



Structural Analysis of the Evolution Mechanism of Online Public Opinion and its Development Stages Based on Machine Learning and Social Network Analysis

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Abstract

Internet public opinion is a complex and changeable system, and its trend development is characterized by explosive, evolutionary uncertainty, concealment and interactivity due to the participation of the vast number of Internet users. Today, with the rapid development of network information technology, public opinion has an increasing influence on the stable development of society. Computational intelligence is the frontier field of artificial intelligence development, and computational intelligence is used to mine and analyze public opinion text information and study the evolution of online public opinion. This paper uses the Changchun Changsheng Vaccine Incident as an example, and the netizens' degree of attention to emergency-related keyword searches in the Baidu Index as a descriptive variable for the development of network public opinion. After applying the optimal segmentation algorithm, the development of public opinion is divided into phases. On this basis, a social network analysis is adopted to analyze the spatial and topological structure of each phase of network public opinion, using data from the Sina Weibo platform. Based on optimal segmentation, the development of network public opinion of the Changchun Changsheng Vaccine Incident can be divided into four phases, namely latent, spreading, control, and stable; each phase has different spatial and topological characteristics. Corresponding policy suggestions on network public opinion governance are put forward for each phase.

Keywords Emergencies · Network public opinion · Phased development · Structural analysis · Emergency management · Case study

1 Introduction

China is in a critical period of economic and social transformation in which many contradictions and risks that require citizens to adjust to a changing dynamic among different social groups lead to frequent public emergencies. Some government agencies have inadequate governance, regulations, control, and communication to manage emergencies effectively, while others ignore or counteract the interests of individuals engaged in event information dissemination. This has led netizens to promote the dissemination of network public opinion of emergencies. Only by actively

guiding the public and quickly quelling emergencies can social peace and stability be maintained. General Secretary Xi Jinping made it clear at the National Network Security Information Work Conference that network governance capabilities should be improved. His objective is to form a comprehensive network governance pattern featuring government-led management, media cooperation, supervision, and netizen self-discipline. Therefore, it is necessary to: (1) identify the developing mechanisms of network public opinions related to emergencies; (2) identify the network topology of network public opinion at different phases; (3) conduct a spatial analysis on each phase of the network public opinion development; and (4) put forward phased optimization suggestions for governance to ensure that the proposed countermeasures can guide the development of network public opinion rationally, scientifically, and efficiently.

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2 Literature review

In China, a significant part of current academic research focuses on the propagation law of public opinion and on effectively guiding its healthy development. Public opinion presents itself in various states with different characteristics. It also develops and changes; the time development of network public opinion of unconventional emergencies is the directional change in netizens' attention to such emergencies (using search engines) over time. The development scale is based on the progressive stages of different life cycles. In this study, we focus on issues that caused widespread public concern in 2018, using the Changchun Changsheng Vaccine Incident as a case study. First, we used the optimal segmentation algorithm to identify the different stages of the development of an event. Next, we conducted a social network analysis to examine the characteristics of the network structure of the event at different propagation stages and to uncover the qualitative propagation law of the public opinion event at each life cycle stage.

Network public opinion refers to the sum of various attitudes, opinions, and emotions expressed by the public, in response to public events, and disseminated through the Internet within a certain time and space [1]. As such, network public opinion is also a reflection of social conditions and public opinion. Network public opinion of emergencies refers to the views and opinions expressed by netizens on emergencies, as disseminated through Internet platforms [2]. The development of network public opinion of emergencies is a dynamic process involving three types of actors; namely the government, the network media, and netizens [3]. Emergencies are reflected in and perceived through public opinion, and while netizens are producers of public opinion, the network media are an important force in the promotion and development of public opinion. Equally, in China, the government is a body tasked with regulating and guiding public opinion. Thus, the government needs to grasp the patterns and characteristics of the development of public opinion to play a decisive guiding role [4]. The public's need to explore the truth about an event and the overall desire to maintain social justice are the driving mechanisms for the spread and diffusion of the network public opinion about that event. The development of public opinion has thus become more complex and uncertain, with new opportunities for disseminating information and opinions; this has attracted widespread attention in academia [5].

Many scholars in China have used case studies to test a hypothesis by analyzing a specific situation. This paper uses a particular event as a case study and analyzes it to uncover the development process of network public

opinion of emergencies, with an eye to informing the development of best practices for managing these processes [6]. Using the social network analysis method, Kang et al. (2014) conducted an empirical analysis on the speed and scope of the spread of network public opinion following the "11.16" school bus accident, thus providing a strategic solution to guide network public opinion in the wake of this emergency [7]. Zhu and Wang (2019) examined the case of "Child Abuse Incidents in RYB Kindergartens" and concluded that early warning systems for social emotions, control of information pollution, and disclosure of event handling information are critical to the management of network public opinion [8]. Cao and Li (2019) used the "Yabuli Incident" as an example and revealed that social network public opinion is jointly influenced by public opinion events, media, netizens, multiple subjects of the government, and related factors, and that the government can improve its ability to guide and control public opinion events [9].

Scholars have researched the subject elements and development stages in the evolution of online public opinion on emergencies, mostly revealing the shape or law of the evolution of online public opinion from two dimensions: process and subject. Current research has different ways to divide the stages of social network opinion evolution, including the three-stage theory with the division of latent → proliferation → fading [10]. The four-stage theory that divides latent → sudden → spread → end [11]; The five-stage theory of latency → emergence → acceleration → maturity → decline as a division [12]; The six-stage theory of latent period → growth period → spread period → outbreak period → decline period → death period is the way to divide [13]. There are also the "four points and four stages" [14] and the multi-stage theory [15], which are based on the communication characteristics of emergencies. At different stages of the evolution of social network public opinion, its propagation elements, element characteristics, and element association relations all present differences. Although scholars have not yet reached a consensus on the stage division of public opinion evolution, the development of online public opinion is generally considered to have a certain life cycle, following the vein extension rule of conception, spurt, proliferation, and decay.

As a comprehensive set of theoretical concepts and analytical methods, the social network analysis method provides new insights into the mechanisms at work. It allows for both individual-level and system-level analyses, which gives the method the potential to explain changes in structural relationships and their results [16]. The formation and development of public opinion cannot be separated from the communicative relationships among citizens; therefore, the social network analysis method has a specific reference value for public opinion research [17].

Al Omoush (2017) conducted empirical research based on public opinion data on unexpected events and classified events according to the time, region, and emotional attitudes of relevant subjects, thereby analyzing the depth of network public opinion dissemination [18]. Tokakis et al. (2019) analyzed the scope and effect of opinion leaders' influence in emergencies to evaluate their comprehensive influence on network public opinion [19]. After reconstructing the route of online public opinion dissemination, Zeng and Zhu (2019) conducted a quantitative analysis on the topological structures of public opinion dissemination, such as the small-world effect, power-law distribution, and community structure [20]. Kang et al. (2014) used the case of the "4.20" Ya'an earthquake to analyze the network structure of public opinion and identify the key nodes in its dissemination during emergencies [21]. Wang et al. (2018) analyzed the information dissemination characteristics and social network attributes of network public opinion [22]. Wang and Sun (2017) used a social network analysis to measure and analyze the structure of the "Wei Zexi Incident" public opinion dissemination network [23]. Finally, Zhao and Wang (2018) used the case of the flood disaster in Daxian Village to excavate and identify key nodes in public opinion dissemination and to explain their internal structural features and development rules [24].

This paper considers the combination of time and space of network public opinions in emergencies as the starting point, uses the netizens' attention of the Baidu index as the real data for quantitative analysis in the time stage, and uses the optimal segmentation algorithm to divide the continuous data of time into four evolution stages according to the evolution law of data, so as to find the evolution characteristics of the time of network public opinions. Following this, the social network analysis method is used to analyze the spatial evolution of network public opinion in each stage. Thus, its temporal and spatial evolution rules provide a new research method for the spatial and temporal transmission evolution rules of other emergency network public opinions, which is more conducive to monitoring the evolution of irregular emergency network public opinions, and to reducing the secondary harm risk of irregular emergency.

3 Research Hypotheses

The spatial structure of networks circulating event information comprises the mutual relations between primary and secondary disseminating, or receiving, subjects. Different subjects have different modes of interaction, thus forming different network topologies. When the subjects are closely connected, their number is large, and the interconnection among the nodes is relatively complex; the nodes will connect to form a complex social network group. However,

network public opinion of emergencies is itself a complex social network with multiple hierarchical structures that exist due to the connection of multiple subjects engaged in the interactive development, generation, dissemination, and reception of relevant information. In the process of collecting and disseminating information on emergencies, individuals involved in a network continuously send and receive information to promote its broader circulation, thus forming a large "group social network." The network media's rapid development have gradually made it a platform for the communication of social ideology, culture, and public opinion. There are many uncertain factors in the process of transmitting and circulating information on emergencies, and network media influence the way nodes are connected through various kinds of information. Therefore, our first research hypothesis is as follows: As the promoter of the development of network public opinion of emergencies, the network media play a key role in shaping the network structure.

During a critical period of social transformation and conflict in China, the active degree of network public opinion has been on the rise. Netizens have concentrated their attention on the process of occurrence, development, and dissemination of public emergency information, and the explosive spread of relevant event information has led to the openness, popularity, and instability of online public opinion of emergencies. Meanwhile, media platforms have also become venues to spread negative information about an emergency, and this negative content generates public rumors that can cause widespread panic. Once an emergency is consistent with the anti-social sentiment of Internet users, it is easy for a public opinion crisis to emerge and endanger social stability. In the communication process of online public opinion of emergencies, the government, online media, and netizens are the three most important subjects. The interactions among these three have an impact on the popularity, pace of spread, and development of an online public opinion of emergencies; it is thus meaningful to study the role of government in the development process. Therefore, our second research hypothesis is that in the development phase of network public opinion of emergencies, the government's role is to guide public opinion continuously.

4 Research Methods and Model Construction

4.1 Optimal Segmentation Theory

The temporal development of public opinion of emergencies and data on social conditions and public opinion is a continuous process. By using continuous data on netizen attention to emergency-related search terms in the Baidu index, the development of network public opinion may be

divided into orderly progressive phases. Scholars in natural sciences, including geology, hydrology, and information systems, have made advances in research in orderly progressive phases [25]. Optimal segmentation theory and optimal segmentation algorithm can effectively solve the problem of time series segmentation, as the data used in this study demonstrated through continuous clustering characteristics. Optimal segmentation algorithm comprises the following steps: (1) The sums of squared deviations of the measured data are used as the diameter of ordered clustering (segmentation) so as not to break the time series; (2) the sums of squared deviations of various types are obtained by traversing the segmentation; and (3) these are compared to select the minimum value, thus obtaining the ordered progressive phases.

4.2 Social Network Analysis Method

Yousefi-Nooraie et al. (2012) describes the social network analysis method as an analysis of the relationship between behavioral subjects. By capturing the interaction and interplay among a group of people, one can ascertain the behavioral patterns in a given environment and uncover the socio-spatial structure reflected in these relationships. The social network analysis method usually adopts matrices to present data and charts to present the network structure. ‘‘Central-ity’’ is one of social network analysis’ foci. Subsequently, factors indicating the positions netizens and other subjects occupy within the social network structure, whether they are in the central position, and what kind of power they have, all demonstrate the influence of individuals in the network structure. By using social network analysis, we can analyze the phased overall morphology of the network structure and identify the subjects that may occupy important positions, or have greater influence, at any given phase [26, 27].

$$C_D(N_i) = \sum_{j=1}^g x_{ij}(i \neq j). \tag{1}$$

In today’s complex Internet environment, information about emergencies is a special type of information in a disseminating situation, and the network space structure based on event information mainly consists of information management subjects, transmission routes, transmission subjects, and inter-subject relationships. In the process of information generation and transmission, the constant sending and receiving of messages lead to an intensive sharing of information that results, in a sociological sense, in a ‘‘group social network.’’ In existing research on the development of online public opinions on emergencies, group research is generally transformed into research on specific subjects, and the context and nature of the crisis is typically central in the discussion.

4.3 Construction of Optimal Segmentation Model

Data on the development phases of network public opinion of emergencies are defined as $X = (X_1, X_2, X_3, \dots, X_j)$, where X_j represents the specific value of searches by netizens obtained on the j -th day of the development process. The specific calculation process for the phased development of network public opinion of emergencies is as follows. [28]

4.3.1 Data Normalization

The continuous data X_j in matrix X is normalized by Formula 2 to obtain Y_j , the normalized matrix of which is $Y = (Y_1, Y_2, Y_3, \dots, Y_n)$.

$$Y_j = (x_j - \min\{x_i\}) / (\max\{x_i\} - \min\{x_i\}) \tag{2}$$

4.3.2 Calculation of the Variation Matrix

Assuming that the normalized matrix distribution within a certain period $[a, b]$ is $[Y_a, Y_{a+1}, Y_{a+2}, \dots, Y_b]$, the differential value of network public opinion development in this period is expressed as follows:

$$d_{ab} = \sum_{\alpha=a}^b [Y_\alpha - \bar{Y}(ab)]^2 \quad \text{and} \tag{3}$$

$$\bar{Y}(ab) = \left(\sum_{\alpha=a}^b Y_\alpha \right) / (b - a + 1).$$

When the matrix Y is divided into k segments, a variation matrix $D = (D_1, D_2, D_3, \dots, D_k)$ can be obtained and the following can be calculated: $D_i = [d_{ab}]$, $i = 1, 2, \dots, k$

4.3.3 Division of the Optimal Segmentation Points

If $P(n, k)$ represents that n consecutive search engine attention values in the matrix Y are divided into k segments and $k=2$, then the optimal segmentation points can be obtained by the objective function shown in Eq. 3.

$$e[P(n, 2)] = \min_{2 \leq j \leq n} \{D(1, j - 1) + D(j, n)\}. \tag{4}$$

When $k=3$, the optimal segmentation points can be obtained by the objective function shown in Eq. 4.

$$e[P(n, 3)] = \min_{2 \leq i, j, 3 \leq j \leq n} \{D(1, j - 1) + D(i, j - 1) + D(j, n)\}$$

$$= \min_{3 \leq j \leq n} \{P[j - 1, 2] + D(j, n)\}. \tag{5}$$

Through such continuous iterations, the objective function formula that confirms the division of network public opinion into k segments can be obtained as follows:

$$e[P(n, k)] = \min_{k \leq j \leq n} \{e[P(j - 1, k - 1)] + D(j, n)\}. \tag{6}$$

Finally, the inverse method is used to solve Eq. 6; that is, the optimal segmentation points for division into k-1 phases can be obtained.

4.3.4 Determination of the Optimal Number of Phases

As the optimal segmentation method does not calculate the exact number of segments, the ratio method is required to determine the optimal k value:

$$a = \ell[P(n, k)] / \ell[P(n, k + 1)]. \tag{7}$$

According to the operation rules, the larger the value represented by a, the better the effect of dividing it into k + 1 segment rather than k segments. In addition, when the value of a is infinitely close to 1, this indicates that there is no need for an iterative inversion.

4.3.5 Validation of the Segmentation Result

To determine the most suitable number of segments, we must ensure that the segmentation result conforms to the rules of an F-test. The mathematical formula for calculating the F-test value is as follows:

$$F = \frac{\left\{ \sum_{j=1}^n [Z_j - \bar{Z}(1, n)]^2 - e[P(n, k)] \right\} / (k - 1)}{e[P(n, k)] / (n - k)}. \tag{8}$$

According to the operation rules, when the F-test value is higher than the given significance level, the validation has passed. This suggests that the effect of dividing the temporal

development of network public opinion into k segments is relatively significant and that the obtained k-1 optimal segmentation points are effective segmentation points.

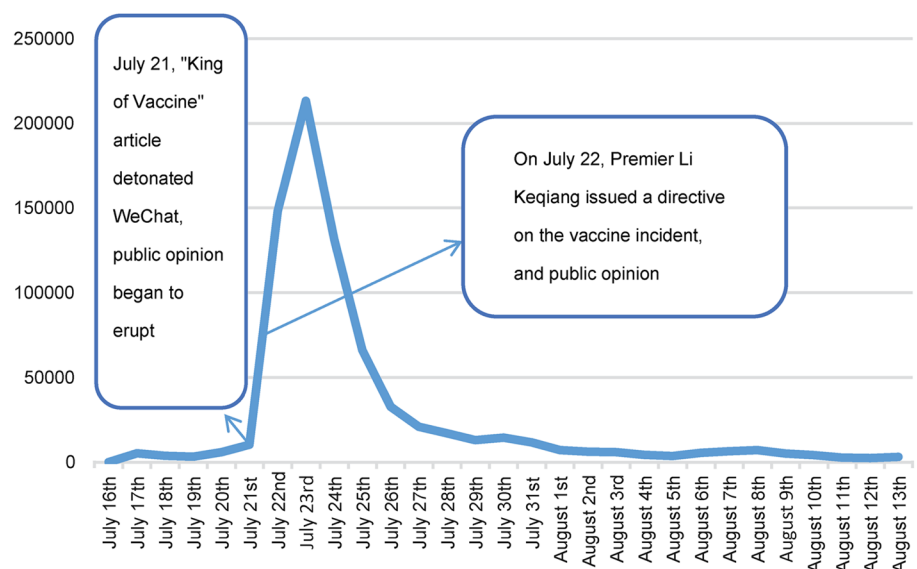
5 Empirical Results and Discussion

Figure 1 shows that the Changchun Changsheng Vaccine Incident began to attract public attention in July 2018. As netizens have unlimited scope for emotional expression and demands, both they and the media paid attention to the political/public discussion. During this unexpected event, netizens experienced a crisis of trust in the government, and this inevitably became the focus of public opinion.

During the Changchun Changsheng Vaccine Incident, it was evident that social media intensified the process of accumulating and generating public opinion, and latent discussions resulted in an outbreak of public opinion online in a short time.

On July 15, 2018, the state drug administration (now the National Medical Product Administration) issued a notice regarding the company’s vaccine fraud. On July 19 and 20, Changsheng Bio-Technology Co., Ltd. and the Shenzhen Stock Exchange reacted to the development. On July 21, 2018, “Beast Lord,” a former Southern Weekend journalist, published “The king of vaccines” on his official public WeChat (a social media application) account. It quickly drew the attention of a circle of netizens and an online platform, which led to the rapid dissemination of the event from its incubation. Different types of “self-published media,” more commonly known as “self-media,” which is created by the general public to release and disseminate their own news and information, condemned the vaccine company’s fraudulent behavior.

Fig. 1 On Changchun Changsheng vaccine incident



After just 6 days, netizens gradually moved from being concerned about the event to expressing distrust in vaccine safety in general, as well as distrust in regulators. When a large amount of information floods the Internet, public opinion intensifies. Netizens became concerned for their own security, and their distrust of authorities also had a sustained effect on public opinion.

When emergencies occur, such as the Changchun Changsheng Vaccine Incident, the platforms which network media are most likely to turn to for gathering information are Baidu and Weibo. These platforms are thus an important medium for communication and discussion. Figure 1 illustrates the number of hits on a Baidu search using search terms related to the “Changchun Changsheng vaccine” between July 16, 2018, and August 13, 2018, demonstrating the trend of netizens’ concern about the event over time.

6 Results of Data Processing and Analysis

This study used “Changchun Changsheng Vaccine Incident” as a keyword to search the Baidu index. It also used continuous data on netizens’ attention to this incident over the course of 29 days, from July 16, 2018 to August 13, 2018, as the real-world data on temporal development phases of

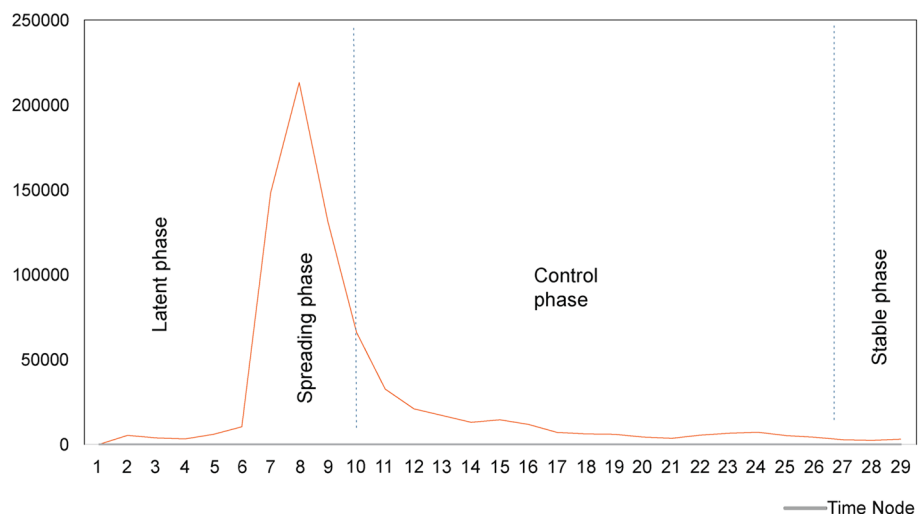
network public opinion of this incident ($X = [0, 5280, 3832, 3179, 5949, 10,362, 148,189, 213,230, 131,408, 66,003, 32,676, 20,935, 16,962, 12,986, 14,541, 11,706, 7102, 6199, 5928, 4310, 3599, 5470, 6508, 7132, 5138, 4156, 2729, 2373, 3089]$). MATLAB7.0 software was used to normalize the above data ($Z = [0.0138, 0.0069, 0.0038, 0.0170, 0.0379, 0.6915, 1.0000, 0.6120, 0.3018, 0.1437, 0.0880, 0.0692, 0.0503, 0.0577, 0.0443, 0.0224, 0.0181, 0.0169, 0.0092, 0.0058, 0.0147, 0.0196, 0.0226, 0.0131, 0.0085, 0.0017, 0, 0.0034]$). The variation matrix D of X was calculated using Eq. 3, from which the minimum variation value of network public opinion development under k segments could be determined (as illustrated in Table 1 and Fig. 1).

As the development of network public opinion may be divided into different phases, the optimal segment number of the index is determined by Eq. 7. Through our calculations, we found that $a_{34} = 0.8364 > a_{23} = 0.722$ and that the larger the optimal segment value of the index, the better. Therefore, the minimum variation values when $k = 4$ and $k = 3$ were substituted into Eq. 4, thus deriving the F -values of 0.4563 and 0.2576, respectively, which are less than the test value of 3.049 when the significance level is 0.05. However, when $k = 4$, the F -value is closer to 3.049. Thus, through repeated iterations and significance level tests, the development of the network public opinion of the “Changchun Changsheng Vaccine Incident” was divided into four phases: latent, spreading, control, and stable (as illustrated in Fig. 2). From here, it can be seen that the evolution of online public opinion of sensational events is basically consistent with the “four-stage” evolution mechanism: first, under the stimulation of key events, online public opinion bursts into the open stage; second, with further development of the situation, netizens and the media pay attention; third, the degree of public opinion escalates and emotional infection helps intensify public opinion of the Internet that then enters the dissemination

Table 1 Minimum variation value and optimal segmentation points of network public opinion under k segments

k value	Segmentation points	Variation minimum	Optimal Segmentation point	Optimal Segmentation date
1	1	1.0258	6	July 22
3	2	1.2264	6,8	July 24
4	3	1.6987	6,9,27	August 12

Fig. 2 Analysis of the development phases of network public opinion of the Changchun Changsheng Vaccine Incident



stage; and fourth, with the intervention of the government and other governance entities, or the public's "emotional slack," the public opinion curve has an inflection point and the mood of Internet public opinion is tense. When the situation eased, the influence of the event began to decline, attention gradually cooled, and online public opinion entered the stage of control. However, based on the event's cessation or the appearance of other public opinion events, people no longer pay attention to the original one, network public opinion evolves to a stable stage and then gradually disappears, and the public opinion information ecosystem reaches an equilibrium state. Of course, because public opinion has a memory function, once a similar incident occurs again, the dispelled online public opinion will be retrieved and enter a new round of online public opinion evolution cycle.

6.1 Analysis of the Spatial Structure of Network Public Opinion in the Latent Phase of Development

Weibo is a mainstream social media platform in China and an effective tool for think tanks to use social media to develop knowledge services, disseminate knowledge, and guide public opinion. Given its longevity and influence, Sina.com—one of the "four major portals in China"—was used as the research platform for this study. Using the search function provided by the Sina Weibo platform, we searched using "Changchun Changsheng Vaccine Incident" as the keyword. A total of 50 individuals who disseminated the event through Sina Weibo and achieved the highest numbers of reposts were selected. Following this, 5 of these 50 were selected randomly as initial information distribution nodes, and another 5 individuals who reposted or commented on posts about this incident from these 5 sources were randomly selected as secondary information distribution nodes. For this incident, we established a 75*75 dissemination matrix model and analyzed the spatial dissemination effect among the 75 nodes.

Latent phase (July 16, 2018, to July 21, 2018)

In the latent phase, the emergency incident had just occurred, and only public advocacy groups and members of the public with vested interests in the incident paid attention to the emergency information. As evident from the spatial structure diagram in Fig. 3, the main dissemination groups that promoted the development of public opinion in this phase were the official media or opinion leaders who had relevant information about the Changchun Changsheng Vaccine Incident.

A dual-core network spatial structure formed during the latent phase. It had two different factions: one centered on "Headline News" and one on "Interface." "Headline News" established direct connection channels with "Beijing News" and "Kaidi Network," while "Interface" established direct



Fig. 3 Spatial structure diagram of the latent phase of network public opinion of the Changchun Changsheng Vaccine Incident

information exchange channels with "CCTV Finance" and "National Business Daily." The nodes within these two factions were interconnected, thus improving the speed of information exchange between them. However, the factions had no relationship with each other. Therefore, while the information flow within the factions was smooth, the flow between the factions was more difficult. This demonstrates that in the latent phase of the development of network public opinion of emergencies, each faction is isolated from the other, making it difficult to carry out quick and effective information dissemination.

6.2 Analysis of the Spatial Structure of Network Public Opinion in the Spreading Phase of Development

Spreading phase (July 22, 2018, to July 24, 2018)

In this phase, network public opinion demonstrated a pulsed rapid growth trend. Most netizens learned about the Changchun Changsheng Vaccine Incident and expressed their personal opinions through Internet platforms, which accelerated the widening and deepening of public opinion dissemination. At this time, netizens who participated in the information dissemination were mainly motivated by exogenous attractions such as curiosity and related interest, and by endogenous impetuses such as power and achievement. After 9 days of development, the spatial structure of the network public opinion of the Changchun Changsheng Vaccine Incident finally formed 18 factions (Fig. 4). Among them, "Headline News" belonged to 16 factions, "People's Daily" belonged to 24 factions, and "Shanghai Huangpu" belonged to seven factions simultaneously.

of netizens in the short term, their attention to the event will gradually decrease over time, the public mood will tend to stabilize, and the network public opinion will gradually enter a relaxed phase until the next major event occurs. If the relevant authorities do not handle such emergencies effectively, the force of the reaction through network public opinion will be even stronger. If relevant authorities respond promptly and positively, they can, to a certain extent, actively guide public opinion, thereby promoting its healthy development. As government authorities continue to intervene in the handling of incidents, the public will pay less attention to emergencies. When new public events occur, these will divert the attention of netizens away from earlier events, and network public opinion will gradually enter a decelerated phase. In this phase, the emotions generated by different ideological groups among netizens slowly subside.

7.1 Policy Recommendations

(1) In the latent phase of network public opinion of public emergencies, the speed of information disclosure by government departments should be increased, and effective emergency measures should be taken. In this phase, only a few netizens have information about public emergencies, and only some will participate in the discussions. As netizens pay little attention to emergencies, and enthusiasm for disseminating information is very low at this point, netizens' opinions do not form a large-scale storm of public opinion dissemination. There is, therefore, a window of opportunity for information disclosure by government departments, and their efforts to deal with public emergencies determine the speed and dissemination enthusiasm of network public opinion. The failure of government departments to take prompt and effective measures following a public emergency is a fundamental reason for the continuous development, intensification, and spread of network public opinion.

(2) Guidance of public opinion in the network media should be strengthened during the spreading phase of public emergencies. The network media should establish a standard to pursue their own values, report event information fairly and truthfully, report real-time information about public emergencies to the public, and supervise government departments as they manage public emergencies. However, the network media should also exert their particular function as a "second supervisor;" they should attempt to understand government departments' plans and decisions to manage emergencies by strengthening interaction with them, and they should convey the departments' emergency response measures to the public promptly so that the public can access accurate and practical information. This enables the government to guide the trend of network public opinion in the right direction. Relevant theories about network public opinion are indispensable for guiding it during public emergencies.

Only by scientifically applying the theories of "gatekeeper" and agenda-setting in network public opinion can the government cooperate with mainstream media, release accurate and detailed information, satisfy the public's right to know, actively guide network public opinion, reduce public losses, and maintain social stability. The "gatekeeper" theory has played an important role in managing public emergencies, for example, by facilitating on-site interventions, encouraging the rolling release of news, enabling timely response to public questions, and eliciting positive responses to adverse reports. Therefore, the government should ensure the accuracy of information to avoid misunderstanding and misinformation among the public. Important data, facts, figures, and locations should be reviewed and verified continuously to issue authoritative and reliable information openly, transparently, and truthfully, and to guide the public's online behavior promptly and effectively.

The keen attention of the public makes it easy for public information on emergencies to become the focus of network public opinion. Everyone wants to be the first to report. During the spreading phase, the government should take the initiative to release information and build a benign and harmonious public opinion environment.

(3) In the face of public emergencies, the government's first response must be to disclose clear and correct information, because public panic can be caused by the lack of information or credulous reliance on gossip and online rumors due to insufficient information sources. Building an honest government is the most important step that it can take to effectively control and guide the development of network public opinion. Therefore, it is necessary to establish laws and regulations related to the government's disclosure of information about public emergencies; specify the government's responsibility to disclose such information; establish a system for the government to exchange information with online media, netizens, and other social groups; revise and adjust government information dissemination in real-time.

(4) Netizens, as one of the three main groups of actors that influence the development of network public opinion, have the right to speak freely and maximize their own interests in all the phases of network public opinion of public emergencies. However, the state's power to maintain public safety and order must correspond to the individual rights of netizens. In response to public crises, netizens should take the initiative and actively assume corresponding social responsibilities.

Netizens' obligations and rights are inseparable. In essence, by undertaking corresponding obligations, netizens are protecting their own legitimate rights (such as the right to unimpaired life, health, and property). Moreover, as individuals embedded in social relationships, netizens who ignore the interests of others or cause damage to the legitimate interests of others when dealing with public crises will

undoubtedly be punished and restrained at the social morals level. Netizens' active participation in public crises is an important supplement to government measures, and it can significantly reduce or even eliminate the limitations of such measures. The network public opinion propagation of public health events like new crown pneumonia is characterized by significant time change particularity, spatial distribution diversity, and periodicity of evolution process.

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Author Contribution ZXL participated in data curation, methodology, validation, resources, funding, writing-original draft preparation conceptualization, formal analysis, writing-review and editing, screening questionnaires and tables. XW participated in conceptualization, supervision and project management, all authors have read and agreed to the published version of the manuscript.

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Declarations

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Informed Consent Not applicable.

Ethical Approval Not applicable.

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