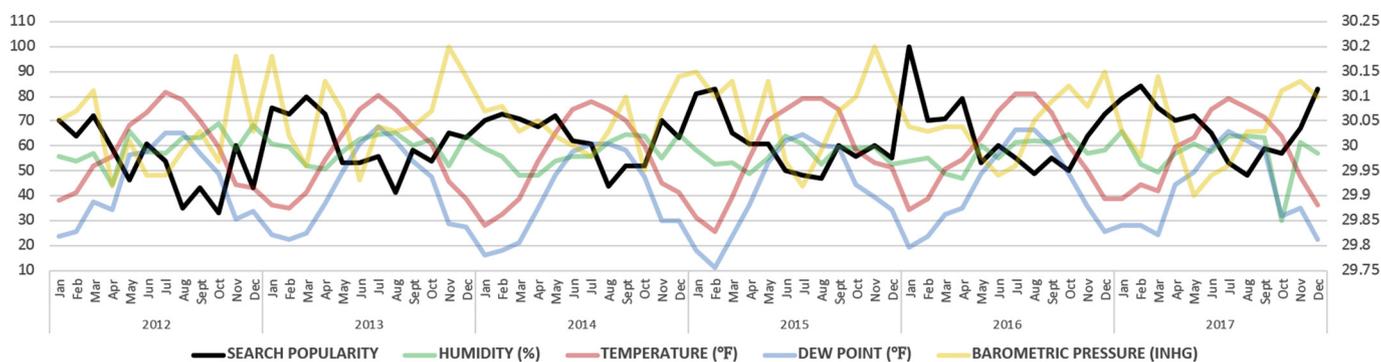


Fig. 1. Epistaxis search activity versus climate factors in Philadelphia, Pennsylvania. Search popularity, temperature (F), and percent humidity are measured on the left primary axis, and barometric pressures are measured on the right secondary axis.

increased frequency of epistaxis in winter months [1,9–14]. One particular study reported a decrease of 40% of emergency room visits during summer months [15].

In an era of constantly evolving information technology and electronically available health information, patients are frequently turning to internet resources for symptom-related information and basic medical advice [16–20]. Previous studies have illustrated a positive association between environmental factors and internet searches for health information related to illnesses and their symptomatology [21,22]. Google is currently the most widely used search engine in the world, with a research firm reporting a market share of up to 90% of all search queries in the United States as of the year 2018 [23]. A feature known as Google Trends has geographically displayed search data and volume history for specific terms since January 2004 [17,24]. In conjunction with climate trends issued by the National Centers for Environmental Information, herein we aim to illustrate a correlation between Google internet searches for terms related to epistaxis and changes in environmental conditions related to temperature, humidity, and barometric pressure.

2. Materials and methods

2.1. Google Trends

Internet search activity data were exclusively obtained from the Google Trends website at “<https://google.com/trends/>” maintained by Google Inc. (Mountainview, California). A *topic trends* search was conducted for “nosebleed”, a feature which consolidates several variants of epistaxis related search phrases to provide the most accurate measurement of activity. Results were then visualized for several years in order to condense search activity by month, instead of weeks, to correlate with monthly climate data. Monthly search activity was then extracted from Google’s website from the years 2012 through 2017 and limited to six cities in the United States: New York, New York; Los Angeles, California; Chicago, Illinois; Houston, Texas; Atlanta, Georgia, and Philadelphia, Pennsylvania. The purpose of including multiple cities allows the authors the opportunity to investigate whether climate factors correlate consistently despite differences in geographic location. Since search trend data omits any personal user information, Institutional Review Board (IRB) approval was not necessary as per the standing policy of the IRB of Medical College of Georgia – Augusta University (Augusta, Georgia).

2.2. Climate data

Monthly climate data including average temperature, barometric pressure, and dew point temperature was obtained from single weather stations in each metropolitan area through the National Centers for Environmental Information (Asheville, North Carolina) for 2012–2017.

The weather stations included in the analysis are as follows: 94789/JFK from John F. Kennedy International Airport, 13739/PHL from Philadelphia International Airport, 94846/ORD from Chicago O’Hare International Airport, 12960/IAH from George Bush Intercontinental Airport in Houston, 13874/ATL from Hartsfield–Jackson Atlanta International Airport, and 23174/LAX from Los Angeles International Airport [25]. Relative humidity for each month was calculated using the August-Roche-Magnus approximation, a function of dew point and average temperature values.

2.3. Statistical analysis

All data was maintained in a Microsoft Excel 2016 worksheet (Microsoft Corporation, Redmond, Washington). Spearman correlation coefficients comparing trend data with individual climate factors was calculated using SPSS Statistics 21.0 (IBM, Armonk, New York). Significance of correlation for each dataset was computed using a 2-tailed Student’s *t*-test. The significance level was set at $\alpha = 0.05$ for all tests.

3. Results

In cities with greater seasonal shifts in weather (Philadelphia, Chicago, and New York), the overall trend data assumed a more sinusoidal wave pattern over time, with popularity mostly peaking in January through March and most diminishing by July through October. Interestingly, search activity over time was less predictable in the cities with more temperate climates (Houston, Los Angeles). This can be observed in the graphed data for each city in Figs. 1 through 6. All Spearman correlation coefficients (*r*) calculated can be located in Table 1.

3.1. Average temperature

Temperature was found to have a statistically significant negative correlation with Internet search trend data in Philadelphia, Chicago, New York, and Atlanta ($r_{temp} = -0.72$, $r_{temp} = -0.62$, $r_{temp} = -0.8$, and $r_{temp} = -0.45$ respectively). Unlike these very strong correlations, Los Angeles and Houston were found to have a weak negative correlation respectively ($r_{temp} = -0.12$, $r_{temp} = 0.02$), although these values were not statistically significant.

3.2. Relative humidity

Relative humidity was shown to have statistically significant negative correlations with search activity in Philadelphia, New York, Los Angeles, Atlanta, and Houston. Philadelphia and New York was observed to have strong relationships ($r_{humidity} = -0.57$, $r_{humidity} = -0.63$ respectively), while Los Angeles, Atlanta, and

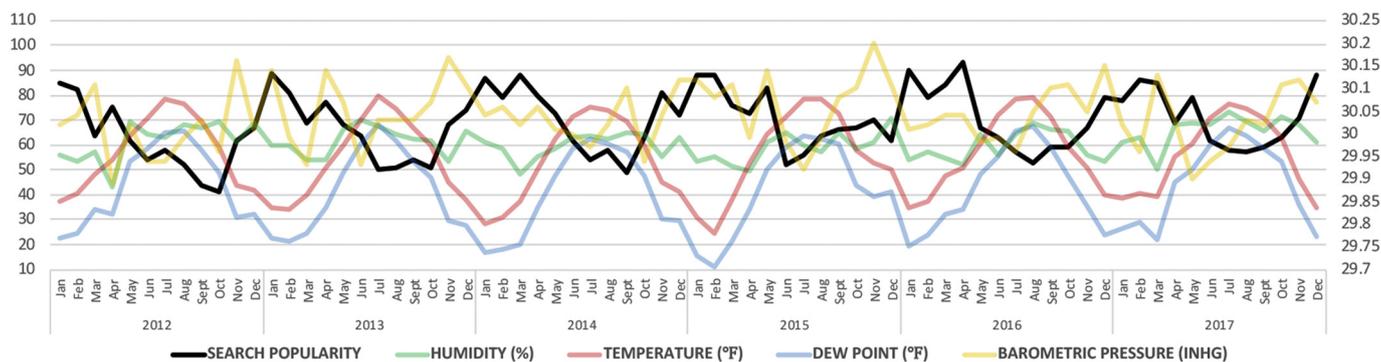


Fig. 2. Epistaxis search activity versus climate factors in New York City, New York. Search popularity, temperature (F), and percent humidity are measured on the left primary axis, and barometric pressures are measured on the right secondary axis.

Houston showed more moderate levels of correlation ($r_{\text{humidity}} = -0.44$, $r_{\text{humidity}} = -0.42$, $r_{\text{humidity}} = -0.4$ respectively). An unusual finding was the weakly positive correlation in Chicago ($r_{\text{humidity}} = 0.11$), however, this was not statistically significant.

3.3. Dew point

Statistically significant negative correlations with Google Trends data was measured in Philadelphia, Chicago, New York, and Los Angeles. The strongest correlations were seen in Philadelphia, New York, and Chicago ($r_{\text{dew point}} = -0.74$, $r_{\text{dew point}} = -0.82$, $r_{\text{dew point}} = -0.65$ respectively). A moderately negative correlation was observed in Atlanta ($r_{\text{dew point}} = -0.49$). A weakly negative correlation was seen in Atlanta and Houston ($r_{\text{dew point}} = -0.3$, $r_{\text{dew point}} = -0.13$), although the latter city was not found to be significant.

3.4. Barometric pressure

Barometric pressure was found to have a weak positive correlation overall with statistical significance only observed in Philadelphia, New York City, and Atlanta ($r_{\text{barometric}} = 0.3$, $r_{\text{barometric}} = 0.27$, $r_{\text{barometric}} = 0.31$ respectively). Chicago, Los Angeles, and Houston were also observed to have weak correlation values ($r_{\text{barometric}} = 0.23$, $r_{\text{barometric}} = 0.22$, $r_{\text{barometric}} = 0.13$, respectively), however, these were found to be statistically insignificant.

4. Discussion

The increasing utility of the general population on the internet for health information has had a fundamental impact on the manner in which medical knowledge is sought and obtained. In 2012, a large population-based survey demonstrated that 91% of individuals used online search engines to find information on the Web, of which 83%

had a preference for Google over other search engines [26]. Moreover, Google generates more Web-related traffic than any other website [27], thus capturing a large population proportion. Google Trends has proven to be a valuable resource in demonstrating geographic and temporal relationships between internet search activity and disease processes in Otolaryngology. One study from 2015 used Google Trends to demonstrate the connection between mountain cedar pollen levels and internet search activity in Texas [22]. Another 2015 study from the Dallas-Fort Worth metro region looked at the connection between internet searches for sinusitis and patterns of seasonal influenza-like illness as well as environmental nitrogen dioxide levels [21].

In the present study, Google Trend data demonstrated a sinusoidal pattern with peaks in January through May and troughs in June through December. In general, epistaxis search activity (ESA) was inversely correlated with dew point, humidity, and temperature, with the strongest trends seen in Philadelphia, New York, and Atlanta. The search trends in these areas were more waveform and predictable than in Houston and Los Angeles, areas with more stable seasonal weather patterns. Barometric pressure, on the other hand, had a weak positive correlation with ESA in Philadelphia, New York City, and Atlanta, but this trend did not hold for the other metropolitan areas studied. It is important to note that Houston demonstrated the lowest correlation with weather factors which may be the result of the overall low search popularity figures when compared to the other cities.

As epistaxis is a common otolaryngologic-related reason for emergency visits in the United States, a better understanding of its seasonality is paramount in guiding specific health policies. Specifically, Web-based and social media communication regarding weather-related epistaxis risk indices may prove beneficial in informing epistaxis patients effectively; in fact, recent literature endorses the use of the internet and social media in informing clinicians and empowering patients [28]. By understanding where the strongest trends of epistaxis exist in a real-time fashion, high risk populations can be better targeted

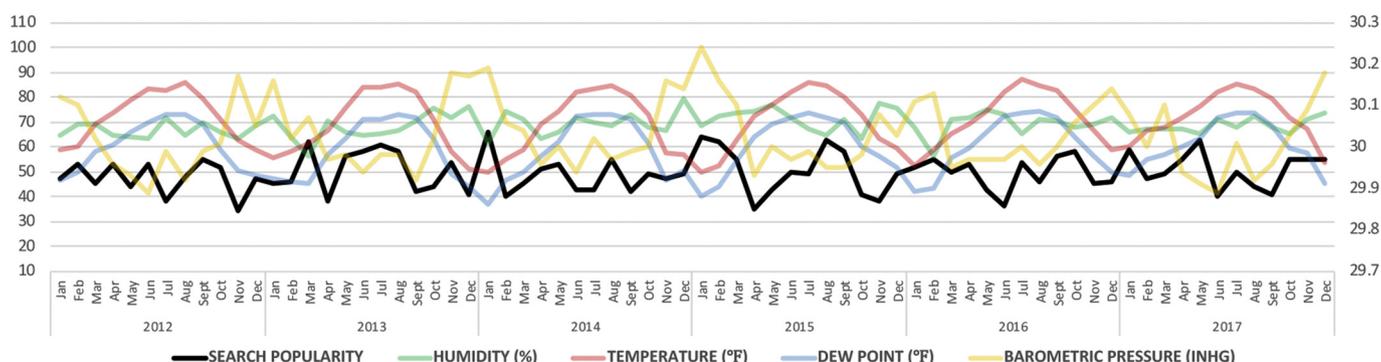


Fig. 3. Epistaxis search activity versus climate factors in Houston, Texas. Search popularity, temperature (F), and percent humidity are measured on the left primary axis, and barometric pressures are measured on the right secondary axis.

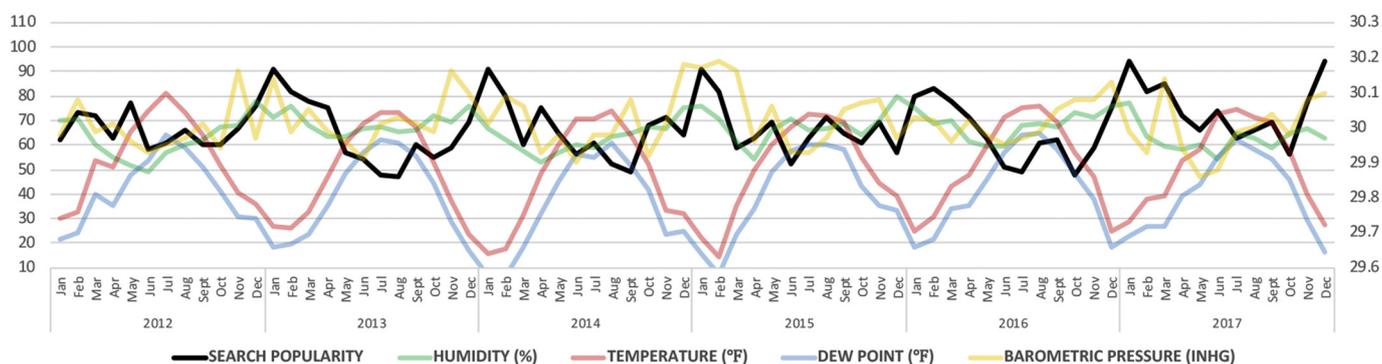


Fig. 4. Epistaxis search activity versus climate factors in Chicago, Illinois. Search popularity, temperature (F), and percent humidity are measured on the left primary axis, and barometric pressures are measured on the right secondary axis.

by public health efforts, thereby mitigating the tremendous morbidity and cost that epistaxis accounts for.

The seasonal parameter with the strongest relationship with ESA was dew point. In simple terms, dew point is a measure of the absolute moisture in the air. Therefore, absolute air moisture is the most important weather-related factor related to ESA identified by this study, and was consistent regardless of geography. One possible explanation for this trend is that low dew points cause dryness of the nasal mucosa, predisposing vessels for injury. Interestingly, the relationship between epistaxis and dew point has not, to our knowledge, been studied previously. There is no mention of dew point in relation to epistaxis anywhere in the English literature. As the exact etiology of epistaxis remains unclear, this is an important finding that warrants further investigation. A prospective study relating dew point and rates of epistaxis may prove to be valuable in elucidating the factors involved in the pathophysiology of epistaxis.

In contrast, relative humidity, a function of dew point and temperature, has been well-studied [29,30], with the general consensus being that as humidity drops, rates of epistaxis rise. Relative humidity is a concept that represents the amount of moisture in the atmosphere compared to the amount of moisture that can be present in the atmosphere at a given temperature. Despite the body of literature supporting the inverse relationship between relative humidity and rates of epistaxis, a couple studies disagree. One large retrospective analysis of 4315 patients from Alberta, Canada found no correlation between humidity and epistaxis admissions rates [9]. Another retrospective British study correlating weather-related variables to 1071 admissions for epistaxis demonstrated that the variance in admission rates due to humidity was < 1%, and thus irrelevant [31]. These studies however, were limited in their scope of geography. The analyzed data reported herein of the browsing behavior of millions of Internet users suggests statistically significant inverse relationships between humidity and ESA across the United States.

Similarly to humidity, a strong inverse relationship was also observed between ESA and average daily temperature; another finding that agrees with previous literature. Several previous analyses have likewise suggested a negative correlation between epistaxis-related emergency department visits and average temperature [9,29]. One large Italian study demonstrated a peak incidence of epistaxis in winter months, with a strong negative correlation seen between average daily temperature and epistaxis admissions [29]. One 2005 study from London, on the other hand, did not find any correlation between hospital admissions and ambient temperature; it is important to note that this analysis only included admissions, thereby limiting the criteria for patient inclusion [32]. Echoing similar correlations observed with dew point and humidity, the trends demonstrated in the present analysis were strongest in areas with greater seasonal variability: New York, Philadelphia, and Chicago.

Of all the meteorological factors studied herein, the connection between barometric pressure and ESA was the weakest. We did observe a positive correlation in Philadelphia, New York City, and Atlanta, but the trend was not as strong as the negative relationships between ESA and humidity, ambient temperature, and dew point. This is a finding that warrants further investigation, as we did not account for the effects caused by abrupt changes in barometric pressure, which may be more telling than absolute monthly barometric pressures. Other studies likewise found no statistically significant correlation between epistaxis and atmospheric pressures [13,30,31]. These studies, like ours, do not account for abrupt changes in atmospheric pressure that have been suggested as possible causes for epistaxis.

Although this study helps establish a stronger relationship between meteorological factors and epistaxis, there are certain limitations inherent to our analysis. First, our study excludes other environmental factors that may confound our results (i.e., pollution, ozone level, nitrogen dioxide levels, etc.). Additionally, the search popularity data provided from Google is relative to the city population at each moment

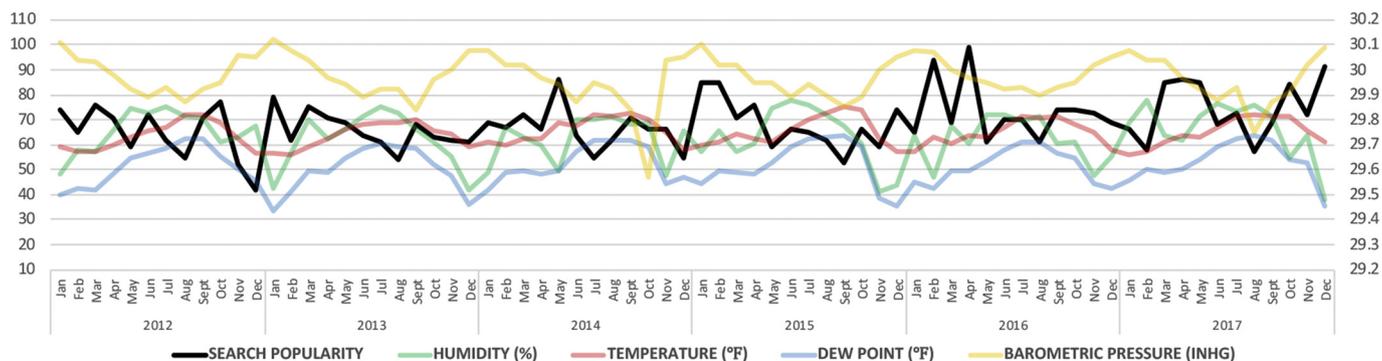


Fig. 5. Epistaxis search activity versus climate factors in Los Angeles, California. Search popularity, temperature (F), and percent humidity are measured on the left primary axis, and barometric pressures are measured on the right secondary axis.

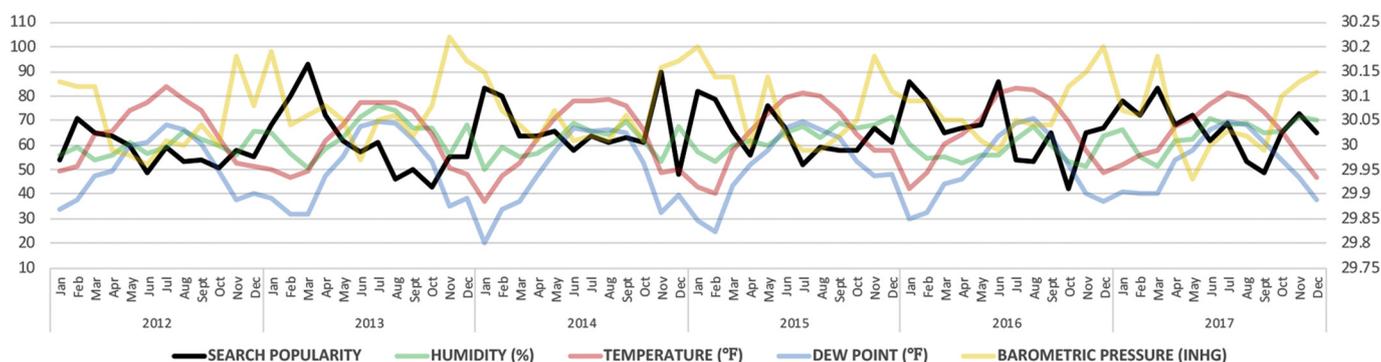


Fig. 6. Epistaxis search activity versus climate factors in Atlanta, Georgia. Search popularity, temperature (F), and percent humidity are measured on the left primary axis, and barometric pressures are measured on the right secondary axis.

Table 1
Spearman correlation rates for climate factors and search popularity.

| | Relative humidity | Average temperature | Barometric pressure | Dew point |
|---------------|-------------------|---------------------|---------------------|-----------|
| Philadelphia | -0.57** | -0.72** | 0.30** | -0.74** |
| Chicago | 0.11 | -0.62** | 0.23 | -0.65** |
| New York City | -0.63** | -0.80** | 0.27** | -0.82** |
| Los Angeles | -0.44** | -0.12 | 0.22 | -0.30** |
| Atlanta | -0.42** | -0.45** | 0.31** | -0.49** |
| Houston | -0.40** | -0.02 | 0.13 | -0.13 |

** Indicates p value < 0.05.

in time, so we were unable to calculate numerical differences in search popularity between each city. Google Trends also does not provide any data regarding age, race, or gender so no conclusions regarding demographics can be made based on these metrics. A marketing firm, Further, published demographic analytics in 2015 which showed that Google searchers were more likely to be between the ages 18–44, while users over the age of 45 were more likely to use Bing or Yahoo search [33]. This suggests that Google searches analyzed herein are likely skewed by a younger userbase. Lastly, no quantitative assessment of the actual burden of epistaxis over the course of this time period exists for each metropolitan region that could be utilized for comparison. For this reason, caution should be advised when considering the implications of such search activity analyses.

5. Conclusion

Epistaxis is a common condition affecting greater than half the population at some point in their lifetime, with climate variables previously suggested as potential risk factors. Our analysis showed strong correlations in ESA with dew point temperature, average temperature, and relatively humidity, particularly in metropolitan areas with large seasonal shifts in climate. To our knowledge, this is the first study to correlate epistaxis-related Google Trends search activity to objective meteorological factors across multiple major metropolitan cities, each with unique climate patterns. It is also the first to suggest a strong negative correlation between dew point and ESA, a trend that warrants further investigation.

Widespread utilization of Internet search engines for health-related information has provided the authors a novel opportunity to utilize Google Trends to examine epidemiologic factors related to epistaxis. The results of this 6-year analysis provide practitioners with a clearer illustration of the role of weather-related variables in epistaxis across the United States, and highlight potential geographic regions where these variables may be more influential than others. Analyzing Internet search activity in future epidemiologic studies may improve the targeting of high risk populations that could ultimately benefit from increased public health awareness to mitigate morbidity and its

associated costs.

Financial disclosures

None.

Conflicts of interest

None.

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