IMPACT OF COVID-19 CASES ON ONLINE SEARCHES FOR COGNITIVE SYMPTOMS AND PERSISTENT COVID-19 SYMPTOMS IN BRAZIL

Kelly da Silva[1], Nathália Monteiro Santos[2], Paulo Ricardo Martins-Filho[3], Franciely Oliveira de Andrade Santos[4], Franklim Oliveira Souza[5], Ronaide Paula dos Santos[6], Raphaela Barroso Guedes-Granzotti[7] and Priscila Lima dos Santos[8]

ABSTRACT

Objetive: This study aims to investigate the impact of COVID-19 case numbers on online searches for persistent cognitive symptoms in Brazil. Material and Methods: Utilizing Google Trends™ as a proxy, we analyzed the relative normalized search volume numbers for "memory loss," "forgetfulness," and "persistent COVID-19" from March 2020 to November 2023. Result: Pearson correlation analysis was employed to explore the relationship between search volumes and registered COVID-19 cases per epidemiological week. The study revealed variable search patterns for cognitive symptoms, with "forgetfulness" showing significant̂ly higher search volumes than "memory loss" and "persistent COVID-19." Conclusion: A weak to moderate significant correlation was found between search volumes for cognitive symptoms and the number of COVID-19 cases, particularly in the first two weeks following diagnosis. This indicates an immediate public response to COVID-19 infections with increased online information-seeking behavior regarding cognitive issues. Our findings underscore the significance of infodemiology and infoveillance in monitoring public health concerns, especially during pandemics.

[1] PhD in Psychobiology
Graduate Program in Applied Health Sciences, Federal University of Sergipe - UFS, Lagarto, Brazil.
E-mail: kelly.fonoufs@gmail.com
[2] Master's Degree in Applied Health Sciences
Health Sciences Graduate Program, Federal University of Sergipe - UFS, Aracaju, Brazil.
E-mail: nathaliamonteiro.fono@gmail.com
[3] Graduate Program in Applied Health Sciences, Federal University of Sergipe - UFS, Lagarto, Brazil.
Health Sciences Graduate Program, Federal University of Sergipe - UFS, Aracaju, Brazil.
PhD in Health Sciences
E-mail: prmartinsfh@gmail.com
[4] Graduate Program in Applied Health Sciences, Federal University of Sergipe - UFS, Lagarto, Brazil.
Bachelor's Degree in Physical Therapy
E-mail: francis12_oliveira@hotmail.com
[5] Graduate Program in Applied Health Sciences, Federal University of Sergipe - UFS, Lagarto, Brazil.
Master's Degree in Applied Health Sciences
E-mail: franklimsouza1425@gmail.com
[6] Graduate Program in Applied Health Sciences, Federal University of Sergipe - UFS, Lagarto, Brazil.
Master's Degree in Applied Health Sciences
E-mail: ronaide.paula@gmail.com
[7] Graduate Program in Applied Health Sciences, Federal University of Sergipe - UFS, Lagarto, Brazil.
PhD in Neuroscience
E-mail: raphaelabgg@academico.ufs.br
[8] Graduate Program in Applied Health Sciences, Federal University of Sergipe - UFS, Lagarto, Brazil.
Health Sciences Graduate Program, Federal University of Sergipe - UFS, Aracaju, Brazil.
PhD in Health Sciences
E-mail: plimabio@academico.ufs.br

INTRODUCTION

Long COVID, also known as "post-COVID syndrome" or "post-acute sequelae of SARS-CoV-2 infection", is a multisystemic condition that encompasses often severe symptoms following a SARS-CoV-2 infection[1]. Cognitive disorders, particularly memory, are part of these symptoms and seem to be associated with mechanisms of systemic infection that trigger neuroinflammation, hypoxia, and cerebral dysfunction[2].

In Brazil, one of the countries most impacted by the pandemic, neuropsychological complications following COVID-19 have been prevalent among the population[3]. In this infodemiological and ecological study, we utilized Google Trends™ as a proxy to analyze online health information-seeking behavior, investigating interest in Brazil regarding memory loss, forgetfulness, and persistent COVID-19 throughout the COVID-19 pandemic. Furthermore, we assessed the impact of the number of registered COVID-19 cases per epidemiological week in the country on the online information-seeking behavior concerning cognitive issues and the persistence of COVID-19 symptoms.

MATERIAL AND METHODS

Operationally, Google Trends™ is an analytical tool that employs advanced algorithms to process extensive search data from Google, and it has been effectively used for infodemiology and infoveillance in public health, especially during health crises [4,5]. For this study, the keywords "memory loss," "forgetfulness," and "persistent COVID-19" (Table 1) were used, and search results were expressed as relative normalized search volume numbers (RNSNs). RNSNs range from 0 to 100 and reflect how many searches were performed with a keyword relative to the total number of searches in the region over time. A value of 100 represents the moment when the search term reached its peak popularity. RNSNs were extracted weekly from March 22, 2020 (epidemiological week 13/2020) to November 26, 2023 (epidemiological week 48/2023), and scores for each term were plotted on a vertical bar graph. Additionally, registered COVID-19 cases per epidemiological week in Brazil were extracted from official data provided by the National Council of Health Secretaries[6].

Table 1. Search terms in English and Portuguese for cognitive symptoms and persistent COVID-19 as analyzed in Google Trends.

| Keywords		Topic
In English Language	In Portuguese Language	
"Memory loss"	"Perda de memória"	Disease

| "Forgetfulness" | "Esquecimento" | Subject |
| "Persistent COVID-19" | "COVID-19 persistente" | Syndrome |

The relationship between the Internet search volumes for memory loss, forgetfulness, and persistent COVID-19 and the number of confirmed COVID-19 cases was explored through Pearson correlation analysis. Moreover, we identified the post-diagnosis temporal point at which the search interest for information on the Internet about the persistence of the disease's symptoms, including memory loss and forgetfulness, became significant. For this, we employed a lagged cross-correlation analysis with a moving average, where initially the time series were smoothed by applying a moving average to reduce short-term variability and highlight more consistent trends over time. Subsequently, correlations between the time series for different time lags were calculated, thus identifying how the relationship between the variables changes with time displacement. Correlations were categorized as follows: extremely weak (r = 0-0.19), weak (r = 0.2-0.39), moderate (r = 0.40-0.59), high (r = 0.6-0.79), and very strong (r = 0.8-1.0). Analyses were conducted using R software (R Foundation for Statistical Computing, Vienna, Austria) with a 5% significance level.

RESULTS AND DISCUSSION

The quantitative analysis reveals distinct patterns in Internet searches related to memory, forgetfulness, and persistent COVID-19 (Figure 1). Searches for "memory" showed an average RNSN of 29.31 with a standard deviation of 7.05, indicating moderate variation over time, and reaching peaks of 40 in March and May 2022. "Forgetfulness" exhibited a significantly higher and more variable search volume, with an average RNSN of 71.63, a standard deviation of 12.49, and a maximum peak of 100 in the last weeks of March and June 2022. In contrast, "persistent COVID-19" displayed a more volatile search pattern, possibly reflecting the waves of the pandemic, with an average of 11.92, a standard deviation of 10.67, and a peak of 58 in the first week of February 2022 during the emergence of the SARS-CoV-2 Variant of Concern (VOC), Omicron.

Figure 1. (A) Weekly search activity on the Internet about forgetfulness, memory loss, and persistent COVID-19 from March 22, 2020 to November 26, 2023. (B) Number of COVID-19 cases in Brazil from March 22, 2020 to November 26, 2023.
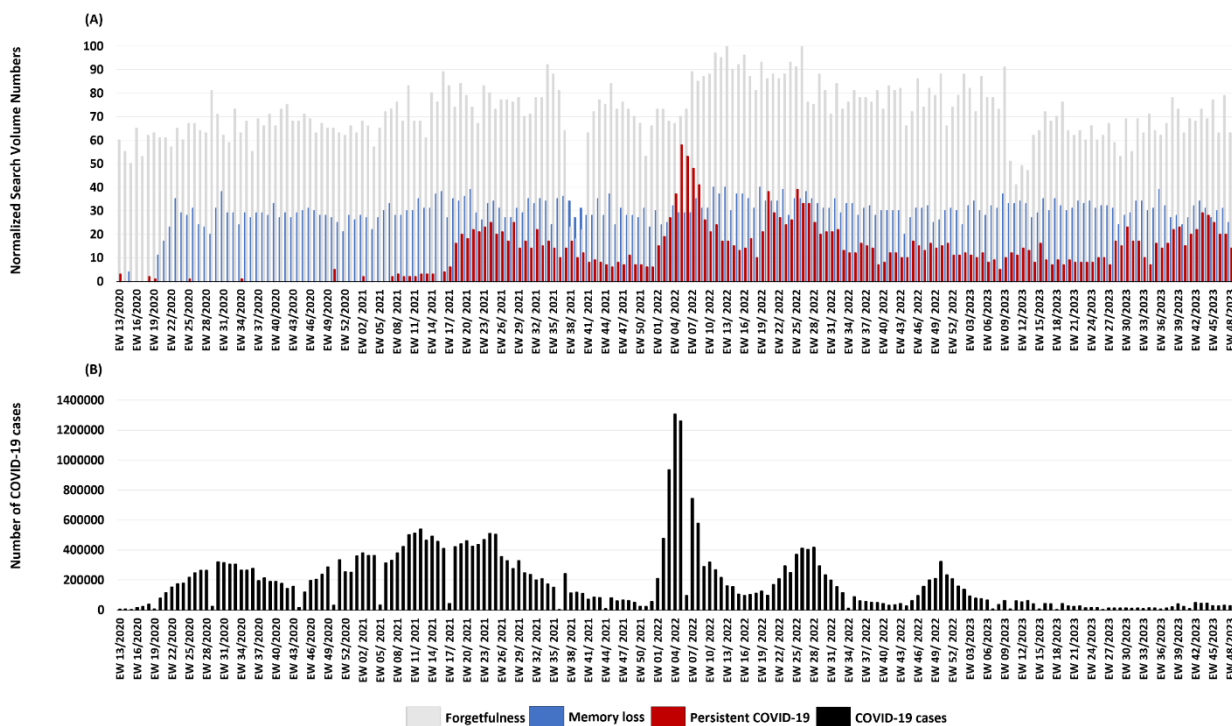
We identified a significant, positive, weak to moderate correlation between search volumes related to memory and forgetfulness (r = 0.34; 95% CI 0.20 – 0.46; p < 0.001), memory and persistent COVID-19 (r = 0.33; 95% CI 0.20 – 0.45; p < 0.001), and forgetfulness and persistent COVID-19 (r = 0.36; 95% CI 0.23 – 0.47; p < 0.001). Additionally, our results indicate a significant correlation between the incidence of COVID-19 cases in a given epidemiological week and the search for information on the Internet about the persistence of the disease's symptoms in the first (r = 0.28; 95% CI 0.14 – 0.40; p < 0.001) and second (r = 0.20; 95% CI 0.06 – 0.33; p = 0.007) weeks following. However, from a time lag of three weeks, there was no correlation between the number of COVID-19 cases and the search for information on the Internet about persistent COVID-19. Increases in search frequencies for forgetfulness issues were also observed in the first (r = 0.20; 95% CI 0.06 – 0.33; p = 0.006) and second (r = 0.17; 95% CI 0.03 – 0.31; p = 0.020) weeks following the diagnosis of COVID-19. No relationship was observed between the number of COVID-19 cases and interest in memory loss.

To the best of our knowledge, this was the first study to investigate interest in cognitive impairments and persistent COVID-19 using Web-based big data and explore its relationship with the number of COVID-19 cases in a real-world scenario. For this, Google

Trends™ provides data that are particularly relevant to understanding the dynamics of the pandemic, where a population's reactions—measured through interest in searching for information on the Internet—change in response to an external event. However, from a sociological perspective, it is imperative to consider disparities in Internet access among broad swathes of the population, as well as the diversity in approaches employed by individuals when searching for information on the same topic on the Internet. This consideration is crucial for a more accurate and contextualized analysis of online search behavior[7].

In our study, we observed a higher volume of searches for "forgetfulness" compared to "memory loss," which can be attributed to a combination of clinical, linguistic, and cultural factors. Firstly, "forgetfulness" is a more generic and accessible term, possibly preferred by individuals seeking information on mild cognitive symptoms or memory lapses, in contrast to the term "memory loss," which might be associated with more severe medical conditions. Moreover, the way symptoms of COVID-19 and its cognitive implications were addressed by the media and in online discussions might have influenced this trend. Forgetfulness may have been highlighted as a more common or less alarming symptom in everyday contexts, reflecting general concerns of people during a period of stress and uncertainty. This difference in search patterns highlights how public perception and the language used to describe health symptoms can vary significantly, especially in response to global events like a pandemic.

Despite differences in search volumes observed throughout the pandemic among these terms, there appears to be relative vigilance and concern of the Brazilian population regarding long-term symptoms associated with COVID-19, such as those affecting cognition and memory. Our findings reveal a significant correlation between the rise in COVID-19 cases and a subsequent spike in online searches for information on persistent symptoms as early as the first two weeks following diagnosis. This public response anticipates by far the three-month period following infection, defined by the World Health Organization for the diagnosis of long COVID-19[8]. Additionally, marked interest in specific symptoms, such as forgetfulness issues, illustrates a concentrated concern on cognitive aspects, aligning with the reported symptoms of post-COVID syndrome[9]. On the other hand, the decrease in correlation over time suggests a possible reduction in interest or risk perception as the temporal distance from the initial infection increases, and the symptoms of the disease disappear for most people. Despite inherent limitations to different study designs, follow-up

time, measurement methods, and diagnostic criteria, a prevalence of 5% to 50% of long COVID has been reported, being higher the more severe the initial symptoms of the disease[10-12].

CONCLUSION

In summary, our findings indicate a significant correlation between the incidence of COVID-19 cases and the search for information on prolonged symptoms of the disease, mainly those related to cognition and memory, in the first two weeks following diagnosis. These findings highlight the relevance of infodemiology and infoveillance in public health to monitor and respond to the population's concerns and information needs in real time, especially during public health crises like the COVID-19 pandemic. The ability of Google Trends™ to reflect public interest in real-time offers a valuable tool for health authorities in planning communication and health education strategies, enabling a more agile and targeted response to the population's emerging concerns.

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