



Daily Effects of COVID-19 News on Personal Protective Behaviors Through COVID-19 Anxiety: The Significance of Direct Wuhan Epidemic Experience

Jing Du¹ · Xue Ni Zheng¹ · Jin Nam Choi² · Yuan Xiang¹

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Abstract

Background Drawing on cognitive appraisal theory, this study investigates the effect of daily COVID-19 news on daily anxiety and protective behaviors (e.g., wearing masks and washing hands). This study proposes that such processes, leading to self-protection, are highly likely when individuals have directly experienced the Wuhan epidemic at the beginning of 2020, which is the most serious COVID-19 outbreak in history.

Methods The positive effect of daily COVID-19 news on daily protective behaviors through daily COVID-19 anxiety was examined in this study, which was hypothesized to be accentuated by direct Wuhan epidemic experience. An online survey based on the experience sample method (ESM) was conducted during the COVID-19 epidemic in Hebei Province, China, at the beginning of 2021, in which 82 working adults participated in a daily survey for five consecutive days. Once a day during the five-day period, the participants reported their daily COVID-19 news exposure, daily COVID-19 anxiety, and daily protective behaviors. Wuhan epidemic experience was measured by the place of residence of the participants during the 2020 Wuhan epidemic through a separate general survey conducted before the ESM survey.

Results Analysis of 392 day-level data confirmed the positive link between daily COVID-19 news and daily protective behaviors, mediated by daily COVID-19 anxiety ($b = 0.03$, $SE = 0.01$, $p = 0.018$). Furthermore, the mediated effect was significant for the participants with direct COVID-19 experience in Wuhan in 2020 ($b = 0.05$, $SE = 0.03$, $p = 0.041$) but not significant for those without direct experience in Wuhan ($b = 0.01$, $SE = 0.01$, $p = 0.461$). Thus, the results confirmed the positive moderating role of Wuhan epidemic experience.

Conclusions The analysis reveals the psychological mechanism through which COVID-19 information promotes self-protection measures to control the infectious disease and highlights the importance of direct COVID-19 experience in generating such an effect.

Keywords COVID-19 news · COVID-19 anxiety · Protective behaviors · Wuhan epidemic experience · Public health

Introduction

The Coronavirus disease 2019 (COVID-19) emerged as one of the most severe infectious diseases in recent history. The WHO recommended personal protective behaviors such as maintaining social distancing, using personal protective equipment (e.g., masks), and frequent hand washing as effective ways to ensure safety in the face of COVID-19 [1]. As local epidemics tend to recur unexpectedly from time to time, maintaining people's awareness and promoting their protective behaviors are crucial to contain and prevent the spread of COVID-19 to the general public. This study investigates how people respond to local epidemics to advance the public health literature and how people with different

✉ Jin Nam Choi
jnchoi@snu.ac.kr

Jing Du
jdu@whu.edu.cn

Xue Ni Zheng
xnzheng2@whu.edu.cn

Yuan Xiang
yxiang@whu.edu.cn

¹ Economics and Management School, Wuhan University, Wuhan 430072, China

² Graduate School of Business, Seoul National University, 1 Gwanak-ro, Gwanak-gu, Seoul 08826, South Korea

COVID-19 experiences respond to media coverage differently and exhibit varying protective behaviors.

Media coverage is a key channel for encouraging the public to adopt effective preventive measures [2, 3]. Nevertheless, how media coverage as a stimulus shapes individual protective behaviors through emotional mechanisms remains unclear. Some studies indicated that encountering news about COVID-19 can lead to feelings of depression and anxiety, as well as engagement in protective behaviors [4]. On the contrary, other studies noted that negative emotions experienced during the COVID-19 period can hinder one's compliance with protective measures [5]. With the continuous occurrence of secondary epidemics in various areas, the COVID-19 pandemic has become a distal potential threat with uncertainty, especially for people in unaffected areas. This distal threat of COVID-19 can elicit perceptions of uncertainty and loss of control in individuals, manifested by elevated anxiety, rather than fear, about the infectious disease [6, 7].

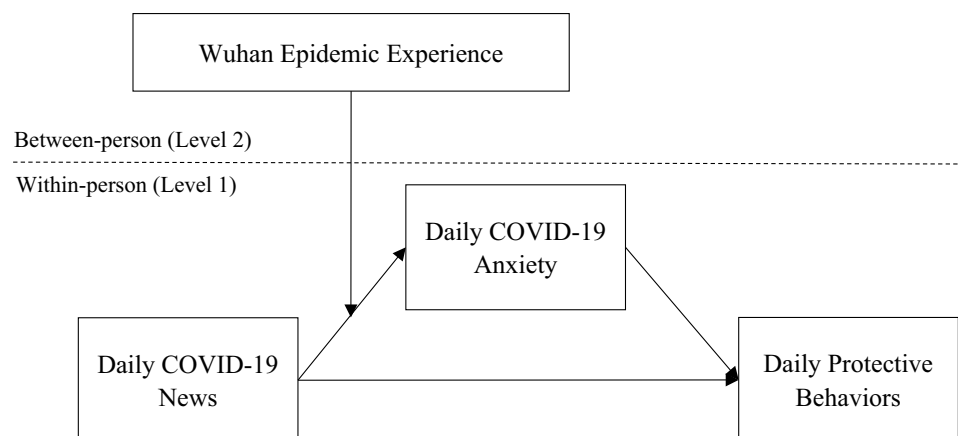
To elaborate on a person's emotional and behavioral responses to media coverage of COVID-19, we draw on cognitive appraisal theory. This theory proposes that individuals evaluate stressors in two stages [8]. In the primary appraisal of a stressor, individuals ascertain its personal relevance and valence. If the stressor is deemed personally relevant with either positive or negative consequences, a secondary appraisal takes place to assess one's ability to cope with the stressor. The emotional and coping responses that follow depend on the outcomes of this two-stage appraisal [9]. Thus, we theorize that COVID-19 news prompts individuals to evaluate local epidemics as potential threats (through primary appraisal), and they may feel that these threats are difficult to manage with their available coping resources (through secondary appraisal). These cognitive appraisals provoke an emotional response of heightened anxiety, which can then induce individuals to adopt adaptive behaviors for self-protection.

However, individuals' emotional and behavioral responses to COVID-19 news may not be the same [10]. Some people may relax their vigilance against subsequent local epidemics

because of pandemic fatigue or apathy, whereas others may take the media coverage seriously and change their behaviors [11]. Previous studies revealed the inconsistent moderating effects of disaster experiences (e.g., earthquakes and floods) on individuals' response when reexposed to disasters [12–15]. Earthquakes and floods have the characteristics of suddenness, long intervals, and relatively low preventability [5]. However, local COVID-19 epidemics recur within short intervals and have a certain degree of preventability. We propose that individuals' previous COVID-19 experience may affect their response to subsequent epidemics [16–19]. In this respect, the Wuhan epidemic in 2020 demonstrates the highest uncertainty and risk, which aroused unprecedented panic among the residents, thereby being seared into their memory [10, 20, 21]. In this study, we identify an individual's residence in Wuhan in 2020, during the first outbreak and lockdown, as a critical contingency strengthening the effects of COVID-19 information on anxiety related to the local epidemic and resulting self-protective behaviors.

Drawing on cognitive appraisal theory [8, 9], we aim to clarify the role of a local COVID-19 epidemic in shaping the emotional and coping responses of people with different levels of direct exposure to the epidemic. Specifically, we identify a pivotal emotional mechanism that mediates the effect of COVID-19 epidemic information on individuals' self-protective behaviors. We also explore the differential effects of COVID-19 information on individuals with different epidemic experiences (i.e., Wuhan versus non-Wuhan residents). We test the current research model shown in Fig. 1 by examining day-level development within the context of a local COVID-19 epidemic. We adopt the experience sampling method (ESM) to investigate the highly time-sensitive and fluctuating nature of the current phenomenon, which often unfolds daily owing to the rapid spread of the virus and changing numbers of confirmed cases. The current analysis advances practical strategies to promote the voluntary participation of individuals in public health recommendations by proactively adopting protective measures.

Fig. 1 Research model



Daily COVID-19 News Driving Daily Anxiety and Protective Behaviors

COVID-19, with characteristics of being highly infectious and concealed, can harm people's health to varying degrees, from causing fever and coughs to pneumonia and death [22]. Thus, individuals may feel anxious about and threatened by continuous media coverage of the spread of COVID-19, dramatic images, and the skyrocketing numbers of confirmed cases [23]. For most people, media coverage is their main source of information on the pandemic. In this study, we examine the level of daily COVID-19 news, which represents individuals' degree of exposure to information about COVID-19 from the media on any given day. Specifically, COVID-19 news refers to the frequency, severity, and geographical proximity of news concerning the local epidemic as received by the participants.

As a primary information carrier, daily COVID-19 news can be a source of stress and increased anxiety for individuals [20, 21]. According to cognitive appraisal theory, individuals perceive and evaluate environmental events, which can induce distinct emotional reactions and trigger coping behaviors [24]. In the primary appraisal, individuals will find the risk of contracting COVID-19 to be a plausible threat to their health, which can be accentuated by the sense of uncertainty associated with the volatile nature of the COVID-19 pandemic [3]. In the secondary appraisal, individuals will find themselves unable to fully control the situation. Such evaluations of threat and uncontrollability will tend to elicit adverse emotional reactions, such as anxiety [9]. As the situation of a local COVID-19 epidemic varies daily with new developments, COVID-19 anxiety in daily life and at work will fluctuate correspondingly. Therefore, the more severe the COVID-19 news received by individuals on any given day, the higher their level of COVID-19 anxiety on the same day. Thus, we propose the day-level relationship in the following hypothesis:

Hypothesis 1: Daily COVID-19 news will be positively related to daily COVID-19 anxiety.

We further propose that COVID-19 anxiety will likely promote the level of personal protective behaviors, such as maintaining social distancing, wearing of masks, and frequent hand washing. Cognitive appraisal theory suggests that individuals adopt coping behaviors in response to threats to reduce their distasteful emotional state of anxiety [8]. Being beyond one's control, the spread of the virus is an unavoidable threat that may make individuals anxious. The most direct and effective strategy to diminish uncertainty and anxiety associated with COVID-19 is to adopt personal protection measures, as recommended by the WHO, to ensure one's health and safety. Individual protective behaviors are an effective way to avoid the pandemic threat [1].

Therefore, increasing such behaviors would be a reasonable daily behavioral strategy to cope with perceived uncertainty and anxiety caused by one's exposure to COVID-19 news on any given day [21]. Accordingly, daily COVID-19 news can indirectly shape individuals' precautionary and protective behaviors on the same day through its direct effect on their daily COVID-19 anxiety. Therefore, we propose the following hypothesis on the day-level indirect effect:

Hypothesis 2: Daily COVID-19 news will be indirectly related to daily personal protective behaviors through daily COVID-19 anxiety.

Wuhan Epidemic Experience as a Moderator

Previous disaster experience can affect individuals' attitudes and behaviors when they are exposed to another disaster [18, 19]. For example, the emotional trauma experienced by earthquake survivors predisposes them to emotional trauma in subsequent disasters [25]. Similarly, the likelihood of developing anxiety and depression is significantly high for those who had been diagnosed with COVID-19 or know someone who was diagnosed with or died from COVID-19 [16]. The mental health of people with COVID-19 experiences may be further affected by illness severity as well as proximity to an infected person (self and close-to-distant network) [17]. Individuals who have experienced traumatic events have increased sensitivity to negative information and are prone to heightened emotional arousal, which may be related to the automatic recollection of their traumatic experiences [26].

For individuals who experienced the Wuhan outbreak, though most of them did not contract COVID-19 or witness the infection of their loved ones, they all experienced a traumatic event. During the Wuhan outbreak in early 2020, people in Wuhan were exposed to extremely high levels of risk and accompanying anxiety to the extent that the COVID-19 pandemic became a personal trauma [10, 27]. Residents suffered from severe social and economic disruptions, which caused physical and psychological harm. With the restimulation of the COVID-19 pandemic, people in Wuhan are more likely to focus on negative information about the pandemic compared with people living outside Wuhan, whose experiences may have been less severe, because Wuhan residents can automatically recall the contextualized and specific details and emotions from their experience during the 2020 outbreak, such as their worry about friends and neighbors being infected, anxiety about obtaining protective materials, and fear of their own risk of infection [26]. Thus, direct experience of the Wuhan outbreak will increase the emotional arousal level of individuals in response to incoming COVID-19 news on a local epidemic, thereby leading to intense anxiety.

Hypothesis 3: Wuhan epidemic experience will positively moderate the day-level relationship between daily COVID-19 news and daily COVID-19 anxiety, such that the relationship will be more positive for Wuhan residents than for others.

As hypothesized previously, people who suffer from COVID-19 anxiety will be highly willing to adopt self-protection measures against the disease to reduce their anxiety and risk of infection. COVID-19-related protective behaviors require immediate resource investment (e.g., time and money) and are difficult to maintain over a long period of time and thus may only be partially implemented for the general population [5]. Such a defensive response for self-protection is related to the arousal level of individuals caused by a stimulus. High-arousal stimuli can enhance negativity bias compared with low-arousal stimuli [28], which can help detect environmental hazards and mobilize defensive behaviors. Accordingly, if individuals with Wuhan epidemic experience tend to develop a high arousal level from the stimulus of COVID-19 news, then they will likely appreciate the importance of protective behaviors and engage in such behaviors [18]. With direct exposure to the pandemic by residing in the hardest hit region, such individuals may be highly responsive to COVID-19 emotionally and behaviorally [12]. In summary, Wuhan epidemic experience can increase the emotional arousal level of individuals in response to COVID-19 news, thereby accentuating the indirect relationship between daily news and protective behaviors for COVID-19. Thus, we propose the following moderated mediation hypothesis:

Hypothesis 4: Wuhan epidemic experience will positively moderate the day-level indirect relationship between daily COVID-19 news and daily personal protective behaviors through daily COVID-19 anxiety, such that the indirect relationship will be more positive for Wuhan residents than for others.

Methods

Participants and Procedure

To test the current model, we used the ESM, which emphasizes the evaluation of variables that fluctuate during a short period of time through the repeated measurement of the same individuals. Daily surveys based on the ESM can reveal intra-individual variability in experiences and behaviors [29]. In the face of COVID-19 epidemics, individual emotions and behaviors can change dynamically within a short period of time, as the epidemic situation fluctuates daily. Therefore, in this study, we used the

ESM to record the participants' emotional and behavioral responses to COVID-19 news during a local epidemic through daily repeated measurements.

We conducted a survey during a local epidemic outbreak in Shijiazhuang, Hebei Province, China, in January 2021. According to the Health Commission of Hebei Province, the first confirmed case in Shijiazhuang was reported on January 2. This local epidemic led to 934 confirmed cases and 387 asymptomatic infections until January 28, when the number of confirmed cases and asymptomatic infections ceased to climb. This short local outbreak provides a window of opportunity for us to observe individual emotions and behaviors in the quickly unfolding crisis. We conducted a daily survey for five consecutive days during the initial phase of this local epidemic in Hebei, that is, January 4–8, 2021.

We invited 88 part-time MBA students from a university in Wuhan to participate in the survey. We informed the participants about the purpose of the research and procedure and gave them an assurance of confidentiality. Two days before conducting the five-day ESM survey, we instructed the participants to complete a general baseline survey, in which they reported their Wuhan epidemic experience in 2020 and provided information on the control variables (age, gender, trait anxiety, and workload). We sent the daily ESM survey to each participant at 3:00 pm, which they were to complete by 5:00 pm, every day for five days, from the third to the seventh day after the outbreak in Hebei (January 4–8, 2021). The participants reported on the same measures of COVID-19 news, COVID-19 anxiety, and protective behaviors daily for five consecutive days.

Of the 88 invited MBA students, 86 completed the general survey, and 82 completed the daily online survey (response rate = 93.2%). The participants received a smartphone prompt via a messenger service each day, and all 82 participants completed the daily survey for five consecutive days, as prompted. The participants gained a thorough understanding of the research objectives and significance in the first author's class, which they were attending at the time of the local epidemic. Thus, they provided full support for the daily surveys, which were incentivized with USD 1 per day. Consequently, we received 392 daily responses (out of a possible 410 responses from 82 participants over five days), with a day-level response rate of 95.6%. In the analysis sample, 52 participants with Wuhan epidemic experience completed 249 daily surveys (4.79 days per person on average), and 30 non-Wuhan participants completed 143 daily surveys (4.77 days per person on average). We conducted the data collection in accordance with the ethical guidelines of the institution where we conducted this research.

Among the participants, 52.4% were male, with an average age of 32.93 years ($SD = 8.32$) and an average work

experience of 9.30 years ($SD = 4.49$). The participants worked for different types of employers, including private firms (41.46%), state-owned enterprises (31.71%), foreign firms (12.19%), government agencies (10.98%), and joint ventures (3.66%). All the participants had a college degree and performed various functions in marketing, finance, engineering technology, and human resource management.

Measures

In this study, we used published scales to assess the current variables. As the original scales were in English, we invited two bilingual researchers to complete the English-to-Mandarin translation-back-translation procedure [30]. We used a Likert-type five-point scale (1 = strongly disagree to 5 = strongly agree) as the response format for all the scale items, except for the demographic and residence variables.

Daily COVID-19 News Daily COVID-19 news refers to the daily frequency, severity, and geographical proximity of news concerning the local epidemic as perceived by the participants. We developed a three-item measure based on Caldas, Ostermeier, and Cooper to assess the level of daily COVID-19 news [31]: “Today, from various media channels (radio, WeChat, Weibo, Shake, and so on), I received news that COVID-19 cases have been detected in the province,” “Today, the news reported that the current COVID-19 epidemic is becoming severe,” and “Today, the news reported COVID-19 cases that are close to my location.” The mean coefficient alpha across the five days was 0.77.

Daily COVID-19 Anxiety Daily COVID-19 anxiety measures the intensity of the anxiety experienced by the individuals each day regarding the COVID-19 epidemic. In this study, we adopted a four-item scale from Trougakos et al. [1]: “Today, I am worried about catching COVID-19,” “Today, I am worried that catching COVID-19 will affect my life and work,” “Today, I am worried that my health will get worse because of COVID-19,” and “Today, I am worried that the COVID-19 epidemic will spread around my city.” The mean coefficient alpha across the five days was 0.92.

Daily Protective Behaviors The daily survey also evaluated how well the participants protected themselves from COVID-19 daily. We adopted the CDC guidelines to measure protective behaviors using seven items [32]: “Today, I maintained a distance of at least 1 m from others in public and at work,” “Today, I stayed home except for essential tasks (e.g., work, medical appointments, and so on),” “Today, I washed my hands or used an antibacterial hand gel frequently and carefully,” “Today, I avoided touching my face,” “Today, when coughing or sneezing, I aimed inside my elbow or into a tissue,” “Today, I wore a mask correctly,”

and “Today, I wore a mask throughout my outings or face-to-face interactions.” The mean coefficient alpha across the five days was 0.87.

Wuhan Epidemic Experience As an individual-level moderator of the day-level relationship, the participants reported the city where they were residing during the initial outbreak and subsequent lockdown of Wuhan. In this study, we measured the moderator with a single item: “In which city did you live during the epidemic outbreak in Wuhan in 2020? (1 = Wuhan, 0 = non-Wuhan areas).” All the participants reported that they have not moved to a new city since 2020; thus, they have been living in the same city since the start of the COVID-19 pandemic.

Control Variables According to prior studies, age, gender, trait anxiety, and workload can affect individual anxiety [33, 34]. We controlled such variables in this study. We measured trait anxiety developed by Carver and White [35], which includes 10 items ($\alpha = 0.88$, e.g., “I’m afraid I will do something wrong”). The workload measure was based on a five-item scale developed by Spector and Jex [36] ($\alpha = 0.87$, e.g., “My workload is greater than I can do”).

Analytic Strategy

First, we calculated the intraclass correlation values to test whether the current variables were suitable for the ESM. Second, we tested the empirical validity of the current day-level variables in the measurement model including daily COVID-19 news, daily COVID-19 anxiety, and daily protective behaviors through multilevel confirmatory factor analysis (MCFA) using Mplus 8.3. Finally, we tested the hypotheses using the multilevel moderated mediation model. The statistical analyses employed group-mean centering for the within-person (day-level) variables and grand-mean centering for the between-person (individual-level) variables [37]. In this study, we examined the hypothesized mediation and moderated mediation effects using a Monte Carlo simulation (20,000 replications) to construct the confidence intervals (CIs) around the estimates [38].

Results

We collected 392 valid day-level observations from 82 participants through repeated measurements for five days. The data included between-person variables (Wuhan epidemic experience, age, gender, trait anxiety, and workload) and within-person variables (daily COVID-19 news, daily COVID-19 anxiety, and daily protective behaviors). Given the nested nature of the data, we first conducted variance component analysis for the within-person variables to test the appropriateness of the

ESM and use of multilevel analytic procedures. The within-person and between-person variances were 60.62% ($p < 0.001$) and 39.38% ($p < 0.001$) for daily COVID-19 news, 27.93% ($p < 0.001$) and 72.07% ($p < 0.001$) for daily COVID-19 anxiety, and 22.35% ($p < 0.001$) and 77.65% ($p < 0.001$) for daily protective behaviors. The results confirmed the significant day-level variation in the current variables, which justified the multilevel analysis.

In this study, we performed MCFA to test the convergent and discriminant validity of the study variables. To maintain a proper ratio between the sample and parameters to be estimated, we created three-item parcels by randomly assigning the seven items of daily protective behaviors [39]. The results showed that the hypothesized three-factor model exhibited a satisfactory fit ($\chi^2 [64] = 104.92$, $p < 0.001$, CFI = 0.96, TLI = 0.95, SRMR [within] = 0.04, SRMR [between] = 0.10, RMSEA = 0.04). The hypothesized measurement model significantly outperformed the two-factor model (combining daily COVID-19 news and anxiety) and one-factor model, thereby verifying the empirical distinctiveness of the variables. Table 1 presents the mean, standard deviation, correlation, and reliability of the variables included in the current analysis.

Main and Mediation Effect Hypothesis Testing

Hypotheses 1 and 2 proposed that daily COVID-19 news is positively related to daily COVID-19 anxiety, which will mediate the relationship between daily COVID-19 news and daily protective behaviors. We tested the hypotheses using multilevel path analysis, with the controls (age, gender, trait anxiety, and workload) modeled at the between-person level. As reported in Model 1a in Table 2, daily COVID-19 news had a significant positive effect on

daily COVID-19 anxiety ($\gamma = 0.29$, $SE = 0.04$, $p < 0.001$), thereby supporting Hypothesis 1.

As shown in Table 2, the direct effect of daily COVID-19 news on daily protective behaviors was significant and positive ($\gamma = 0.08$, $SE = 0.04$, $p = 0.030$). Furthermore, daily COVID-19 anxiety was a significant predictor of daily protective behaviors ($\gamma = 0.12$, $SE = 0.05$, $p = 0.012$). Moreover, the indirect effect of daily COVID-19 news on daily protective behaviors through daily COVID-19 anxiety was significant and positive ($b = 0.03$, $SE = 0.01$, $p = 0.018$), with the 95% CI [0.01, 0.07] based on 20,000 bootstrapped samples, which excluded zero. The patterns provided empirical support to Hypothesis 2.

Moderation and Moderated Mediation Hypothesis Testing

Hypothesis 3 identified Wuhan epidemic experience as a positive moderator in the relationship between daily COVID-19 news and daily COVID-19 anxiety. To test this moderating effect, we included the interaction term between Wuhan epidemic experience and daily COVID-19 news in the multilevel path analysis after controlling for age, gender, trait anxiety, and workload and the corresponding main effects. As reported in Model 2a in Table 2, the interaction term had a significant effect on daily COVID-19 anxiety ($\gamma = 0.25$, $SE = 0.13$, $p = 0.045$). We further probed this significant interaction through simple slope analysis. As depicted in Fig. 2, the positive effect of daily COVID-19 news on daily COVID-19 anxiety was significant for the individuals who lived in Wuhan during the epidemic in 2020 ($\gamma = 0.39$, $SE = 0.09$, $p < 0.001$), but not significant for those who lived elsewhere ($\gamma = 0.15$, $SE = 0.09$, $p = 0.084$). The difference between the effects was significant (difference = 0.24, 95% CI [0.01, 0.48]). Therefore, the positive relationship between

Table 1 Means, Standard deviations, and correlations for all variables

Variables	<i>M</i>	<i>SD</i>	1	2	3	4	5	6	7	8
Between-Person Level										
1. Gender	0.52	0.50		0.22**	-0.07	-0.02	0.04	-0.10	-0.12	-0.16
2. Age	32.93	8.37			-0.17	0.11	0.16	-0.08	-0.05	0.11
3. Trait anxiety	2.70	0.78			(0.88)	0.01	0.11	0.26*	0.18	0.10
4. Workload	2.70	0.92				(0.87)	-0.06	0.16	-0.10	-0.02
5. Wuhan epidemic experience	0.63	0.49						-0.22*	0.04	0.15
Within-Person Level										
6. Daily COVID-19 news	3.07	0.99						(0.77, 0.64)	0.52**	0.11
7. Daily COVID-19 anxiety	2.46	1.16						0.46**	(0.92, 0.81)	0.43**
8. Daily protective behavior	3.42	1.03						0.13*	0.39**	(0.87, 0.84)

Within-person level, $N = 392$; Between-person level, $N = 82$. Alpha coefficients are in parentheses on the diagonal. Within-person correlations are shown below the diagonal and between-person correlations are shown above the diagonal. Gender: Male = 1, female = 0. Wuhan residence: Wuhan = 1, non-Wuhan = 0

* $p < 0.05$; ** $p < 0.001$

Table 2 Multilevel path model results

Predictors	Mediation		Moderated Mediation	
	Model 1a	Model 1b	Model 2a	Model 2b
Between-Person Level Variables	Person-level COVID-19 Anxiety	Person-level Protective Behavior	Person-level COVID-19 Anxiety	Person-level Protective Behavior
Gender ^a	-0.17 [-0.55, 0.21]	-0.26 [-0.62, 0.11]	-0.23 [-0.69, 0.23]	-0.36 [-0.78, 0.06]
Age ^a	0.01 [-0.02, 0.03]	0.02 [-0.01, 0.04]	0.001 [-0.03, 0.03]	0.02 [-0.01, 0.04]
Trait anxiety ^a	-0.01 [-0.27, 0.25]	0.11 [-0.14, 0.36]	0.22 [-0.06, 0.51]	0.12 [-0.14, 0.38]
Workload ^a	-0.24* [-0.45, -0.03]	0.07 [-0.14, 0.28]	-0.12 [-0.36, 0.12]	-0.04 [-0.25, 0.18]
Person-level COVID-19 news ^a	0.98** [0.60, 1.37]	-0.40 [-0.87, 0.08]		
Person-level COVID-19 anxiety ^a		0.54** [0.29, 0.80]		
Wuhan epidemic experience ^a			0.04 [-0.42, 0.49]	0.23 [-0.18, 0.64]
Within-Person Level Variables	Daily COVID-19 Anxiety	Daily Protective Behavior	Daily COVID-19 Anxiety	Daily Protective Behavior
Daily COVID-19 news ^b	0.29** [0.21, 0.37]	0.08* [0.01, 0.15]	0.27** [0.15, 0.39]	0.08* [0.01, 0.15]
Daily COVID-19 anxiety ^b		0.12* [0.03, 0.21]		0.12* [0.03, 0.21]
Daily COVID-19 news × Wuhan epidemic experience			.25* [0.01, 0.50]	0.08 [-0.09, 0.24]

* $p < 0.05$; ** $p < 0.001$

^aBetween-person variables ($N = 82$)

^bWithin-persons variables ($N = 392$)

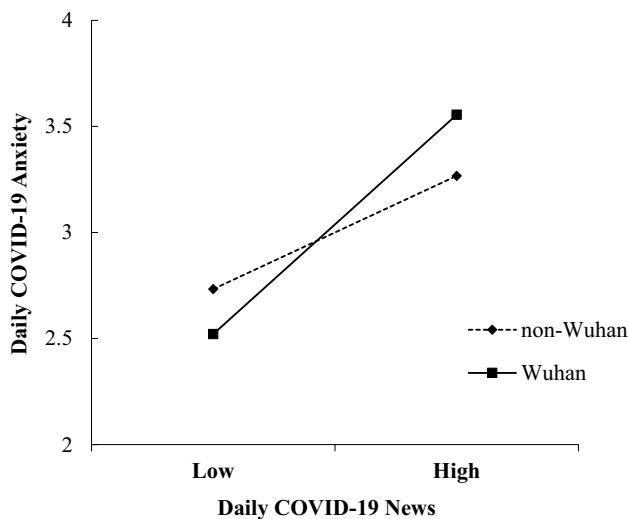


Fig. 2 Moderating effect of Wuhan epidemic experience on within-person relationship between daily COVID-19 news and daily COVID-19 anxiety

COVID-19 news and COVID-19 anxiety was strong and statistically significant for the Wuhan residents but not for the other participants, thereby supporting Hypothesis 3.

Hypothesis 4 posited that Wuhan epidemic experience will moderate the indirect relationship between daily COVID-19 news and daily protective behaviors via daily COVID-19 anxiety. To check the significance of the hypothesized moderated mediation, we tested the conditional indirect effects using the bootstrapping procedure [40]. Specifically, we conducted multilevel modeling to examine whether the estimated indirect effects of daily COVID-19 news on daily protective behaviors via daily COVID-19 anxiety differed for the Wuhan versus non-Wuhan residents. The day-level indirect effects were significant for the Wuhan residents ($b = 0.06$, $SE = 0.03$, 95% CI [0.01, 0.13]) and non-Wuhan residents ($b = 0.03$, $SE = 0.02$, 95% CI [0.01, 0.06]), but the effect size was much larger for the Wuhan residents than for the non-Wuhan residents. The two indirect effects significantly differed from each other at the 90% level ($b = 0.03$, $SE = 0.02$, 90% CI [0.001, 0.061]), which provided preliminary support to Hypothesis 4.

To further explore the effect of Wuhan epidemic experience, we divided the analysis sample into two groups according to residence: the Wuhan group (between-person level $n = 52$, within-person level $n = 249$) and non-Wuhan group (between-person level $n = 30$, within-person level $n = 143$). Then, we tested the direct-, indirect-, and moderated-effect hypotheses separately using the two groups. As shown in Table 3, for the Wuhan group, daily COVID-19 news was a significant predictor of daily COVID-19 anxiety ($\gamma = 0.41$, $SE = 0.05$, $p < 0.001$), which in turn had a significant positive effect on daily protective behaviors ($\gamma = 0.13$, $SE = 0.06$, $p = 0.034$). The relationship between daily COVID-19 news and daily protective behaviors was also significant and positive, regardless of whether it was a direct effect ($\gamma = 0.11$, $SE = 0.05$, $p = 0.028$) or an indirect effect, through daily COVID-19 anxiety ($b = 0.05$, $SE = 0.03$, $p = 0.041$, 95% CI [0.01, 0.11]). By contrast, for the non-Wuhan group, daily COVID-19 news was not significantly related to daily COVID-19 anxiety, and its direct and indirect effects on daily protective behaviors were not significant (direct: $\gamma = 0.04$, $SE = 0.06$, $p = 0.510$; indirect: $b = 0.01$, $SE = 0.01$, $p = 0.461$). The contrasting patterns of results from the subgroup analysis indicated that the participants' emotional and behavioral reactions to daily COVID-19 news were quite different for the individuals from Wuhan versus those from other areas, which is consistent with Hypothesis 4.

Discussion

As COVID-19 spread globally for an extended period of time on a large scale, people have been pushed to the post-pandemic era, characterized by intermittent outbreaks of local epidemics that exert a continuous and dynamic impact. At this juncture, exploring how and when individuals respond to local epidemics and voluntarily perform personal protective behaviors, as recommended by the WHO, is of considerable significance to public health. Grounded in cognitive appraisal theory [8, 9], this study theorized and validated the psychological mechanism accounting for the effect of local epidemics based on COVID-19 news on desirable self-protective behaviors. This study also revealed that the individuals with distinct personal experiences and living in close proximity to the epicenter (Wuhan) in 2020 responded more strongly than those from non-Wuhan areas.

The current analysis of 392 day-level observations collected from 82 working adults for five consecutive days during a local outbreak supported most of the hypotheses. Daily COVID-19 news was indirectly and positively related to daily protective behaviors by raising daily COVID-19 anxiety. Furthermore, compared with the non-Wuhan residents, the Wuhan residents were more sensitive to COVID-19 news of the local epidemic, resulting in higher daily COVID-19 anxiety and more protective behaviors. The

Table 3 Results of multilevel path analysis between wuhan and non-wuhan residents

Predictors	Wuhan Residents		Non-Wuhan Residents	
	Person-level COVID-19 Anxiety	Person-level Protective Behavior	Person-level COVID-19 Anxiety	Person-level Protective Behavior
Gender ^a	-0.23 [-0.69, 0.23]	-0.10 [-0.52, 0.32]	-0.32 [-0.92, 0.28]	-0.24 [-0.97, 0.50]
Age ^a	-0.01 [-0.04, 0.01]	0.02 [-0.01, 0.04]	0.15*** [0.08, 0.22]	0.01 [-0.16, 0.18]
Trait anxiety ^a	-0.01 [-0.33, 0.30]	0.16 [-0.12, 0.44]	0.13 [-0.31, 0.57]	-0.16 [-0.67, 0.36]
Workload ^a	-0.18 [-0.41, 0.06]	-0.10 [-0.32, 0.12]	-0.17 [-0.57, 0.25]	0.53* [0.04, 1.02]
Person-level COVID-19 news ^a	1.10*** [0.60, 1.60]	-0.08 [-0.68, 0.52]	1.28*** [0.66, 1.90]	-0.75 [-2.37, 0.87]
Person-level COVID-19 anxiety ^a		0.49** [0.18, 0.80]		0.61 [-0.34, 1.55]
Within-Person Level Variables	Daily COVID-19 Anxiety	Daily Protective Behavior	Daily COVID-19 Anxiety	Daily Protective Behavior
Daily COVID-19 news ^b	0.41** [0.31, 0.52]	0.11* [0.01, 0.21]	0.10 [-0.02, 0.22]	0.04 [-0.07, 0.14]
Daily COVID-19 anxiety ^b		0.13* [0.01, 0.24]		0.07 [-0.09, 0.23]

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

^aBetween-person variables ($N = 82$, $N_{\text{wuhan}} = 52$, $N_{\text{non-wuhan}} = 30$)

^bWithin-persons variables ($N = 392$, $N_{\text{wuhan}} = 249$, $N_{\text{non-wuhan}} = 143$)

implications for theory and practice are discussed below, along with this study's limitations, indicating the need for further investigation.

Theoretical Implications

The current findings make several important contributions to the literature on human behaviors concerning public health in the face of increasing threats of pandemics. First, this study revealed the positive function of COVID-19 information in prompting personal protective behaviors, thereby identifying ways to improve public health against infectious diseases. Researchers highlighted the detrimental impact of media coverage on crisis events, which disseminates disaster-related information that may induce anxiety and trauma among the recipients [40]. Likewise, the consumption of COVID-19 news may increase anxiety and risk perception significantly, thereby decreasing individuals' psychological wellbeing [21]. This study extends the scope of this line of research by considering the potential benefits of COVID-19 news in shaping desirable behaviors by linking individuals' anxiety with their protective behaviors.

With awareness of life-threatening uncertainty gained from COVID-19 information, individuals may experience anxiety as a natural emotional reaction [9]. Although feeling anxious about the situation can impair mental health, it can also promote the coping behaviors necessary for self-conservation. Based on cognitive appraisal theory [8, 9], this study proposed that COVID-19 anxiety triggered by COVID-19 news may be a psychological mechanism motivating individuals' self-protection against the disease. In this respect, the epidemic information offered by the media can be effectively leveraged to facilitate voluntary self-protective behaviors to enhance public prevention, besides specific government policies and regulations.

Second, the analysis demonstrated that Wuhan epidemic experience functioned as a moderating contingency for the effects of daily COVID-19 news on daily anxiety and subsequent protective behaviors against the disease. This study underscored that Wuhan epidemic experience made the Wuhan residents highly susceptible to news information about subsequent local epidemics and urged them to respond effectively. Thus, this study answers the recent call for additional epidemic research on the role of temporal dimensions that may affect individual psychological reactions and behaviors in subsequent epidemic situations [1, 31].

The COVID-19-related experiences of Wuhan residents with a first-hand account of the outbreak and lockdown in 2020 are profound, which enable them to automatically recall memories of the outbreak easily and enhanced their sensitivity to information about COVID-19 and subsequent epidemics in 2021 [26]. Studies showed that people's experiences contribute to their beliefs about whether and how they should prepare

for natural disasters [12]. People may attempt to alleviate their heightened anxiety and uncertainty by further strengthening their self-protection and adopting the recommended behaviors for their health and safety. By contrast, the subgroup analysis indicated that the non-Wuhan residents did not respond emotionally to daily COVID-19 news, and their daily protective coping behaviors were not significantly affected by COVID-19 information and related anxiety (Table 3). Such contrasting patterns confirmed the mechanism of profound disaster experiences such that only those with direct COVID-19 experience in a city once hit hard by the pandemic became vigilant and sensitive to subsequent local epidemics [41]. To a certain extent, this study further determined that the disaster's "ripple effect" is applicable to the prediction of consequences and responsiveness involving COVID-19 over temporal dimensions of distance [10].

Practical Implications

The results indicated that COVID-19 information, warnings, and expert recommendations conveyed through public media or news may not be effective for individuals without direct COVID-19 experience. The effects of COVID-19 news were significant only for the Wuhan residents with first-hand experience. Research showed that disaster experiences elicit limited positive emotions, while significantly amplifying stress reactions, thereby negatively affecting mental health and wellbeing [16, 17]. However, as shown in this study, Wuhan epidemic experience can be beneficial in that it may make people highly sensitive to the negative stimuli of the local epidemic and thus steadfast in their adherence to protective guidelines.

Accordingly, improving the sensitivity to COVID-19 information of individuals with no previous direct epidemic experience is crucial to promote the adoption of personal protective behaviors, as recommended by the WHO. For instance, with direct experience of the initial outbreak, the Wuhan residents reported intense emotional responses to COVID-19 news that were related to the increase in their protective behaviors. In this sense, public health management and disease prevention for people with little epidemic experience can be quite challenging, because such individuals may not be responsive to public messages and information about COVID-19.

To address such challenges, media coverage content on infectious diseases can be designed to offer personalized, customized, and detailed messages to appeal emotionally to and assist people. Such media content with specific and personal details can help enhance immersive feelings in individuals with no prior first-hand experience to develop emotional reactions and behavioral changes targeted at COVID-19 and other infectious diseases. The effect of such

media strategy can be maximized when combined with appealing and charismatic communicators, compelling scientific evidence on the mechanisms and importance of protective behaviors, and incentives [42]. Past studies on fear-based messaging have demonstrated that intense anxiety can obstruct adequate information processing, consequently reducing the impact of such messages on protective behaviors [43]. As a result, to enhance information processing, it is essential for the media to precisely portray the protective behaviors in fear-evoking news that can assist in averting damage. Overall, public health management may disseminate a wealth of appealing information designed to persuade people of the importance and benefits of personal protection for epidemic prevention and control.

Limitations and Future Prospects

The current findings should be interpreted considering several limitations that can provide directions for further research. First, the current data were collected from 82 working adults over five consecutive workdays, resulting in 392 day-level observations that revealed the daily fluctuations and relationships between the study variables. Although the current sample size is comparable to that of extant studies based on the ESM and meet the guide for required statistical power [44], the present study encourages future studies to collect data from a larger sample representing different cultural and national contexts.

Second, despite the collection of information for the focal variables for five consecutive days using the ESM, the current data represented self-reported repeated measurements. Self-reported measures are limited by individual differences in self-awareness and susceptibility to response biases, which potentially influence the precision of reported thoughts, emotions, and behaviors [45]. Consequently, the self-report data used in this study may raise issues related to potential common method bias and the difficulty in establishing causal relationships. This limitation could lead to another possible explanation for our results, that is, the Wuhan residents may be highly susceptible to COVID-19 anxiety and thus pay considerable attention to news about the pandemic. Future research should conduct a longitudinal study and assess the study variables using multiple sources, such as coworkers' or spouses' reports on the protective behaviors of the focal individuals.

Third, this study evaluated Wuhan epidemic experience using place of residence. Although the Wuhan outbreak was the most far-reaching COVID-19 epidemic, other COVID-19 outbreaks that occurred at different times may have shaped individual thoughts and behaviors. Future research may extend the current findings by considering various COVID-19 epidemics to further explore the role of prior experience in COVID-19 responses.

Despite the above limitations, the current analysis revealed the significance of COVID-19 information conveyed through the media in promoting the recommended self-protective behaviors, particularly among individuals with first-hand experience. Hence, this study provides recommendations on efficacious strategies to control and prevent infectious diseases such as COVID-19 through the voluntary behaviors of the general public. In this respect, a critical research agenda should be to explore other psychological mechanisms beyond COVID-19 anxiety that can drive the recommended self-protection measures necessary to control the spread of COVID-19. For example, people respond to COVID-19 media coverage and anti-pandemic policies with diverse cognitive and emotional reactions, such as developing a sense of responsibility, feelings of honor or guilt, or fear of missing out or gratitude for receiving free vaccines. With the extended pandemic owing to the unexpected emergence of new virus variants, people may demonstrate complacency or fatigue toward COVID-19, as suggested by recent studies [11]. Thus, exploring such natural but detrimental psychological developments will contribute to improving public health during the period characterized by the pandemic.

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Data Availability The data that support the findings of this study are available from the corresponding author upon reasonable request.

Declarations

Ethical Approval This research was supported by the Institute of Management Research, Seoul National University. All procedures performed in the study were in accordance with the ethical standards of the Institute of Management Research and with the 1964 Helsinki Declaration and its subsequent amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all the individual participants included in the study.

Conflict of Interest The authors declare that they have no conflict of interest.

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