An Early-warning Indicator System of Public Opinion Risk in Widespread Power Outages in City area Based on a Large Regional Power grid in China

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Abstract. This paper builds an early warning indicator system for public opinion risk based on the practical needs of public opinion management in large-scale urban power outages, and further examines the effectiveness of the early warning indicator system using the case of the "Chengdu high-temperature power restriction" incident. First, semi-structured interviews were conducted with four staff members of the Publicity Department of the State Grid Corporation of China (Sichuan Electricity Branch), who are responsible for public opinion management. Based on the interview data, the four key dimensions of the early warning indicator system were compiled, and the conceptual structure and dimensions of the indicators were refined on the basis of the interview data. Second, the study invited six academic experts on public opinion risk management to analyse the structure and content of the indicator system with Analytic Hierarchy Process, and finally obtained the weights in each indicator system to form a complete early warning indicator system with risk level as the result. Finally, based on the case data and online public opinion data provided by State Grid, the risk level results of the indicator system were used to compare with the risk assessment levels of the six experts and staff. It is found that the dimensions of concern for State Grid in public opinion management are different from ordinary public opinion events, and that it is necessary to combine the focus events with the public opinion situation. In terms of the understanding of the risk level, this study also explores the differences in the risk level according to the actual needs of the staff, which ensures that the results can be applied to the department's practical work.

Keywords: public opinion risk; early-warning indicator system; power outages event

1 Introduction

Large urban blackouts are a prominent representative event that occurs when electricity production is actively or passively disturbed by external forces. This leads to load shedding in the power grid, which in turn has a serious impact on national security, social stability and the daily lives and productivity of citizens. Such events are not only characterized by large-scale impacts, long power outages, and difficulties in restoration, but are also prone to regional public opinion discussions, the formation of rumours that are not in line with the objective reality, and the impact on social order. In recent years, large-scale urban power outages caused by high temperatures, floods, earthquake[1] and other unexpected reasons have had a great impact on

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the lives of aboriginal people, triggering active public discussion on large-scale urban power outages, especially when public opinion is driven by complex reasons and presents many negative impacts, which to a certain extent increases the difficulty of coping with large-scale urban power outages. It even leads to serious social opinion risks.

Therefore, it is necessary to form an effective and precise public opinion risk warning for large-scale power outages in urban areas to help relevant subjects make more informed decisions. The key to realise public opinion warning lies in identifying what scenarios form risks, and establishing a public opinion risk warning indicator system for large-scale power outages in urban areas has become an urgent task.

In order to study in details the risk of social public opinion in the urban blackout event, we pay attention to the performance of social media in the dissemination of public opinion. The rapid expansion of the Internet has led to the emergence and proliferation of social media networks, and these platforms have become key to the way individuals and communities share information, knowledge, and opinions, forming a gathering place for public opinion. This study takes online public opinion as the focus of risk research, and builds a public opinion early warning indicator system that takes into account the needs of staff working in the State Grid Corporation of China with dealing with the focusing events.

2 Literature review

The research on public opinion risk is achieving a peak among scholars in these years. As for direction of most existing researches of public opinion risk , it can be broadly categorized into two types. One type focuses on "decision-making" and establishes a model based on existing public opinion data[2], typically utilizing research tools such as BP neural networks[3] and grey relational analysis[4], [5]. This type of research aimed at various types of decision-making is also usually inextricably linked to game theory[6].Another type, rooted in communication studies, constructs theoretical analytical frameworks[7], It often emphasizes descriptive scenarios to answer the question of what constitutes risk[8] , how we can control the dissemination of public opinion in the context of communication mechanisms[9][10] and what can influence the dissemination of public opinion[11].

Focusing on researches of early warning research of public opinion, they followed the logic “Build first, assess later”, and their approaches are various. Grounded Theory[12] , fuzzy-set qualitative comparative analysis[13] are method to explore the elements of the indicator system, commonly seen are also Random Forest Algorithm[14]. Correlation analysis[15] , fuzzy comprehensive evaluation model[16] generally are employed to predict or evaluate public opinion risk. In order to enhance accuracy and scientific validity. Some improved model occurred, multivariable discrete grey model[17], blockchain technology (BT) network system for optimization[18], rolling fractional grey model[19] and so on are typical. Using mix methods has also become a trend. For example, the mix of AHPSort II and SMAA[20], Grey Relational Analysis and Evaluation Laboratory (GRA-DEMATEL) method[4].

The shortcomings of the given studies can be seen to be that too much emphasis is placed on the pure public opinion, and omitted research to the source of the event, or it can be called “focusing event”, which will probably induce self-interested responses and influenced public

opinion[21].There is a proneness towards fuzziness, overlooking the specificity of public opinion in different events. One thing that is undeniable, however, is that the use of social media data mining to analyse public opinion has become a more representative trend[22]. Above all, What we should pay attention to is that the topics of public opinion possess distinct characteristics. Different topics exhibit varying levels of topic sensitivity in the process of public communication, and their dissemination paths differ[23]. **What's more,** the entities dealing with public opinion display uniqueness. Entities involved in handling public opinion have certain requirements concerning the objective events referred to by public opinion[24]. For example, the landing points for addressing public opinion needs differ between public sectors and private enterprises.

3 Approach

A large amount of research has been done to provide a theoretical reference for the indicator system of public opinion risk, but since this study is concerned with the analysis of public opinion risk in urban large-scale power outage events, it is necessary to take into account the specificity of the subjects involved in urban large-scale power outage events to approach a reasonable and practicable indicator system. Thus, this paper use methods of Semi-structured Interview and Analytic Hierarchy Process to establish the indicator, and further with testing risk level in a real example which is compared by officer in power company with given rules, approach shows in Figure 1.

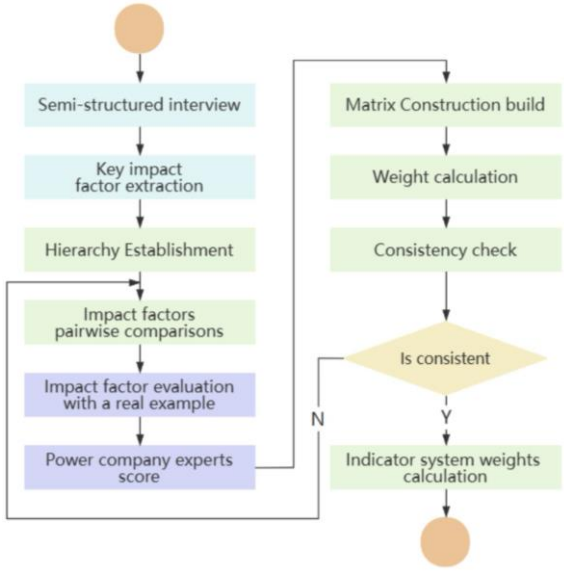

Figure 1 Approach.

3.1 Semi-structured interview

Semi-structured interview represents a method of qualitative research characterized by a flexible yet organized approach to gathering information from participants[25]. Unlike structured

interviews that follow a predetermined set of questions, and unstructured interviews that allow for open-ended conversation without a specific guide, semi-structured interviews strike a balance between the two. In a semi-structured interview, researchers develop a set of key questions or topics to be addressed during the interview. However, there is room for the interviewer to explore additional avenues or probe deeper into certain responses based on the participant's input.

In this study, semi-structured interviews were used to find out the key factors that should be paid attention to in the early warning of public opinion risk, and based on this, further conceptual elements were formed as the basis of AHP.

3.2 Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP), introduced by the American scholar Thomas L. Saaty in 1970, is a multi-criteria decision analysis method[26]. It aids decision-makers in making rational decisions by decomposing complex decision problems into hierarchical structures and conducting pairwise comparisons of elements at each level.[27] The fundamental principles of AHP involve the following steps:①Hierarchy Establishment②Pairwise Comparisons ③ Matrix Construction④ Weight Calculation ⑤ Consistency Check.

4 Establishment of indicator

4.1 Content of indicator

The starting purpose of the interviews was to explore the factors that the staff of the power company preferred to focus on in their practice of dealing with public opinion as a basis for the content of the early warning indicator system. Therefore, the study interviewed four staff members and one key manager of the publicity department , which is a department dedicated to dealing with online public opinion in the State Grid Corporation of China (Electricity Branch in Sichuan Province). The results of the interviews were collated to classify the content of the indicator system into four first-level indicators: (i) the impact of the event (ii) the breadth of public opinion (iii) the intensity of public opinion (iv) the emotional intensity of public opinion. Under the discussion of the working group, 13 secondary indicators were further set. The whole indicator system is constructed as shown in Table 1.

Table 1. Content of indicator.

First-level indicators	Secondary-level indicators	Third-level indicators
Impact of event	Outage intensity	Reduced supply load
		Grid event level
	The impact of urban operation	The number of voltage losses in the substation
		Whitelisting coverage
	The impact of Social and livelihood	The number of users involved
		The duration of the outage
Dissemination Breadth of public opinion	Attention of authoritative media platform	*Number of media in certain list*
	Attention of self-media platforms	Number of post over 1,0000 view

	Attention of Cross-regional	Number of IP addresses Cross-regional
Dissemination intensity of public opinion	Sensitivity of Topic	Outage size (area range)
		Important User Levels
	Spread of Topic	Number of posts exceeding 30 retweets
		Number of posts exceeding 100 likes
		Number of posts with more than 500,000 followers
	Rise Trend of Topic	Highest rise of per unit in searching
		Highest rise of per unit in posting
Emotional intensity of public opinion	Initial Affective Attitudes	Sentiment Analysis of Initial text
	Secondary affective attitudes	Sentiment Analysis of Comment text
	Emotional dynamics	Highest increases in Negative sentiment per unit

Impact of event refers to the direct tangible impact that occurs during a widespread outage and is an objective description of the outage.Breadth of Public Opinion Concerns refers to the combined scope or consideration of the public attention and interest aroused.Intensity of public opinion dissemination refers to the spread, perception, and upward trend of public opinion as it spreads within a society or community. Emotional intensity of public opinion the depth and intensity of emotional reactions and sentiments expressed by the public on specific issues, policies, or government actions, which highlights the passionate and emotional nature of public attitudes.

4.2 Definition of Weights

The system of indicators shown above is vast. It should be noted that all the numbers in the table is related to the same event, and as what has said above, this research use AHP to define the weights. The square matrix A = $[a_{ij}]$ of order ***n*** having only positive elements and satisfying $a_{ij} > 0$.The structure of a pairwise comparison matrix of order ***n*** is as follows(1):

$$A = \begin{bmatrix} a_{11} & a_{12} & a_{13} & \cdots & a_{1n} \\ a_{21} & a_{22} & a_{23} & \cdots & a_{2n} \\ a_{31} & a_{32} & a_{33} & \cdots & a_{3n} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ a_{n1} & a_{n2} & a_{n3} & \cdots & a_{nn} \end{bmatrix} \quad (1)$$

Where i=j and a_{ij}=1, where i<j and $a_{ij} = \frac{1}{a_{ji}}$.

Further hierarchical single sorting can be reduced to the problem of computing the largest eigenroot of a judgement matrix λ_{max} and its eigenvector W, and satisfying the (2):

$$\lambda_{max} = \sum_{i=1}^{n} \frac{(AW)_i}{nW_i} \quad (2)$$

Finally using *Consistency Indices* to identify the rationality of judgments showing as (1-3). The inconsistency measure ***CI*** is derived as the negative average of the eigenvalues associated with the positive reciprocal matrix A, The ***RI*** indicates that the indicator is obtained by taking the arithmetic mean of several repetitions of the computation of the characteristic roots of the random judgement matrix, and its value is obtained by looking up the given table. The result is showed in **Table 2.**

$$CR = \frac{CI}{RI}, \text{CI}=\frac{\lambda_{max}-n}{n-1} \quad (3)$$

Where λ_{max} is maximum value in square matrix A,and n is the dimension of the matrix.

Table 2. Weight of indicator.

First-level	Weight	Second-level	Weight
Impact of event	0.113	Outage intensity	0.317
		The impact of urban operation	0.358
		The impact of Social and livelihood	0.325
Breadth of public opinion	0.452	Attention of authoritative media platform	0.421
		Attention of self-media platforms	0.356
		Attention of Cross-regional	0.223
Dissemination intensity of public opinion	0.284	Sensitivity of Topic	0.387
		Spread of Topic	0.195
		Rise Trend of Topic	0.418
Emotional intensity of public opinion	0.151	Initial Affective Attitudes	0.215
		Secondary affective attitudes	0.357
		Emotional dynamics	0.428

5 Application of indicator

In order to confirm the accuracy of the indicators above, we used a case from power company that have been deal with, thus we can acquire risk perception of it from the officer dealed with it and compare it with indicators result. If the risk level calculated by the indicator system is similar to the risk perception of the staff, then the indicators have ability to serves as an early-warning model.

5.1 Overview of Case

The dynamics of electricity supply and demand in Chengdu shifted from a state of "scarcity" at its peak in July 2022 to a state of "double scarcity" that persisted throughout the day, triggering the initiation of public deliberations. Beginning on 11 August, the government implemented three levels of measures to safeguard power supply, with comprehensive power restrictions; on 15 August, the government decided to require all industrial power users to suspend production for six days; on 21 August, the provincial government initiated a Level 1 Emergency Response, and on 25 August, the power restrictions were further extended to 11 days. As of 31 August, with the improvement in weather conditions, the pressure on power supply was effectively alleviated, allowing Chengdu to gradually return to normal power supply.

5.2 Collection of data and Preprocessing

Regarding the confirmation of the time of the case, it suggested that the government notification occurred from 15th to 31st in August 2022, with the phrase 'Chengdu outage' on the 17th storming to the top ten list in China on the Sina platform hot-search list and lasting for more than five hours, which generated over 200 million views and 27 thousand discussions. The study analyses public opinion from 9th August to 7th September, with account of incubation and dissipation of public opinion.

5.2.1 Collection of data

There are two main sources served as data collection: first them come from the the State Grid Corporation of China (Sichuan Electricity Branch) referring to "impact of the event" with objective outage data. Second this research further uses the Python crawler to obtain the cyberspace data which can be seen as public opinion. The data mainly from Sina Weibo, TikTok platforms and power company. Sina is a platform including overwhelming users and charactered by instant interaction, thus resulting rapid dissemination of opinions and informing large scale. TikTok is a mainstream short-form video medium in China, which sever as a centralized site for original creators to produce media content, impacting on the dissemination of public opinion.

5.2.2 Processing of data

According to statistics, the case above generated 278,235 pieces post in given list which directed the work in publicity department, while these posts include strikers and some invalid information. Thus, three principles are applied in this study:(i) strikers and symbolic expressions will be filtered out. (ii) Retweeted posts that do not have likes, comments and second retweets are not counted in the analyzed list. (iii) Media platform posts that were less than 5% of the total were excluded from the analysis.

We processed the collected data as follows: firstly, the positive and negative directions of the indicators were judged and the negative indicators were flipped; secondly, the third-level indicators under the same second-level indicator were given equal weight; and thirdly, the value ranges under the third-level indicators were all calculated to [0,1]. This treatment enables the indicator system to be comparable and consistent with the research assumptions implicit in it.

5.3 Dynamic evolution of public opinion

It suggested that dynamic evolution of public opinion plays a paramount role in defining the risk level, and the research analyzed the trend of public opinion in detail. Above all, 149,352 pieces of post are selected, through the Figure 2 we can see the trendency within these 30 days.There are two peaks period of public opinion, one is at 17th August, another is at 5th September.

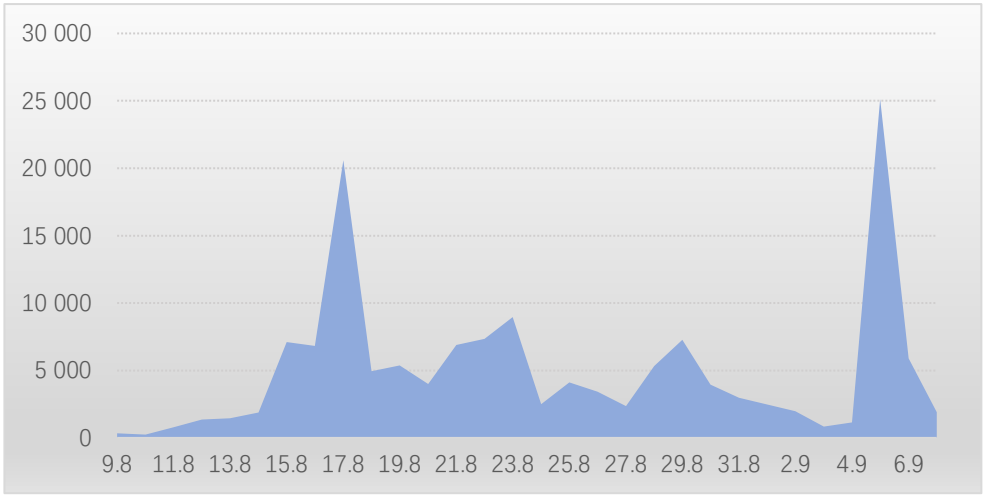

Figure 2 Dynamic evolution of per day.

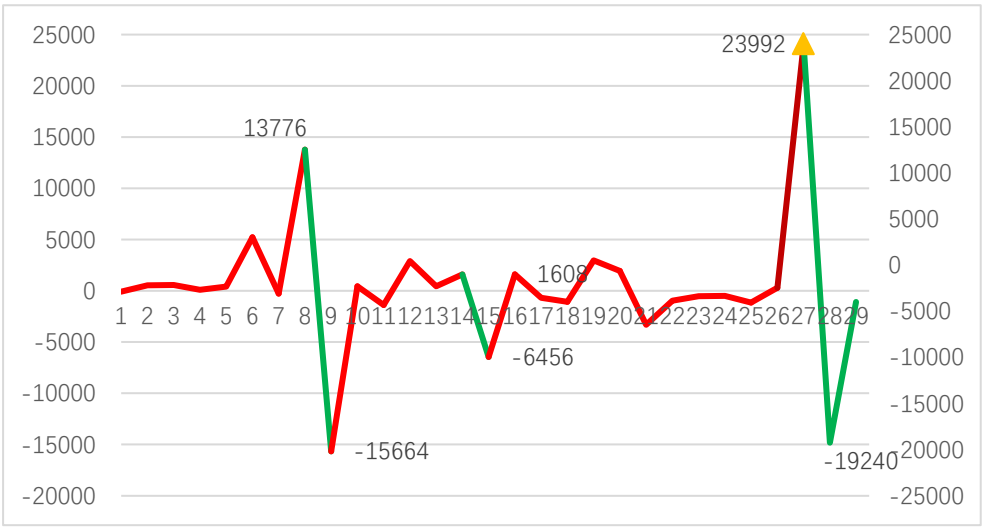

Figure 3 UNIT growth.

Unit growth is also calculated, which is showed in Figure 3. There are two peaks of increasing, showing the same tendency with post number. The peak on August 17 was brought about by the policy announcement, and it is worth noting that the peak on September 5 far exceeded that on August 17 both in terms of total volume and growth. Further analysis of the content of the controversy on September 5 found that the two terms "earthquake" and "power restriction" in the post were highly correlated, which can be interpreted to mean that the measures of having to suspend and restrict power supply due to the high temperatures have not yet been fully completed, and that orderly restoration of power supply was being carried out all over the country, and the news of the earthquake in the city of Luding, Sichuan Province, sparked off a chain of heat in the summer of the double difficulties of the public opinion.

5.4 Assessment of Risk level

In response to the practical needs, we have organized and clarified five distinctive risk levels, each associated with specific response measures. As the risk level escalates, the scope of response from the public relations department responsible for handling sentiment, including the departments to disseminate information and respond to public demands, increases accordingly. The judgment of the five risk levels and the corresponding response scenarios are outlined in the table 3 below,α referring the final scores at the indicator system.

Table 3. Clarification of risk level.

Risk level	Scores Standards	Corresponding Measures
Level I	$0.8 \leq \alpha$	Cooperate with provincial energy departments in repairing circuits and public relations, etc.
Level II	$0.6 \leq \alpha < 0.8$	Integration of existing information to the authorities of municipal energy management in government
Level III	$0.4 \leq \alpha < 0.6$	Marketing Department prepares for external public relations
Level IV	$0.2 \leq \alpha < 0.4$	Sharing information and Providing alerts to relevant company departments
Level V	$0 \leq \alpha < 0.2$	Enhancing public opinion monitoring by Ministry of Communication

Based on the indicator scores, α is defined with 0.4782 , and the selected case has been classified as Risk Level III. After that, we invited 6 officers whose work aims to check public opinion information and share the risk signal to other department. Moreover, 6 experts who work on emergency and public opinion areas also join the assessment. we showed the Description Overview of Case to scorers. Finally, 10 scorers' assessment results are in agreement with ranking by the indicator, and we can initially judge the accuracy of the indicator with 83.33%.

After that, we make compare between the measures in ever practice work at the given case and the measures listing in Table 3. The leader working in Publicity department will apply this indicator into several examples to up accuracy and mentor work.

6 Conclusion

This study is grounded in the practical needs of state-owned enterprises (SOEs) in the context of large-scale power outages in Chinese cities. It has constructed a public opinion risk indicator system that can be applied to actual work scenarios, taking into consideration the specificity of power outage events and exploring the specific requirements of SOEs in managing public sentiment. The developed warning system holds certain reference significance for practical application. However, there are limitations of universal application other countries in this study.

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References

[1] Y. Zhang, L. Xu, C. Deng, W. Mao, H. Jiang, and L. Li, "Resilience Improvement Strategy of Distribution Network Based on Network Reconfiguration in Earthquake Disaster Scenario," presented at the 2023 Panda Forum on Power and Energy (PandaFPE), Chengdu, China, 20233, pp. 2193-2197.

[2] M. Birjali, M. Kasri, and A. Beni-Hssane, "A comprehensive survey on sentiment analysis: Approaches, challenges and trends," *Knowl.-Based Syst.*, vol. 226, p. 107134, Aug. 2021, doi: 10.1016/j.knosys.2021.107134.

[3] X. Huang, H. Jin, and Y. Zhang, "Risk assessment of earthquake network public opinion based on global search BP neural network," *PLOS ONE*, vol. 14, no. 3, p. e0212839, Mar. 2019, doi: 10.1371/journal.pone.0212839.

[4] Z. Luo, Y. Xue, and J. Su, "Evaluating Information Risk Propagation in Complex Public Opinion Environments Based on the Improved Grey Relational Analysis—Decision Making Trial and Evaluation Laboratory Method," *Systems*, vol. 11, no. 9, Art. no. 9, Sep. 2023, doi: 10.3390/systems11090472.

[5] L.-J. Peng, X.-G. Shao, and W.-M. Huang, "Research on the Early-Warning Model of Network Public Opinion of Major Emergencies," *IEEE Access*, vol. 9, pp. 44162–44172, 2021, doi: 10.1109/ACCESS.2021.3066242.

[6] L. Cao, G. Wei, and J. Su, "Public opinion spread risk assessment model on third-party payment rough network," *Appl. Soft Comput.*, vol. 95, p. 106532, Oct. 2020, doi: 10.1016/j.asoc.2020.106532.

[7] W. Jiang, Q. Yong, N. Liu, and Y. Luo, "RAPOT: An Adaptive Multifactor Risk Assessment Framework on Public Opinion for Trial Management," *Wirel. Commun. Mob. Comput.*, vol. 2021, May 2021, doi: 10.1155/2021/5514003.

[8] J. Yan, Y. You, Y. Wang, and D. Sheng, "Understanding the Complexity of Business Information Dissemination in Social Media: A Meta-Analysis of Empirical Evidence from China," *Complexity*, vol. 2021, pp. 1–13, Jun. 2021, doi: 10.1155/2021/7647718.

[9] S. Ren and C. Li, "Public opinion communication mechanism of public health emergencies in Weibo: take the COVID-19 epidemic as an example," *Front. Public Health*, vol. 11, Nov. 2023, doi: 10.3389/fpubh.2023.1276083.

[10] N. Ma, G. Yu, and X. Jin, "Quantified multidimensional public sentiment characteristics on social media for public opinion management: Evidence from the COVID-19 pandemic," *Front. Public Health*, vol. 11, Mar. 2023, doi: 10.3389/fpubh.2023.1097796.

[11] L. Sun and Y. Zhang, "Research on the impact of information interaction between government and media on the dissemination of public opinion on the internet," *Heliyon*, vol. 9, no. 6, p. e17407, Jun. 2023, doi: 10.1016/j.heliyon.2023.e17407.

[12] C. Zhang, N. Ma, and G. Sun, "Using Grounded Theory to Identify Online Public Opinion in China to Improve Risk Management—The Case of COVID-19," *Int. J. Environ. Res. Public. Health*, vol. 19, no. 22, Art. no. 22, Jan. 2022, doi: 10.3390/ijerph192214754.

[13] S. Gao, Y. Zhang, and W. Liu, "How Does Risk-Information Communication Affect the Rebound of Online Public Opinion of Public Emergencies in China?," *Int. J. Environ. Res. Public. Health*, vol. 18, no. 15, Art. no. 15, Jan. 2021, doi: 10.3390/ijerph18157760.

[14] T. Chen, X. Yin, L. Peng, J. Rong, J. Yang, and G. Cong, "Monitoring and Recognizing Enterprise Public Opinion from High-Risk Users Based on User Portrait and Random Forest Algorithm," *Axioms*, vol. 10, no. 2, Art. no. 2, Jun. 2021, doi: 10.3390/axioms10020106.

[15] X. Zeng, "A Composited Framework for High-precision Network Public Opinion Risk Event Prediction," in *2021 4th International Conference on Information and Computer Technologies (ICICT)*,

Mar. 2021, pp. 226–232. doi: 10.1109/ICICT52872.2021.00045.
[16] X. G. Chen, S. Duan, and L. Wang, “Research on trend prediction and evaluation of network public opinion,” *Concurr. Comput. Pract. Exp.*, vol. 29, no. 24, p. e4212, 2017, doi: 10.1002/cpe.4212.
[17] S. Yan, Q. Su, Z. Gong, and X. Zeng, “Fractional order time-delay multivariable discrete grey model for short-term online public opinion prediction,” *Expert Syst. Appl.*, vol. 197, p. 116691, Jul. 2022, doi: 10.1016/j.eswa.2022.116691.
[18] Z. Wang, S. Zhang, Y. Zhao, C. Chen, and X. Dong, “Risk prediction and credibility detection of network public opinion using blockchain technology,” *Technol. Forecast. Soc. Change*, vol. 187, p. 122177, Feb. 2023, doi: 10.1016/j.techfore.2022.122177.
[19] S. Yan, Q. Su, Z. Gong, X. Zeng, and E. Herrera-Viedma, “Online public opinion prediction based on rolling fractional grey model with new information priority,” *Inf. Fusion*, vol. 91, pp. 277–298, Mar. 2023, doi: 10.1016/j.inffus.2022.10.012.
[20] L. Liu, Y. Tu, and X. Zhou, “How local outbreak of COVID-19 affect the risk of internet public opinion: A Chinese social media case study,” *Technol. Soc.*, vol. 71, p. 102113, Nov. 2022, doi: 10.1016/j.techsoc.2022.102113.
[21] B. H. Bishop, “Focusing Events and Public Opinion: Evidence from the Deepwater Horizon Disaster,” *Polit. Behav.*, vol. 36, no. 1, pp. 1–22, Mar. 2014, doi: 10.1007/s11109-013-9223-7.
[22] X. Dong and Y. Lian, “A review of social media-based public opinion analyses: Challenges and recommendations,” *Technol. Soc.*, vol. 67, p. 101724, Nov. 2021, doi: 10.1016/j.techsoc.2021.101724.
[23] G. Blair, A. Coppock, and M. Moor, “When to Worry about Sensitivity Bias: A Social Reference Theory and Evidence from 30 Years of List Experiments,” *Am. Polit. Sci. Rev.*, vol. 114, no. 4, pp. 1297–1315, Nov. 2020, doi: 10.1017/S0003055420000374.
[24] W. Han, X. Liyu, and W. Youzi, “Analysis of the Situation Faced by New Media Propaganda in State-owned Enterprises,” *J. Phys. Conf. Ser.*, vol. 1187, no. 5, p. 052077, Apr. 2019, doi: 10.1088/1742-6596/1187/5/052077.
[25] H. Kallio, A.-M. Pietilä, M. Johnson, and M. Kangasniemi, “Systematic methodological review: developing a framework for a qualitative semi-structured interview guide,” *J. Adv. Nurs.*, vol. 72, no. 12, pp. 2954–2965, 2016, doi: 10.1111/jan.13031.
[26] Y. Liu, C. M. Eckert, and C. Earl, “A review of fuzzy AHP methods for decision-making with subjective judgements,” *Expert Syst. Appl.*, vol. 161, p. 113738, Dec. 2020, doi: 10.1016/j.eswa.2020.113738.
[27] W. Ho and X. Ma, “The state-of-the-art integrations and applications of the analytic hierarchy process,” *Eur. J. Oper. Res.*, vol. 267, no. 2, pp. 399–414, Jun. 2018, doi: 10.1016/j.ejor.2017.09.007.