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Communication

A Real-Time Infodemiology Study on Public Interest in Mpox (Monkeypox) following the World Health Organization Global Public Health Emergency Declaration

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Abstract: Google Trends (GT) is a useful real-time surveillance tool for epidemic outbreaks such as monkeypox (Mpox). GT provides hour-by-hour (real-time) data for the last seven days of Google searches. Non-real-time data are a random sample that encompasses search trends from 2004 and up to 72 h. Google Health Trends (GHT) API extracts daily raw search probabilities relative to the time period and size of the underlying population. However, little is known about the utility of GT real-time surveillance and GHT API following the public health announcements. Thus, this study aimed to analyzed Mpox GT real-time, non-real-time, and GHT API data 72 h before and after the WHO declared Mpox a public health emergency of international concern (PHEIC) in the top five Mpox-affected countries. Joinpoint regression was used to measure hourly percentage changes (HPC) in search volume. The WHO PHEIC statement on Mpox generated 18,225.6 per 10 million Google searches in the U.S. and Germany (946.8), and in 0–4 h, the HPC increased by an average of 103% (95% CI: 37.4–200.0). This study showed the benefits of real-time surveillance and the GHT API for monitoring online demand for information on emerging infectious diseases such as Mpox.

Keywords: infodemiology; Google trends; Google health trends API; monkeypox; surveillance; public health; infoveillance

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1. Introduction

The World Health Organization (WHO) declared the current outbreak of monkeypox (Mpox) as a public health emergency of international concern (PHEIC) on 23 July 2022 (9 a.m. Coordinated Universal Time [UTC]) [1]. Since early May 2022, over 82,000 confirmed Mpox cases and 65 deaths have been reported in over 100 non-endemic countries, and most of them are from the United States (U.S.), Spain, Germany, France, and the United Kingdom (U.K.) [2]. This is the first time that several Mpox cases and clusters have been observed in non-endemic countries. Given the rapid pace at which Mpox cases are rising globally, improving public knowledge is essential for containment and mitigation, particularly about Mpox transmission and the onset of symptoms.

Epidemiologic forecasting of disease spread and proper identification of the most at-risk individuals in society are necessary to ensure an effective response capable of limiting the spread of the disease. Experiences from the COVID-19 pandemic have shown that epidemiologic models of the spread of the disease could become extremely contentious, and accurate modelling and forecasting are needed. Some attempts at using more advanced techniques such as machine learning to forecast the spread of COVID-19 have been made [3]. However, two problems persist in forecasting new disease outbreaks. First, different diseases have different methods of transmission and, second, outbreaks of relatively novel diseases or outbreaks at scale of diseases which have previously had very limited

transmission may lack sufficient prior data on which to building initial machine learning models. As such, attempts at real-time forecasting which do not require the accumulation of prior data for the building of a forecasting model may be useful in the early stages of novel outbreaks.

The current Mpox outbreak is a useful test case for this. Although endemic cases have been reported in Africa since 1970, confirmed case numbers have been only in the order of hundreds per decade (although the Democratic Republic of Congo reported >10,000 suspected, but not confirmed, cases for the first decade of this century, and >18,000 for the second decade) [4]. The current outbreak dwarfs this in scale, with an average of >10,000 per month since May across the world. Additionally, while Mpox may be transmitted via several avenues [5], transmission in the current outbreak has been primarily sexual, especially amongst men who have sex with men [6–9]. This different preferential avenue of transmission means that conventional modelling of diseases transmitted primarily through other means (e.g., COVID-19, flu) cannot be applied, and new forecasting models are needed. However, the low case numbers, being mostly endemic to certain African countries [10], means that little prior data are available on which to build initial machine learning forecasting models and highlights the need for real time forecasting methods, even if only in the initial periods until sufficient data are available for more robust models. However, for a real-time data source to be useful for, and indicative of, infection spread, it should be free of media attention, although not necessarily independent of media attention, as media attention itself may be related to a certain extent to infection spread [11].

Google Trends (GT) is a free and open tool that provides real-time and archived data on Google search trends for selected keywords and topics over time. In public health, GT data are widely used to monitor disease outbreaks, forecasts, and explore health-seeking behavior [12]. GT offers real-time data on an hour-by-hour basis for the last seven days of Google searches, and non-real-time data are a random sample of real-time data that captures search trends from 2004 and up to 72 h before a user search [12]. Previous studies have used GT real-time to investigate the Google searches for abortion medications in the US [13] and the influence of Brazilian politicians on fires in the Amazon [14]. However, no studies on Mpox used real-time data or the Google Health Trends (GHT) API to examine public interest. Therefore, examining real-time data to assess public interest in Mpox after the WHO PHEIC announcement could be useful for public health decisions. Thus, based on previous research [15,16], the purpose of this study was to evaluate public interest in Mpox through real-time, non-real-time, and GHT API data 72 h before and after the WHO declared Mpox a PHEIC in the top five Mpox affected countries.

2. Materials and Methods

2.1. Data Collection and Measure

Using Google Trends data (https://trends.google.com/, accessed on 1 October 2022), this study examines the hour-to-hour Google searches in the U.S. and European countries (Spain, Germany, France, and U.K.) relating to Mpox from 20 July (9 a.m. UTC) to 26 July 2022 (9 a.m. UTC). For each country, the search criteria used was the topic "Monkeypox (disease)"—with the Freebase ID/m/01k6yf [17]—to standardize searches between countries. We used Mpox as a topic, as this returns the results of a group of terms that share the same concept in any language (as classified by Google) for both real-time and daily RSV. For the U.S. and U.K., this would incorporate searches for "monkeypox" and "monkey pox" as well as other searches which Google's AI algorithms would classify as related to those search terms. For France, this would incorporate the English searches, as well as searches for "variole (du) singe"; for Germany, it would also include "affenpocken", and for Spain, it would include "viruela (del) mono". Google Trends provides "search interest" data as relative search volumes (RSV, %) for both real-time and non-real-time data, measuring the number of search terms or topic in a standardized scale, normalized ranging from 0 (no interest) to 100 (the highest interest). A higher RSV indicates that more users are searching for a specific term or topic at a given location and time. To assess the impact of

the WHO's declaration of Mpox as a PHEIC on the public interest, we collected real-time data on an hourly basis for three days (72 h) before and after WHO's announcement. For non-real-time data, we collected daily RSV in five countries—U.S., Spain, Germany, France, and U.K.—from 20 July to 26 July 2022.

2.2. Google Health Trends API

GHT API, formally known as Google Flu Trends API [18] is a private API that requires a valid API key that is supplied by Google. Google returns 10–15% of raw search data as the 'probability' of the search query (multiplied by 10 million) during a short search session for each API call. The Google Health API methodology is described in detail elsewhere. [19,20]. The Google Trends Extended for Health extraction tool is an Excel workbook for accessing data from the GHT API [21] which was used to collect daily raw Mpox search probabilities in the U.S., Spain, Germany, France, and U.K from 18 May (Mpox first case reported in the U.K) to 30 September 2022. The raw search probabilities are not available for hourly data but do provide a probability relative to the time period and the size of the underlying population, so that the probability of searches could be compared more accurately across countries.

2.3. Statistical Analysis

For each country, we plotted line charts to describe Mpox search trends in real-time, non-real-time, and GHT API data. A Joinpoint regression analysis was performed to identify significant changes in search trend in the hourly RSV (UTC) over time in each country using the Joinpoint regression software version 4.9.0.1 (https://surveillance.cancer.gov/joinpoint/, accessed on 1 October 2022) developed by the National Cancer Institute [22]. This software analyzes trend changes at time points known as "joinpoints" and estimates the regression function from previous joinpoints [23]. The hourly percentage change (HPC) was used to summarize linear trends in search volume, and a maximum of three joinpoints were allowed for characterizing the data.

3. Results

3.1. Google Trends Daily RSVs

As shown in Figure 1, the U.S. and the U.K. had the most Google Trend daily RSV for Mpox as a topic following the WHO PHEIC statement on 23 July 2022, whilst Spain, Germany, and France had the least. The figure shows Google searches scaled relative to the region (U.S.) and time (24 July) with the highest daily RSV, which is itself set to 100. It is clear that interest was highest in the U.S., where it remained high, and lowest in the three European countries, which appeared relatively unaffected by the WHO PHEIC announcement. By contrast, the U.K. experienced a brief surge in interest, which tailed off very quickly.

3.2. Google Health Trends API

The raw non-real time daily search probabilities from 18 May to 30 September are shown in Figure 2—note the differing y-axes showing search probabilities (multiplied by 10^7) scaled to the time period for each region. The WHO PHEIC statement on Mpox generated a Google search probability of 18,225.6 per 10 million searches in the U.S., the U.K. (15,177.7), Spain (1306.7), France (1107.9), and Germany (946.0) (Figure 2). However, in the U.K. (52,144 per 10 million on 23 May 2022), Germany (43,717 on 21 May 2022), Spain (41,649 on 19 May 2022), and France (38,001 on 20 May 2022), Mpox searches peaked during the early stage of the Mpox outbreak. In the U.S., the search probability during this time was only 27,604.9 per 10 million searches on 23 May 2022, and the highest search probability occurred when the U.S. government declared the Mpox a public health emergency on 4 August 2022 ($41{,}181 \times 10^7$).

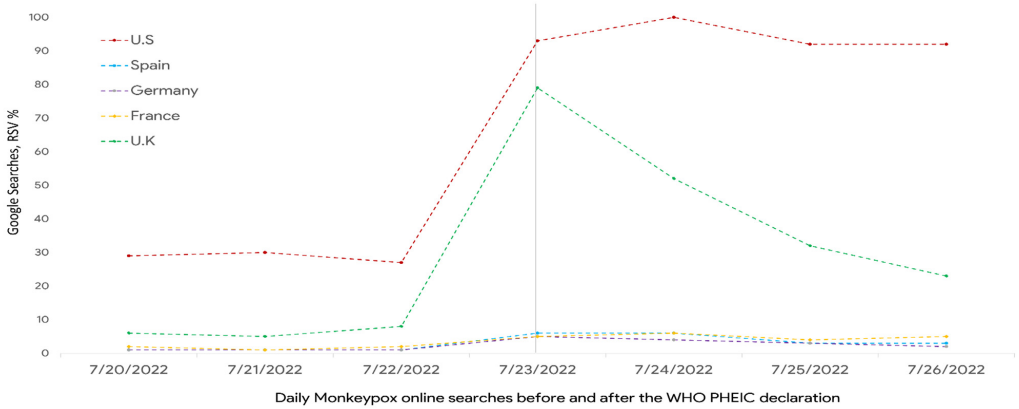

Figure 1. Monkeypox online searches three days before and just after the WHO declaration of Monkeypox outbreak as a Public Health Emergency of International Concern (PHEIC).

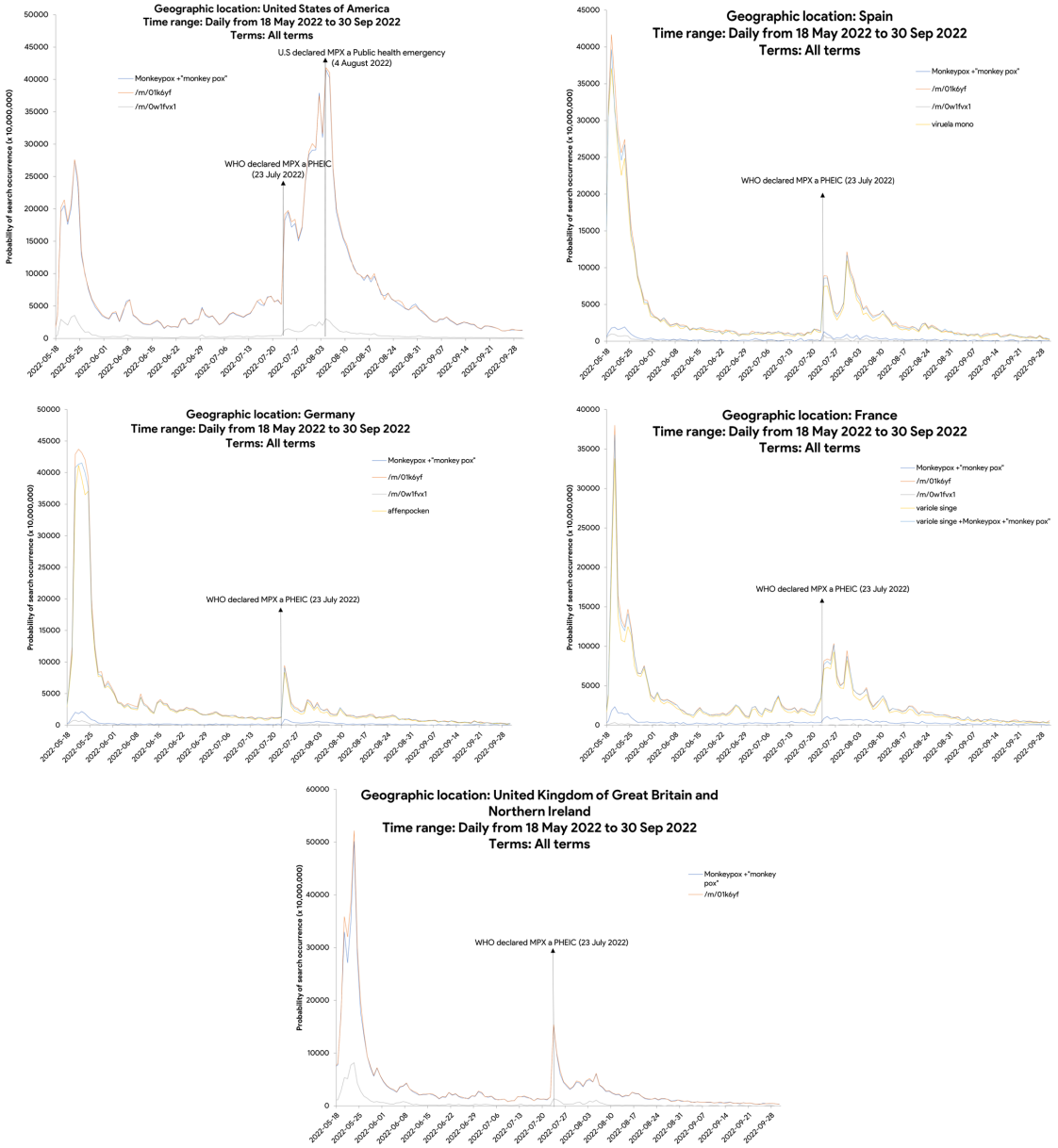

Figure 2. Google search probability before and after WHO declaration of Monkeypox outbreak as a Public Health Emergency of International Concern (PHEIC).

3.3. Real-Time Mpox Searches

Isolating hourly search trends 72 h (UTC) before and after the WHO's PHEIC announcement revealed that Mpox searches spiked immediately in the U.S., Spain, Germany, France, and the U.K. (Figure 3). Furthermore, the Mpox hourly RSVs peaked (in the figure, the points scaled by Google Trends to 100) immediately in the U.K. (0 h; 23 July, 9 a.m. UTC) and Germany (0 h; 23 July, 9 a.m. UTC), followed by the U.S. (1 h; 23 July, 10 a.m. UTC), Spain (5 h; 23 July, 2 p.m. UTC), and France (63 h; 25 July, 5 p.m. UTC) as the WHO's PHEIC announcement. In contrast with Figure 1, search interest is reflected independently for the time period for each region, and not scaled to the U.S. peak, so that each country's distribution, for the same time period (UTC), is scaled such that the highest RSV for that country is set to 100. This is obtained by entering the search query into the Google Trends website for each country individually and then downloading the data, instead of entering all five countries simultaneously (which would result in scaling of all countries relative to the country with the highest search interest).

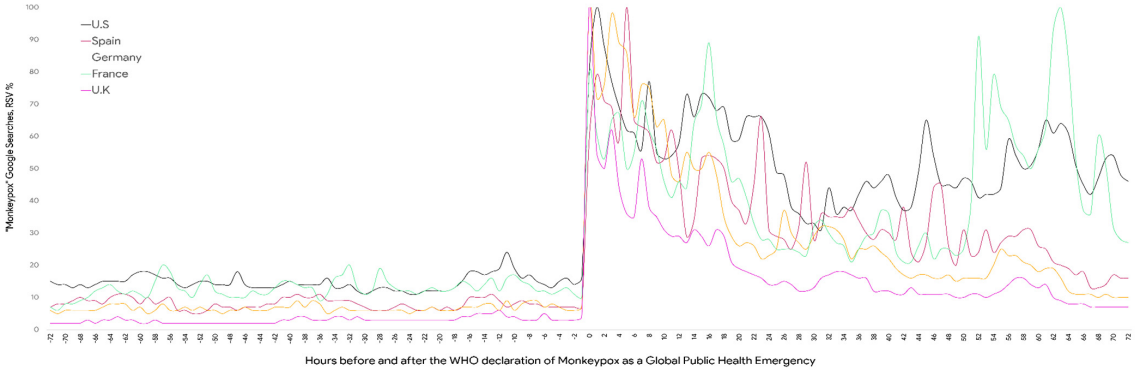

Figure 3. Monkeypox online real-time hourly searches before and just after the WHO declaration of Monkeypox outbreak as a Public Health Emergency of International Concern (PHEIC).

3.4. Real-Time Mpox Trend Analysis

Using Joinpoint regression, temporal trends in the real-time Mpox search in the hourly RSVs following the WHO PHEIC declaration revealed that Google searches for Mpox in all these countries were significantly increased on average by HPC: 103% (95% CI: 37.4–200.0) immediately after the WHO PHEIC announcement. Briefly, a significant upward trend in public interest was noticed in the U.S. by HPC: 80.3% (95% CI: 16.8–179.3), Spain (106.6%, 95% CI: 12.5–279.3), Germany (145%, 95% CI: 52.8–294.5), and the U.K. (149.9%, 95% CI: 40.3–344.9), but not in France (HPC: 72.8%, 95% CI: −23.1–288.2). This sharp increase in public interest was short-lived; after four hours of the announcement, a downward trend was noticed with an average HPC of −3.6% (95% CI: −4.3–−2.9). More details in Table 1.

Table 1. Joinpoint regression showing hourly percentage changes in "Monkeypox" relative search volumes on Google Trends—72 h before and just after WHO PHEIC declaration.

Country	Period (UTC)	Mean (SD)	Hourly Percentage Changes (95% CI)	Test Statistics (t)	*p*-Value
U.S. (3 joinpoints)	20 July (9 a.m.) to 23 July (7 a.m.)	14.5 (2.2)	0.0 (−0.2–0.2)	0.2	0.876
	23 July (7 a.m.) to 23 July (10 a.m.)	52.5 (44.0)	80.3 (16.8–179.3)	2.7	0.008
	23 July (10 a.m.) to 24 July (4 a.m.)	49.6 (17.6)	−2.4 (−3.1–−1.7)	−7.0	<0.001
	24 July (4 a.m.) to 26 July (9 a.m.)	26.6 (8.0)	0.7 (0.3–1.1)	3.4	0.001

Table 1. *Cont.*

Country	Period (UTC)	Mean (SD)	Hourly Percentage Changes (95% CI)	Test Statistics (t)	*p*-Value
Spain (2 joinpoints)	20 July (9 a.m.) to 23 July (7 a.m.)	8.0 (1.6)	−0.2 (−0.5–0.1)	−1.6	0.120
	23 July (7 a.m.) to 23 July (10 a.m.)	38.0 (36.7)	106.6 (12.5–279.3)	2.4	0.020
	23 July (10 a.m.) to 26 July (9 a.m.)	36.4 (17.3)	−1.9 (−2.1–−1.6)	−15.0	<0.001
Germany (3 joinpoints)	20 July (9 a.m.) to 23 July (7 a.m.)	6.6 (1.0)	0.1 (−0.1–0.3)	1.4	0.157
	23 July (7 a.m.) to 23 July (10 a.m.)	46.2 (47.3)	145.5 (52.8–294.5)	3.7	<0.001
	23 July (10 a.m.) to 24 July (6 p.m.)	58.8 (20.5)	−5.7 (−7.1–−4.4)	−8.3	<0.001
	24 July (6 a.m.) to 26 July (9 a.m.)	20.2 (6.7)	−1.9 (−2.2–−1.6)	−11.8	<0.001
France (3 joinpoints)	20 July (9 a.m.) to 23 July (7 a.m.)	12.7 (2.7)	0.4 (0.0–0.7)	2.0	0.042
	23 July (7 a.m.) to 23 July (10 a.m.)	72.5 (1.3)	72.8 (−23.1–288.2)	1.3	0.183
	23 July (10 a.m.) to 24 July (7 a.m.)	58.6 (7.9)	−3.1 (−4.1–−2.0)	−5.7	<0.001
	24 July 4 (7 a.m.) to 26 July (9 a.m.)	43.1 (20.7)	1.4 (3.2–5.3)	5.3	<0.001
U.K (3 joinpoints)	20 July (9 a.m.to 23 July (7 a.m.)	2.9 (0.9)	0.9 (0.6–1.1)	7.3	<0.001
	23 July (7 a.m.) to 23 July (10 a.m.)	40.5 (46.5)	149.9 (40.3–344.9)	3.1	0.002
	23 July (10 a.m.) to 23 July (9 a.m.)	32.3 (12.8)	−5.6 (−6.9–−4.3)	−8.3	<0.001
	24 July (9 a.m.) to 26 July (9 a.m.)	11.9 (3.1)	−1.4 (−1.8–−0.9)	−6.4	<0.001

4. Discussion

As internet searches have become a critical source of health information [12], understanding real-time health information-seeking behavior can act as a proxy indicator of public health needs and trends in online searches about the Mpox virus outbreak. The current global Mpox outbreak has presented a unique opportunity to evaluate the use of real-time data for epidemiological modelling of disease spread, in that the current outbreak is, despite low confirmed case numbers in Africa over several decades, a relatively novel phenomenon globally. Additionally, it is a disease with a very different primary mode of transmission than other outbreaks that have been in focus in recent years. However, Google Trends data can only truly serve to inform epidemiologic models if they are truly indicators of disease spread, not of media attention. Yan et al. [24] conducted a lag-correlation analysis to examine public attention and the monkeypox pandemic by −36 to +36 days-lag in the top 20 countries, with the majority cases through 30 September 2022. This analysis shows a considerable spike in Google Trends for Mpox search worldwide, with roughly a 13-day priority and daily diagnosed cases internationally. Although previous studies have used the traditional Google Trends (daily RSV) approach to explore public attention on the Mpox epidemic [15,16,24–27], no studies have considered the real-time RSV or GHT API. To the

best of our knowledge, this is the first study to introduce and compare three potential monitoring approaches to examine the variations in real-time and non-real-time surveillance following the WHO PHEIC declaration on the current Mpox epidemic. Bhagavathula et al. [15] compared the first 60 days of Google searches on Mpox with COVID-19 during the same time period and found that the Mpox searches did not increase with cases. On the contrary, the study by Martins-Filho et al. [26] found a stagnation in COVID-19 search activity and an increase in monkeypox interest, especially in North America, Europe, and Australia. These findings suggest that exploring online search patterns can provide unique insights into public interest and help characterize people's responses to the COVID-19 pandemic and ongoing Mpox epidemic.

Using Google Trends real-time data, this study demonstrates that interest searches significantly varied between real-time and non-real-time samples. The real-time data showed that internet searches for Mpox-related information reached a record high immediately following the WHO PHEIC declaration on Mpox in the U.K., Germany, the U.S., and Spain, but not in France. After four hours of the WHO PHEIC statement, their interest steadily went down, and only the U.S. and France showed an increase in Mpox searches after 48 h. Previous findings demonstrated the lack of online public interest when containment efforts demanded public attention [23]. These include public education campaigns to help people understand what actions to take when exposed to a disease or displaying symptoms, effective isolation procedures, and the duration of the quarantine period needed. Encouraging health authorities to partner with popular digital platforms such as Google Trends and using real-time data can help with monitoring interest levels and engaging the general public when messaging is rapidly changing. Although we did not compare the RSVs to case numbers for each country for this study, it would appear as if searches are related more to the WHO declaration and subsequent media exposure than actual infections [16,17].

This study is limited in that it cannot confirm that any search was linked to Mpox cases nor evaluate the demographic attributes of those conducting the searches. The presumptive association between real-time RSV and the public interest has limitations, and the accuracy in measuring the public interest using Google Trends is not validated. Google Trends only provides real-time data (hourly RSV) for seven days, and non-real-time RSV had a greater variability. As a result, any study conducted using Google Trends is inherently difficult to replicate [28]. Therefore, caution should be taken while interpreting the Google Trend results. Although GHT API cached data are more accurate, obtaining better estimates of the true value requires multiple samples [20]. Furthermore, GHT API data remains inaccessible to researchers, and data extraction require a valid API key.

5. Conclusions

Mpox is currently a global health emergency and is also a useful test case for the use of real-time data to monitor the spread of a relatively novel disease, as well as a disease with a specific preferential method of transmission in terms of the current outbreak. This study revealed a 103% increase in public interest in top five Mpox-affected countries immediately following the WHO PHEIC announcement. However, search interest waned after the announcement, so that search interest appeared to reflect media attention more than disease spread. This study also described the benefits of Google Trends real-time surveillance and the use of the GHT API to monitor how public health announcements impact the online demand for information on new infectious diseases such as Mpox. Continued real-time surveillance of online public interest and the development of novel communication methods to tailor targeted messaging to reach the public regarding Mpox and emerging infectious diseases are unmet needs. More research is needed to determine the utility of GT real-time data for Mpox prevention, testing, and vaccination. Additionally, other novel disease outbreaks, or even outbreaks of other diseases which may have shown relatively low cases for a period of time (e.g., new measles outbreaks in areas where vaccination rates have dropped), should be examined using the same methodology. Given

that media attention appears to play a definitive role in online search interest, further work is also needed for real-time methods of monitoring disease spread itself.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/info14010005/s1.

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