Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.

Epilepsy & Behavior 126 (2022) 108489

Contents lists available at ScienceDirect

Epilepsy & Behavior

journal homepage: www.elsevier.com/locate/yebeh

Brief Communication

Did the COVID-19 pandemic impact help-seeking behavior for seizure management? A Google Trends™ study

Maryam J. Syed *, Seher Khan, Meghan Kataria, Deepti Zutshi

Department of Neurology, Wayne State University School of Medicine, Detroit, MI, USA

ARTICLE INFO

Article history:
Received 3 November 2021
Revised 26 November 2021
Accepted 29 November 2021
Available online 3 December 2021

Keywords:
Google Trends
Epilepsy
Seizures
COVID-19

ABSTRACT

Google Trends™ is a popular tool for analyzing healthcare-seeking patterns based on observed changes in the relative search volume (RSV) of the queries made on the Google™ search engine. Google Trends™ was increasingly utilized during the pandemic to assess the impact on mental health, risk communication, the impact of media coverage, and preparedness prediction. The objective of this study was to evaluate the impact of the Coronavirus disease 2019 (COVID-19) pandemic on help-seeking behaviors for seizures and/or epilepsy by assessing the changes in seizure-related online queries in periods before and since the advent of the COVID-19 pandemic on Google Trends™. We compared the RSV volumes in the year prior to and during the COVID-19 pandemic against weekly COVID-19 positive cases for each state and US census regions Search terms were categorized according to seizure symptoms or seizure treatment. Our study showed no significant increase in the RSV for seizure and epilepsy-related searches during the COVID-19 pandemic via Google Trends™. Public health entities and medical systems may use Google Trends ™ as a way to predict national, regional, and local patient needs and drive resources to meet patient demands.

© 2021 Elsevier Inc. All rights reserved.

1. Introduction

The Coronavirus disease 2019 (COVID-19) pandemic caused significant disruption to healthcare delivery systems worldwide. As of September 2021, about 40 million people in the United States (U.S) have been infected, with approximately 743,410 deaths [1]. The massive influx of COVID-19 patients has nationally overburdened hospitals as the rapid depletion of medical supplies, rationing of healthcare providers and ancillary staff resulted in calls for reassessing the triaging criteria for neurologic admissions and transfer to hospitals [2]. The turmoil faced by hospitals has also been widely reported by news and social media outlets, as means of both maintaining transparencies and cautioning the public against poor adherence to hygiene practices and personal protective equipment such as masks, and during the later stage of the pandemic, vaccine hesitancy or refusal. A probable downside of the news reports and inside scoops from hospital facilities was the generation of fear of exposure to the infection in a clinical setting, resulting in deterrence and delay in receiving medical help warranted for treatable and preventable acute medical conditions such as myocardial infarction, stroke, and hyperglycemia crises [3]. One Centers for Disease Control and Prevention (CDC) report estimated that 40.9% of U.S adults avoided medical care during the pandemic secondary to concerns about COVID-19, of which 12% avoided urgent or emergency care [4]. Google Trends™ is a popular tool for analyzing healthcare-seeking patterns based on observed changes in the relative search volume (RSV) of the queries made on the Google™ search engine [5–7]. Google Trends™ was increasingly utilized during the pandemic to assess the impact of mental health [5], risk communication [6], the impact of media coverage, and preparedness prediction [7]. The objective of this study was to evaluate the impact of the COVID-19 pandemic on the help-seeking behaviors for seizures and/or epilepsy by assessing the changes in seizure-related queries in periods before and since the advent of the COVID-19 pandemic on Google Trends™.

1.1. Methodology

1.1.1. Data collection

Google Trends™ provides a platform to query the RSV of a keyword over a given period in a given region. RSV ranges from 0 to

Abbreviations: COVID-19, Coronavirus disease of 2019; RSV, Relative search volume.

* Corresponding author at: Department of Neurology, Wayne State University School of Medicine, 4201 St. Antoine, UHC-8D, Detroit, MI 48098, USA.
E-mail address: maryam.syed@med.wayne.edu (M.J. Syed).

https://doi.org/10.1016/j.yebeh.2021.108489
1525-5050/© 2021 Elsevier Inc. All rights reserved.

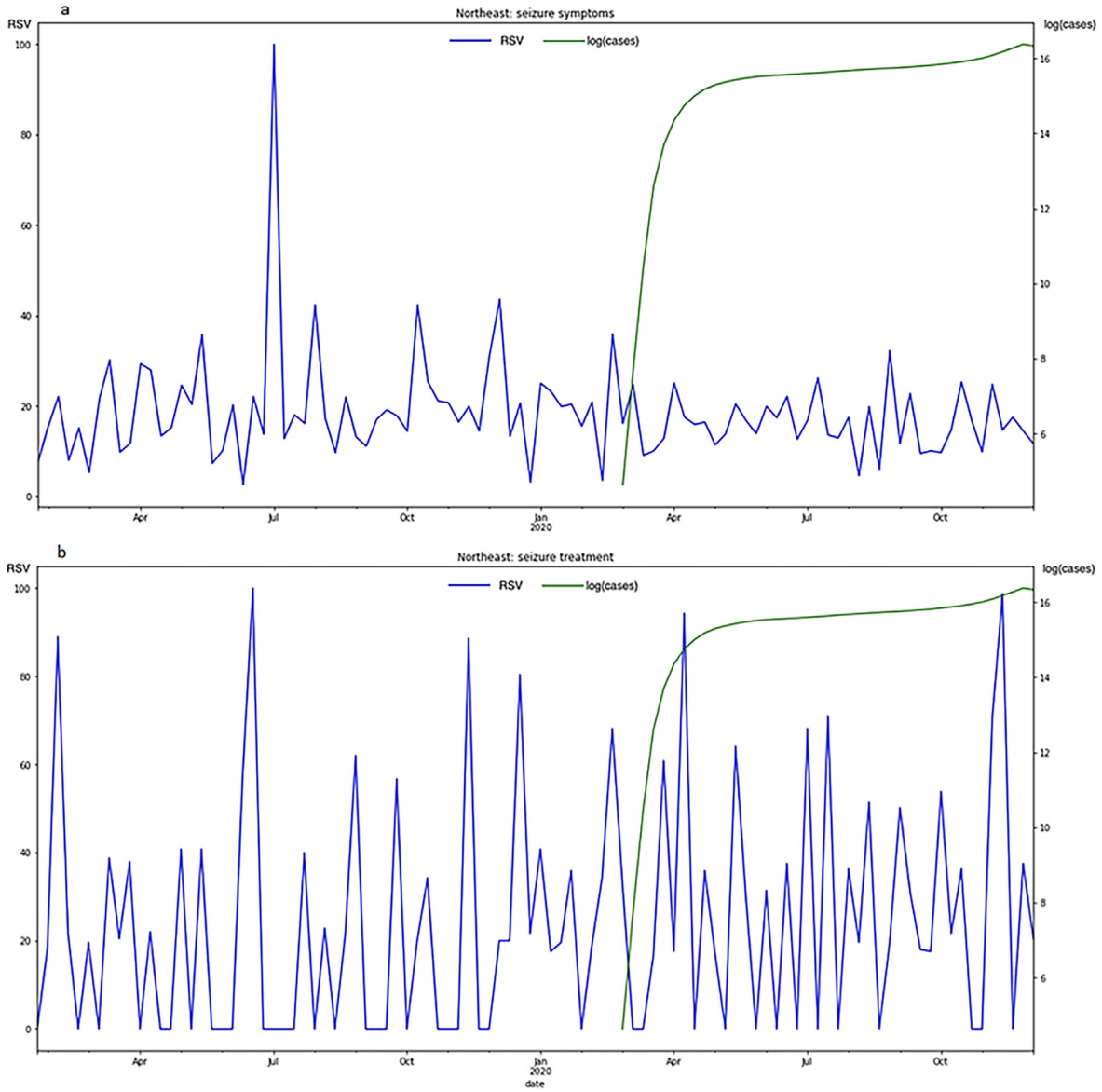

Fig. 1. (a and b) RSV (relative search volume) and Cases by category for Northeast, 2019-01-22 to 2020-12-06. (a and b) illustrate the number of RSV spikes for both keyword categories: seizure symptoms (a) and seizure treatment (b) in the Northeast from January through December 2020 period (COVID-19 period), compared to the January to December 2019 (control period). Log scale (dotted line) illustrates the exponentially growing COVID-19 cases.

100, where a higher number for a point of time indicates a larger portion of searches. Each team member was designated the task to create a list of keywords or search phrases that are most likely to be used for searching seizure-related information online. A previous infodemiological study of online behavior for epilepsy-related search terms was also used as a reference to include pertinent keywords [8]. The list of keywords was pooled together, and repetitions were removed. The finalized list of keywords was divided into two categories: seizure symptoms (“epilepsy help”, “epilepsy seizure”, “multiple seizures”, “seizure brain damage”, “seizure breathing”, “seizure death”, “seizure fever”, “seizure injury”, “seizure symptoms”, “seizure risk”, “seizure twitching”, “SUDEP”, “sudden unexplained death”, “epilepsy death”) and seizure treatment (“how to stop seizure”, “seizure medicine”, “seizure plan”, “seizure position”, “seizure response”, “stop seizure”, “what to do during a seizure”, “what to do for a seizure”).

We queried each keyword in Google Trends™, for each state (i.e., 50 US states and the District of Columbia) with search property of “web searches” and “all categories”, for January 27, 2019 to December 6, 2020 period. This time range was chosen to include the 12 months preceding the first case of COVID-19 in the United States (January 2020) as a control for normal trends in searching these terms. The resulting weekly RSV data were downloaded and data were compiled into a single file with a date (first day of the week), state, keyword, and RSV columns. State-wide daily COVID-19 cases data from January 26, 2020, to December 11, 2020, were downloaded from “The COVID-19 Tracking Project” at *The Atlantic* [9]. No institutional review board approval was required as these were publicly available data.

1.1.2. Google Trends™ and COVID-19 data

Keywords were grouped into two categories: seizure symptoms and seizure treatments. The states were also reviewed individually and grouped into their respective U.S census regions (West Midwest, South, and Northeast) [10].

To make the analysis feasible, the 2244 weekly RSV series (i.e., one series per state-keyword pair) were aggregated to produce 8 weekly RSV series (one series per region-category pair) by taking

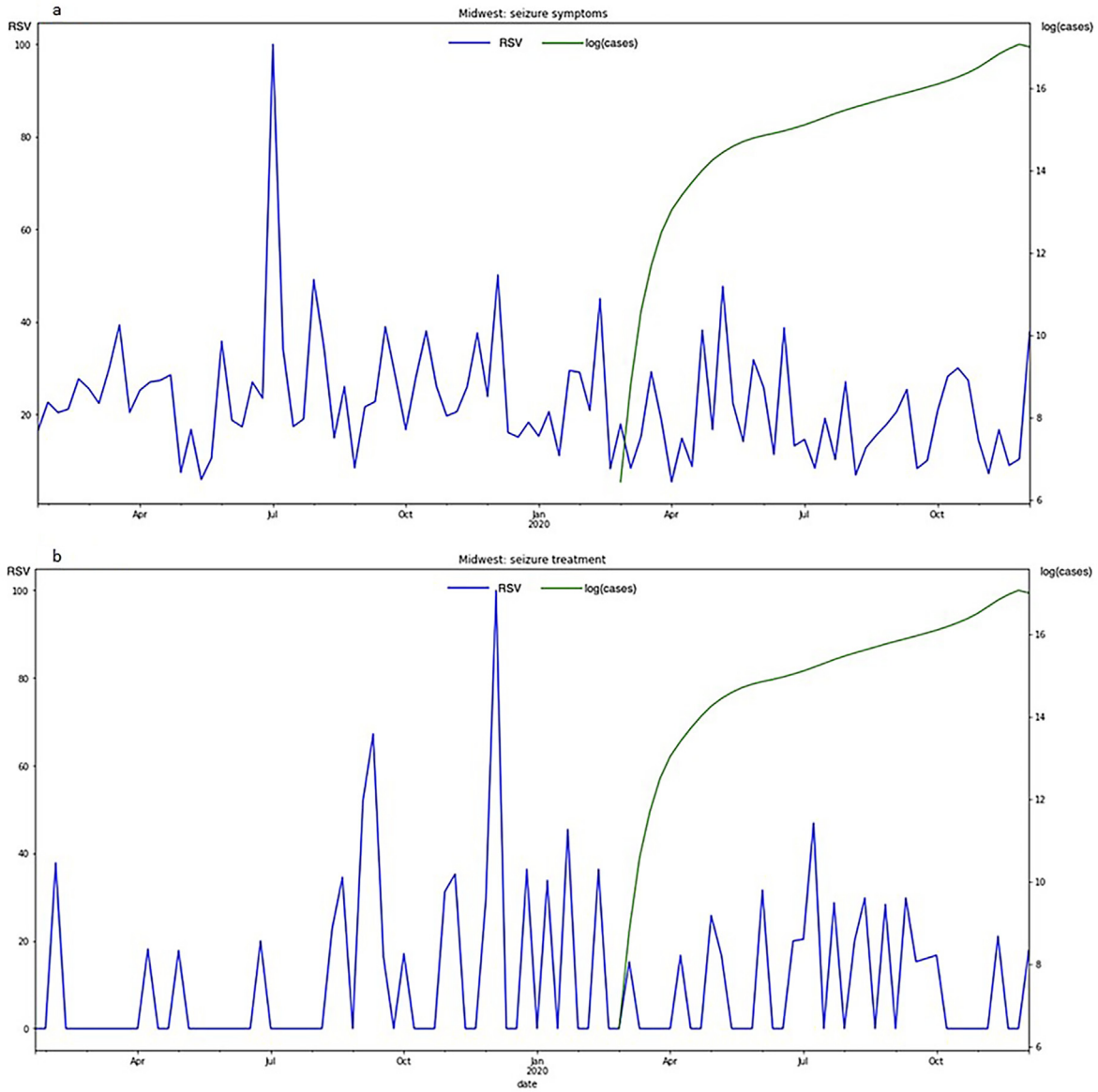

Fig. 2. (a and b) RSV (relative search volume) and Cases by category for Midwest, 2019-01-22 to 2020-12-06. (a and b) illustrate the number of RSV spikes for both keyword categories: seizure symptoms (Fig. 1a) and seizure treatment (Fig. 1b) in the Midwest from January through December 2020 period (COVID-19 period), compared to the January to December 2019 (control period). Log scale (dotted line) illustrates the exponentially growing COVID-19 cases.

simple averages. Since the raw RSV figures are a portion of total searches in the entire period rather than absolute searches, averaging meant each state in each region was given equal weight, irrespective of their population.

The number of daily COVID-19 cases was aggregated into weekly series for comparison with the similarly organized RSV data. Similarly, COVID-19 data were also organized by region (by summing up total cases in the constituent states).

The RSV for each category and region was plotted against the respective region's COVID-19 case series. Log scale was used for the exponentially growing COVID-19 cases in the plots inline for visualizing epidemiological data to highlight changes in growth rate [11]. Correlations between RSV series with the respective absolute COVID-19 cases series were also calculated for the overlapping period (January 26, 2020 to December 6, 2020).

To ascertain whether the structure of the RSV series was different after the first COVID-19 case became known in the U.S, we conducted the Mann–Whitney *U* test to compare the series over the pre-COVID control period (January 27, 2019 to January 19, 2020) with series over the COVID-19 period (January 26, 2020 to December 6, 2020 (COVID-19 period).

Table 1
Mann–Whitney *U* test results comparing RSV (Relative Search Volume) series for the control period vs COVID-19 period by category and region.

Region	Category	Mann Whitney *U* Test *P*-value
Northeast	seizure symptoms	0.133
	seizure treatment	**0.038***
Midwest	seizure symptoms	0.027
	seizure treatment	0.430
West	seizure symptoms	0.160
	seizure treatment	0.128
South	seizure symptoms	0.094
	seizure treatment	0.422

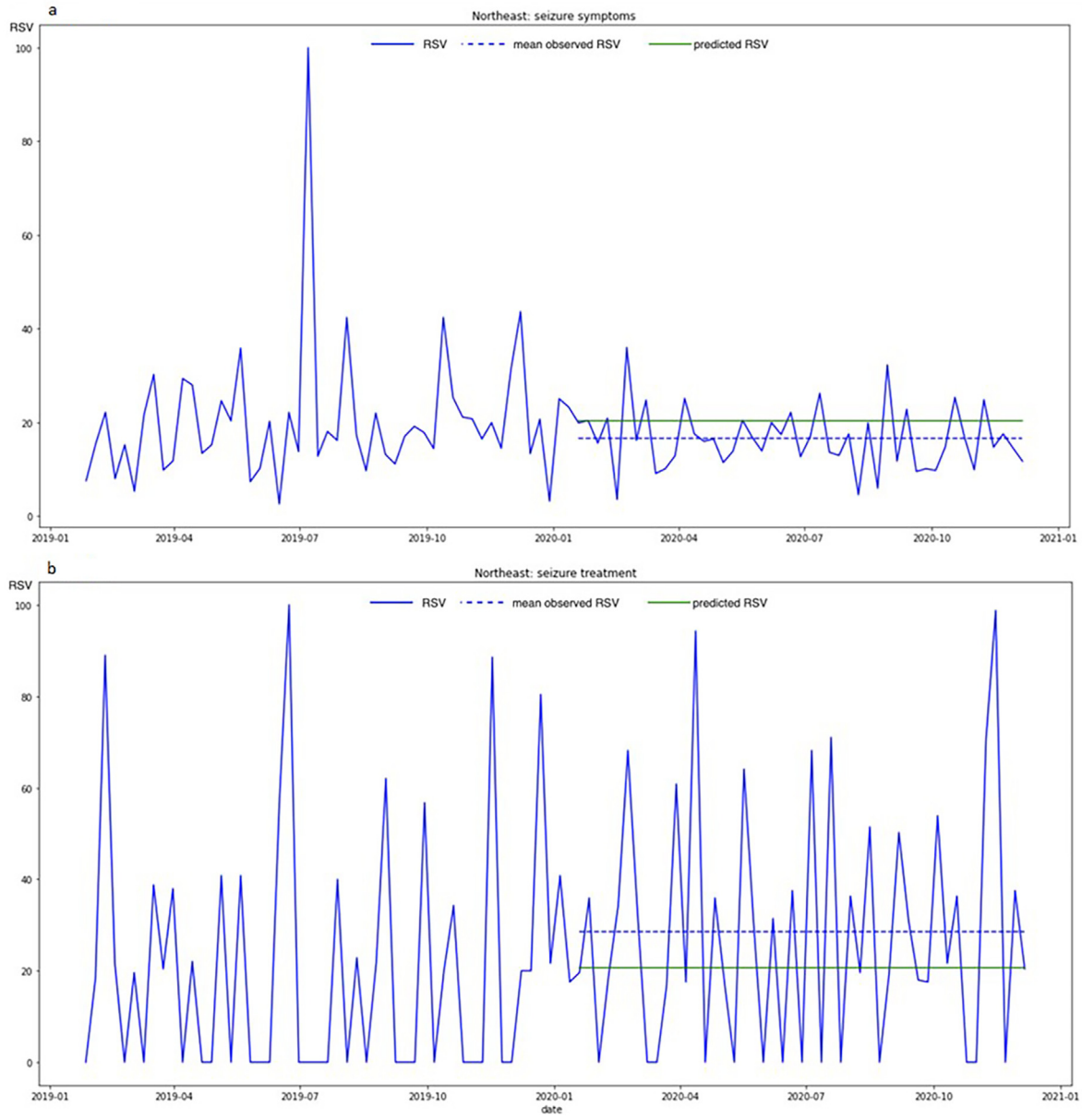

Fig. 3. (a and b) Observed and predicted RSV (relative search volume) for both keyword categories: seizure symptoms (a) and seizure treatment (b) in the Northeast from January through December 2020 period (COVID-19 period), compared to the January to December 2019 control period. (a and b) illustrate the application of the control-period based predictive model of the RSV (dotted line), and the observed RSV (blue line) for the "seizure symptoms" (a) and "seizure treatment" (b) categories for the COVID-19 period in the Northeast.

Our final step was to model the RSV data based on the control period and predict RSV for the COVID-19 period. The observed and predicted RSVs were then used to conduct a pooled two-tailed t-test to test the hypothesis that the presence of COVID-19 had resulted in a change in RSV for each category, in each region.

1.1.3. Data processing and analysis

Data processing and analysis were carried out using open source numerical and statistical Python packages on Google Colab. Graphs were plotted using *matplotlib 3.2.2* [12], and *arima* modeling and forecasting were done using *pmdarima 1.8.2* [13].

2. Results

Overall, no increase in RSV was observed after the beginning of the pandemic compared to the control period. Moreover, no significant correlations were found in RSV for each topic and region against the respective region's COVID-19 case series (Supplement table 1).

For the Northeast region, the number of spikes for "seizure treatment" was significantly higher during the COVID-19 period (p-value = 0.038), compared to the control period (Fig. 1a and b). Although a similar greater number of spikes were observed for both categories in the Midwest between July 2020 and October 2020 (Fig. 2a and b), they were not statistically significant (Table 1).

With the predictive model in place for RSV, "seizure treatments" in the Northeast was the only a combination where observed searches were higher after the first COVID-19 case compared to the predicted searches (Fig. 3). However, after applying a two-tailed test, we found the difference was not significant (p-value = 0.662).

3. Discussion

We used the Google Trends™ seizure-related search results to assess whether seizure or epilepsy help-seeking behavior was impacted by the COVID-19 pandemic. We hypothesized that a significant increase in seizure-related search queries during the COVID-19 pandemic could serve as an indicator of altered help-seeking behavior with a possible increased reliance on online information for self-treatment. Internet search engines, such as Google™, are increasingly being utilized by patients for medical literature, including first-aid actions and information about disease prognosis. This is indeed true for epilepsy and seizure-related internet searches [8,14]. Google Trends™ have been previously used in epilepsy with trends in seizure searches being associated with alcohol-related seizures during holidays associated with high alcohol consumption as well as health-issues concerning famous celebrities [15,16], known as the 'Robin Williams' Phenomenon' [17,18]. Additionally, since the COVID-19 pandemic, Google Trends™ has been vital in shedding light on certain healthcare behaviors. Ayers et al. documented a spike in anxiety-related searches on Google Trends™ at the beginning of the pandemic, suggestive of self-diagnostic/help-seeking behavior for panic and anxiety attacks [5]. Similarly, Walker et al. demonstrated a significant overlap between the health queries about loss-of-smell globally with the onset of the COVID-19 pandemic [19]. Recent studies have shown a significant drop in acute admissions for seizures since the pandemic [20,21]. This is contrary to the predictions of increased seizure incidence because of acute mental stress, sleep deprivation, reduced access to healthcare and pharmacies, and drastic changes to clinical practice [20,22]. In light of these predictions and the popular use of Google Trends™ data as the surrogate of help-seeking behavior, we found it reasonable to test our hypothesis. Our results showed that there was no significant increase in seizure and epilepsy-related searches during the COVID-19 pandemic, hence we were not able to assess any changes in help-seeking behavior via Google Trends™. However, the greater number of spikes in the Northeast and the Midwest regions, corresponding to the respective COVID-19 spikes in these regions does suggest increased help-seeking behavior. Similarly, searches for "seizure treatments" showed above-average RSV compared to the predictive, albeit non-significant (Supplement table 1). There are a few possibilities for our findings, firstly, perhaps our vocabulary, although comprehensive, failed to capture additional keywords or phrases that might have been used for seizure queries, which is the major limitation of our study. Secondly, epilepsy reportedly affects 1.2% of the U.S population [23], compared to more prevalent conditions like heart disease (4.6%) [24] and anxiety disorders (2.7–9.5%) [25], this might have resulted in non-significant results due to smaller Google Trends™ search volumes. Lastly, searches were only carried out in the keywords/phrases in the English language, not accounting for the various multi-lingual individuals of the population.

4. Conclusion

Internet searches are often the first approach for individuals seeking medical information for acute and chronic health conditions. Google Trends™ is an excellent resource for studying online behavior to ensure that medical literature available online is accurate and helpful. Our study did not show a significant increase in help-seeking behavior for seizures and epilepsy-related health queries. Future studies should utilize a more direct approach to studying the impact of COVID-19 on internet searches for epilepsy to better understand this issue. Public health entities and hospitals may use Google Trends™ as a way to predict local patient needs.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.yebeh.2021.108489.

References

[1] CDC. COVID-19 Data Tracker. In 2021.
[2] Ranney ML, Griffeth V, Jha AK. Critical supply shortages - the need for ventilators and personal protective equipment during the Covid-19 pandemic. N Engl J Med 2020;382:e41.
[3] Lange SJ, Ritchey MD, Goodman AB, Dias T, Twentyman E, Fuld J, et al. Potential indirect effects of the COVID-19 pandemic on use of emergency departments for acute life-threatening conditions — United States, January–May 2020. MMWR Morb Mortal Wkly Rep 2020;69:795–800.
[4] Czeisler ME, Marynak K, Clarke KEN, Salah Z, Shakya I, Thierry JAM, et al.. Delay or avoidance of medical care because of COVID-19-19-related concerns — United States, June 2020. In MMWR Morb Mortal Wkly Rep; 2020;1250–1257.
[5] Ayers JW, Leas EC, Johnson DC, Poliak A, Althouse BM, Dredze M, et al. Internet searches for acute anxiety during the early stages of the COVID-19 pandemic. JAMA Intern Med 2020;180:1706–7.
[6] Husnayain A, Fuad A, Su E-Y. Applications of Google Search Trends for risk communication in infectious disease management: A case study of the COVID-19 outbreak in Taiwan. Int J Infect Dis 2020;95:221–3.
[7] Ortiz-Martinez Y, Garcia-Robledo JE, Vasquez-Castaneda DL, Bonilla-Aldana DK, Rodriguez-Morales AJ. Can Google(R) trends predict COVID-19 incidence and help preparedness? The situation in Colombia. Travel Med Infect Dis 2020;37:101703.
[8] Brigo F, Igwe SC, Ausserer H, Nardone R, Tezzon F, Bongiovanni LG, et al. Why do people Google epilepsy? An infodemiological study of online behavior for epilepsy-related search terms. Epilepsy Behav 2014;31:67–70.
[9] The COVID-19 Tracking Project at The Atlantic. In 2020.
[10] Bureau USC. Census Bureau Regions and Divisions with State FIPS Codes. In.
[11] Sevi S, Aviña MM, Péloquin-Skulski G, Heisbourg E, Vegas P, Coulombe M, et al. Logarithmic versus linear visualizations of COVID-19 cases do not affect citizens' support for confinement. Canadian J Pol Sci Rev Can Sci Polit 2020:1–6.
[12] Hunter JD. Matplotlib: A 2D graphics environment. Comput Sci Eng 2007;9 (3):90–5.
[13] Smith TG, et al. pmdarima. 2017.
[14] Brigo F, Trinka E. Google search behavior for status epilepticus. Epilepsy Behav 2015;49:146–9.
[15] Mahroum N, Bragazzi NL, Sharif K, Gianfredi V, Nucci D, Rosselli R, et al. Leveraging Google Trends, Twitter, and Wikipedia to investigate the impact of a celebrity's death from rheumatoid arthritis. J Clin Rheumatol 2018;24:188–92.
[16] Bragazzi NL, Watad A, Brigo F, Adawi M, Amital H, Shoenfeld Y. Public health awareness of autoimmune diseases after the death of a celebrity. Clin Rheumatol 2017;36:1911–7.
[17] van Campen JS, van Diessen E, Otte WM, Joels M, Jansen FE, Braun KPJ. Does Saint Nicholas provoke seizures? Hints from Google Trends. Epilepsy Behav 2014;32:132–4.
[18] Brigo F. Impact of news of celebrity illness on online search behavior: the 'Robin Williams' phenomenon'. J Public Health (Oxf) 2015;37:555–6.
[19] Walker A, Hopkins C, Surda P. Use of Google Trends to investigate loss-of-smell-related searches during the COVID-19 outbreak. Int Forum Allergy Rhinol 2020;10:839–47.

[20] Leung WCY, Lau EHY, Kwan P, Chang R-K. Impact of COVID-19 on seizure-related emergency attendances and hospital admissions - A territory-wide observational study. Epilepsy Behav 2021;115:107497.
[21] Alkhotani A, Siddiqui MI, Almuntashri F, Baothman R. The effect of COVID-19 pandemic on seizure control and self-reported stress on patient with epilepsy. Epilepsy Behav 2020;112:107323.
[22] Wirrell EC, Grinspan ZM, Knupp KG, Jiang Y, Hammeed B, Mytinger JR, et al. Care delivery for children with epilepsy during the COVID-19 pandemic: an international survey of clinicians. J Child Neurol 2020;35:924–33.
[23] Zack MM, Kobau R. National and State Estimates of the numbers of adults and children with active epilepsy — United States, 2015. MMWR Morb Mortal Wkly Rep 2017;66:821–5.
[24] Statistics. NCfH. Percentage of angina for adults aged 18 and over, United States, 2019. National Health Interview Survey. In 2019.
[25] Terlizzi EP VM. Symptoms of generalized anxiety disorder among adults: United States, 2019. In Hyattsville, MD: National Center for Health Statistics. 2020.