The predictive research of the Coronavirus Disease-2019 outbreak in Turkey

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Abstract

Aim to evaluate the relationship between the number of newly confirmed Coronavirus Disease 2019 (COVID-19) cases and public concern in Turkey via Google Trends[TM].

The data on relative search volumes for 5 keywords related to coronavirus and prevention from the disease (COVID-19, coronavirus, face mask, hand washing, disinfectant) were obtained between March 10, 2020, and June 16, 2020. The daily numbers of newly confirmed cases were obtained from the Ministry of Health's COVID-19 information platform. Time-lag correlations for the time lag between - 17 and + 17 days were used to assess whether search queries on Google predicted new COVID-19 cases. The relative search volumes for COVID-19 and coronavirus increased 2-3 weeks before cases, with the highest correlations between searches and cases observed - 9 and - 17 days early, respectively. Although relative search volumes for the terms of handwashing and disinfectant increased 13-14 days earlier, interest in face masks increased 4 days earlier. Public searches about disease prevention have negative correlations with the worldwide case/death rates in the first wave.

The number of confirmed COVID-19 cases was predicted by examining the search behavior of the public using Google Trends[TM].

Introduction

On March 10, 2020, the first Coronavirus Disease 2019 (COVID-19) case was detected in Turkey[1] and announced a day after the outbreak can be considered a pandemic by the WHO (World Health Organization).[2] In just one year, the number of cases in Turkey reached 2.5 million whereas in the world, it reached 100 million, and more than 2 million people died worldwide.[3] As the number of cases and deaths increases, the public is searching to know better about disease prevention methods and symptoms.[4,5] Public health literacy is reflected in Internet searches.[4]

The number of Internet users worldwide has exceeded 4 billion.[6] With the increase in Internet access, the public is using search engines like Google Search to access health-related information before visiting a doctor.[7,8] A study conducted in Turkey, 2019, reported that 81% of the participants use the Internet to search for health-related information.[9] Eysenbach[10] defined Infodemiology as "the science of distribution and determinants of information in an electronic medium, specifically the Internet, or in a population, with the ultimate aim to inform public health and public policy", and Infoveillance as "the longitudinal tracking of infodemiology metrics for surveillance and trend analysis". The Infodemiology and Infoveillance studies, which provide data to analyze and predict human behavior, have played an important role in health informatics over the last decade, as the use of the Internet is increasing, and online resources are increasingly accessible.[10,11] In 2009, Ginsberg[7] stated that search behaviors could predict influenza epidemics 1-2 weeks before the Centers for Disease Control and Prevention. In the following years, Google Search data were used to predict H1N1 influenza (swine-origin influenza A),[12] Ebola,[13] West Nile Virus outbreaks.[14] Infodemiological studies on the

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coronavirus outbreak have been published in some countries investigating the symptoms of the disease or public concerns. In addition, several studies were examining the association between Google Search and the COVID-19 pandemic with lag correlation.[11,15,16] It was reported that there was a correlation between public concern and the number of cases 11.5 days ago in 12 different countries[11] and 20 days ago in the United Kingdom.[16]

To date and to the best of our knowledge, no study has been published on the health literacy regarding COVID-19 in Turkey. The primary aim of this infodemiological study was to evaluate the relationship between public concern and the number of newly confirmed COVID-19 cases in Turkey. The secondary aims were to evaluate the relationship between the search behavior and the number of newly confirmed COVID-19 cases in Turkey according to the period before and after the peak, and also the first wave and the second wave. The null hypothesis was that there was no correlation between the spreading rate of the disease and the searches of Internet users in Turkey.

Materials and methods

Research Approval
The Republic of Turkey, Ministry of Health Directorate General Primary Health Care Services gave scientific research approval for COVID-19 (reference no: 2020-06-20T17_02_18).

Retrieval of Data from Google Trends[TM]
The search engine market in Turkey is dominated by Google.[17] Google Trends[TM] is a public portal that provides the daily data of search activities of Internet users. In the determined time frame, the search activities reflect the relative search volume (RSV) according to absolute search volume.[8] The day when the RSV equals 100, there are the most search queries; and when RSV equals 50, it refers to half of the maximum query (https://support.google.com/trends/).[18]

Keyword Selection and Search Criteria
Terms to related coronavirus and prevention from the disease were searched for Turkey via the Google Trends[TM] tool from March 10, 2020, to June 16, 2020. The search was

filtered since this date, since the first case in Turkey was reported on March 10, 2020. Five keywords "COVID-19, coronavirus, face mask, handwashing, and disinfectant" were searched on June 20, 2020. The search was applied with the "web search" option of Google Trends[TM] in the Turkish language by filtering "all query categories", and the location parameter to "Turkey". Searches without double quotation marks include query results for all combinations (like 'mask', 'mask face' or 'face mask') of all words in the term.[19] Therefore, terms were queried with a double quotation. The plus sign (+) meaning "or" was used among all terms to retrieve the total search volume of the terms. Relative search volumes less than 1 were considered zero.

The daily numbers of newly confirmed cases were acquired from the COVID-19 website of the Ministry of Health (https://covid19.saglik.gov.tr/).[1] The frameworks specified by Mavragani and Ochoa[19] and Nuti et al.[20] were used in Google Trends[TM] queries and the presentation of the method.

Data Analysis
Similar to Effenberger et al.,[11] time-lag correlations were applied to evaluate the association between the search queries in Google Trends[TM] and the change of newly confirmed COVID-19 cases. Pearson correlation coefficient was used for the time lag between -17 and + 17 days. The Shapiro-Wilk test was used to determine whether the continuous variables were normally distributed. Pearson correlation test was used to analyze the relationship between the normally distributed variables. The statistical analyses were performed using the Statistical Package for the Social Sciences for Windows version 22.0. The significance level was set at the value of 0.05.

Results

The data on newly confirmed cases/deaths and the relative search volumes of keywords in Turkey from March 10, 2020, to June 16, 2020, were shown in Figure 1. The number of cases in Turkey increased until April 11, 2020, then showed a fluctuating decline and then started to increase again after June 6, 2020. Search queries related to COVID-19 (COVID-19 and coronavirus terms) of Internet users in

Turkey increased by about 2-3 weeks before the peak of newly confirmed cases. The findings of search queries on protection from the disease were different. RSVs for terms disinfectant and handwashing reached peak levels 1 month before the peak of newly confirmed cases and just one day after the first case reported in Turkey. RSVs for the term face mask increased on April 5, 2020. In about a week, interest in the face mask dropped, and then the interest level (RSV) remained below 10% of the maximum interest. However, COVID-19 and coronavirus queries never fell below 40% of the maximum interest. The terms coronavirus, COVID-19, handwashing reached two peaks consistent with the number of cases. Nevertheless, it was observed that the searches face mask and disinfectant were not affected by the second increase in the number of cases.
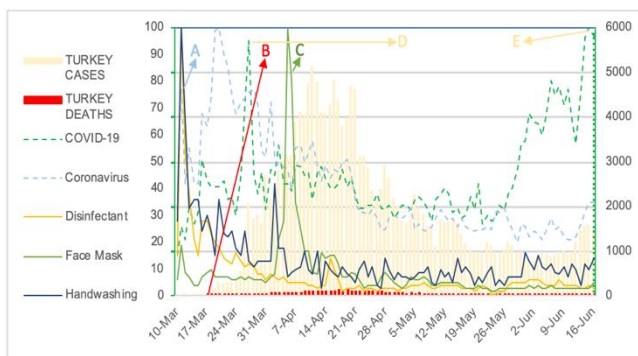

Figure 1. RSVs for the keywords 'COVID-19', 'coronavirus', 'face mask', 'handwashing', 'disinfectant', and the number of daily new-confirmed cases/deaths in Turkey.

WHO announced at point A (March 11, 2020) that COVID-19 can be considered a pandemic. The first death in Turkey was reported at point B (March 17, 2020). At point C (April 6, 2020), the Turkish government announced that face masks would be distributed through pharmacies. The first peak of COVID-19 searches in Turkey was at point D, and the second was at point E.

The search for the face mask reached its peak on April 5 (Figure 1). On April 6, the Turkish government temporarily banned the sale of face masks and decided to distribute free face masks from pharmacies.[21] The correlation of interest in face masks with the number of newly confirmed cases/deaths in Turkey before and after the mask distribution was shown in Table 1. After the

change in face mask sales, searches for the term face mask showed a high correlation with both the number of cases and deaths.

		Face mask	
		New cases	New deaths
Before (n = 28)	r	0.253	0.284
	p	0.19	0.14
After (n = 71)	r	0.807*	0.732*
	p	<0.001	<0.001

Table 1. The correlation of face mask queries between RSV and the number of newly confirmed cases in Turkey before and after the ban[†] on the sale of masks.
[†]The ban on the sale of masks was announced: 6 April;
*Correlation is significant at the 0.05 level.

The correlation coefficients between the RSV indices of five search terms and the newly confirmed cases calculated with time lags of - 17 and + 17 days were presented in Table 2. COVID-19 and coronavirus queries reached the highest correlation between the RSV and the number of newly confirmed cases with a lag of - 17 and - 9 days, respectively (Figure 2). The correlation between the number of newly confirmed cases and the term COVID-19 was negatively correlated with the 4-day lag time. The correlation patterns of disinfectant and handwashing calculated with time lags of - 14 and - 13, respectively, were similar. Face mask search reached the highest correlation with a lag of - 4 days and the correlation gradually decreased.
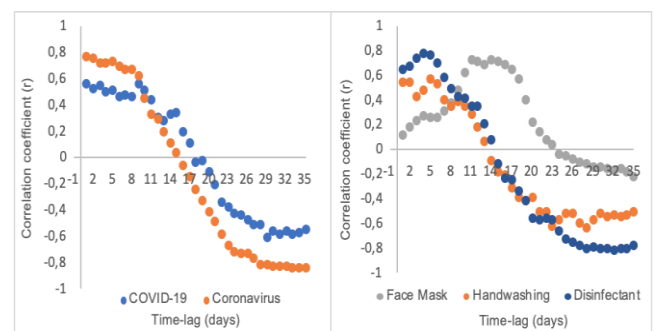

Figure 2. Time-lag correlations between RSVs and newly confirmed COVID-19 cases for Turkey.

	COVID-19		Coronavirus		Face Mask		Handwashing		Disinfectant	
	r	p	r	p	r	p	r	p	r	p
lag -17	0.555*	0.001	0.767*	0.001	0.121	0.487	0.538*	0.001	0.641*	0.001
lag -16	0.527*	0.001	0.753*	0.001	0.175	0.314	0.537*	0.001	0.674*	0.001
lag -15	0.545*	0.001	0.711*	0.001	0.236	0.173	0.426*	0.011	0.742*	0.001
lag -14	0.498*	0.002	0.711*	0.001	0.273	0.112	0.479*	0.004	0.777*	0.001
lag -13	0.509*	0.002	0.732*	0.001	0.256	0.137	0.569*	0.001	0.766*	0.001
lag -12	0.461*	0.005	0.697*	0.001	0.264	0.125	0.527*	0.001	0.693*	0.001
lag -11	0.472*	0.004	0.663*	0.001	0.313	0.067	0.401*	0.017	0.579*	0.001
lag -10	0.456*	0.006	0.674*	0.001	0.380*	0.025	0.347*	0.041	0.487*	0.003
lag -9	0.556*	0.001	0.625*	0.001	0.485*	0.003	0.391*	0.020	0.427*	0.010
lag -8	0.516*	0.001	0.453*	0.006	0.625*	0.001	0.353*	0.038	0.412*	0.014
lag -7	0.440*	0.008	0.326	0.056	0.728*	0.001	0.279	0.105	0.355*	0.036
lag -6	0.298	0.082	0.286	0.096	0.715*	0.001	0.183	0.292	0.345*	0.042
lag -5	0.275	0.109	0.194	0.265	0.691*	0.001	0.058	0.740	0.207	0.234
lag -4	0.333	0.051	0.105	0.548	0.729*	0.001	-0.09	0.606	0.076	0.663
lag -3	0.344*	0.043	0.032	0.857	0.717*	0.001	-0.183	0.292	-0.119	0.498
lag -2	0.197	0.258	-0.059	0.735	0.686*	0.001	-0.206	0.235	-0.229	0.185
lag -1	0.104	0.551	-0.144	0.410	0.652*	0.001	-0.307	0.073	-0.248	0.151
lag 0	-0.041	0.815	-0.247	0.153	0.564*	0.001	-0.393*	0.019	-0.334*	0.050
lag 1	-0.029	0.868	-0.329	0.054	0.403*	0.016	-0.412*	0.014	-0.417*	0.013
lag 2	-0.104	0.550	-0.408*	0.015	0.226	0.191	-0.389*	0.021	-0.556*	0.001
lag 3	-0.206	0.235	-0.485*	0.003	0.139	0.425	-0.501*	0.002	-0.572*	0.001
lag 4	-0.341*	0.045	-0.583*	0.001	0.078	0.654	-0.509*	0.002	-0.558*	0.001
lag 5	-0.374*	0.027	-0.673*	0.001	0.038	0.830	-0.626*	0.001	-0.568*	0.001
lag 6	-0.420*	0.012	-0.712*	0.001	-0.042	0.813	-0.564*	0.001	-0.663*	0.001
lag 7	-0.441*	0.008	-0.724*	0.001	-0.053	0.762	-0.514*	0.002	-0.727*	0.001
lag 8	-0.479*	0.004	-0.728*	0.001	-0.075	0.670	-0.520*	0.001	-0.751*	0.001
lag 9	-0.505*	0.002	-0.772*	0.001	-0.101	0.564	-0.597*	0.001	-0.771*	0.001
lag 10	-0.510*	0.002	-0.809*	0.001	-0.119	0.496	-0.635*	0.001	-0.797*	0.001
lag 11	-0.608*	0.001	-0.818*	0.001	-0.143	0.413	-0.570*	0.001	-0.793*	0.001
lag 12	-0.557*	0.001	-0.827*	0.001	-0.148	0.396	-0.517*	0.001	-0.799*	0.001
lag 13	-0.578*	0.001	-0.831*	0.001	-0.161	0.357	-0.542*	0.001	-0.803*	0.001
lag 14	-0.559*	0.001	-0.822*	0.001	-0.173	0.319	-0.527*	0.001	-0.812*	0.001
lag 15	-0.580*	0.001	-0.839*	0.001	-0.158	0.366	-0.548*	0.001	-0.800*	0.001
lag 16	-0.574*	0.001	-0.836*	0.001	-0.181	0.305	-0.533*	0.001	-0.807*	0.001
lag 17	-0.544*	0.001	-0.841*	0.001	-0.225	0.207	-0.503*	0.003	-0.782*	0.001

Table 2. Lag correlation coefficients and p values between Internet search data and daily newly confirmed COVID-19 cases/deaths, Turkey, March-June 2020.
*Correlation is significant at the 0.05 level.

The correlations between the RSVs of terms in Turkey and the newly confirmed cases/deaths in the world before and after the peak were summarized in Table 3. Before the peak of queries, the terms coronavirus and disinfectant were negatively correlated with the number of newly confirmed cases/deaths, while face mask searches were positively correlated.

It was observed that the public concern reflected on the search volume as two waves in line with the number of cases. In queries regarding COVID-19 in Turkey, the first wave was observed from March 10 to May 22, and the second wave from May 23 to June 16.

The correlations of queries with the number of newly confirmed cases in Turkey and worldwide in the first and second waves were presented in Table 4. The median (interquartile range 1 - 3) RSVs of the first and second waves were shown in Table 5. While there was a significant decrease in the median of coronavirus and face mask queries, there was an increase in the median of the COVID-19 query (p = 0.001).

		COVID-19	Coronavirus	Disinfectant	Face mask	Handwashing
		New cases				
Before (n = 18)	r	- 0.006	- 0.599*	- 0.773*	0.670*	- 0.208
	p	0.98	0.009	<0.001	0.002	0.41
After (n = 17)	r	- 0.278	- 0.005	0.082	- 0.304	0.196
	p	0.28	0.99	0.75	0.24	0.45
		New deaths				
Before (n = 18)	r	0.029	- 0.495*	- 0.810*	0.639*	- 0.196
	p	0.91	0.04	<0.001	0.004	0.44
After (n = 17)	r	- 0.017	0.207	0.561*	0.395	0.306
	p	0.95	0.43	0.02	0.12	0.23

Table 3. The correlations between the RSVs in Turkey and the newly confirmed cases and deaths in the world before and after the peak[†].
[†]Peak: 20 March, the first peak of the RSV of COVID-19 terms; *Correlation is significant at the 0.05 level.

			COVID-19	Coronavirus	Disinfectant	Face mask	Handwashing
			1.wave[†] (n = 74)				
World	New cases	r	- 0.154	- 0.666*	- 0.652*	- 0.325*	- 0.602*
		p	0.19	<0.001	<0.001	0.005	<0.001
	New deaths	r	0.236*	- 0.275*	- 0.479*	0.278*	- 0.406*
		p	0.04	0.02	<0.001	0.02	<0.001
Turkey	New cases	r	0.388*	- 0.061	- 0.431*	0.434*	- 0.413*
		p	0.001	0.61	<0.001	<0.001	<0.001
	New deaths	r	0.225	- 0.252*	- 0.615*	0.234*	- 0.528*
		p	0.05	0.03	<0.001	0.05	<0.001
			2.wave[‡] (n = 25)				
World	New cases	r	0.533*	- 0.313	0.077	0.320	0.254
		p	0.006	0.13	0.72	0.12	0.22
	New deaths	r	0.084	- 0.423*	0.142	0.245	0.179
		p	0.69	0.04	0.50	0.24	0.39
Turkey	New cases	r	0.100	0.408*	- 0.506*	- 0.237	- 0.204
		p	0.64	0.04	0.01	0.25	0.33
	New deaths	r	- 0.779*	0.142	0.014	- 0.300	- 0.301
		p	<0.001	0.50	0.95	0.14	0.14

Table 4. Pearson correlation matrix between Google Searches and the newly confirmed case numbers of Turkey and the world in the first and second waves.
[†]First wave: 10 March – 22 May; [‡]Second wave: 23 May – 16 June; *Correlation is significant at the 0.05 level.

	1. wave[†]		2.wave[‡]		p
	Median	25% - 75%	Median	25% - 75%	
COVID-19	37.50	32.00-43.00	65.00	47.00-77.00	0.001*
Coronavirus	42.50	29.00-55.00	25.00	22.00-29.00	0.001*
Disinfectant	4.00	3.00-11.00	4.00	3.00-5.00	0.11
Face mask	7.00	5.00-9.00	3.00	3.00-3.00	0.001*
Handwashing	10.50	7.00-17.00	10.00	7.00-12.00	0.13

Table 5. The median RSVs of keywords in the first and second waves.
[†]First wave: 10 March - 22 May; [‡]Second wave: 23 May - 16 June; *Correlation is significant at the 0.05 level.

Discussion

Obtaining data in earlier stage of an epidemic helps policymakers on healthcare make evidence-based decisions. In addition, announcing the interpretations of these data through the media prevents the spread of rumors in the public and ensures the participation of the public in disease prevention measures. At the beginning of the COVID-19 pandemic, although the origin of the disease was unknown and the rate of spread was very high, China established an effective surveillance system and managed to control the disease by ensuring timely detection, recording, monitoring, updating, sharing of data via media. The Ministry of Health of Japan also asked its national authorities to follow the surveillance system and be aware of respiratory diseases of unknown etiology in China.[22]

There were infodemiological studies evaluating online public interest or awareness programs through Google Trends.[11,23] Moreover, some studies correlated Google Trends data with the number of COVID-19 cases in different countries.[11,24-27] However, to the best of our knowledge, there was no study conducted on this subject in Turkey, where there were 5 million COVID-19 cases. This study was applied to examine the potential use of Google Trends in predicting the course of the COVID-19 outbreak in Turkey. All search engines used in Turkey were not included in the study, but in 2020 81% of the public used Google as an online search engine.[28] Infodemiological studies such as the current study can expand and/or support the data of existing studies.[20]

It was shown that the public search behavior predicted COVID-19 cases in China about 9 days ago,[15] in the United States about 19 days ago.[27] In Turkey, it was observed that the newly confirmed cases and the COVID-19 query had the highest correlation 9 days earlier and the Coronavirus query had the highest correlation 17 days earlier (Table 2). These findings were similar in countries such as the United Kingdom, Italy, and Germany, as well as in China and the United States.[11,15,27] The second-highest day of the coronavirus search in Turkey was 22 days before the peak period of the number of cases. The announcement of the first death in Turkey was 3 days before that day, which may have caused the interest to increase so early (Figure 1). With the beginning of the lockdown measures

in Turkey in mid-March,[29] a decrease was observed in the number of cases, and a decrease was observed in Google searches -2-3 weeks before the cases- in line with this. It was observed that the searches increased only 1-3 days before the cases in Taiwan.[24] The fact that the number of cases has not yet reached its peak at the dates examined in the study might have caused low predictive power. Queries for COVID-19 peaked in mid-March, and the level of interest was almost the same at the end of June. However, the coronavirus queries fell below 25% of maximum interest in June.

Lin et al.[4] reported that there was no correlation between handwashing and the number of cases in 21 countries. However, the correlation of the number of cases with the terms handwashing and disinfectant related to disease prevention in the present study was highest 13 and 14 days ago, respectively. Although the day with the highest correlation coincided with exactly the day when WHO declared COVID-19 a pandemic,[30] it would not be correct to say that the pandemic announcement entirely caused this effect, as there was a medium to high correlation. Maybe it could be said that it increases the effect. Moreover, if the increase was totally due to the pandemic announcement, the highest correlation in coronavirus and COVID-19 searches would have been observed during this period.

It was observed that face mask queries had the highest correlation with the number of cases only 4 days earlier. One day after the panic about face mask has a sudden increase on April 6, the Turkish government banned the sale of paid face masks and decided to distribute the masks regularly and free of charge from pharmacies.[31] After the pharmacies started distributing 5 masks every 10 days for each person, it was seen that the panic about the face mask abruptly subsided. Also, it was observed that there was a high positive correlation between face mask queries and the number of cases/deaths after the face mask sales policy changed (Table 1).

When the relationship of RSV values before and after the peak of coronavirus searches in Turkey with the number of cases/deaths in the world was evaluated, it showed a negative correlation with the case/death numbers of COVID-19 and disinfectant-related searches. However, it showed a high positive correlation with face

mask searches (Table 3). As the lag correlation table (Table 2) shows, as queries increased approximately 3 weeks before the number of cases, public interest has already begun to decline in the ascending period of cases. However, the interest in face masks might have remained alive due to the controversy of wearing a mask as a precaution in the early days of the outbreak[32] and the subsequent temporary shortage of face masks with the sudden increase in demand.

The reason why the public concern was growing earlier than other epidemics might stem from attracting higher attention due to its very high spread/mortality rate,[33] as well as being a newly diagnosed disease. Furthermore, as the study shows, not only sick people but also people who are curious about ways to avoid COVID-19 might be searching the Internet.[24,34] It should also be noted that testing suspicious persons and identifying them as newly confirmed cases takes time and prolongs the lag time.

When the correlations of the two waves were examined separately, the correlations were different according to the case/death rate in the world or in Turkey (Table 4). In the first wave, while public searches about disease prevention have negative correlations with the worldwide case/death rates, no relationship was found in the second wave. The increase in the interest's median in COVID-19 was statistically significant in the second wave, and the interest's median for coronavirus and face masks decreased significantly.

In addition to the newly confirmed number of cases, factors such as the news and WHO's announcements might also affect the public's search behavior.[35] It is difficult to clearly distinguish the influence of the media, as announcements and news reports about outbreaks increase in relation to the increasing number of cases. Bento et al.[36] stated that there was a short-lived 36% increase in the public interest following the announcement of the first local case. Sousa-Pinto et al.,[37] on the other hand, reported that the media slightly affected anosmia searches, but had no effect on coronavirus search.

The Google Trends[TM] was used to assess 'dentist' and 'toothache' queries during the COVID-19 pandemic of public in the US, the UK, Sweden, Poland and Italy. The study showed the lowest interest in the term 'toothache' a week

before the peak of cases, and then an increase in searches for 'dentist' during the lockdown.[38] During the periods when COVID-19 cases increase, non-emergency treatments could be postponed or aerosol-generating procedures can be avoided, if possible, in order to prevent infection.[39] As a result of the dentists' compliance with the precautions, 75% of the dentists stated that they did not perform dental treatment during the quarantine period and 70% stated that they faced a financial burden.[40]

This study suggests that such online search data can be valuable in predicting the extent and spread of outbreaks and taking precautions early — with the limitations. Moreover, they also provide data about the most appropriate time for national awareness programs or disease prevention campaigns related to infectious disease. One of the limitations of this study was that confounding effects such as the influence of the media cannot be completely eliminated. A general limitation of these studies was that there was not yet a clear standardization for Google Trends data analysis. Also, according to the findings of the study, the null hypothesis was rejected.

Conclusions

The search behavior of the public presented a preview of COVID-19. Google Trends is a tool that presents the public's online search behavior and can be used to monitor local outbreaks. Nevertheless, these findings should be interpreted with caution as increases in public search behavior may be influenced by national news reports or/and the government's disease prevention campaigns.

Declaration of Interest

The authors report no conflict of interest.

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