Google Trends Data and COVID-19 in Europe: correlations and model enhancement are European wide

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Abstract

The current COVID-19 pandemic offers a unique opportunity to examine the utility of Internet search data in disease modelling across multiple countries. Google Trends data (GTD) indicating the volume of Internet searching on 'Coronavirus' were obtained for a range of European countries along with corresponding incident case numbers. Significant positive correlations between GTD with incident case numbers occurred across European countries, with the strongest correlations being obtained using contemporaneous data for most countries. GTD was then integrated into a lag distributed model; this improved model quality for both the increasing and decreasing epidemic phases.

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Summary

The current COVID-19 pandemic offers a unique opportunity to examine the utility of Internet search data in disease modelling across multiple countries. Google Trends data (GTD) indicating the volume of Internet searching on 'Coronavirus' were obtained for a range of European countries along with corresponding incident case numbers. Significant positive correlations between GTD with incident case numbers occurred across European countries, with the strongest correlations being obtained using contemporaneous data for most countries. GTD was then integrated into a lag distributed model; this improved model quality for both the increasing and decreasing epidemic phases.

Keywords : Surveillance, Model, COVID-19, SARS-CoV-2, Google Trends

Introduction

The current Coronavirus (COVID-19) pandemic has become an Internet phenomenon, leading newsfeeds and trending on news forums globally. Understandably, there is widespread public interest, which is being met by blanket media coverage of an unprecedented nature. The Internet is now the favoured first port of call for those seeking healthcare information (Diaz et al., 2002; Andreassen et al., 2007). Therefore, such digital information is likely to be playing a key role in public communication during the current crisis.

Data generated though such Internet searching has long been known to be useful for disease monitoring and surveillance (Brownstein et al., 2009; Eysenbach, 2011; Anema et al., 2014; Mavragani et al., 2018). Resources, such as Google Trends, which provide data on the volumes of Internet searching upon specific topics, have been identified as being potentially useful sources of real time data (Carneiro and Mylonakis, 2009; Nuti et al., 2014). Such data sources may possibly reflect disease occurrence quicker and more accurately than traditional, but slower, disease monitoring through official channels. Studies examining the relationship between Internet searching and disease occurrence have become commonplace (Carneiro and Mylonakis, 2009; Mavragani et al., 2018). However, as recently highlighted, although many studies describe relationships and seek correlations, few studies use such data to its full potential utilising it in disease forecasting and modelling (Mavragani et al., 2018). Additionally, whether relationships between Internet search data and disease occurrence occur across national boundaries is rarely examined; typically such studies examine such relationships within only a single national country.

Thus, here the aim was not only to examine whether such correlations between Google Trends data and COVID-19 cases occurred, but also to utilise such data in modelling; could such data enhance traditionally based models using reported case numbers? Additionally, were such relationships apparent, and model enhancement occur, across a wider geographical range than a single nation? Coronavirus is a pan-European problem, with epidemics developing almost simultaneously across many countries. This situation provides a unique opportunity to examine whether such data can enhance modelling across multiple countries, continent wide.

Materials and Methods

Data relating to Google Internet searching on the single search term 'Coronavirus' was downloaded for a range of European countries from the Google Trends website (*https://trends.google.com/trends*) (Google Trends, 2020) on the 14 March 2020. GTD indexes the volume of search interest against a benchmark index of 100. Data was collected for several European countries where COVID-19 cases have been confirmed. 'Coronavirus' was selected as a search term due to the ubiquitous use of this name in popular parlance across Europe. 'Coronavirus' is part of the official definition of this condition, 'coronavirus disease 2019 (COVID-19)' (World Health Organization, 2020). Google translate showed that 'Coronavirus' was commonly used across the majority of European countries involved in our analyses.

Data was collected on 15 Mar 2020 for a 51-day period running from 23 Jan 2020 to 13 Mar 2020. This encompassed the initial phases of the outbreak, from the potential threat from COVID-19 being highlighted by WHO in a statement on 30 January 2020 (WHO, 2020). Corresponding incidence data was obtained from the GitHub database (https://github.com/CSSEGISandData/COVID-19) of the Coronavirus COVID-19 Global Cases by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University (JHU) homepage, which is being updated daily based on WHO, CDC, ECDC, NHC and DXY and local media reports (Dong et al., 2020). Data for the decreasing phase of the European epidemic was obtained similarly on 27 July 2020 for a 90-day period from 27 Apr to 25 Jul 2020. Spearman's rank cross-correlation analysis between incident case number and corresponding Google search volumes was performed using a +-40 days lag.

Time series modelling of incident cases was performed using generalized additive models. The spline described non-linear effect of numerical date was added to the model as an independent variable with or without lag-distributed country specific GTD. Incident case numbers were added as the explained variable. Models were compared with the Akaike Information Criteria. All analyses were performed with R (version 3.6.3) (The R Core Team, 2020) using the mcgv (Wood, 2004) and dlnm package (Gasparrini, 2011).

Results and Discussion

Cross correlation analysis

Table 1 shows results of Spearman Rank contemporaneous correlations between GTD and incident case numbers for different European countries. The increasing and decreasing phases of each country's epidemics were also examined. For the increasing phase, the correlation was significant in all countries studied. With cross correlation analyses, in the majority of cases the correlation was strongest at a median of 0 day (IQR: 0-1) lag (Figure 1). In other words, GTD was contemporaneous with incident cases (with the notable exception of Ireland, where it preceded it by 18 days).

This pattern was also observed when data describing the decreasing phase of the epidemic was examined. All but two countries had significant moderate to strong positive correlations between GTD and incident case numbers (the exception being Sweden and France). With cross correlation analyses the median lag was also 0 days (IQR: -2.5-0, further details in the Supplementary material S1).

Modelling incident case numbers

Extending standard models with GTD improved model quality (AIC without GTD: 6041.446; with GTD: 6038.929). To validate results, the same model fitting with data describing mostly the decreasing phase of the epidemic was performed. These findings may confirm the results of the previous modelling; model quality was slightly better with the addition of GTD data (AIC without GTD: 13101.59; with GTD: 13100.27). Detailed results are available as Supplementary material (S1).

Examination of social media use and its relationship to disease incidence is now commonplace. across multiple countries.

Crosscorrelations showed a clear relationship between GTD and reported case incidence across a number of European countries. The quality of time series modelling, as indicated by AIC values, was also enhanced by the addition of GTD. This suggests that such data could be of real utility in disease modelling and possibly forecasting across country boundaries. This could be of potential utility where traditional disease surveillance is challenging.

Country specific factors, possibly differences in testing and case reporting probably plays a critical role. Reported case numbers may not truly reflect disease occurrence, possibly only how vigorous testing regimes are. This was mitigated by examining increasing and decreasing phases of the epidemic separately; reported case numbers are likely to be more reliable at the beginning of an epidemic when the majority of cases can be identified.

A recent review highlighted the fact that although the number of studies examining the relationship between Internet searching and disease occurrence is growing, few such studies go beyond data description and use such data in disease modelling and forecasting (Mavragani et al., 2018). This is demonstrated by previous studies on conditions related to COVID-19. For example, studies examining GTD and MERS-Cov outbreak (Fung et al., 2013; Shin et al., 2016). Studies examining the correlation between GTD and COVID-19 are rapidly appearing (Effenberger et al., 2020; Husnayain et al., 2020; Walker and Sulyok, 2020) . However, none of these studies has used such data in disease modelling as was performed here.

In conclusion, GTD showed a strong contemporaneous correlation with incident case numbers across Europe. It also enhanced the quality of disease models using solely case numbers for a range of European countries. This improvement suggests such techniques could be used across country boundaries. This is potentially important as COVID-19 reaches new states, especially ones where testing and surveillance are not as reliable as in Europe.

Conflict of Interest Statement : We have no conflict of interest to declare.

Ethic Statement : The authors confirm that the ethical policies of the journal, as noted on the journal's author guidelines page, have been adhered t*o*. No ethical approval was required since completely anonymized data were obtained from publicly available sources.

Data Availability Statement: All data and the statistical analyses code are available under the link: https://github.com/msulyok/COVID19GoogleTrendsEurope

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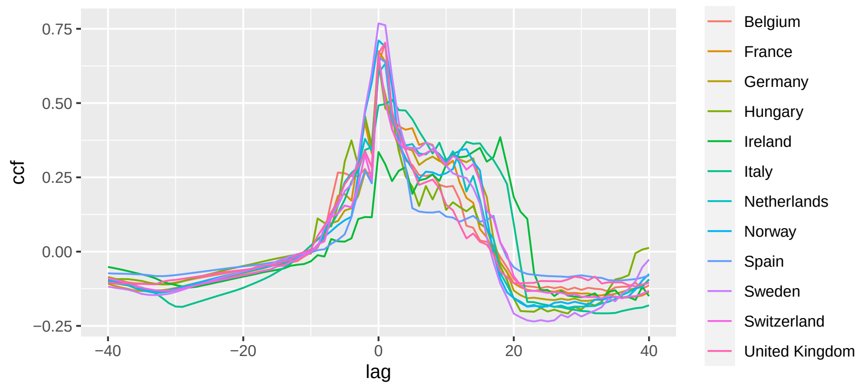
Figures and Tables

Table 1: Spearman Rank contemporaneous correlations between GTD and COVID-19 incident daily case numbers for a number of European countries (GTD: Google Trends Data)

	increasing phase		decreasing phase	
Country	Rho-value	P-value	Rho-value	P-value
Belgium	0.688	<0.001	0.778	<0.001
France	0.791	<0.001	-0.049	0.643
Germany	0.808	<0.001	0.39	<0.001
Hungary	0.470	<0.001	0.588	<0.001
Ireland	0.405	<0.001	0.618	<0.001
Italy	0.802	0.003	0.831	<0.001
Netherlands	0.688	<0.001	0.75	<0.001
Norway	0.767	<0.001	0.459	<0.001
Spain	0.779	<0.001	0.464	<0.001
Sweden	0.805	<0.001	0.137	0.199
Switzerland	0.716	<0.001	0.332	0.001
United Kingdom	0.775	<0.001	0.785	<0.001

Figure 1: Spearman Rank Cross Correlations between GTD and COVID-19 incident daily case numbers for a number of European countries. Upper plot: increasing phase, lower plot decreasing phase of the epidemic (ccf: cross correlation Rho value).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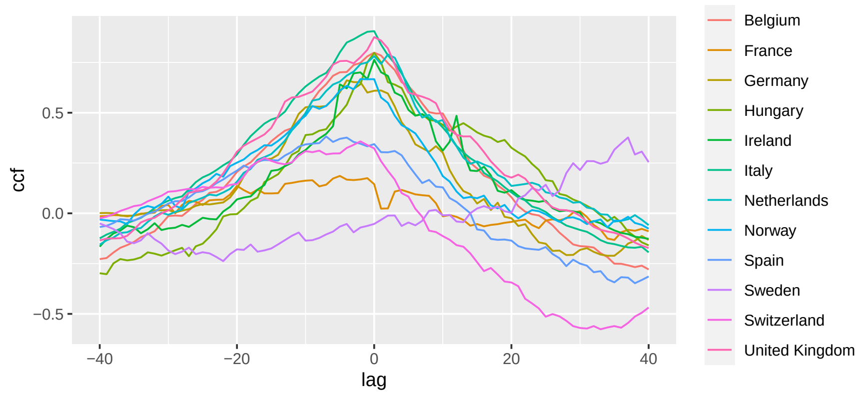
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