Network Structure Analysis of Weibo Public Opinion Dissemination During the COVID-19 Pandemic (Postprint)

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Abstract

[Purpose/Significance] The COVID-19 pandemic is the most significant public health emergency since the founding of the People's Republic of China in terms of transmission speed, infection scope, and prevention and control difficulty. Weibo serves as a crucial arena for the dissemination of COVID-19-related public opinion. Strengthening targeted research on Weibo public opinion regarding public health emergencies facilitates effective response to such public opinion. [Method/Process] Based on social network analysis, this study explores the network structural characteristics of COVID-19 public opinion dissemination, as well as the positions and roles of various communication actors. [Results/Conclusion] COVID-19-related Weibo public opinion exhibits network characteristics of massive volume, numerous nodes, and complex relationships. Different types of Weibo users play distinct roles in network dissemination: official media Weibo accounts, commercial media Weibo accounts, and self-media accounts occupy different communication positions and possess varying levels of communication capacity within the public opinion network of emergency events. In the process of responding to and guiding public opinion on public emergencies, extensive cooperation among various media types should be promoted.

Full Text

Preamble

Title: Network Structure Analysis of COVID-19 Public Opinion Dissemination on Weibo

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Abstract: [Purpose/Significance] COVID-19 is the most rapidly spreading, widely infectious, and difficult-to-control major public health emergency since the founding of the People's Republic of China. Weibo serves as an important platform for COVID-19 public opinion dissemination, and strengthening targeted research on public health emergency discourse on Weibo is conducive to effective emergency response. [Method/Process] Based on social network analysis, this study explores the network structural characteristics of COVID-19 public opinion dissemination and the positions and roles of various communication actors. [Result/Conclusion] COVID-19 public opinion on Weibo exhibits network characteristics of massive volume, numerous nodes, and complex relationships. Different types of Weibo users play distinct roles in network dissemination, with official media accounts, commercial media accounts, and self-media accounts occupying different positions and possessing varying communication capacities in emergency public opinion networks. Responding to and guiding public opinion on public emergencies requires promoting extensive cooperation among diverse media types.

Keywords: COVID-19; Weibo; public opinion dissemination; network structure

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According to the "2020 Q1 Weibo Data Analysis Report" released by Xigua Data Platform, Weibo had 516 million monthly active users in 2019, maintaining growth for four consecutive years. This massive user base and convenient information publishing methods make Weibo one of China's most important information exchange platforms. In recent years, breaking information about numerous domestic emergencies has been released and disseminated through Weibo. Through posting, forwarding, commenting, and @ functions, information quickly aggregates on the platform, facilitating the convergence and resonance of opinions and emotions to form public opinion on emergencies.

From late 2019 to early 2020, the COVID-19 epidemic spread across China. The intensity of public opinion, number of focal points, and overall impact triggered by the epidemic and response efforts exceeded any previous emergency. Due to its large user base and convenient publishing methods, Weibo became a crucial origin and dissemination arena for COVID-19 public opinion, necessitating strengthened research on public health emergency discourse on this platform.

1. Research Review

1.1 Conceptual Definitions

Network public opinion refers to the emotions, cognition, and evaluations generated by netizens and online media regarding people, events, and viewpoints involving public politics, public affairs, and public interests [1]. Emergency event network public opinion occurs when individuals or groups in society express and

disseminate information about emergencies—including emotions, attitudes, intentions, viewpoints, or behavioral tendencies—through various online channels in cyberspace [2]. Therefore, this paper argues that public health emergency network public opinion constitutes a series of complex information published and disseminated on the Internet by the public and organizations through new media terminals regarding public health emergencies involving public safety and interests, including cognition, emotions, evaluations, and behavioral tendencies toward the emergency and related events. As a special form of network public opinion, public health emergency discourse shares common characteristics such as rapid dissemination, great destructiveness, diversification, and sharpness, while also exhibiting higher risk, derivability, focus, and complexity of subject interaction than general network public opinion [3].

1.2 Overview of Related Research

With the arrival of the network society and intensifying public health emergency hazards, scholars have increasingly focused on public health emergency network public opinion from perspectives of public management, sociology, and information science. Research approaches can be summarized as follows: First, analysis of social media's role and characteristics in public health emergency management, where social media can quickly convey official and critical information while providing basic data for decision-making [4-5], though independent user dissemination tends to be more misleading with poorer quality and reliability than government or news agency sources [6]. Second, exploration of evolution patterns, with Ding Xuejun et al. arguing that public health emergency discourse comprises personal viewpoints, official viewpoints, and rumors that form public opinion through a "stimulus-response" pattern [7], while Teng Wenjie identifies four stages: precursor, outbreak, fluctuation, and decline [8]. An Lu and Du Tingyao confirm that stakeholders' concerns on Weibo about public health emergencies evolve from convergence to divergence and back to convergence, whereas WeChat concerns show convergence-to-divergence with sustained stability [9], with topic evolution in different periods affecting stakeholders' emotional evolution [10]. Third, research on influencing factors, where leadership capacity [11] and communication inequality [12] affect dissemination effectiveness. Fourth, analysis of public communication dilemmas, as Mao Yong and Yu Jinming identify low grassroots risk communication capacity, media type confusion hindering public priority discernment, inadequate social monitoring, and insufficient direct public communication [13]; M. McCauley et al. note that during disease outbreaks, public stigmatization of events and officials is common as people seek culprits to alleviate fear [14]; and Y. Ophir finds significant differences between CDC communication objectives and actual media content [15]. Consequently, public health emergency management should promptly disclose accurate information, strengthen inter-departmental communication and cooperation, build public trust, guarantee the right to know, and encourage public participation [16]. Fifth, exploration of multi-layer network dissemination models, where traditional single-channel models use SIS and SIR frame-

works to study derivative dissemination and social network impacts [17], while multi-layer models examine online-offline interactive dissemination and coupling between virtual social networks and real-world interpersonal networks [18].

1.3 Research Review

Existing research demonstrates scholars' adequate attention to public health emergency public opinion. Weibo's diversification of dissemination actors helps expand information breadth and depth but faces problems of low information quality and unclear priorities that affect dissemination quality and can trigger derivative propagation. Current research lacks in-depth analysis of different network media's functions and roles during emergencies, and comparative studies using Weibo as the research field for public health emergencies remain rare. This paper employs social network analysis to measure the network structure of COVID-19 public opinion on Weibo, analyzing overall and individual position structures to discuss dissemination laws and support effective response and guidance.

2. COVID-19 Event and Research Design

2.1 Overview of the COVID-19 Event

On November 30, 2019, Wuhan hospitals discovered suspected SARS patients. On December 31, hospitals isolated patients, the Wuhan Health Commission began external reporting, initiated virus testing, investigated the Huanan Seafood Market, and the National Health Commission deployed an expert team to Wuhan. On January 2, 2020, the first COVID-19 patients were placed under observation. On January 11, Wuhan recorded its first COVID-19 death. On January 20, the CPC Central Committee issued its highest-level directive, appointed Zhong Nanshan as expert group leader, and Wuhan established its COVID-19 Prevention and Control Command. As the virus spread nationwide, experts including Academician Zhong Nanshan released prevention information, with Zhong confirming human-to-human transmission. On January 23, Wuhan locked down completely, while Zhejiang and Guangdong activated Level I public health emergency responses. By January 25, 30 provincial-level jurisdictions had activated Level I responses. On January 24, a second outbreak occurred in Wuhan with rapidly increasing confirmed cases and deaths nationwide. As of 24:00 on May 21, 31 provinces and the Xinjiang Production and Construction Corps reported 82,971 cumulative confirmed cases (82 existing, 8 severe), 78,255 cured and discharged cases, 4,634 deaths, and 7 suspected cases [20].

2.2 Research Design

2.2.1 Research Objectives The COVID-19 epidemic represents a major nationwide public health emergency. Various official, commercial, and self-media actors released epidemic information and tracked developments while the public

participated in dissemination through mobile terminals. In the Internet era, network public opinion dissemination features subject diversification and flattened communication. This study therefore aims to explore the overall structural characteristics of the dissemination network and the positions and roles of various actors to objectively summarize Weibo public opinion dissemination laws and provide reference for effective improvement and control.

2.2.2 Analytical Methods Social network analysis is an interdisciplinary method developed by sociologists integrating mathematics, graph theory, and sociology to study social structures and node relationships. It examines node relationships in specific environments, analyzes relationship characteristics, and explores impacts on social structure [21]. Combined with software tools, it can visualize node interactions. Weibo serves as the primary tool for the public and organizations to track social hot events, making public health emergency public opinion networks on Weibo a type of social network. This study crawls Weibo mobile data and employs social network analysis to examine COVID-19 public opinion, using network parameters for description and Ucinet and NetDraw for structural measurement and exploration, including network density analysis, centrality analysis, cohesive subgroup analysis, and member position structure analysis.

2.2.3 Data Sources After the COVID-19 outbreak, network public opinion spread rapidly across Internet platforms, attracting widespread attention and generating numerous hot search topics on Sina Weibo. On Weibo's mobile hot search pages, topic hosts can pin epidemic information, conduct Q&A sessions, push popular posts, and add discussion sections. This study therefore selected Sina Weibo's mobile platform for data analysis. Given the numerous related topics, the study used Weibo accounts participating in COVID-19 discussions as nodes and connections formed through following or forwarding as relationships. Using typical sampling with Python, topics were crawled on May 21, 2020 using keywords "Wuhan," "novel pneumonia," "novel pneumonia epidemic," "novel coronavirus," and "confirmed cases." One hundred fifty-four high-attention topics were selected, totaling 206.615 million discussions. After removing duplicate and low-relevance users, 220 event-focused nodes were finalized and an adjacency matrix constructed, with visualization results shown in Figure 1 [Figure 1: see original paper].

3. Characteristics and Main Body of COVID-19 Public Opinion Dissemination on Weibo

3.1 Analysis of Public Opinion Dissemination Nodes

The dissemination process of public health emergency public opinion typically divides into formation, outbreak, and decline stages. While COVID-19 has not ended, the current public opinion evolution shows three-stage characteristics but does not completely match this pattern. During the formation period, "The

Beijing News" confirmed and released "Wuhan Central Hospital Denies SARS Rumor," becoming the first epidemic report. Subsequently, "CCTV News" first issued official epidemic information, triggering massive forwarding that reached 25,000 reposts. "The Beijing News" was also the earliest media to track the epidemic. Concentrated reporting from numerous media including "People's Daily," "Lifeweek," "Toutiao," and "The Paper" pushed epidemic public opinion to its first climax. Later, as the epidemic spread, hot events such as "Zhong Nanshan Confirms Human-to-Human Transmission" (108,000 disseminations), "Wuhan Lockdown" (10.36 million disseminations), "Road Blocking and Village Sealing in Epidemic Prevention" (187,000 disseminations), "Medical Teams Departing," and "Resumption of Work and Production" were widely disseminated on Weibo, creating multiple public opinion climaxes. As COVID-19 gradually stabilized, related Weibo posts began to decline. In the initial stage, government Weibo accounts, official media, and commercial media all actively reported prevention and control information. "The Beijing News" issued the first report, and official media such as "Xinhua Net" and "People's Net" followed up, making these posts key nodes. On new media platforms enabling real-time information release, epidemic posts by media and celebrity accounts also attracted numerous followers, with Hu Ge's tribute to frontline medical staff attracting 130,000 forwards and comments. Clearly, opinion leader information received far more attention than ordinary users, reflecting that communication capacity determines node status in Weibo public opinion networks.

3.2 Characteristics of Public Opinion Dissemination

3.2.1 Massive Volume and Rapid Dissemination COVID-19 has low fatality but strong transmissibility, with fast infection speed and large diffusion area, posing greater and more direct threats to life and health that attracted nationwide attention. Meanwhile, because Weibo relationships can be either strong ties based on real life or weak ties based on interests and values, Weibo public opinion forms more quickly. This epidemic's total volume and dissemination speed greatly exceeded general hot events. On January 19, 2020, as Wuhan's confirmed cases multiplied, pneumonia-related hot search information experienced explosive dissemination. Topics around keywords like Wuhan, pneumonia, and confirmed cases continuously fermented, with "National Confirmed COVID-19 Cases" reaching 14.77 billion reads and 3.023 million discussions, and "Novel Coronavirus" reaching 16.71 billion reads and 2.792 million discussions.

3.2.2 Rapid Formation and Transformation of Topics COVID-19 itself lasted relatively long, and due to incomplete public information, media misguidance, and convenient viewpoint expression on Weibo, the epidemic's public opinion focus easily shifted. After the epidemic's occurrence, Weibo public opinion moved from focusing on epidemic development to daily necessities prices, antiviral drugs, and local government governance, with multiple climaxes occurring during this process.

3.2.3 Coexistence of Emotional Expression and Rational Thinking Due to Weibo's simple and direct information publishing and identity concealment, netizens can quickly and boldly express opinions. Overall, current Weibo public opinion is dominated by emotional venting. Under limited information, extreme emotions easily form and remain unstable, with alternating onlooker accusations and cheering support. Some in-depth rational thinking exists in public opinion, but its tone is mostly negative, pessimistic, and critical, lacking constructiveness.

3.2.4 Drastic Changes Public opinion presents peak-valley patterns with epidemic changes, often spreading rapidly in short time to cover massive audiences and push public opinion to its peak, forming mighty torrents of discourse that quickly attenuate afterward as attention continues declining.

3.3 Measurement of the Main Body Network

3.3.1 Overall Network Density Analysis The network density analysis reveals three key findings: First, the overall network density is 0.078, indicating low interactivity in public opinion sharing among nodes and needing improved overall cohesion. Second, the shortest path length between two points is 2.6, meaning two nodes can on average connect with others through fewer than three intermediaries, showing relatively convenient communication. Third, the cohesive subgroup density (E-I Index) is -0.535, indicating no small groups with high internal cohesion have emerged in the dispersed network structure.

3.3.2 Network Centrality Analysis Betweenness centrality measures a subject's intermediary capacity—the more positions it occupies, the more subjects need to connect through it. The centrality analysis reveals: First, many core nodes exist, with numerous nodes occupying central positions and publishing initial and disseminated information (see Figure 1). Second, besides official media, commercial media and self-media nodes can directly connect with other members, possessing good public opinion control capabilities (see Table 1). The top 5 nodes by betweenness centrality are "People's Daily," "Communist Youth League Central Committee," "Blueberry Doctor," "Xie Na," and "CCTV News." "People's Daily" has the strongest ability to guide other subjects, with most needing to disseminate through it. Doctor self-media "Blueberry Doctor" and celebrity "Xie Na" rank third and fourth, indicating doctor self-media may hold more core positions than celebrity media during COVID-19.

Analyzing by media type: Official media: "People's Daily" occupies an absolutely core position as the most important node with greater control, while "Communist Youth League Central Committee," "CCTV News," and "Xinhua Viewpoint" also have high centrality. Commercial media: "Weibo Hotspot," "Weibo Charity," and "Phoenix Net Video" have lower betweenness centrality than official media but maintain relatively high central positions. Self-media: Bloggers and doctors including "Blueberry Doctor," "Beijing Things Unknown

to Beijingers," and "Chief Physician Xu Rongdong" have relatively high centrality as key nodes for publishing and disseminating public opinion. Ordinary users in "hot" and "viewpoint" categories under related topics are scattered at network edges.

3.4 Exploration of Subject Positions

3.4.1 Cohesive Subgroup Analysis The cohesive subgroup analysis shows the network contains numerous subgroups, with official and commercial media-dominated subgroups having relatively closer connections. Dissemination subjects including "People's Daily," "CCTV News," "Toutiao News," "Sina News," and "Pear Video" repeatedly appear across subgroups, demonstrating relatively higher collaborative interactivity.

3.4.2 Subject Structure Position Analysis This analysis includes structural hole index and core-periphery measurement. The structural hole index measures non-redundant relationships between two subjects—when a subject connects two otherwise unconnected subjects, it occupies a structural hole and plays a "bridge" function in obtaining heterogeneous information, monopolizing access, and controlling information flow [22]. The analysis reveals: In absolute effective size measurement, "People's Daily" and "CCTV News" exceed 100, having the most non-redundant factors and acting most freely with minimal restrictions. Other nodes like "Communist Youth League Central Committee," "The Paper," and "Pear Video" also have relatively high effective sizes.

In relative effective size measurement, "People's Daily," "Xie Na," "Communist Youth League Central Committee," "Blueberry Doctor," "CCTV News," "Toutiao News," "Weibo Hotspot," and "Pear Video" have higher efficiency, acting more efficiently across the network. In node total constraint, "People's Daily" and "CCTV News" have the most structural holes, are least restricted, and possess strong structural hole utilization ability, mainly playing information communication bridge roles, while "Blueberry Doctor" and "Xie Na" have relatively high constraint, fewer structural holes, and are easily controlled. In network hierarchy, "CCTV News" occupies the most core position, followed by "People's Daily," "Communist Youth League Central Committee," and "Toutiao News."

Core-periphery measurement also shows official media including "People's Daily," "CCTV News," and "Xinhua Viewpoint," commercial media including "Toutiao News," "Sina Video," and "Pear Video," and self-media/doctor nodes including "A Gui Commentary," "Beijing Things Unknown to Beijingers," and "Chief Physician Xu Rongdong" occupy relatively core positions, while other nodes remain at network edges.

Further analysis reveals: First, almost all subjects are constrained by others, indicating widespread structural holes. "People's Daily" and "CCTV News" occupy the most structural hole positions (see Table 2), playing "bridge" functions among numerous subjects and connecting groups including commercial media

and self-media. Building more "bridges" facilitates COVID-19 information exchange and sharing. Second, different subjects present a core-periphery structure with official media at the core, commercial media and self-media expanding outward, and ordinary public at the outermost edge. Core-area subjects establish strong connection bonds with frequent interaction and smooth information sharing. Therefore, peripheral subjects' enthusiasm should be enhanced to actively establish weak connections with core subjects for information interaction and sharing.

3.5 Analysis of Different Media Type Positions

In the media network of COVID-19 public opinion dissemination, various media nodes demonstrate high synergy, close connections, and high information sharing (see Figure 2 [Figure 2: see original paper]). Overall, differences exist between information dissemination subjects and information active subjects: On one hand, from hub node (boxes) size distribution, "People's Daily," "CCTV News," "Xinhua Viewpoint," and "Toutiao News" bear very large dissemination responsibilities. Other subjects like "Pear Video," "China Voice," and "The Paper" also bear large responsibilities as important information dissemination subjects with absolute connection numbers and high recognition. External nodes continuously expand the network by connecting with them. Therefore, optimizing these influential information dissemination subjects enhances public influence and attracts more external nodes. On the other hand, from active node (circles) size distribution, "Red Star News," "China Youth Daily," "Xinhua Viewpoint," and "Tianfu Morning News" are most active, having more frequent and closer connections with dissemination subjects. By actively connecting with hub nodes, they achieve public opinion flow and sharing while creating new information and contributing dissemination power. Therefore, fully utilizing these active subjects' innovative potential to create new information while sharing basic information expands dissemination influence and transforms them into dissemination subjects.

In the individual network of COVID-19 public opinion dissemination, individual nodes show lower synergy than media nodes, with lower interactivity and information sharing. From hub node size distribution, celebrity subjects like "Gao Xiaosong" and "Xie Na" and self-media individuals like "Keluoliao," "Blueberry Doctor," and "Medical Notes" bear very large dissemination responsibilities. From active node size distribution, "Chief Physician Xu Rongdong," "A Gui Commentary," "Dr_{Ren}," and "Medical Notes" are more active, especially "Chief Physician Xu Rongdong," which is most active with the greatest dissemination potential. When improving the network, attention should be paid to nodes with both high hub degree and high activity, such as "Medical Notes," which possesses both dissemination power and activity for stronger influence (see Figure 3 [Figure 3: see original paper]).

4. Conclusions and Discussion

This paper statistically organized node relationships in the COVID-19 Weibo public opinion dissemination network and measured structural characteristics of dissemination subjects. The main conclusions are:

Regarding overall public opinion, COVID-19 discourse on Weibo features numerous nodes and complex relationships, with various media voicing opinions on the epidemic and response events while maintaining strong inter-media synergy. Regarding dissemination structure, significant differences exist among media types: First, official media, especially central media like "CCTV News" and "Xinhua Viewpoint," rank high in centrality, collaborative interactivity, and structural position as core nodes with strong dissemination capacity, rich information sources, rapid response, and wide influence. Official media clearly possess high information acquisition ability and credibility, forming the center of Weibo public opinion. Second, commercial media rank lower than official media in centrality, collaborative interactivity, and structural position but maintain relatively high status, with an obvious "multi-head competition" trend where portal websites, video media, and news media have comparable influence. Third, self-media has risen, with some influence comparable to commercial and local official media. Among self-media, epidemic relevance determines node importance—information-oriented self-media has greater influence; doctor self-media publishing professional medical knowledge has become an important node; and celebrity media still occupies important positions in hot events due to numerous followers.

Public health emergencies have become important non-traditional security threats, and Weibo is a crucial public opinion arena requiring strengthened targeted research. This study reveals functional and influence differences among network media in the public opinion field through social network analysis. Achieving good response effects requires enhanced inter-media cooperation. Official media Weibo accounts, especially central official media, occupy the network center with stable, extensive audiences and high trust, though their single, fixed dissemination methods may cause audience fatigue. Bloggers, field experts, celebrities, and influencers are main online opinion leaders with significant influence. Cooperation among different media types enhances dissemination effects, improves information accuracy, and ensures correct public opinion guidance.

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Author Contributions

Yao Leye: Guided topic selection, thinking, writing, and revision;
Wu Xi: Drafted and revised the paper;
Li Ming: Revised framework and paper.

Note: Figure translations are in progress. See original paper for figures.