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Internet search volumes in brain aneurysms and subarachnoid hemorrhage: Is there evidence of seasonality?

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ABSTRACT

Objective: Results of previous studies examining seasonal variation in the incidence of aneurysmal subarachnoid hemorrhage (SAH) are conflicting. The aim of this brief report is to investigate whether there is a seasonal effect in online search queries for SAH that may reflect an association between meteorological factors and aneurysm rupture.
Patients and methods: We used the Google Trends data service to analyze the volume of internet queries for SAH on Google's search engine from January 1, 2004 to November 2016. We used comprehensive search terms and collected data from: USA, Canada, and countries known for their high prevalence of SAH (Finland, and Japan), as well as worldwide search volume. Potential seasonal variations in the data were assessed by comparative non-parametric tests and curve-fit regression model.
Results: Our analyses revealed that USA had the highest median value in cumulative search scores (115 vs. 86, 46, 46 for Finland, Canada and Japan, respectively). The term "brain aneurysm" was the commonly used search term among countries, followed by "cerebral aneurysm". There was no evidence of seasonality in any of the countries studied on both univariate tests and regression time-adjusted analysis.
Conclusions: There are no seasonal variations in internet search query volume for SAH. Further studies are needed to explore whether online search volumes correlate with the actual incidence of SAH.

1. Introduction

Studying risk factors for aneurysmal subarachnoid hemorrhage (SAH) allows for better understanding of pathophysiology, improved preventative strategies, and more efficient use of limited healthcare resources. Some risk factors, such as hypertension, smoking, and ethnicity are well-known [1], but other often-overlooked factors such as meteorological conditions and seasonality, are still topics of controversy. Some previous studies have shown an increase in the occurrence of SAH in the wintertime and a nadir in the summer [2–5], whereas others have instead reported a increase in the spring [3], summer [6], or autumn [7]. Still others however have found no relation at all between season and SAH occurrence [1,8–11].

Recently, publications have shown that internet search volumes can provide insight on patterns of disease and population health behavior [12,13]. The application of internet data in healthcare research may be complementary to other, more traditional, sources of information such as patient surveys and hospital data [12]. A systematic review has shown that previous studies that have used internet search volumes to evaluate public interest found that observational data of disease-specific seasonal trends correlated well with external datasets [12]. Specifically, Garrison et al. [14] found that Google search volumes for "leg cramps" were significantly seasonally correlated with new quinine prescriptions, a surrogate marker for new diagnosis of nocturnal leg cramps, in British Columbia. Additionally, Breyer et al. [15] found that Google search volumes for "kidney stones" were correlated both seasonally and regionally with emergent hospital admissions caused by nephrolithiasis, as seen on the Nationwide Inpatient Sample database of the United States.

Therefore, the aim of our study is to investigate whether there is a seasonal variation in the online search volume for aneurysmal SAH that may reflect an association between seasonal variation and aneurysm

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rupture.

2. Materials and methods

Google Trends is a publically accessible and free data service (https://www.google.com/trends/) hosted by Google Inc. that provides search volumes for any term used on their online engine. Google Trends analyzes a portion of the three billion daily Google searches and provides downloadable, observational data on geospatial and temporal patterns in search volumes for user-specified terms. This data is provided in a standardized score of the keyword used in the search with a value that ranges from 0 to 100. A value of 0 indicates minimal volume for the specific search queries and maximum volume for a value of 100.

We used Google Trends data to assess online activities related to SAH and its primary pathology, and collected worldwide and country-specific data (USA, Canada, and highly prevalent countries with SAH such as Finland and Japan) from the start of January 2004 to November 2016. A comprehensive search strategy was employed to determine the seasonality effect in internet search volume for SAH. The search was performed by applying the following search terms: *"subarachnoid hemorrhage"*, *"intracranial aneurysm"*, *"cerebral aneurysm"* and *"brain aneurysm"*. These terms were translated to other languages for our search on non-English speaking countries using online translator tools. We performed the search in the official language of the selected countries, and in countries with multiple official languages, we chose the language that the majority of the population spoke (English for USA, English for Canada, Finnish for Finland, Japanese for Japan). Our previous work showed that these terms were the most widely used keywords by online users interested in SAH and brain aneurysms [16]. We collected search volume scores for each term per month and then stratified them by the seasons (winter, spring, summer, and fall).

2.1. Statistical analysis

Because searches for "brain aneurysm" or "cerebral aneurysm" on Google Trends could refer to either "ruptured" or "unruptured" aneurysms, we performed our analysis using Google Trends standardized scores for each term (0–100) and with cumulative values of these scores for all the keywords (which can be above 100) used during the search period per season. Summary statistics including mean; median; standard deviation and interquartile range (IQR) for all scores were calculated. Our collected data were not normally distributed. Therefore; non-parametric; two-tailed tests were performed to evaluate potential differences in number of search scores among seasons (Kruskal–Wallis test). To assess the seasonal effect in worldwide searches and in country-specific scores; we visualized internet search volume as a time series and fit them using a non-linear regression with a sinusoidal model to capture seasonal patterns as described by Garrison et al. [14] P-values were considered statistically significant if less than 0.05. All analyses were performed with GraphPad PRISM for Windows software (version 6.00; GraphPad Software; San Diego; CA).

2.2. Ethical considerations

As per the Canadian Tri-Council Policy Statement for research ethics, our study does not necessitate a review by an institutional research ethics board, since all data collected are publicly available.

3. Results

Our analyses revealed that USA had the highest median values in cumulative search scores (115 vs. 86, 46, 46 for Finland, Canada and Japan, respectively). The term "brain aneurysm" was the commonly used search term among countries (median: 43, IQR: 28–52) followed by "cerebral aneurysm" (median: 41, IQR: 38–51). "SAH" and "in-
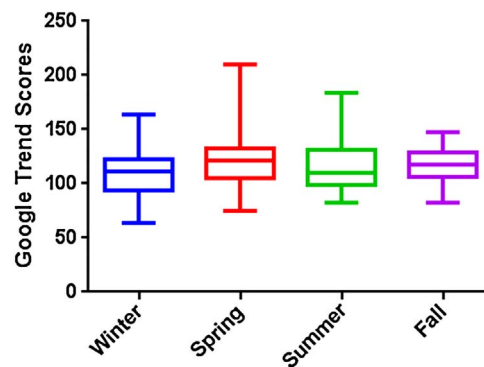

Fig. 1. Box-whisker plots for cumulative search values per season (worldwide) showing no evidence of seasonal effect. There were no significant differences between groups. Similar results were seen in each country from our sample using both individual and cumulative scores.

tracranial aneurysm" had a similar median search score of 29 (IQR 22–36). Supplementary Table S1 lists all cumulative search score results for all terms and their volume worldwide and in each specific country included in our analysis.

There was no evidence of seasonal variation in search queries regarding aneurysmal SAH in any of the countries studied on univariate tests. Median and IQR values for cumulative search scores by the seasons in all countries (winter, spring, summer, and fall) were similar and not statistically significant as shown in Fig. 1. On regression time-adjusted analysis (Fig. 2), the sinusoidal/seasonal model was not able to capture any seasonal patterns among world-wide and country-specific search volumes (R^2 values range 0.009–0.02).

4. Discussion

Our findings on the lack of seasonal variation in SAH are well supported by several studies which used hospital admission datasets [8,9] and population data-bases [1,10,11]. Field and Hill [9] assessed all stroke hospital admissions in the city of Calgary, Canada, over a five year period, and did not find any seasonal variation in overall stroke incidence or SAH occurrence. Cowperthwaite and Burnett [8] analyzed SAH admissions across 155 US hospitals and similarly did not find any seasonal trends or any significant correlation between daily SAH admission volume and meteorological changes in temperature, humidity, or atmospheric pressure. A study of the US Nation-wide Inpatient Sample database also found no significant monthly or temperature related effect in the incidence of SAH [1]. Similar results have also been found in analyses of Finnish [10] and English [11] regional datasets.

There have been several pathophysiological theories linking seasonal and meteorological factors to aneurysmal rupture although some appear to be contradictory. A general increase in blood pressure with colder temperatures has been suggested to increase risk [2]. In addition, changes in behavioural habits that accompany lower temperatures including less physical activity, as well as changes in tobacco and alcohol consumption may be important [1]. Sunlight has also been shown to affect blood pressure through alteration of circadian rhythms, with evidence showing increased SAH hospital admissions in the morning and early afternoon [17]. Vitamin D deficiency itself has been associated with higher blood pressure [2,17].

Despite some potentially sound biological explanations justifying the seasonal variability of SAH admissions in some studies, others have repeatedly failed to replicate these findings. There are multiple possible explanations for this discordance. It has been suggested that previous studies that have found a seasonal relationship with SAH may have been affected by confounding factors or bias [8]. Rothwell et al. [11] suggested that seasonal trends might merely be an artifact of referral bias in hospital-based studies. Additionally, there is variable expression of well-established risk factors for SAH, such as hypertension, tobacco