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COVID-19 Increases Online Emotional and Health-Related Searches

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Abstract

Objective: 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 hypothesized that when the prevalence rates of COVID-19 increase, people would experience more fear, which in turn would predict greater rates of protective behaviors, seeking 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 indicated by internet search volumes in Google Trends. Cross-temporal analyses were conducted.

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 information searches.

Conclusion: Findings suggest that exposure to prevalence rates of COVID-19 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, intention, protective behavior, health knowledge, panic buying, fear

Searching for Cures: COVID-19 and Online Emotional and Health-Related Searches

Since the coronavirus outbreak in January 2020, COVID-19 has infected around two million people and led to more than 119,700 deaths (Johns Hopkins Coronavirus Resource Center, 2020). The World Health Organization has announced 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 March 11, 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 human beings all over the world, 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 hypothesized 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. This prediction is consistent with fear appeal theories, which posit that threat of a disease elicits fear, which in turn motivates people to initiate behavioral changes and improve health knowledge (Floyd, Prentice-Dunn, & Rogers, 2000; Kok, Bartholomew, Parcel, Gottlieb, & Fernández, 2014; Ling, Kothe, & Mullan, 2019; Rogers & Prentice-Dunn, 1997). There are several reasons which justify our theoretical model (COVID-19 prevalence $\rightarrow$ fear $\rightarrow$ health-related knowledge and behavioral outcomes) we posited.

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 washing hands, social distancing, quarantining, and wearing masks when necessary (World Health Organization, 2020b). Moreover, people may be keen to know 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 uncertainty caused by COVID-19 (e.g., city lockdown), 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 (Van Bavel et al., 2020). Due to worries about the lack of daily necessities, people might irrationally stockpile things, such as

food, toilet papers, hand sanitizers, 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 emotional search terms would explain the relationships between the prevalence rate of COVID-19 and search terms of protective behaviors, health knowledge, and panic buying.

The Present Research

The present study aims to demonstrate the immediate impact of COVID-19 pandemic on health-related internet searches. To achieve our research aims, we utilized 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 desires and intentions, such as risky behavior, religiosity, pursuit of

luxury products, and academic dishonesty (Neville, 2012; Payne, Brown-Iannuzzi, & Hannay, 2017; Pelham et al., 2018; Walasek & Brown, 2015).

We retrieved the Google search volume data for four countries, including 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 so that we were able to use the same keywords in English to examine internet searches of their citizens. We retrieved data of Google search volume by using keywords that index fear-related emotions, protective behaviors, health knowledge, and panic buying (see Table 1). We hypothesized 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, fear-related emotions would mediate the associations of COVID-19 with protective behaviors, health knowledge, and panic buying behaviors.

Findings will inform the coping efforts through online activities when being exposed to a pandemic. Findings will also be informative for health policymakers, health care 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 till March 24, 2020. The prevalence rates of COVID-19 were log-transformed and standardized before analyses.

To examine whether the data of Google Trends 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 reflected people's psychological concerns.

Protective behaviors were indexed by search volume data using four keywords: *mask*, *hand washing*, *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 four countries ($r_s > .55, p_s < .001$, see details in Tables S1-S4). Because all search volumes of keywords increased in exponential curve patterns (see Figure 1a-1d), we log-transformed and standardized data. Then we computed a composite score by averaging four behavior scores, with higher scores indicating more searches for protective behaviors.

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

Panic buying was indicated by search volume data of using two keywords: *panic buying* and *stockpile*, which reflected motivation for excessive buying. The two types of buying behavior showed moderate to high correlations between each other across four countries ($r_s > .70, p_s < .001$). After log-transformation and standardization of the data, we

computed a composite score by averaging two buying behavior scores, with higher scores indicating more searches for panic buying.

Fear-related emotions were indicated by search volume data of using three keywords: *fear*, *worry*, and *panic*. We first checked a broad scope of negative emotions, which were operationalized 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 between each other across four countries ($r_s > .48$, $p_s < .001$); 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 standardized 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

To test the hypothesis, we conducted cross-temporal analyses within countries. Cross-temporal analyses within countries provide a stronger test of our hypotheses compared to cross-national analyses because the former naturally controls for numerous third variable confounds associated with between country differences (e.g., government policy, public health system, elderly population) (Oishi, Kesebir, & Diener, 2011).

As mentioned above, because all scores showed exponential curve patterns, we conducted log-transformation and standardization with all scores (Bishara & Hittner, 2012), with which we were able to use multiple linear regression to analyze 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 fear-related emotions in the associations of the prevalence rates of COVID-19 with protective behaviors, health knowledge, and panic buying.

Results

COVID-19 and internet searches

The COVID-19 prevalence rate significantly predicted searches for protective behaviors in 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 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 ($B = 0.88$, $SE = 0.06$, $t = 14.8$, $p < .001$), 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 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 confirming cases of COVID-19 were associated with more searches for panic buying.

These results are consistent with the hypothesis 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 fear-related emotions would mediate the associations of COVID-19 with protective behaviors, health knowledge, and panic buying. We regressed protective behaviors, health knowledge, and panic buying on both COVID-19 and fear-related emotions, respectively (see Tables S5-S16). We reported significant mediation effects in Figures S1-S10.

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]) and Australia (indirect effect = -0.04, $SE = 0.04$, 95%CI = [-0.11, 0.05]).

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]), Australia (indirect effect = 0.22, $SE = 0.05$, 95%CI = [0.13, 0.33]).

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])

These results support the hypothesis that 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 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 hypothesized 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 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 fear-related emotions.

The present findings are in line with the fear appeal approach that threat of a disease arouses fear 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, & Li, 2018; Oishi, 2014), and demonstrates that the prevalence rate of a disease can be considered as a direct psychological threat and useful for changing health-related intentions.

Although we can only indicate that internet searches might represent intentions for behavioral changes, 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, learn 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 minimizing 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 recognize 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 hand washing and social distancing) to increase people's efficacy in fighting against COVID-19.

More searches for panic buying reflect increased desires for excessively storing 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., elderly, disabled people) (The 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 panic spread and loss of control.

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

Country	Variable	Search terms	Cronbach's alpha
United States	protective behavior	mask, hand washing, social distancing, quarantine	0.936
	health-related knowledge	vaccine, immunity	0.976
	panic buying	panic buying, stockpile	0.945
	fear-related emotions	fear, panic, worry	0.963
United Kingdom	protective behavior	mask, hand washing, social distancing, quarantine	0.927
	health-related knowledge	vaccine, immunity	0.966
	panic buying	panic buying, stockpile	0.969
	fear-related emotions	fear, panic, worry	0.846
Canada	protective behavior	mask, hand washing, social distancing, quarantine	0.929
	health-related knowledge	vaccine, immunity	0.988
	panic buying	panic buying, stockpile	0.821
	fear-related emotions	fear, panic, worry	0.822
Australia	protective behavior	mask, hand washing, social distancing, quarantine	0.921
	health-related knowledge	vaccine, immunity	0.978
	panic buying	panic buying, stockpile	0.853
	fear-related emotions	fear, panic, worry	0.809

Figures 1a-1d. Prevalence rates of COVID-19 and search volumes in the United States, United Kingdom, Canada, and 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.