Themes and Evolution of Misinformation During the Early Phases of the COVID-19 Outbreak in China—An Application of the Crisis and Emergency Risk Communication Model

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Social media has enabled misinformation to circulate with ease around the world during the novel coronavirus disease 2019 (COVID-19) pandemic. This study applies the Crisis and Emergency Risk and Communication model (CERC) to understand the themes and evolution of misinformation on the Internet during the early phases of the COVID-19 outbreak in China, when the epidemic developed rapidly with mysteries. Drawing on 470 misinformation rated as false by three leading Chinese fact-checking platforms between 1 January and 3 February 2020, the analysis demonstrated five major misinformation themes surrounding COVID-19: prevention and treatment, crisis situation updates, authority action and policy, disease information, and conspiracy. Further trend analyses found that misinformation emerged only after the nationwide recognition of the crisis, and appeared to evolve relating to crisis stages, government policies, and media reports. This study is the first to apply the CERC model to investigate the primary themes of misinformation and their evolution. It provides a standard typology for crisis-related misinformation and illuminates how misinformation of a particular topic emerges. This study has significant theoretical and practical implications for strategic misinformation management.

Keywords: COVID-19, misinformation, internet, surveillance, crisis communication, fact-checking

INTRODUCTION

The Internet, especially social media, has caused considerable concerns on their roles in promoting misinformation during health crises like disease outbreaks (Tandoc et al., 2018; Waszak et al., 2018). Misinformation can be broadly defined as "information presented as truthful initially but that turns out to be false later on" (Lewandowsky et al., 2013). It may inhibit effective outbreak communication by amplifying public fear and misleading the public to develop practices that might harm their health (Poland and Spier, 2010; Swire and Ecker, 2018). Particularly, in the current coronavirus disease 2019 (COVID-19) pandemic, the United Nations has warned a

"misinfo-demic" that is spreading harmful health advice on the Internet[1].

A rapidly growing body of literature has investigated the misinformation surrounding disease outbreaks, such as the current COVID-19 pandemic. Research has found that a quarter of social media information (e.g., Twitter, YouTube) contained medical misinformation and unverified content pertaining to the COVID-19 pandemic (Kouzy et al., 2020; Li et al., 2020). Over two-thirds of the top 110 popular websites from the Google Search engine were found to have a low quality of COVID-19 information (Cuan-Baltazar et al., 2020).

Different typologies of misinformation were also identified in previous studies (Bastani and Bahrami, 2020; Brennen et al., 2020). Brennen et al. (2020) found 9 topics of COVID-19 misinformation, with falsehoods about "public authority action," "community spread," "general medical advice," and "prominent actors" as the most prevalent topics. Bastani and Bahrami (2020) identified 5 main categories of misinformation, including "disease statistics," "treatments, vaccines and medicines," "prevention and protection methods," "dietary recommendations," and "disease transmission ways." Similarly, studies surrounding the Ebola and Zika outbreak found misinformation about disease health impacts, vaccinations, and disease transmission mechanisms (Oyeyemi et al., 2014; Sommariva et al., 2018; Vijaykumar et al., 2018).

However, two essential research gaps can be identified. First, none of the studies utilized a theoretical model to guide the development of their misinformation typologies. Particularly, it is essential to develop a topology of crisis-related misinformation based on a crisis communication model. A theoretical typology of crisis-related misinformation can facilitate comparisons and integration of previous findings by providing a standard framework. This can also inform better health communication and in turn improve crisis management.

Second, how misinformation emerges and evolves during disease outbreaks remain unclear, preventing strategic crisis management on combating misinformation. Theories indicate that misinformation like rumors is induced during health crises because of the public's unsatisfied information needs (Rosnow, 1991; DiFonzo and Bordia, 2007). Rumors can often play crucial roles in reducing public feelings of anxiety and uncertainty that are triggered by the unknown and threatening circumstances (Rosnow, 1991; DiFonzo and Bordia, 2007). Hence, as the situations develop swiftly during disease outbreaks like COVID-19, it is likely that different types of misinformation emerge and evolve in different time frames corresponding to the information needs of the public. Nevertheless, none of the existing research has explored the temporal patterns of misinformation.

An Application of the Crisis and Emergency Risk Communication Model

This research aims to address the above research gaps by adopting the Crisis and Emergency Risk Communication Model (CERC)

to examine the typology and evolution of misinformation during the early phases of a disease outbreak. The CERC is a communication model that guides authorities' communication strategies at different stages of the risk and crisis lifecycle, "from risk, to eruption, to clean-up and recovery, and on into evaluation (p. 51)" (Reynolds and Seeger, 2005). The latter three stages mark the containment and the end of the crisis, when misinformation may not be prevalent. Therefore, this study focuses only on the first two stages of a health crisis. As the model is developed based on the audiences' information needs (Reynolds and Seeger, 2005), it provides the temporal patterns of those needs that can be used to theorize the typology and evolution of crisis-related misinformation.

The pre-crisis stage is the first stage of the CERC model when the crisis is yet to occur. The authorities will need to heighten the public awareness of the potential crisis by warning the public, providing risk information, and educating self-preventions. However, in the context of crisis-related misinformation, as the CERC model suggests that the public is generally not aware of the crisis at this stage (Reynolds and Seeger, 2005), it can be expected that there will be no misinformation during the pre-crisis stage.

The second stage of CERC is the initial stage when the crisis occurs and when the public is first aware of the crisis. The model demonstrates uncertainty reduction, self-efficacy, and reassurance as the three main communication strategies at this stage (Reynolds and Seeger, 2005). In the context of an infectious disease outbreak (Lazard et al., 2015; Lwin et al., 2018), reducing uncertainty is to provide information on case reports and crisis-related events. Messages on self-efficacy are to communicate personal preventions and treatments. Reassurance is information about government interventions. That is, the initial stage is characterized by three urgent information needs: crisis situation updates, self-preventions, and reassurance from authority-initiated actions. Accordingly, misinformation about crisis situations, self-preventions, and authority actions will be prominent at this stage. Specifically, the public requires more accurate understandings of the disease as the crisis continues to develop (Centers for Disease Control and Prevention, 2018; Lwin et al., 2018). Hence, misinformation about disease natures is expected to surge at the later period of the initial stage.

Though the CERC model suggests that misinformation will develop surrounding the four themes during the initial stage of an outbreak, it does not provide detailed predictions on how these four themes of misinformation emerge and evolve within the stage. It is important to understand the rapid evolution of misinformation because disease outbreaks often develop swiftly with many mysteries within the initial stage. Also, breaking news and government responses will be put forth rapidly within this period. It is crucial to explore if government actions and media reports will affect the emergence of misinformation.

This study takes the COVID-19 outbreak in China as a valuable opportunity for applying the CERC to understand the typology and evolution of crisis-related misinformation. Particularly, this research aims to analyse the themes and temporal patterns of COVID-19 misinformation by utilizing data from fact-checking platforms.

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[1]United Nations. Hatred going viral in 'dangerous epidemic of misinformation' during COVID-19 pandemic. Available online at: https://news.un.org/en/story/2020/04/1061682 (accessed June 26, 2020).

The COVID-19 and Fact-Checking Platforms in China

On 31 December 2019, the first cases of COVID-19 were reported in Wuhan, China (Zhu et al., 2020). The disease has been put under national surveillance since 11 January (Tu et al., 2020). A week later, Guangdong, Shanghai, and Beijing reported their first imported cases from Wuhan. As of 23 January, all but two provinces of China reported confirmed cases[2]. The following days witnessed the quarantine of Wuhan and other cities in the Hubei province[3]. The disease continued to spread and has seen a broader outreach in China since 27 January, but the number of daily new cases began to drop after 3 February[4].

The COVID-19 outbreak has triggered massive amounts of misinformation on social media within China. Fake reports on new cases and unverified information about prevention from the disease (e.g., Taking vitamin C can prevent the disease) have been circulated with ease. Fact-checking platforms, which aim to debunk fake news and online falsehoods, provide novel data sources for misinformation surveillance during the outbreak. This study analyses data from three such platforms, including Jiaozhen, Ding Xiang Yuan, and Toutiao.

Jiaozhen is the leading Chinese fact-checking platform that aims to fight against health-related falsehoods[5]. It is jointly run by the Health Communication Working Committee of China Medical Doctor Association and Tencent, the company that hosts the most active social media application, WeChat. This platform is providing real-time information services during the COVID-19 outbreak in China, by curating and reviewing hot topics in public health from news and social media with the help of artificial algorithms. Ding Xiang Yuan[6], which is the leading social networking site for health professionals in China, has developed a fact-checking platform specifically for the COVID-19 outbreak. The platform is specializing in debunking medical-related misinformation surrounding the disease. Finally, Toutiao is the Chinese leading online news media. It provides services to counter fake news during the crisis by gathering falsehoods from news media[7].

Hypotheses and Research Questions

H1: Misinformation will emerge surrounding crisis situation updates, prevention and treatment, authority action and polity,

and disease information during the initial stage of the COVID-19 outbreak in China.

RQ1: How did different themes of misinformation emerge during the first two stages of the COVID-19 outbreak suggested by the CERC model?

METHODS

Data Extraction

All fact-checking articles published between 1 January and 3 February 2020 were extracted from the three platforms, namely Jiaozhen, Ding Xiang Yuan, and Toutiao. The investigation period marked the first two stages of the outbreak. The pre-outbreak stage was from 1 January to 20 January; the initial stage was from 21 January till the end of the investigation. The two stages were categorized as above because the China government recognized the COVID-19 crisis by confirming human-to-human transmission of COVID-19 and starting daily national reports on the outbreak on 20 January, and the disease began to be contained after 3 February[4]. The extraction yielded 524 articles, of which 225 on Jiaozhen, 69 on Ding Xiang Yuan, and 230 on Toutiao.

Data Coding Procedures

Data coding of the articles involved several procedures. First, the author and a student assistant independently scanned all articles with their titles and full texts and identified 470 articles that are related to the COVID-19 outbreak. The interrater agreement of the scanning was 100%. Of those relevant articles, 434 rated their fact-checked stories as false. These include 155 articles on Jiaozhen, 64 on Ding Xiang Yuan, and 215 on Toutiao.

Second, the 434 articles were then thematically analyzed with two steps. In step 1, a codebook was developed by the author. The CERC was applied to develop the typology of COVID-19 related misinformation. As discussed, four major themes were derived from the CERC (Reynolds and Seeger, 2005; Lwin et al., 2018): (1) prevention and treatment: misinformation on measures or medication for disease prevention or treatment; (2) crisis situation updates: misinformation on updates or events related to new or existing cases, or other crisis-related situations; (3) authority action and policy: misinformation on government policies taken against the disease or other public policies; and (4) disease information: misinformation pertaining to disease spreading mechanisms, diagnosis, and other disease-related information.

To ensure all themes of misinformation would be captured, an open coding procedure was also employed (Bernard et al., 2016). The fifth theme was derived from the open coding procedure: (5) conspiracy: false statements or accusations that the virus is human-made or that some countries utilized the virus as a bioengineered weapon. The author and the student assistant then read the posts independently and identified finer topics under each of the five themes. The team met to discuss disagreements and agreed on the final codebook.

In step 2, the author and another student assistant independently went through the title and full text of each article and categorized them into themes and topics guided by the

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TABLE 1 | Themes and examples of misinformation.

Themes	Example	Jiaozhen	Ding Xiang Yuan	Toutiao	Sum	%
Prevention and treatment		**66**	**38**	**33**	**137**	**31.6%**
Folk medicine	Taking Vitamin C can prevent the novel coronavirus disease.	30	14	13	57	13.1%
Folk measures	Taking a hot bath can prevent the novel coronavirus disease.	13	11	7	31	7.1%
Clinical treatment	Good news! The vaccine for the novel coronavirus disease is now ready.	13	5	9	27	6.2%
Mask	People should wear a surgical mask with the colored surface facing out when they show respiratory symptoms and with that surface facing internally when they are well.	10	8	4	22	5.1%
Crisis situation updates		**30**	**2**	**89**	**121**	**27.9%**
Case updates	Dr. Zhong Nanshan confirmed with the coronavirus disease.	11	1	43	55	12.7%
Local events	A Hubei news anchor put on a surgical mask when she was broadcasting the news on-screen.	12	1	31	44	10.1%
Local corruption	The Wuhan Red Cross was found to sell vegetables that were donated by the general public.	3	0	7	10	2.3%
Foreign events	116 visitors from Wuhan were refused entry into Singapore.	4	0	8	12	2.8%
Authority action and policy		**33**	**2**	**67**	**102**	**23.5%**
Isolation controls	The Guangzhou government plans to put the city under quarantine.	17	1	50	68	15.7%
Medical measures	The Wuhan government plans to disinfect the city with a large-scale spray.	5	1	6	12	2.8%
Medical supplies management	The state council bans sale of face masks on all eCommerce platforms.	4	0	4	8	1.8%
Contact tracing	From 3 February, all visitors should make registrations with their real name before entering into hospitals in Shanghai.	3	0	3	6	1.4%
Media management	Wuhan plans to block the Internet connection to stop medical staff from sharing disease-related information to the public.	2	0	3	5	1.2%
Reassurance	National public health emergency response: House rental will be fully free for February and halved for March and April.	2	0	0	2	0.5%
General	The city of Hezhou announces the highest level of the public health emergency for the coronavirus.	0	0	1	1	0.2%
Disease information		**23**	**20**	**21**	**64**	**14.7%**
Spreading dynamics	The coronavirus can be transmitted through eye contact.	11	13	6	30	6.9%
Natural history	The coronavirus has been discovered since 2018.	6	3	8	17	3.9%
Risk factor	Asians are easier to get the coronavirus infection.	4	4	5	13	3.0%
Epidemiology	The biggest outbreak is coming in 2 days. Stay home.	1	0	2	3	0.7%
Diagnosis	If one sees symptoms of runny nose and expectoration, he or she is not infected by the coronavirus.	1	0	0	1	0.2%
Conspiracy	The coronavirus is a human-made, bioengineered disease.	**3**	**2**	**5**	**10**	**2.3%**
N		**155**	**64**	**215**	**434**	

The bold values indicates the major themes of misinformation, whose counts and percentages should be the sum of values of its subtopics.

codebook. The interrater agreement between the two coders was 87.1%. The coding disagreement was solved by discussions.

RESULTS

Themes of Misinformation (H1)

Table 1 demonstrates the five themes and examples of misinformation. Several topics were identified under the major themes. First, the theme of "prevention and treatment" was predominant, accounting for 31.6% of all misinformation. "Folk medicine" surfaced as one of the most prevalent topics, presenting folk beliefs of alternative medicines such that taking vitamin C can prevent people from the disease. The second common theme was misinformation pertaining to "crisis situation updates," representing a share of 27.9%. Examples in this theme included fake reports that claimed someone had confirmed with the infection or died of the virus.

"Authority action and policy" emerged as another type of misinformation that was widely spreading (23.5%). Particularly, fake news of isolation controls claiming city quarantine plans was the most frequent topic, making up 15.7% of all misinformation. The fourth common theme was "disease information" (14.7%). An example of this theme is the rumor that the COVID-19 could be transmitted through eye contact between people. Conspiracy (2.3%), such that the coronavirus was bioengineered in the lab, was also circulated extensively within China (Cohen, 2020).
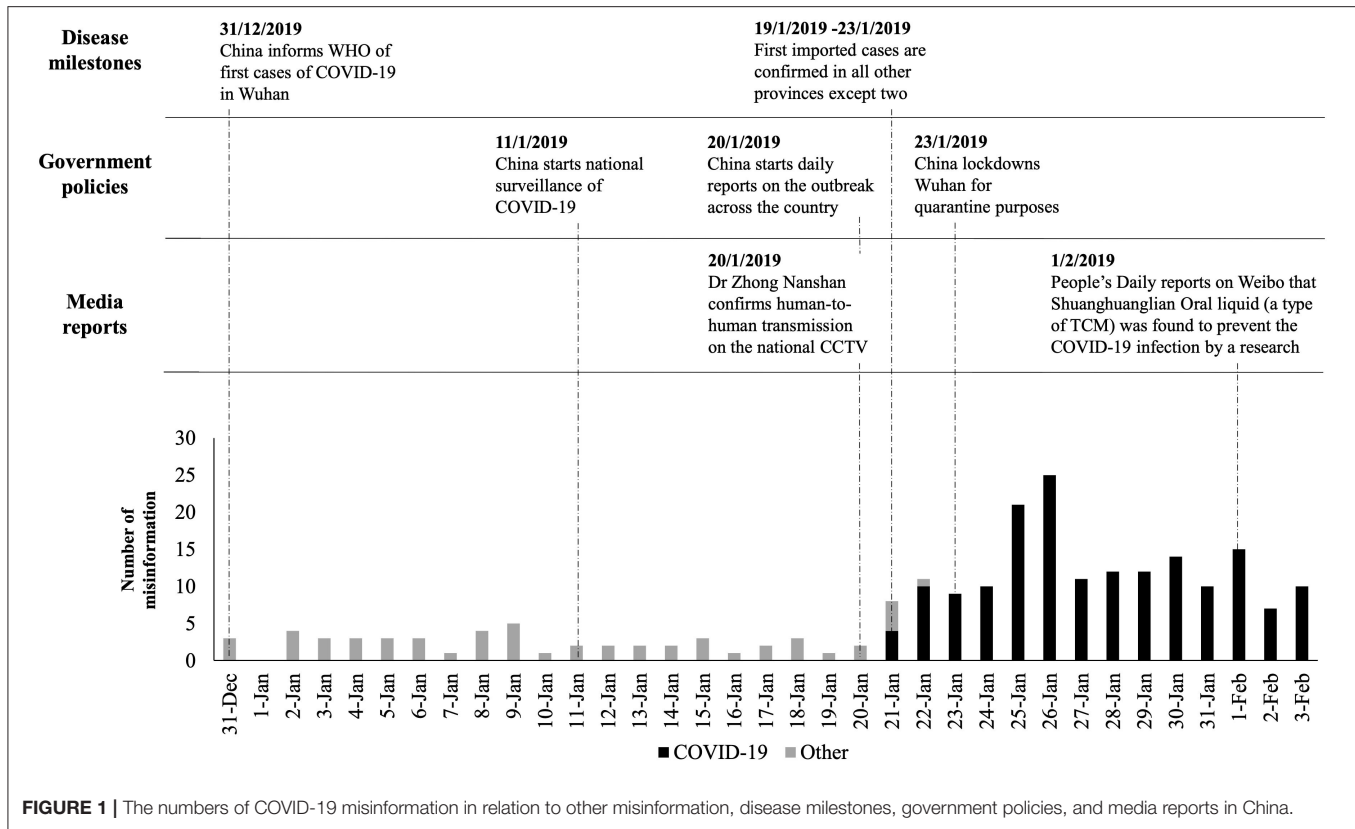
FIGURE 1 | The numbers of COVID-19 misinformation in relation to other misinformation, disease milestones, government policies, and media reports in China.

Evolution of Misinformation (RQ1)

A trend analysis was conducted utilizing Jiaozhen as the only data source. The platform aims to provide timely facts within 24 h after a piece of impactful misinformation emerges online. As such, its data allows investigations of the evolution of misinformation. However, data from the other two platforms are not optimal for trend analysis. Ding Xiang Yuan did not provide a timestamp for its articles, and Toutiao revealed a significant time lag of fact-checking during the investigation period.

Figure 1 shows the numbers of COVID-19 misinformation checked by Jiaozhen between 1 January and 3 February 2020. Fact-checking articles that are not related to the disease were also examined for comparison purposes, presenting the baseline fact-check frequency of the platform. Though the virus infections have been put under national surveillance as early as 11 January, misinformation pertaining to the disease emerged only on 21 January, the day when the crisis was nationally recognized. The number of misinformation peaked at the first 2 days of Chinese New Year (i.e., 25 and 26 January).

Figure 2 demonstrates how different themes of misinformation developed during the initial stage of the outbreak. Particularly, three short meaningful phases were identified within this stage based on disease developments and government actions. The preparation phase (Phase 1; 21–23 January) witnessed the period when the disease was first recognized as a national crisis by the public. Misinformation of prevention and treatment (e.g., folk

medicine) and crisis situation updates (e.g., case reports) was predominant at this phase.

The developing phase (Phase 2; 24–27 January) started from the day when the Wuhan city was quarantined. The number of misinformation surrounding authority actions and policies surged at this phase, becoming the most frequent theme. Rumors of isolation measures accounted mostly for the increase.

The escalating phase (Phase 3) has seen an upsurge of confirmed cases across the country from 27 January to 3 February. Mysteries surrounding the disease, especially its spreading dynamics, become salient. Interestingly, on 1 February, People's Daily, the official newspaper of the Central Committee of the Communist Party of China, reported a study that argued the effectiveness of Shuanghuanglian Oral Liquid, one of traditional Chinese medicine that is familiar to the public, in preventing the disease infection. This media report coincided with an escalation of misinformation on folk medicine.

DISCUSSION

This study is the first to apply the CERC model to investigate the primary themes of misinformation and their evolution during the early stages of the COVID-19 outbreak in China. Across three platforms, the study demonstrated five major themes of misinformation. The four predominant themes were derived from the CERC model, including crisis situation updates, prevention and treatment, authority action and polity, and disease information, supporting H1. From a

FIGURE 2 | Evolution of misinformation themes in relation to crisis phases and the COVID-19 cases in China.
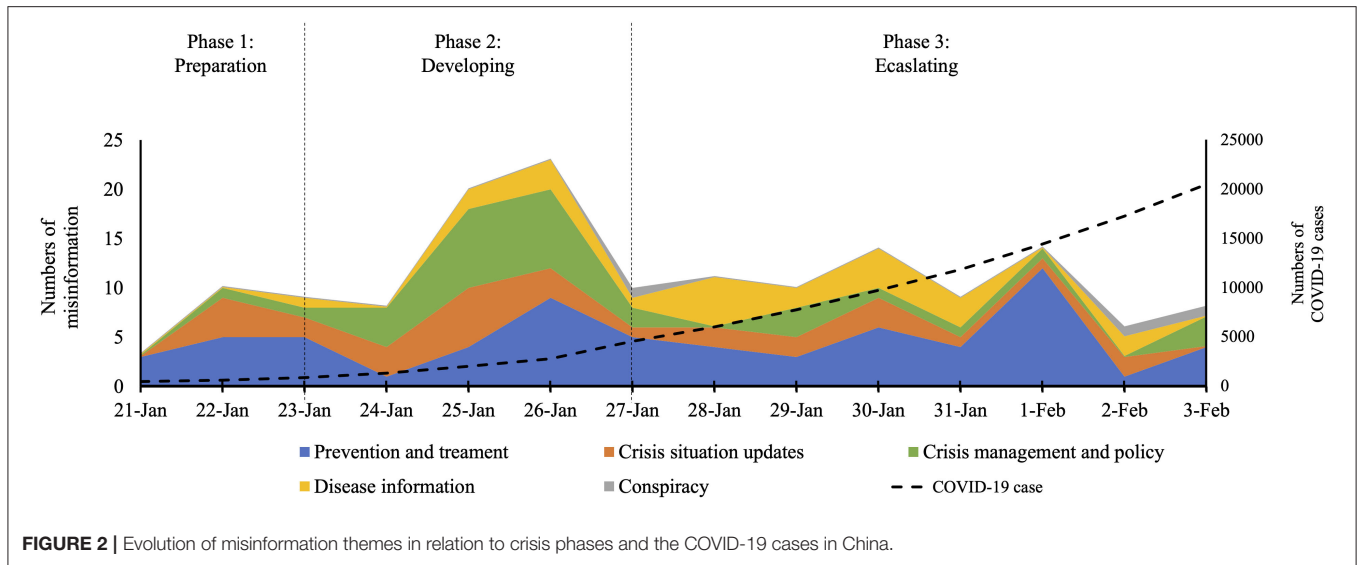
health communication perspective, this study provides a standard typology for crisis-related misinformation. This is helpful as the framework can guide future systematic reviews to summarize and compare previous findings. From the crisis communication perspective, the findings suggest that combating crisis-related misinformation and communicating crisis information are two sides of a coin. Though this insight seems intuitive, it illuminates the theoretical possibilities for future integration for the two distinct research fields. It also suggests that the containment of crisis-related misinformation should be implemented simultaneously along with crisis communication.

However, the CERC model did not predict the emergence of conspiracies, though conspiracies were commonly found during health crises (Sommariva et al., 2018; Wood, 2018). This is likely because conspiracies do not emerge from a particular information need; instead, it serves to provide an immediate and holistic understanding of the situation: why the crisis happened, who benefits from it, and who should be blamed (Bessi et al., 2015; Wood, 2018). Though conspiracies accounted for only a tiny proportion of misinformation, they can significantly tarnish the reputations of health authorities and prevent effective health and crisis communication (Cohen, 2020). Future studies should investigate how they can be efficiently prevented and addressed during health crises.

Regarding temporal patterns (RQ1), misinformation emerged only after the national recognition of the crisis, supporting the intuitive prediction from the CERC. Importantly, government policies and media reports appear to elicit misinformation under some circumstances at the initial stage of the COVID-19 outbreak in China (21 January to 3 February). The findings clearly showed the concurrence between the city quarantine and the upsurge of fake news about government policies, and between People Daily's reports and the circulation of misinformation about folk medicine. Given the relatively short investigation period in this study, the causality of their associations cannot be claimed.

Future studies should focus on a longer period and conduct time series analysis to understand the effects of government policies and media reports on misinformation.

Nevertheless, those concurrences suggest that misinformation might not emerge randomly or evenly across time. Rather, misinformation of a topic may be induced by an event or information on the same topic. This is likely because ongoing events and information can act as circumstantial evidence for misinformation of a similar topic if they are not communicated effectively. This insight goes beyond the current research that predominantly examines when misinformation emerges (Rosnow, 1980, 1988), by suggesting how misinformation of a particular topic emerges. This suggestion is particularly critical for practitioners as it can strategize the allocations of limited communication resources for misinformation debunking. Future research should investigate how misinformation of a topic emerges and spreads along with ongoing events and information.

Additionally, as misinformation often emerge when official information is lacking (DiFonzo and Bordia, 2007), the findings suggest that crisis management policies, especially strong or extreme ones, should be supported by follow-up communication to ease the public from fear and uncertainty. News media should also frame their reports rigorously and scientifically to avoid misunderstandings.

This study has two limitations. First, the trend analysis was conducted with data of only one platform. As **Table 1** clearly shows that different fact-checking platforms tend to gather different themes of misinformation, future research should try to generalize the study results regarding the evolution of misinformation. Second, as this study utilized publicly available data on fact-checking platforms, it is unable to discover mechanisms why particular misinformation is made and circulated. Future studies should conduct surveys and experiments to understand how people create and spread misinformation during a disease crisis.

CONCLUSIONS

This study is the first to apply the CERC model to investigate the themes and evolution of misinformation during the early stages of an infectious disease outbreak. Though the study focused on misinformation that emerged surrounding COVID-19 in China, the findings are expected to be generalized into other public health emergencies because they are largely corresponding to the CERC model. This research is of theoretical and practical interest to communication scholars and practitioners who seek to maximize the effectiveness of outbreak communication by combating misinformation surrounding health crises. Future research should examine how and why misinformation is made and circulated by particular groups of people in specific crisis stages, to achieve successful crisis communication through combating misinformation.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

AUTHOR CONTRIBUTIONS

JL conceptualized the manuscript, analyzed the data, and contributed to the manuscript writing, reviewed the content, and agreed with submission. All authors contributed to the article and approved the submitted version.

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