COVID-19 Increases Online Searches for Emotional and Health-Related Terms

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Background: The COVID-19 pandemic has powerfully shaped people's lives. The current work investigated the emotional and behavioral reactions people experience in response to COVID-19 through their internet searches. We hypothesised that when the prevalence rates of COVID-19 increase, people would experience more fear, which in turn would predict more searches for protective behaviors, health-related knowledge, and panic buying. **Methods:** Prevalence rates of COVID-19 in the United States, the United Kingdom, Canada, and Australia were used as predictors. Fear-related emotions, protective behaviors, seeking health-related knowledge, and panic buying were measured using internet search volumes in Google Trends. **Results:** We found that increased prevalence rates of COVID-19 were associated with more searches for protective behaviors, health knowledge, and panic buying. This pattern was consistent across four countries, the United States, the United Kingdom, Canada, and Australia. Fear-related emotions explained the associations between COVID-19 and the content of their internet searches. **Conclusions:** Findings suggest that exposure to COVID-19 prevalence and fear-related emotions may motivate people to search for relevant health-related information so as to protect themselves from the pandemic.

Keywords: COVID-19, fear, health knowledge, internet search, panic buying, protective behavior

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INTRODUCTION

Since the coronavirus outbreak in January 2020, COVID-19 has infected around 20 million people and led to more than 731,000 deaths (Johns Hopkins Coronavirus Resource Center, 2020). The World Health Organization has pronounced the COVID-19 outbreak a pandemic. It has exerted a profound impact on people's lives and livelihoods around the world (World Health Organization, 2020c). With huge increases in COVID-19 infections, there is a need to understand how people cope with the COVID-19 pandemic. Internet searches provide a window to answer this question.

The internet has become an essential channel for people to seek health-related information (Kalichman et al., 2003; Reeves, 2001). For example, in the United States, about six in ten Americans turn to the internet for health information by using search engines such as Google, Bing, and Yahoo (Pew Research Center, 2013). Internet searches have intensified during the coronavirus outbreak. On 11 March 2020, there were nearly 20 million mentions of coronavirus-related terms, compared with 4 million mentions of Trump and under 2 million mentions of newly canceled NBA games on that day (Molla, 2020). Therefore, huge amounts of coronavirus-related internet searches make it possible to understand how people think of, feel about, and behave as a result of the COVID-19 pandemic.

Previous research has shown that when people are threatened by a disease such as coronavirus, they experience fear-related emotions which could then lead them to adopt protective behaviors, seek more health-related knowledge, and sometimes engage in maladaptive behaviors (Rogers & Prentice-Dunn, 1997; Ruiter, Kessels, Peters, & Kok, 2014; Witte, Meyer, & Martell, 2001). In this article, we suggest that COVID-19, as an imminent and ongoing threat to humanity, may elicit emotional and behavioral reactions online. We predicted that increasing cases of COVID-19 may be associated with more internet searches associated with fear-related emotions, protective behaviors, health knowledge, and even maladaptive behaviors. More specifically, we hypothesised that searches related to fear-related emotions would explain associations of cases of COVID-19 with searches on protective behaviors, health knowledge, and maladaptive behaviors.

Our hypotheses are consistent with fear appeal theories, which posit that the threat of a disease elicits fear, and fear in turn motivates people to initiate behavioral changes and improve health knowledge (Floyd et al., 2000; Kok, Bartholomew, Parcel, Gottlieb, & Fernández, 2014; Ling, Kothe, & Mullan, 2019; Rogers & Prentice-Dunn, 1997). There are several reasons which justify our proposed theoretical model (COVID-19 prevalence → fear → health-related knowledge and behavioral outcomes).

First, in terms of protective behaviors and health knowledge, people may have intentions to adopt behaviors and gain knowledge about COVID-19 based on health advice from official authorities, such as the World Health Organization.

The World Health Organization, as well as governments of many countries, has suggested adopting several protective behaviors, including handwashing, social distancing, quarantining, and wearing masks (World Health Organization, 2020b). Moreover, people may be keen to access health-related knowledge about vaccines and immunity which can enhance their self-efficacy to fight against COVID-19. When the prevalence rate is increasing, people may search for protective behaviors and health knowledge more often.

Second, facing the uncertainty caused by COVID-19 (e.g. city lockdowns), people can also demonstrate maladaptive behaviors to protect themselves. During periods of disasters in human history such as pandemics, public panic is not uncommon. People are worried about survival so they can sometimes act blindly and excessively (Clarke, 2002). A typical excessive behavior in response to COVID-19 is panic buying (Vab Bavel et al., 2020). Due to worries about the lack of daily necessities, people might irrationally stockpile things such as food, toilet paper, hand sanitisers, and face masks. Panic buying has been widely reported in recent media (e.g. Lufkin, 2020). However, it remains unclear what might account for this panic buying. We predicted that when the prevalence rate is increasing, people may also engage in information searches related to panic buying more often.

Third, perceptions of a pandemic threat can lead to negative emotional reactions, such as fear-related emotions (Van Bavel et al., 2020). During a pandemic, the media tends to report infection cases and mortality cases, rather than recovery cases. Hence, fear is transmitted faster in a pandemic than usual (Depoux et al., 2020). Indeed, as COVID-19 spreads all over the world, public fear seems to be rising in many countries (Garrett, 2020). To avoid feelings of anxiety and distress, the World Health Organization has advised people not to focus on news about COVID-19 too much, because watching, reading, or listening to news about COVID-19 will exacerbate fear (World Health Organization, 2020a). Here, we predicted that when the prevalence rate is increasing, people tend to use fear-related emotional search terms more often; moreover, fear-related search terms would explain the relationship between the prevalence rate of COVID-19 and search terms of protective behaviors, health knowledge, and panic buying.

Taken together, the above-mentioned literature suggests that COVID-19 as a disease threat might be associated with internet searches related to fear-related emotions, protective behaviors, health knowledge, and panic buying. According to fear appeal theories, disease threats can arouse fear emotions, which lead to health-related behaviors such as knowledge seeking and protective behaviors (Kok et al., 2014; Ling et al., 2019; Rogers & Prentice-Dunn, 1997). Therefore, the current study tested whether COVID-19 prevalence would be associated with internet searches related to fear-related emotions, health-related behaviors and knowledge. Furthermore, we tested whether fear-related emotions would mediate the relationship between COVID-19 prevalence and health-related behaviors and knowledge.

THE PRESENT RESEARCH

The present study aims to demonstrate the immediate impact of the COVID-19 pandemic on health-related internet searches. To achieve our research aims, we retrieved COVID-19 prevalence rate data and internet search data. We utilised the Google research tool "Google Trends" to retrieve internet search data. Google Trends provides data related to Google internet search volume with a wide range of search terms using an index ranging from 0 (representing the least popular search term) to 100 (representing the most popular search term). Google search volume data have been demonstrated to be a valid indicator of people's well-being, desires and intentions, such as negative and positive affect, risky behaviors, religiosity, pursuit of luxury goods, and academic dishonesty, among others (Ford, Jebb, Tay, & Diener, 2018; Neville, 2012; Payne, Brown-Iannuzzi, & Hannay, 2017; Pelham et al., 2018; Walasek & Brown, 2015).

We retrieved the Google search volume data for four countries: the United States, the United Kingdom, Canada, and Australia. All four countries are suffering from the COVID-19 pandemic and were chosen as the target countries because the four countries are English-speaking countries. Hense we were able to use the same keywords in English to examine internet searches of their citizens. We retrieved Google search volume data by using keywords that index fear-related emotions, protective behaviors, health knowledge, and panic buying (see Table 1). We hypothesised that in each of the four countries, increasing COVID-19 prevalence would be associated with a greater search volume associated with fear-related emotions, protective behaviors, health knowledge, and panic buying, respectively. Furthermore, internet searches related to fear would mediate the associations of COVID-19 with searches indexing protective behaviors, health knowledge, and panic buying behaviors.

The current study is a timely response to the need for cyberpsychology research during the COVID-19 pandemic (Guitton, 2020). Findings will inform the coping efforts through online activities when exposed to a pandemic. Findings will also be informative for health policymakers, healthcare providers, and official authorities to make decisions on when and how to distribute pandemic-related messages to citizens.

METHOD

The present study used publicly available data and the authors had no interaction with the participants; therefore, human subjects ethical review was not required.

COVID-19 data were retrieved from the website of Johns Hopkins Coronavirus Resource Center (Johns Hopkins Coronavirus Resource Center, 2020). For each country, we used the data of COVID-19 since the date of the first confirmed case in the four countries (the United States, 22 January; the United Kingdom, 31 January; Canada, 26 January; Australia, 26 January) until 24 March

TABLE 1
Variables, Search Terms, and Cronbach's Alphas

Country	Variable	Search terms	Cronbach's alpha
United States	Protective behavior	Mask, handwashing, social distancing, quarantine	.94
	Health-related knowledge	Vaccine, immunity	.98
	Panic buying	Panic buying, stockpile	.95
	Fear-related emotions	Fear, panic, worry	.96
United Kingdom	Protective behavior	Mask, handwashing, social distancing, quarantine	.93
	Health-related knowledge	Vaccine, immunity	.97
	Panic buying	Panic buying, stockpile	.97
	Fear-related emotions	Fear, panic, worry	.85
Canada	Protective behavior	Mask, handwashing, social distancing, quarantine	.93
	Health-related knowledge	Vaccine, immunity	.99
	Panic buying	Panic buying, stockpile	.82
	Fear-related emotions	Fear, panic, worry	.82
Australia	Protective behavior	Mask, handwashing, social distancing, quarantine	.92
	Health-related knowledge	Vaccine, immunity	.98
	Panic buying	Panic buying, stockpile	.85
	Fear-related emotions	Fear, panic, worry	.81

2020. In total, there were 63-day, 54-day, 59-day, and 59-day data points for the United States, the United Kingdom, Canada, and Australia, respectively. With the time series data, we were able to examine the relationship between COVID-19 prevalence and online searches within countries, which allowed us to naturally control for potential third variable confounds (e.g. country differences in healthcare systems and health policies and percentage of elderly in the population) and enable a stronger test of our hypotheses compared to cross-country comparisons and cross-sectional analyses (Oishi, Kesebir, & Diener, 2011; Oishi, Kushlev, & Schimmack, 2018). The prevalence rates of COVID-19 were log-transformed and standardised before the analyses.

To examine whether Google Trends data reflected people's desires and intentions related to COVID-19, we retrieved the search volume data using the keyword *coronavirus*. We found that the prevalence rates of COVID-19 were highly correlated with the searches for the topic *coronavirus* in the United States

(r = .90, p < .001), the United Kingdom (r = .90, p < .001), Canada (r = .79, p < .001), and Australia (r = .86, p < .001), suggesting that Google searches did reflect people's psychological concerns. In addition, past research has shown that using online search terms is a reliable and valid way of approximating psychological and behavioral constructs (Ford et al., 2018; Payne et al., 2017; Pelham et al., 2018; Walasek & Brown, 2015). Therefore, we used online search terms to indicate searches for emotions, health knowledge, and behavior.

Searches for protective behaviors were indexed by search volume data using four keywords: *mask*, *handwashing*, *social distancing*, and *quarantine*, which represented four types of protective behaviors recommended by the World Health Organization (World Health Organization, 2020b) (see all keywords in Table 1). The four types of behaviors showed moderate to high correlations between each other across the four countries (rs > .55, ps < .001, see details in Tables S1–S4). Because all search volumes of keywords increased in exponential curve patterns (see Figure 1a–d), we log-transformed and standardised the data. Then, we computed a composite score by averaging four behavior scores, with higher scores indicating more searches for protective behaviors.

Searches for health knowledge were indexed by search volume data using two keywords: *vaccine* and *immunity*, which reflected people's inclination to seek health-related information, such as the availability of a vaccine and ways of gaining immunity. The two types of health knowledge showed high correlations between each other across the four countries (rs > .93, ps < .001). After log-transformation and standardisation, we computed a composite score by averaging two knowledge scores, with higher scores indicating more searches for health knowledge.

Searches for panic buying were indicated by search volume data of two keywords: *panic buying* and *stockpile*, which reflected motivation for excessive buying. The two types of buying behavior showed moderate to high correlations across the four countries (rs > .70, ps < .001). After log-transformation and standardisation of the data, we computed a composite score by averaging two buying behavior scores, with higher scores indicating more searches for panic buying.

Searches for fear-related emotions were indicated by search volume data of three keywords: *fear*, *worry*, and *panic*. We first checked a broad scope of

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FIGURE 1.   (a) Prevalence rates of COVID-19 and search volumes in the United States. (b) Prevalence rates of COVID-19 and search volumes in the United Kingdom. (c) Prevalence rates of COVID-19 and search volumes in Canada. (d) Prevalence rates of COVID-19 and search volumes in Australia. *Note*: The vertical axis on the left is used for prevalence rates of COVID-19, whereas the vertical axis on the right is used for search volumes. [Colour figure can be viewed at wileyonline library.com]

(a) United States

(b) United Kingdom

(c) Canada

(d) Australia
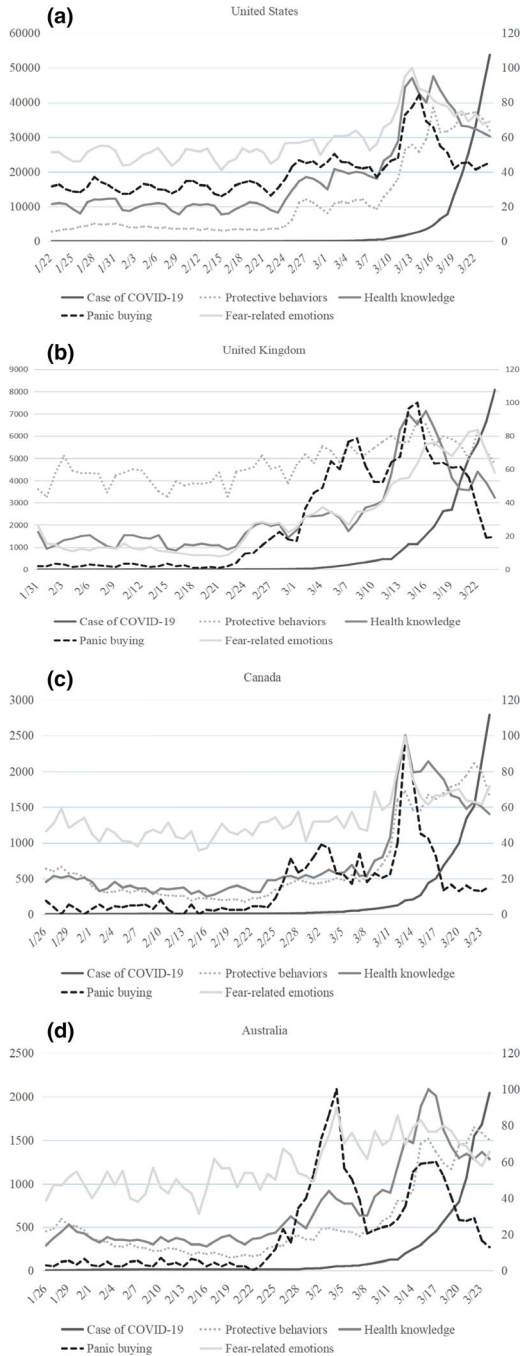
negative emotions, which were operationalised by five keywords: *fear*, *worry*, *panic*, *anxiety*, and *sadness*, which reflected overall negative emotional reactions. Three keywords including fear, worry, and panic showed moderate to high correlations among each other across the four countries (rs > .48, ps < .001); however, the last two keywords, anxiety and sadness, showed mixed correlations (e.g. non-significant or even negative correlations) with the first three keywords. Therefore, we used only three keywords (i.e. fear, worry, panic) as indicators of fear-related emotions. We log-transformed and standardised the data, and then computed a composite score by averaging three emotion scores, with higher scores indicating more searches for fear-related emotions.

All internet search variables demonstrated acceptable reliability (see Cronbach's alphas in Table 1).

Analyses

We matched prevalence rates of COVID-19 and online searches by date for data analyses. To test the hypothesis, we conducted multiple regression analyses within countries. As mentioned above, because all scores showed exponential curve patterns, we conducted log-transformation and standardisation with all scores (Bishara & Hittner, 2012), which enabled us to use multiple linear regression to analyse the data. We conducted a series of multiple linear regressions to examine the association of the prevalence rates of COVID-19 with searches for protective behaviors, health knowledge, and panic buying. Further, we conducted mediation analyses to test mediation effects of searches for fear in the associations of the prevalence rates of COVID-19 with searches for protective behaviors, health knowledge, and panic buying. Mediation analyses were conducted using the Process macro for SPSS (Hayes, 2012), in which indirect effects were estimated with a bootstrapping procedure based on 5,000 bootstrap samples (95% confidence interval).

RESULTS

COVID-19 and Internet Searches

The COVID-19 prevalence rate significantly predicted searches for protective behaviors in the four countries: the United States ($B = 0.88$, $SE = 0.03$, $t = 28.51$, $p < .001$), the United Kingdom ($B = 0.84$, $SE = 0.05$, $t = 18.02$, $p < .001$), Canada ($B = 0.78$, $SE = 0.06$, $t = 12.97$, $p < .001$), and Australia ($B = 0.82$, $SE = 0.05$, $t = 17.15$, $p < .001$), suggesting that increasing numbers of COVID-19 cases were associated with more searches for protective behaviors.

The prevalence rate significantly predicted searches for health knowledge in the four countries: the United States ($B = 0.89$, $SE = 0.06$, $t = 16.26$, $p < .001$),

the United Kingdom ($B = 0.87$, $SE = 0.06$, $t = 13.49$, $p < .001$), Canada ($B = 0.85$, $SE = 0.07$, $t = 12.39$, $p < .001$), and Australia ($B = 0.88$, $SE = 0.09$, $t = 14.8$, $p < .001$), suggesting that increasing numbers of COVID-19 cases were associated with more searches for health knowledge.

The prevalence rate significantly predicted searches related to panic buying in the four countries: the United States ($B = 0.83$, $SE = 0.07$, $t = 12.56$, $p < .001$), the United Kingdom ($B = 0.83$, $SE = 0.07$, $t = 11.1$, $p < .001$), Canada ($B = 0.62$, $SE = 0.09$, $t = 6.77$, $p < .001$), and Australia ($B = 0.61$, $SE = 0.09$, $t = 6.48$, $p < .001$), suggesting that increasing numbers of confirmed cases of COVID-19 were associated with more searches related to panic buying.

These results are consistent with our hypotheses and indicate that in a given country, when the prevalence rates of COVID-19 increased, people searched for protective behaviors, health knowledge, and excessive buying more often. Moreover, these patterns were consistent across the four countries.

Fear-Related Emotions Explain the Link between COVID-19 and Searches

Next, we examined whether searches for fear-related emotions would mediate the associations of COVID-19 with searches for protective behaviors, health knowledge, and panic buying. We regressed searches for protective behaviors, health knowledge, and panic buying on both COVID-19 and searches for fear-related emotions, respectively (see Tables S5–S16). We report significant mediation effects in Figures S1–S10.

Searches for fear-related emotions mediated the association of the prevalence rates of COVID-19 with searches for protective behaviors in the United States (indirect effect = 0.17, $SE = 0.05$, 95% CI [0.10, 0.28]) and Canada (indirect effect = 0.24, $SE = 0.06$, 95% CI [0.14, 0.36]), but not in the United Kingdom (indirect effect = 0.10, $SE = 0.06$, 95% CI [−0.01, 0.21]) or Australia (indirect effect = −0.04, $SE = 0.04$, 95% CI [−0.11, 0.05]).

Searches for fear-related emotions mediated the association of the prevalence rates of COVID-19 with searches for health knowledge in the United States (indirect effect = 0.57, $SE = 0.07$, 95% CI [0.43, 0.71]), the United Kingdom (indirect effect = 0.33, $SE = 0.10$, 95% CI [0.15, 0.53]), Canada (indirect effect = 0.40, $SE = 0.09$, 95% CI [0.23, 0.58]), and Australia (indirect effect = 0.22, $SE = 0.05$, 95% CI [0.13, 0.33]).

Searches for fear-related emotions mediated the association of the prevalence rates of COVID-19 with searches for panic buying in the United States (indirect effect = 0.73, $SE = 0.15$, 95% CI [0.40, 1.01]), the United Kingdom (indirect effect = 0.36, $SE = 0.10$, 95% CI [0.18, 0.58]), Canada (indirect effect = 0.47, $SE = 0.21$, 95% CI [0.04, 0.83]), and Australia (indirect effect = 0.49, $SE = 0.13$, 95% CI [0.26, 0.76]).

We carried out an additional robustness check. Because both searches for panic buying and searches for fear-related emotions (e.g. panic) included the search term *panic*, the search volume data may be overlapping and could have resulted in biased estimates. We conducted a robustness check, in which searches for panic buying were only indicated by the keyword *stockpile*, but not *panic buying*. We found that searches for fear-related emotions mediated the association between prevalence rates of COVID-19 and searches for *stockpile* in three out of the four countries: the United States (indirect effect = 0.44, SE = 0.09, 95% CI [0.24, 0.60]), the United Kingdom (indirect effect = 0.37, SE = 0.09, 95% CI [0.23, 0.56]), and Australia (indirect effect = 0.45, SE = 0.11, 95% CI [0.27, 0.69]). Results were nonsignificant, however, in Canada (indirect effect = 0.29, SE = 0.16, 95% CI [−0.10, 0.53]) although the direction of the coefficient was in the right direction. These results largely replicated the findings using the data of searches for panic buying, except for Canada, which suggests that the mediation effects of searches for fear-related emotions were not mainly due to the overlapping search keywords.

These results support the hypothesis that searches for fear-related emotions mediated the association between the prevalence rates of COVID-19 and searches for health knowledge and panic buying, and partly support the hypothesis that searches for fear-related emotions mediated the association between the prevalence rates and searches for protective behaviors.

DISCUSSION

The present study aimed to understand people's emotional and behavioral reactions to COVID-19 through online searches. We hypothesised that the prevalence rates of COVID-19 would be associated with more searches for protective behaviors, health knowledge, and panic buying through higher levels of searches for fear-related emotions. In general, the hypotheses were confirmed by the results that increasing cases of COVID-19 were associated with more searches for protective behaviors, health knowledge, and panic buying, most of which were mediated by searches for fear-related emotions.

The present findings are in line with the fear appeal approach which argues that the threat of a disease arouses fear-related emotions, which in turn motivates people to seek for behavioral changes and gain health knowledge (Floyd et al., 2000; Kok et al., 2014; Ling et al., 2019; Rogers & Prentice-Dunn, 1997). Moreover, the present study used a socioecological factor (prevalence rate of COVID-19) to predict psychological reactions, which corroborates the perspective of socioecological psychology (Du, Chi, & King, 2019; Du et al., 2020; Du, King, & Chi, 2019; Oishi, 2014; Schaller, 2020), and demonstrates that the prevalence rate of a disease can be considered a direct psychological threat and useful for changing health-related intentions (Du, Chi, & Li, 2018).

Although internet searches might only represent intentions for behavioral changes but not actual behavorial change itself, the fear appeal literature has shown that threat perceptions (e.g. threat severity, threat vulnerability) have comparable impacts on intentions and behaviors (Floyd et al., 2000). Therefore, the implications of the present findings may be also applied to people's behavioral responses to COVID-19, such that when a country has more cases of COVID-19, citizens could be more likely to demonstrate protective behaviors, acquire health information, and conduct excessive buying.

Our findings reveal the need for transparency during a pandemic. When people are aware of the increasing number of COVID-19 cases, they tend to more actively respond to the disease and seek useful information and behavioral changes. The World Health Organization suggests minimising exposure to news about COVID-19 because the exposure causes worry, distress, and anxiety (World Health Organization, 2020a). Based on our findings, we rather suggest that optimal levels of fear are needed, so as to motivate people to adopt protective behaviors.

It is important to note that fear itself is not enough to motivate people to act. Fear functions best when it is coupled with a sense of efficacy (Kok et al., 2014; Rogers & Prentice-Dunn, 1997), such that when individuals are fearful about the disease and also recognise the efficacy of protective behaviors, they are more likely to initiate behavioral changes. COVID-19 has undoubtedly elicited fear. Governments should also provide information on how to protect oneself and one's community against the disease (e.g. through handwashing and social distancing) to increase people's efficacy in fighting against COVID-19.

More searches for panic buying reflect an increased desire to excessively store daily necessities to respond to COVID-19 because most countries affected by COVID-19 advised citizens to stay at home. A potential consequence of panic buying is to deprive people who actually need these supplies from having them (e.g. the elderly, disabled people) (*Guardian*, 2020). To alleviate the impact of COVID-19 and dampen fear and panic buying, governments should deliver timely information on sufficient supplies of basic goods (O'Keefe, 2016) to prevent the spread of panic and loss of control.

Our finding that searches for fear functioned as a mediator does not exclude the possibility of searches for behaviors being mediators. For example, COVID-19 might strengthen some types of behaviors (e.g. panic buying), which would further intensify fear-related emotions. Such hypotheses should be formulated based on other theories, which is beyond the scope of the current study, and deserve additional studies to examine them in future.

The current work has two limitations. First, although the search terms showed good reliabilities across countries, there are other possible search terms that the participants might have used. For example, two keywords, *vaccine* and *immunity*, were used to indicate searches for health knowledge related to COVID-19; however, the two keywords may only partially represent health

knowledge. Future research should consider other keywords (e.g. transmission pathways) and perhaps complement this with surveys that explicitly ask people about their emotional and behavioral reactions to COVID-19. Second, we analysed the time series data by treating each time point as an individual data point. This data analytic strategy has been used in previous research (e.g. Oishi et al., 2011; Oishi et al., 2018). We did not include time as a variable because the current study aimed to examine the association between prevalence rates of COVID-19 and online searches, rather than over-time changes in prevalence rates of COVID-19 or online searches. However, we also acknowledge that future studies can examine the longitudinal associations across time by taking into account the role of time and also considering the autocorrelations among the data points. Future studies may want to address this issue using methods for longitudinal data analysis.

Despite the dismal situation, there is a glimmer of hope. The COVID-19 pandemic gives people a chance to reflect on healthy versus unhealthy behaviors. Healthy behavioral habits such as hand hygiene protect people not only from COVID-19, but also from the flu, acute respiratory syndrome (SARS), Middle East respiratory syndrome (MERS), and even possible pandemics in the future. The current research suggests that seeking health knowledge and healthy behaviors might be encouraged through exposure to prevalence rates of disease and fear-related emotions, which could be used to promote COVID-19 prevention and interventions.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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