



Research article

A synergistic study of policy and literature on rumor governance

Jianbo Zhao^{a,*}, Huailiang Liu^a, Haiping Dong^a, Weili Zhang^a, Jige Xin^a,
Xuan Zhou^a, Zhen Wang^b, Xiaojin Zhang^a, Xinyuan Ren^a, Shanzhuang Zhang^a

^a Department of Economics & Management, Xidian University, 266 Xifeng Road, Xi'an, 710071, Shaanxi, China

^b Department of Electronic Engineering, Xidian University, 266 Xifeng Road, Xi'an, 710071, Shaanxi, China

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ABSTRACT

Rumor governance is an important guarantee for social stability and public safety. Based on the life cycle and crisis cycle model, this paper conducts a synergistic analysis of China's rumor governance policies and regulations and the core scientific research literature on rumor governance in WOS and CNKI. In this paper, we use the TF-IDF algorithm to count the word frequencies of 326 policy and regulation texts, the Jieba-RoBERTa-Kmeans model to cluster high-frequency keywords, and CiteSpace software and the LLR clustering algorithm are utilized to extract and cluster keywords from 391 documents in the WOS database and from 703 documents in the CNKI database. Based on the synergistic analysis of the life cycle model, it is found that the research on policies and regulations precedes the research on literature, and both are in the period of refinement. Based on the synergistic analysis using the co-occurrence comparison of subject terms in the crisis cycle model, it is found that there is a lack of research in the stages of prevention, monitoring, and governance, and this paper proposes the systematic governance mechanism and strategy for crisis resolution that conforms to the trend of life cycle evolution and is synergistic with policy and literature. This study has only selected Chinese policies and regulations, and the proposed governance strategies have not yet been verified in practice; future research can expand the scope and depth of the study and conduct empirical research and pilot projects.

1. Introduction

Rumors are speeches that are artificially fabricated without corresponding factual basis and spread through various channels. They have a wide audience, fast dissemination speed, and great influence on society. They can easily negatively impact the normal social order, infringe on the legitimate rights and interests and physical and mental health of the parties and bystanders, and disrupt the normal order of the public opinion field. Especially under the background of the rapid development of the new generation of information and communication technology and the continuous surge of social thoughts in the new era, rumor dissemination presents the characteristics of diversification, concealment and complexity, making rumor governance face the dilemma of "making rumors with a mouthful, debunking rumors with a broken leg".

Facing the challenges posed by rumors to the modernization of the national governance system and governance capacity, both the government and the academic community have increasingly emphasized rumor management. In terms of policies and regulations, the U.S. government has placed emphasis on managing rumors in the financial sector. Several state governments have explicitly stipulated

* Corresponding author.

E-mail address: zhaojianbo@stu.xidian.edu.cn (J. Zhao).

within financial industry regulations the prohibition of disseminating false rumors about financial institutions. Examples include Chapter 434.310 of the Kentucky Revised Statutes [1], Chapter 6.129 of the Louisiana Laws Revised Statutes [2], Title 23 of the Arkansas Code of 1987 [3], and Section 671 of Article 13-D in the Consolidated Laws of New York [4]. The EU government has introduced the "EU Code of Practice on Disinformation" [5] to strengthen self-regulation by internet companies regarding content on platforms, aiming to combat online rumors at their source. Additionally, the EU has enacted the "Digital Services Act" (DSA) [6] and established a rapid alert system to combat online rumors. This system facilitates swift coordination among EU institutions and member states for jointly regulating and implementing emergency measures in response to misinformation. The Chinese government has explicitly prohibited the dissemination of rumors and activities that disrupt social order in several policy and regulatory frameworks. This includes laws such as the "Public Security Administration Punishment Law of the People's Republic of China," [7] the "Regulations on the Management of Internet Information Services" [8], and the "Postal Law of the People's Republic of China." [9] Furthermore, China has consistently conducted special campaigns such as "Clear and Bright" to combat online rumors and misinformation [10–12].

In the field of scientific literature, scholars have extensively explored rumor management from various perspectives, including the mechanisms of rumor propagation, identification techniques, and debunking methods. The mechanism of rumor propagation serves as the foundation for rumor management, focusing primarily on investigating the patterns and principles governing the generation, dissemination, evolution, and cessation of rumors. Scholars have established social network rumor propagation models based on the SIR (Susceptible-Infectious-Recovered) model [13–16], LiveJournal rumor propagation models integrating social network dynamics [17], stochastic rumor propagation models incorporating the Holling II function [18], rumor propagation models incorporating trust mechanisms [19], as well as discrete non-local delay rumor propagation models [20–22]. These models incorporate variables such as transmission factors and propagation time [23,24], utilizing numerical calculations or steady-state analysis to distinguish different variants of rumor propagation algorithms [17,21,25,26]. Furthermore, scholars combine simulation and network models to assess potential impacts caused by rumors, validating results using simulated data, and ultimately proposing strategies for rumor management based on these findings [16,17]. Based on this analysis, we examine the underlying mechanisms of rumor propagation models and study their dynamic properties [21,27–31] and the negative impacts generated by their dissemination [32–35]. Rumor identification is a technical means of rumor management, and machine learning-based identification methods mainly rely on text and user information. These methods focus on feature extraction [36,37] and classifier construction [38–41]. Deep learning-based identification methods have stronger feature learning capabilities and higher classification accuracy compared to machine learning. Mainstream methods include recurrent neural networks (RNN) [42], convolutional neural networks (CNN) [43,44], LSTM [9], Bi-LSTM [45], BERT [46], deep transfer learning, and more. Rumor debunking is an administrative measure for rumor management, and its research can be traced back to World War II [47]. It includes methods such as laws and regulations [48,49], industry self-regulation [50], social supervision [51], public opinion guidance [52,53], government intervention [54], and the establishment of authoritative professional debunking platforms [55]. However, existing research lacks quantitative and systematic analysis that integrates policy regulations with scientific research literature, which is crucial for the effectiveness and efficiency of rumor management. Therefore, this study attempts to fill this research gap by combining objective and accurate data on rumor policies and regulations, scientific research literature, lifecycle models, and crisis cycle models. The aim is to explore a systematic rumor management mechanism and strategies that align with evolutionary trends and crisis-solving characteristics.

The structure of this article is as follows: In the second part, the research methodology of this article is introduced, including the theoretical framework that integrates the lifecycle and crisis cycle models, the process of data collection and text mining, and the resulting findings. The third part presents a systematic analysis of China's policies and regulations on rumor management, as well as the core research literature on rumor management in the WOS and CNKI database, using the research methodology proposed in this article. The analysis reveals research deficiencies. In the fourth part, a mechanism and strategies for collaborative rumor management are proposed. The fifth part discusses the innovation, limitations, and future prospects of text research. The sixth part concludes the research content of this article.

2. Research method

2.1. Theoretical framework

This paper utilizes China's policies, regulations, and literature from WOS (Web of Science) and CNKI (China National Knowledge Infrastructure) as research samples to study rumor governance strategies. By integrating the content of policies and regulations with that of the literature, it employs the life cycle and crisis cycle models as analytical frameworks. The paper discusses the current state and challenges of rumor governance from various perspectives and levels, proposing strategies that are in line with evolutionary trends and the characteristics of crisis resolution. The life cycle model [56] can reflect the development process of rumor governance in policy and regulation and literature fields, and analyze the evolution of policy and regulation content and literature content from the budding stage, development stage, and improvement stage, providing high timeliness evidence that conforms to the evolutionary trend for the proposal of strategies. The crisis cycle model [57] analyzes the crisis communication theory model, and conducts analysis from three dimensions of prevention, emergency response, and aftermath for the three stages of before, during, and after the crisis, providing high reliability evidence that conforms to the development life cycle of public safety events for the formulation of strategies.

2.2. Data collection

This paper analyzes the current situation and problems of rumor governance based on policy and regulation and literature samples.

The policy and regulation samples were obtained by using "rumor" as the keyword to conduct a full-text fuzzy search in the PKU Law database, and 413 policy and regulation texts issued by the National People's Congress, the State Council, the Supreme People's Court, and the Supreme People's Procuratorate were obtained. After manual screening, irrelevant, duplicate, and invalid samples were eliminated, and 326 samples were finally obtained [58]. The literature samples were retrieved from the core collection of WOS database using rumor-related words "rumor", fake news, disinformation" and governance-related words "govern*", manage*", control*", administer*" to combine keywords, and using wildcards "\$" and "*" to ensure the completeness of the articles [59,60]. The literature sample were retrieved from the CNKI database using "rumor management" as the subject term for journal data retrieval. Articles relevant to "rumor management" were selected through manual reading of titles, abstracts, and other information. In total, 391 documents from the WOS database and 703 documents from the CNKI database were selected [61].

2.3. Text mining

In order to conduct relevant analysis and research on the policy and regulation and literature text data, this paper uses text mining methods to process the data, which are: first, extracting the high-frequency keywords of the text; second, conducting co-occurrence analysis and cluster analysis on the high-frequency keywords.

2.3.1. Text data processing of policies and regulations

(1) Jieba Chinese Segmentation

This paper uses the Jieba Chinese Word Segmentation Library and HIT Stopword List to segment the 326 policy and regulation texts. Then, the TF-IDF algorithm is used to extract the top 20 keywords in terms of importance ranking in each policy and regulation. Each keyword that appears in the policies and regulations is counted only once in the frequency statistics, and the total word frequency is calculated. After manual screening, the TOP30 policy text high-frequency keywords and corresponding word frequencies are obtained as shown in Table 1.

Using the RoBERTa model, the high-frequency keywords are converted into word vectors, and the K-Means method is used to cluster the word vectors. According to the clustering results, the reverse optimization is performed, and the main processes are as follows.

(2) RoBERTa word embedding layer

Each module of RoBERTa model contains multi-head attention mechanism, residual connection and layer normalization, and feed-forward neural network. The word vectors are obtained from the high frequency keywords by one-hot coded representation and the positional coding indicates the relative or absolute position of the word in the sequence, and the word embedding vectors generated by the superposition of the two are used as the inputs X. The Multihead Attention Mechanism performs the parallel operation on the inputs using multiple independent Attention modules with the formulas shown in (1):

$$\text{Attention}(Q, K, V) = \text{Softmax}\left(\frac{QK^T}{\sqrt{d_k}}\right)V \tag{1}$$

Where $\{Q, K, V\}$ is the input matrix and d_k is used as the input matrix dimension. The computed hidden vectors are residual connected with layer normalization, and then the inputs are operated by two fully connected layers of the feed forward neural network, as shown in (2):

$$W_e \max(0, XW_0 + b_0)W'_0 + b' \tag{2}$$

Where $\{W_e, W'_0\}$ is the weight matrix of the two connection layers and $\{b_e, b'_0\}$ is the bias term of the two connection layers.

After the operation, the RoBERTa model better captures the semantic information of the text and obtains the word vectors of high-

Table 1
TOP30 policy text high-frequency keywords and corresponding word frequencies.

Keyword	Frequency	Keyword	Frequency	Keyword	Frequency
rumor	212	science popularization	31	Public sentiment	21
spread	69	politics	30	dispel doubts	21
disseminate	62	stability	30	clarify	19
network	43	propaganda	30	media	18
strengthen	42	epidemic situation	27	internet	18
disrupt	41	public	26	discipline	18
public opinion	38	release	25	authority	17
social order	35	debunk rumors	25	safety	17
guide	34	science	24	fabricate	15
damage	33	response	23	supervise	12

quality high-frequency keywords with high dimensionality and rich semantic information.

(3) K-means clustering

Randomly select k initial points to get k classes, after continuous iteration, so that the clustering results of the loss function is minimized, the loss function can be defined as the sum of the squares of the errors of the distance of each sample point from the center point of the cluster to which it belongs, the formula is shown in (3).

$$L(\alpha, \mu) = \sum_{i=1}^N \|x_i - \mu_{\alpha_i}\|^2 \tag{3}$$

Where x_i represents the i th sample, α_i is the family to which x_i belongs, μ_{α_i} represents the corresponding centroid, and N is the total number of samples.

After the calculation by the Jieba-RoBERTa-kmeans model, as illustrated in Fig. 1, the high-frequency keywords of the policy text are clustered into 3 themes. The results, presented in Table 2, represent the different cycles of rumor management and summarize, from a macroscopic perspective, the main measures and strategies adopted by the government and related agencies in the rumor management process.

Topic 1 refers to rumor prevention and information release, including words such as social order, guidance, science popularization, propaganda, etc. In the early stage of public opinion guidance, the government, authoritative institutions, and mainstream media release authoritative information through guidance, science popularization, and other means to prevent the public from being misled by rumors. Scientific propaganda and authoritative release can help the public improve their ability to identify rumors, thus ensuring that the Internet becomes a healthy and safe information exchange platform.

Topic 2 refers to rumor supervision and public participation, including words such as supervision, politics, public, etc. Political public opinion supervision is a necessary duty of the government and relevant institutions, and the sensitivity of public opinion affects political stability and social security. In the stage of rumor supervision, the government strengthens public opinion monitoring, timely

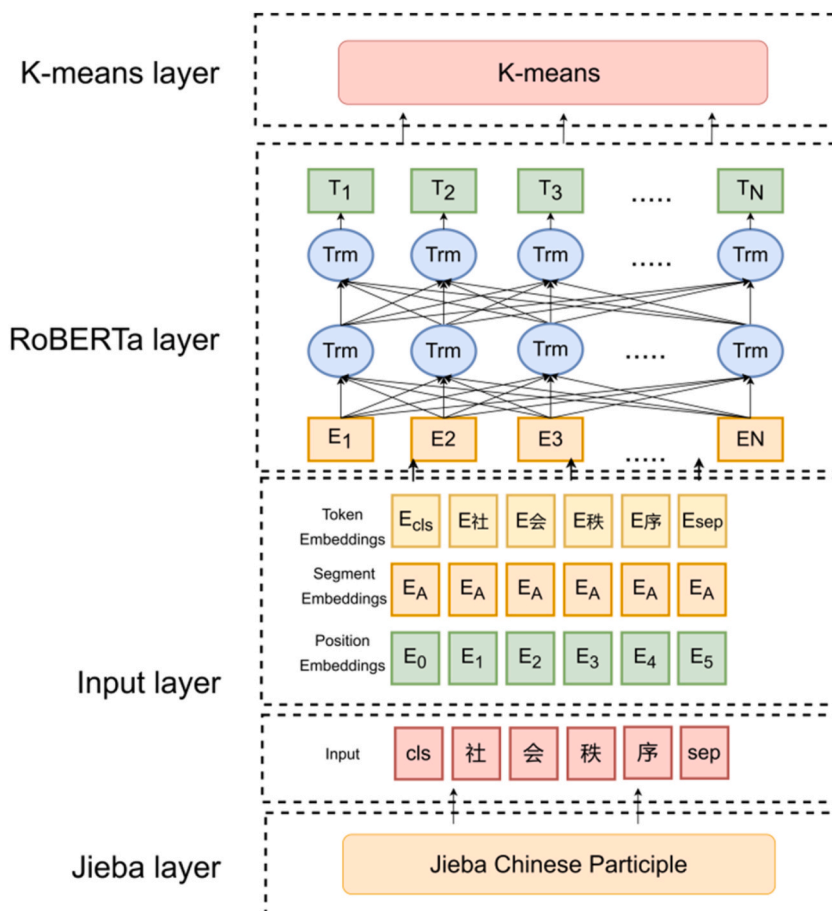


Fig. 1. The high-frequency keywords clustering model for policy text based on Jieba-RoBERTa-kmeans.

Table 2
Keyword clustering table of policy text.

Topics	Keywords(In descending order of frequency)
Topic 1	Rumor, Spread, Disseminate, Social order, Stability, Strengthen, Network, Guide, Science popularization, Propaganda, Release, Science, Media, Internet
Topic 2	Public sentiment, Politics, Public opinion, Discipline, Safety, Supervise
Topic 3	Disrupt, Damage, Epidemic situation, Debunk rumors, Response, Fabricate, Dispel doubts, Clarify, Authority

discovers, and responds to the dissemination of rumors and false information. At the same time, it gradually improves the public reporting system.

Topic 3 refers to debunking rumors and handling emergencies, including words such as epidemic situation, debunking rumors, response, fabrication, clarification, etc. To effectively deal with rumor dissemination and the impact of rumors on emergencies, authoritative institutions can timely respond to and clarify rumors, dispel doubts, and convey scientific and accurate information. For example, in the process of COVID-19 prevention and control, debunking rumors and scientific propaganda have become very important. The government, medical scholars, and mainstream media cooperate to deliver reliable information to the public. At the same time, rumor disseminators are dealt with according to law.

2.3.2. Data processing of document text

In this study, CiteSpace software was used to extract keywords and conduct cluster analysis on 391 documents from the WOS database and 703 documents from the CNKI database separately. After data processing, it was observed that the keywords and clusters of the literature data were highly relevant to the theme of rumor management. Tables 3 and 4 below present the top 30 high-frequency keywords extracted from the texts of the WOS and CNKI databases, along with their corresponding frequencies.

The LLR algorithm [62] was selected as the clustering algorithm for this study. The keywords were clustered, and the resulting literature keyword cluster maps for both WOS and CNKI databases are shown in Figs. 2 and 3, respectively.

Combining the two clustering diagrams, it can be observed that "#1 rumor spreading" and "#7 rumor propagation," "#5 social networking" and "#11 social network," as well as #0 Online rumors, #3 Weibo rumors, #7 Epidemic rumors, #8 WeChat rumors and #10 misinformation. are repeatedly mentioned as synonyms. They are merged into "#7 rumor propagation," "#11 social networks," and #0 Online rumors respectively. At the same time, the search terms #4 Governance and #5 Rumors are excluded from this study. After cleaning up the clustering results, this paper obtained 19 research topic word clusters that reflect the field of rumor governance. In order to further study the content of rumor governance field, based on the application of the crisis cycle model, a second clustering was conducted under human-machine collaboration. Finally, 19 clusters were divided into three main stages of rumor governance: rumor prevention stage, rumor monitoring stage, and rumor governance stage. The specific clustering results are shown in Table 5.

Combined with Tables 5 and it can be seen that different stages of rumor governance have different research focuses. Among them, in the rumor prevention stage, the main source of rumors is online rumors related to some sudden public safety events. During this stage, the focus is on studying how governments, institutions, and media can establish transparent and trustworthy communication channels to alleviate and understand the public's distrust of information, while also enhancing the accuracy and transparency of information dissemination to improve government credibility. For businesses and institutions, the emphasis is on exploring how to establish a good brand image and effective promotional methods to prevent rumors. In the rumor monitoring stage, the main research is to develop artificial intelligence technology and blockchain technology to analyze and mine a large amount of information through algorithms and models; to quickly identify potential rumor information; to help accurately locate the source of rumor dissemination; to monitor and analyze social networks; to help quickly discover signs of rumor dissemination; to take corresponding measures to stop it; to use blockchain technology for rumor data recording and tracing. During the stage of rumor governance, in-depth exploration of game theory and optimal strategy theory is conducted to assist in formulating effective governance measures. Utilizing methods such as information governance and network governance, timely interventions and refutations of rumors are employed, selecting appropriate timing and methods to achieve maximum effectiveness at minimal cost. Additionally, identifying and intervening in influential nodes effectively mitigates the speed and impact of rumor propagation, thereby preventing the proliferation of rumors and contributing to social stability.

Table 3
TOP30 high frequency keywords and corresponding word frequencies in the WOS.

keyword	Word frequency	keyword	Word frequency	keyword	Word frequency
fake news	61	Epidemic model	25	social network	14
spreading model	54	media	25	propagation model	13
social media	52	diffusion	23	global stability	12
information	35	rumor spreading	23	online social networks	11
complex networks	32	impact	23	influence maximization	11
dynamics	31	model	20	stability	10
rumor propagation	29	optimal control	20	twitter	10
social networks	28	behavior	18	rumor control	10
propagation	25	centrality	16	misinformation	10
mechanism	25	stability analysis	15	identification	8

Table 4
TOP30 high frequency keywords and corresponding word frequencies in the CNKI.

keyword	Word frequency	keyword	Word frequency	keyword	Word frequency
Online rumors	418	Weibo rumors	15	Epidemic	11
Governance	106	COVID-19 epidemic	15	Major epidemic	10
Rumor	95	Weibo	15	Governance path	10
Rumor management	87	Propagation mechanism	15	Transmission characteristics	10
Rumor dissemination	31	Governance mechanism	13	Social media	9
Governance measures	25	Harm	13	Countermeasures	9
Emergency events	23	Dissemination	13	Information disclosure	9
Collaborative governance	20	Self-media	12	New media	9
public health emergency	17	COVID-19	12	Sudden public event	9
Governance strategies	16	WeChat rumors	12	Public crisis event	8

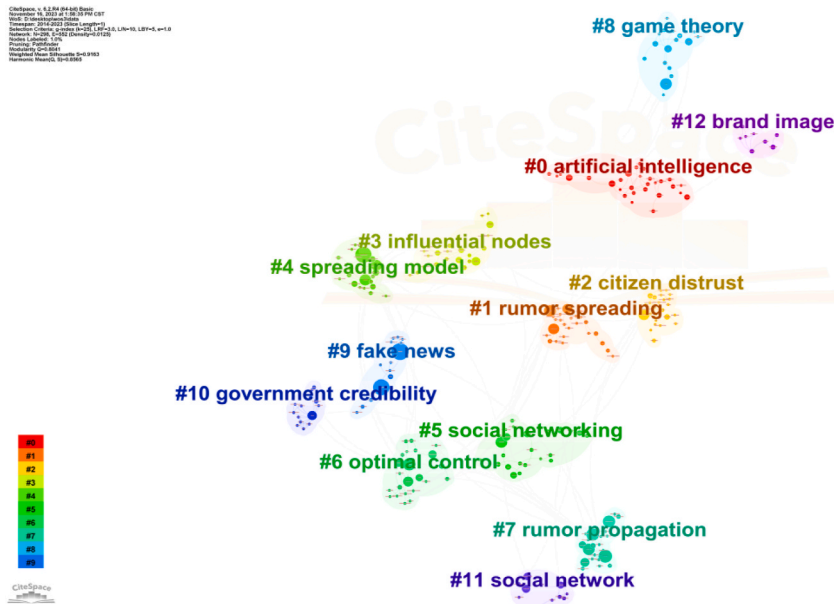


Fig. 2. Keyword clustering map in WOS.

3. Content analysis

3.1. Life cycle analysis of policies, regulations and literature

This paper introduces the life cycle model to the study of rumor governance in policies and literature and divides them into three stages: the budding stage, the development stage, and the improvement stage according to their quantity changes, reflecting the development process and current situation of the rumor governance field. By drawing the annual quantity changes and development stage division charts of policies, regulations, and literature, as shown in Fig. 4, a collaborative analysis is conducted.

Based on the annual publication volume, the lifecycle of policies, regulations, and literature can be divided into.

- (1) Germination Period (1983–2009): During this period, both the policy issuance and literature publication volumes were relatively low and grew slowly, marking the initial exploration stage of rumor management. Although both were in their germination phase, policy research began in 1983, while literature research started in 2005, with policy research preceding literature research.
- (2) Development Period (2009–2020): In this period, the number of policies and literature saw a significant increase due to long-term accumulation, representing the explosive research stage of rumor management. Despite fluctuations in numbers, the overall research outcomes were very significant, especially by 2020, with 36 policies and 173 pieces of literature published.
- (3) Maturation Period (2020-present): The quantity of policies and literature has stabilized after a period of explosive growth, signifying a steady improvement phase in rumor management. It is anticipated that in the coming years, research on rumor management will reach a very mature stage.

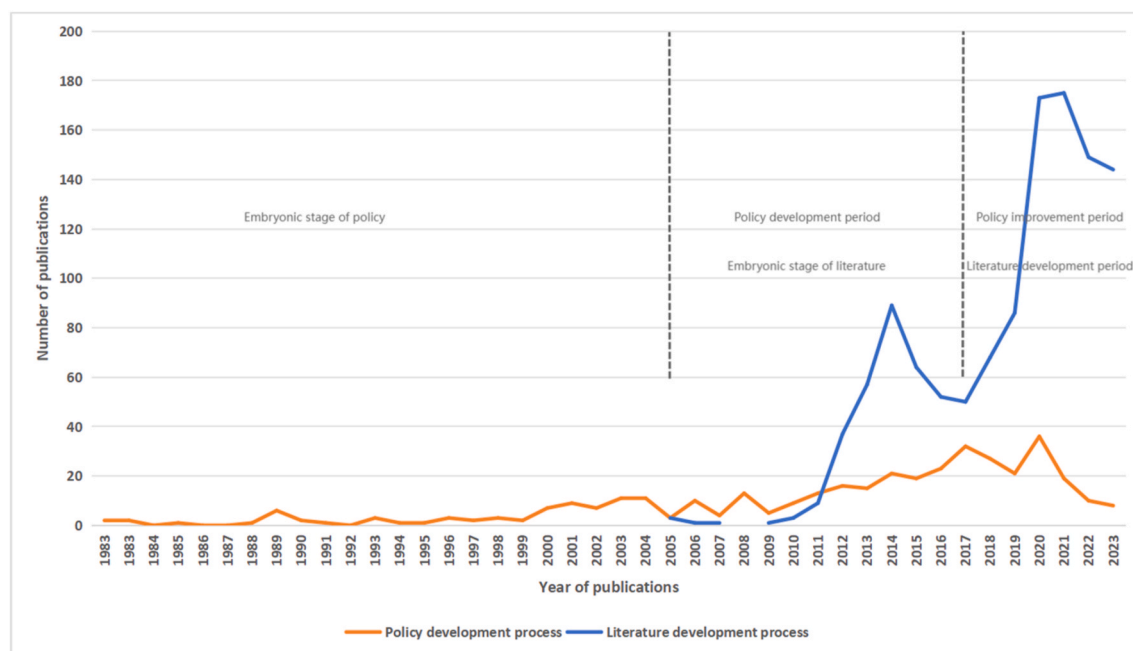


Fig. 4. Annual quantity changes and development stage division charts of policies regulations, and literature.

and response, truly achieve decision-making disclosure, execution disclosure, management disclosure, service disclosure, result disclosure throughout the whole process of work, conduct information release and public opinion response for emergencies, prevent rumor generation and spreading [63]. The Notice of Strengthening the Prevention and Control of Food Safety Rumors and Governance Work by the State Council Food Safety Office and 10 Other Departments” states that central government departments should adhere to the principle of “disclosure as the norm, non-disclosure as the exception”, timely disclose accurate and complete food safety supervision information through various means, so as to limit the space for rumor dissemination [64].

(2) Pre-stage public opinion guidance

This type of policy and regulation requires relevant departments to strengthen science popularization propaganda, conduct public opinion guidance and management according to law and regulations, use authoritative scholars to provide scientific interpretation of information, conduct positive propaganda guidance through various media such as radio, television, newspapers, internet new media, etc., form good social expectations, rectify rumors and pseudo-science information in network communication, improve and guide the public’s cognition level on related issues. “Opinions of the Communist Party of China (CPC) Central Committee Leading Group of the Ministry of Natural Resources on Further Strengthening the Education of Ideal Beliefs and Ethical Values” emphasize “doing a good job in public opinion guidance, implementing ‘responsibility for guarding the land’”, requiring party members and cadres to have clear ideological understanding, strengthen public opinion guidance, avoid losing direction on major principles and values [65]. The National Health Commission repeatedly emphasized the importance of public opinion guidance and propaganda in public cognition of voluntary blood donation work in its reply to the 8131th proposal of the National Health Commission in 2020. It stressed that the State Administration of Radio, Film and Television should make good use of radio, television and network media channels to disseminate knowledge related to voluntary blood donation, enhance the effectiveness of public opinion propaganda [66].

(3) Prohibition of rumor dissemination

This type of policy and regulation requires the government to formulate laws and regulations to clearly prohibit the dissemination of rumors, false information and disturbing social order, and hold violators accountable according to law. Article 14 of “Regulations on the Management of Internet Access Service Business Places” explicitly stipulates the content of prohibiting rumor dissemination, and requires relevant units and individuals not to use Internet access service places to disseminate relevant information. The State Administration of Press, Publication, Radio, Film and Television successively issued a series of regulatory documents such as “Notice on Taking Practical Measures to Stop False Reporting”, “Measures for the Administration of Press Cards”, “Several Provisions on Strictly Preventing False News Reporting”. These documents require press publishing radio and television media to improve their editing system, strengthen editing management, ensure that news reports are true, accurate, comprehensive, objective, and fair. The administrative departments of press, publication, radio, film and television at all levels adhere to administration according to law, continuously strengthen and improve the management of press, publication, radio, film and television media, strictly enforce news

discipline, crack down on news extortion and fake news, investigate and expose a number of typical cases, ensure that relevant reports are objective and accurate, and hold accountable those units or individuals who maliciously hype or spread rumors according to law and regulations [67].

3.2.1.2. Rumor monitoring stage. Government departments attach great importance to public opinion monitoring and public reporting in rumor governance, establish a public opinion monitoring mechanism, actively respond to online public opinion, and encourage the public to participate in reporting rumors, to provide accurate information and eliminate the impact of rumors.

(1) Public sentiment monitoring mechanism

This type of policy and regulation requires government departments to establish and improve the mechanism of public opinion collection, analysis and response, closely follow the public's doubts and misunderstandings about government work, monitor the development trend of online public opinion, and timely obtain relevant information. The Ministry of Agriculture in its 2016 information disclosure work report proposed to establish a public opinion monitoring, analysis and response mechanism, closely monitor the development trend of agricultural public opinion, through the central mainstream media publications, organize scholars to provide scientific interpretation and other forms, timely respond to public opinion, quickly clarify rumors. "Opinions of the General Office of the State Council on Further Strengthening Government Information Disclosure, Responding to Social Concerns, and Enhancing Government Credibility" require all regions and departments to establish and improve the mechanism of public opinion collection, analysis and response. These mechanisms are closely related to the detection work of public opinion related to government work, which can sensitively capture the external doubts, misunderstandings, distortions and rumors about government work, and timely organize scholars to interpret, hold press conferences and other ways to dispel doubts, clarify facts [68].

(2) Public reporting channels

This type of policy and regulation reflects the government's attention and intention to govern rumor reporting, by strengthening public opinion monitoring, tracing the source of rumors, improving the reporting system and strengthening supervision and inspection, aiming to reduce the spread of rumors, maintain social order and public interest. At the same time, it emphasizes the protection of the rights and interests of reporters, encourages the public to actively participate in rumor governance, and forms a joint force of the whole society to resist rumors. "Implementation Opinions on Further Encouraging the Vast Cadres of the Ministry of Education to Take on New Responsibilities and New Actions in the New Era" emphasize the strict implementation of the letter inquiry reply acceptance feedback system, report rumors through letters and visits, and protect the enthusiasm of cadres in the new era [69]. The Outline for the Implementation of Social Governance under the Rule of Law (2020–2025) states that a sound integrated acceptance and disposal system for illegal and harmful information on the Internet should be established to maintain the online public opinion environment [70]. "The opinions of the General Office of the State Council on Establishing and Improving a Comprehensive Regulatory System for Elderly Care Services to Promote High-Quality Development of Elderly Care Services" also emphasize the optimization of elderly care service complaint reporting acceptance process, strengthening public opinion supervision, and promoting stable and rapid development of elderly care service field [71].

3.2.1.3. Rumor governance stage. The policy and regulation at this stage aim to maintain social order, safeguard public safety and stability, and provide scientific and accurate information to the public, by formulating relevant regulations, building scientific rumor dispelling platforms, strengthening cyberspace governance, etc., to prevent rumors from spreading and causing adverse effects on society.

(1) Establishing rumor dispelling mechanism

This type of policy and regulation requires the government to establish a rumor dispelling mechanism, dispel rumors involving rumor content, point out the source of false information and factual truth. Government departments and enterprises are jointly responsible for rumor dispelling work, timely take measures to clarify rumors, protect the public's right to know and legitimate rights and interests. Especially in food safety field [72], since 2010, the State Council Food Safety Office has required food safety supervision departments to strengthen food rumor analysis on regularity and characteristics, establish rumor case database, improve identification and judgment efficiency for similar rumors and seasonal rumors, take measures to stop rumor dissemination, and clarify truth in appropriate ways [73]. In order to purify cyberspace and maintain social stability, the Cyberspace Administration of China pointed out that information service providers should establish a sound network audio-visual rumor dispelling mechanism to crack down on false video and audio dissemination behavior, ensure good network ecology, create a healthy and safe online environment for netizens [74].

(2) Punishing rumor makers

This type of policy and regulation requires the government to strengthen supervision and disposal of network rumors, urge network operators to strengthen management of user information release. For individuals and organizations that create and spread rumors, the government shall hold them accountable according to law, severely crack down on rumor behavior. At the same time, strengthen

cooperation with public security organs, pursue criminal responsibility according to law for those suspected of committing crimes by creating rumors. Since 2014, China has started to crack down on rumor prevention and control in food drug, agricultural production and other fields [75]. Since 2020, legislation has severely punished those who fabricate false epidemic information and deliberately spread it online or through media [76], seriously disrupting social order. Through these measures, rumor-making crimes are severely cracked down, ensuring that the public obtains accurate information, maintaining social stability.

(3) Special action governance For rumor-making, spreading and other illegal and criminal acts

This type of policy requires the government to organize special actions, strengthen the rectification of organizations that create and spread rumors, and at the same time, strengthen social security and stability work, carry out special actions to combat terrorism, severe violence crimes, telecommunication fraud, food and drug crimes, etc. Since 2020, the Cyberspace Administration of China has launched the "Clear and Bright · Crack Down on Network Rumors and False Information" special action, cleaning up more than 54.3 million illegal and harmful information [77], focusing on governing the network chaos of creating and spreading false and untrue information. In the economic and social development, special rectification is carried out for the hot issues of honesty and the dishonest and immoral behavior that the people are concerned about.

3.2.2. Crisis cycle analysis of literature studies

The literature review analyzes the research content and methods of three stages, involving science popularization education and propaganda, information openness and transparency, rumor detection and dissemination monitoring model, rumor clarification and evaluation feedback mechanism, etc.

3.2.2.1. Rumor prevention stage. The literature in this stage mainly discusses how to improve the public's ability to identify and resist rumors through science popularization education and propaganda, information openness and transparency, etc., and prevent the generation and dissemination of rumors from the source.

(1) Science popularization education and propaganda

Science popularization education and propaganda is to enhance the scientific literacy and rumor identification ability of citizens through education and guidance, thereby reducing the influence of rumors. He et al. [78] argued that science popularization education can significantly reduce the likelihood of people believing rumors, and gave some successful examples. Huo et al. [79] introduced two control strategies of scientific knowledge popularization and rumor clarification, and found that these two control strategies can effectively suppress the spread of rumors, increase the spreaders of true information, and reduce the spreaders of rumors. Du Zhiqiang and Zhi Shaorui [80] argue that the fundamental solution to eradicating political rumors on the internet lies in the government's reinforcement of ideological and political education among netizens, as well as the enhancement of their political literacy. They provide specific implementable measures as examples. Fu Hong and Du Zhitao [81], combining the perspectives of "self-organization" in the ubiquitous network environment and the organizational regulation of citizen education by social media from the perspective of "other-organization," construct a rational citizen education system. This system lays a foundational framework for China's long-term governance mechanism in cyberspace.

(2) Information openness and transparency

Information openness and transparency means that the government or media timely release authoritative, accurate, and complete information, to eliminate information asymmetry and uncertainty, and thus avoid the breeding and spreading of rumors. Chen et al. [82] studied the three processes of rumor generation, dissemination and elimination, and showed through mathematical models and experimental simulations that timely information openness and transparency, popularization of scientific knowledge, and improvement of citizens' discernment are effective measures for rumor governance. Zhang Zhaoguo [83] uses the Wenchuan earthquake as an example to illustrate that open information not only can curb the spread of rumors but also enhance government credibility. Huang Hongkai [84] proposes that the uncertainty, ambiguity, and asymmetry of information are the main reasons for the generation and dissemination of rumors, and suggests that achieving transparency and openness in the process of responding to emergencies is an effective approach to prevent and reduce the generation of rumors.

3.2.2.2. Rumor monitoring stage. The literature in this stage mainly focuses on how to use computer technology and mathematical models to detect and monitor rumors on social media, so as to timely discover and deal with rumors.

(1) Rumor detection model

Rumor detection model is an information veracity classification task, which is used to judge the truthfulness of messages on social media. Early research used machine learning-based classifiers, such as Jiang, Li, Ul Haq, Saboor, & Ali, (2021) [40] proposed a stacking classifier based on transformer and support vector machine to achieve rumor detection; Kaur, Kumar, & Kumaraguru, (2020) [36] constructed a multi-level voting model for rumor detection based on 12 machine algorithms including logistic regression, decision tree,

etc. With the development of deep learning, Al-Sarem, Alsaeedi, Saeed, Boulila, & AmeerBakhsh, (2021) [85], Kumar, Asthana, Upadhyay, Upreti, & Akbar, (2020) [86] used a hybrid deep learning model of CNN and LSTM to improve the fast rumor detection based on text; Ma, Gao, Wong, & Assoc Comp, (2019) [87] used adversarial learning and other methods to detect rumors. Wen Tinxin and Gao Qian [88] propose a BiLSTM–CNN–ECA model that combines multi-granularity semantics from both within and outside Weibo to address the problem of incomplete semantic feature extraction in rumor detection caused by the ambiguity and complexity of Weibo text. He Xiaoxia et al. [89] present the BERT-BiLSTM-LML model for continuous Weibo rumor detection based on BERT and BiLSTM.

(2) Rumor dissemination monitoring model

Rumor dissemination monitoring model is a mathematical model used to describe and predict the diffusion pattern of rumors in social networks. Some studies draw on the epidemic spreading model, such as Zhao et al. (2012) [90] adopted the SIHR model, introduced four time periods of susceptible, infected, dormant, and cleared, and simulated the way of rumor spreading in real social networks; Afassinou, (2014) [91] proposed the SEIR rumor spreading model, and pointed out the key role of memory and education factors in rumor spreading. Some studies established a quasi-random rumor spreading model, Zhao, Qiu, Wang, & Wang, (2013) [92] considered the attractiveness and ambiguity of rumor content, and enhanced the realism of the model. Chen An et al. [93] improve the SEIR model by considering factors such as government intervention lag, individual information acceptance conformity, and characteristics of rumor propagation. They construct a dissemination model for pseudo-scientific network rumors during major public health events. Li Zhihong and Zhuang Yunbei [94], building upon the traditional D-K rumor propagation model, propose a new Unknown-Rumor spreader-Non-rumor spreader-Silencer (IS, S_n R) model that accounts for the competitive spread of rumor and non-rumor information.

3.2.2.3. Rumor governance stage. The literature in this stage mainly focuses on how to take quick actions after the rumor is generated, and eliminate or mitigate the losses and harms caused by the rumor. In this stage, the literature mainly discusses how to use rumor clarification and evaluation feedback methods to reduce the harm of rumors to the public and society.

(1) Rumor clarification

Rumor clarification is to explain the truth of rumors by authoritative institutions or individuals, and point out the source and factual truth of rumor information. Yi et al. [95] proposed a new Twin-SIR spreading model, introducing rumor clarification nodes with spreading ability "rumor dispersers", to control the spread of rumors and achieve the purpose of clarifying rumors. Yang et al. [96] analyzed five socialized rumor clarification models for health-related rumors, verified the value of socialized collaboration in rumor clarification, and advocated and encouraged multi-agent participation in synergistic rumor control. Wang Ming [97] analyze the "Douyin Rumor Refutation" platform, created based on a crowdsourcing model, which extensively promotes user participation in the process of rumor management. They validate the advantages of crowdsourced rumor refutation and provide recommendations for government public opinion management departments to construct crowdsourced rumor refutation mechanisms. Xu Qi and Luo Xuedan [98], using the COVID-19 pandemic as an example, depart from the theory of collaborative rumor refutation and empirically demonstrate the collaborative performance of official commercial background rumor refutation platforms during the pandemic. They establish a decentralized, human-machine collaborative platform governance paradigm.

(2) Evaluation feedback

Evaluation feedback should be conducted promptly following rumor governance to assess the impact of rumors, accumulate experience, and derive lessons to enhance the governance mechanism. Li et al. [99] proposed methods to enhance the effectiveness of social media rumor refutation by providing factual evidence, using authoritative information sources, choosing appropriate information frames, etc. through indicator and key factor analysis. Kropf, Wood, & Parsons, (2023) [100] found that factual frames and third-party media help to correct rumors. They suggested that organizations should develop risk management strategies when facing rumors, and pay attention to the frames and sources of information. Ma Chao [52] found that in terms of the characteristics of information dissemination, different entities involved in refuting rumors have their own advantages. There is a tendency towards "elitization" in the community structure, suggesting that the role of "opinion leaders" should be emphasized in the process of collaborative rumor management. Wang Chao [101] point out the significant role of scientific journals in rumor management during public health emergencies. They highlight the importance of using big data to capture public opinion hotspots and providing crucial evaluations, feedback, and experience summaries for rumor management.

3.2.3. A synergistic analysis of the crisis cycle of policy, regulation and literature research

To further analyze the synergy between rumor governance policies and literature, this paper uses grounded theory method, based on the keywords in Tables 1 and 3, combined with the research content of policies and literature, to display them in a keyword fusion way [102], as shown in Table 6. " $\sqrt{\quad}$ " represents that policies or literature are involved in the field, and " \times " represents that there is a lack of research in this aspect. Based on the synergistic analysis theory, this paper compares the keywords in policies and literature, and believes that the keywords that appear synergistically reflect the healthy development status of the field; while the keywords that do

not appear synergistically expose the problems and deficiencies of the field. Therefore, this paper digs out the problems to be solved in rumor governance field from the topics that are not synergistic between policies and literature.

3.2.3.1. Rumor prevention stage. As can be seen from Tables 6 and in the prevention stage before rumors are generated, both policies and regulations and literature have some research content, but there are also some shortcomings: first, there is a lack of formulating information needs and reception methods for different groups, regions, and scenarios, and a lack of corresponding information content standards, resulting in a lack of pertinence and effectiveness of information. Second, there is a lack of using media platforms to conduct legal education, and a lack of popularizing laws and regulations related to rumors, resulting in a decline in public awareness and compliance with rumors. Third, there is a lack of establishing and improving the multi-party synergistic mechanism for media platforms, public, society, etc., and a lack of dynamically adjusting and updating rumor prevention measures.

3.2.3.2. Rumor monitoring stage. During the monitoring phase of rumor generation, both policy and literature have addressed certain aspects, but there are also some shortcomings: Firstly, there is a lack of legislative support and resource allocation for rumor monitoring technology during the rumor monitoring stage. The scarcity of resources such as policies, funding, and manpower makes it difficult to formulate and implement relevant policies, hindering the full development and improvement of rumor monitoring technology. Secondly, there is a lack of channels and incentive mechanisms for the public to report clues during the monitoring stage, leading to suppressed public enthusiasm for discovering and reporting rumors. This limitation hampers the effectiveness and comprehensiveness of rumor detection, potentially resulting in many potential rumors not being promptly exposed and corrected.

3.2.3.3. Rumor governance stage. In the governance stage after rumors are generated, both policies and literature have some research content, but there are also some shortcomings: first, there is a lack of special governance in the form of personalized and customized governance for different targets and objects of rumors, which cannot effectively solve and govern special types of rumors. Second, there is a lack of post-education work after rumor governance. Citizens cannot fully understand the mechanism and harm of rumor generation after experiencing rumors, which will not effectively improve their own rumor prevention awareness. Third, there is a lack of establishing and improving the evaluation mechanism and feedback mechanism. If they cannot timely summarize experience and lessons, cannot timely evaluate the effectiveness and rationality of rumor governance measures, they will not be able to provide effective help for the next rumor prevention and governance.

In summary, through synergistic analysis, it can be found that there is still a common defect in the current rumor governance: whether it is the formulation and implementation of policies and regulations or the content and methods of literature research, they have not formed a complete, synergistic rumor governance system, which is difficult to achieve effective connection and conversion of various links such as monitoring and intervention, prevention and disposal, rumor dispelling and clarification, etc.

4. Recommendations for countermeasures

Based on the results of the life cycle and crisis cycle synergistic analysis, this paper finds that there are some research gaps in the three stages of rumor governance, and proposes a rumor governance strategy synergistic mechanism that integrates policies and regulations with scientific literature. That is, to divide rumor governance into prevention, monitoring, and governance according to the rumor transmission time, through early prevention of rumor generation, mid-term monitoring of generated rumors, and late

Table 6
Synergistic content of rumor governance policies, regulation and literature.

Stage	Key words	synergistic analysis	
		Policies and regulations	literature
Rumor prevention stage	Science Popularization Education	✓	✓
	Information disclosure	✓	✓
	Information Content Standard	✓	×
	Propaganda Guidance	✓	✓
	Media Propaganda	×	✓
	Legal Prohibition	✓	×
Rumor Monitoring Stage	Multi-party synergistic Mechanism	×	✓
	Monitoring Mechanism	✓	✓
	Judgment Mechanism	✓	✓
	Clue Reporting	✓	×
	Cyberspace Management	✓	✓
	Monitoring Technology	×	✓
Rumor governance Stage	Rumor Dispelling Mechanism	✓	✓
	Legal Disposal	✓	✓
	Special Governance	✓	×
	Fact Clarification	✓	✓
	Scientific Education	×	✓
	Impact Assessment	×	✓
	Feedback Mechanism	×	✓

feedback on the rumor governance process, thereby preventing the next rumor generation and forming a circular rumor governance mechanism, as shown in Fig. 5. This approach aims to better govern the various stages of rumor generation. At the same time, it requires the participation of multiple parties such as government, research institutions, media platforms, and the public to carry out effective collaboration and sharing, and contribute to rumor governance work in each stage, so that rumors can be better identified and governed.

4.1. Strengthen media publicity, multi-party coordination and participation

Mainstream media should bear the responsibility of being the voice of the state and the people, guiding public opinion, and integrating social information, and should aim to strike down rumors at the source. They must implement their main responsibility, supervise platform users, and prevent the spread of rumors by verifying the authenticity of information before sharing information online; in addition, they should strengthen the management of online media, search engines, online live broadcast platforms, and so on, to prevent the spread of rumors and false information. The academic community should strengthen legal popularization, improve the public’s ability to identify rumors and false information, so as to better prevent the spread of rumors and false information; it can explore the impact of different social cultures and political systems on rumor prevention by comparing and analyzing different countries and regions’ laws and regulations and industry standards and learn from different regions’ successful experiences and lessons. While considering the multi-party synergistic mechanism, it is necessary to increase the discussion and evaluation of the specific content and methods of social education, analyze and statistic the needs and effects of various groups on rumor prevention, and design more suitable social education programs for different groups.

4.2. Support for technology development, monitoring and reporting in parallel

The government should strengthen legislative support and resource input, continuously promulgate relevant policies and regulations, and timely release and disclose relevant information. It should support data mining, sentiment analysis, social network analysis, meta-analysis, and other technical analyses of the rumor generation mechanism, transmission path and influence, user characteristics, content characteristics, and so on, to improve the accuracy and efficiency of rumor monitoring and do a good job in cyberspace governance. The government should also support scholars to continue paying attention to and researching new types of rumor identification and governance methods, and use a synergistic mechanism to guide policy formulation and technological innovation. Mainstream media should expose and report rumors, strengthen supervision of rumors, guide the public to treat information correctly, and more effectively regulate the behavior of media and all parties. In addition, there is a need to establish a sound

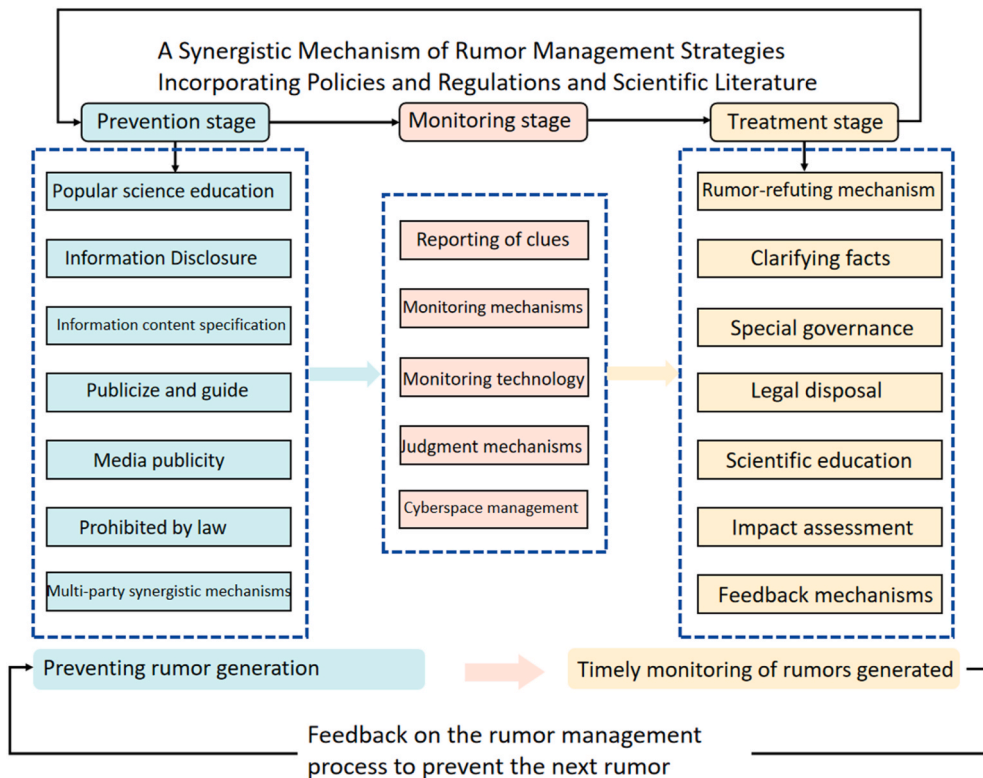


Fig. 5. Rumor governance strategy synergistic mechanism that integrates policies and regulations and scientific literature.

clue reporting mechanism and provide some incentives to encourage the public to actively report rumors, thereby improving the coverage and timeliness of rumor monitoring.

4.3. Focus on specialized governance and timely assessment and feedback

It should give full play to the synergistic role of multiple parties such as government, media, scholars, public, etc., and choose more suitable and effective rumor governance strategies and means according to the transmission speed and influence of rumors in different stages and scenarios. At the same time, it should improve public education, enhance public's ability to identify rumors, improve impact assessment, design more suitable content and forms for rumor governance according to the psychological state and behavior pattern of different targets and objects of rumors. Finally, it should increase quantitative evaluation and feedback on the effect of rumor governance, evaluate rumor governance work by case analysis or questionnaire survey every quarter or year, for a specific field or event, better understand the effect and impact of rumor governance work. Use feedback mechanism to formulate corresponding governance measures for different sources, contents, transmission channels, and judge and prevent the next rumor generation.

5. Discussions

This article systematically examines the current situation and issues of rumor governance from the perspectives of policy regulations and literature, using the lifecycle model [56] and crisis cycle model [57], and proposes governance strategies. The research results of this article have the following significance and impact.

- (1) The research on the development course and trend of rumor governance can point out the direction for the follow-up research. Most of the existing literatures are studied by a single bibliometrics method. Zhu et al. use the method of combining bibliometrics with content analysis to study the research context and development trend of social media health rumors [58]. Ding et al. use literature data to analyze the development process of rumor governance on social media through quantitative analysis and visualization methods and look forward to the future [103]. Through the analysis of the lifecycle of policy regulations and literature, this article reflects the development process in the field of rumor governance. By analyzing the co-evolution, it reveals the laws and characteristics of rumor governance, providing a historical basis for the development direction of rumor governance.
- (2) The division of different life cycles of rumor governance and the combing of corresponding research results are helpful to dig out the shortcomings of existing research. Fang Wenyu divided the spread and governance of rumors into germination period, outbreak period, variation period, extinction period and recurrence period [104]. Chua A Y K et al. divides the life cycle of rumors into three stages: generation, dissemination and control [105]; Chen et al. divide the life cycle of rumors into four stages: incubation period, gradual period, intense period and recession period [94]; Peng et al. divides the whole life cycle of rumors into 20 stages through time series algorithm [106]. Through the crisis cycle analysis of policy regulations and literature, this article divides rumor governance into three stages: prevention, monitoring, and governance, providing an analytical perspective that aligns with both the logical progression in reality and crisis resolution logic. By identifying and addressing the unresolved issues in the field of rumor governance through the identification of non-coordinated thematic terms in policy regulations and literature, this research provides a realistic basis for constructing a rumor governance system.
- (3) The research on rumor governance needs to be based on feasible governance strategies. Chen et al. proposed to grasp the real voice of the people and solve the problem in a targeted manner in the management of online rumors [107]; Zhang et al. put forward an emergency management strategy for the spread of rumors about emergencies [108]; Chen et al. established the model of rumor spreading and information feedback, and put forward the strategies of information transparency and openness [109]. By analyzing the research achievements of policy regulations and literature, this article proposes rumor governance mechanisms and strategies that are in line with evolutionary trends and crisis resolution characteristics, providing feasible solutions and methods for the practice and application of rumor governance.

The research findings of this article have the following limitations.

- (1) The range of data sources reflects the comprehensiveness of the research. Zhu et al. takes SSCI, SCI, PubMed, CSSCI, CSCD and the related databases of core journals of Peking University as data sources [58], Ding et al. identifies and summarizes the literature data in Scopus and WoS from 2010 to 2020 [103], Chaudhari D et al. data of research papers obtained from Scopus database [110], Rani et al. data of literature in WOS from 1989 to 2021 [111], and data of cases of public security administrative punishment used by Yao Fusheng [112]. The data sources of this article mainly come from policy regulations in China and core literature in the WOS database and CNKI database. This may lead to limitations in terms of geographical and literature scope, as it may not fully reflect the policies and characteristics of rumor governance in other countries. Additionally, it overlooks relevant literature data from other databases, which could result in some information gaps.
- (2) The truth and effectiveness of governance strategies need to be tested by practice. Wang Xiwei and others established an evaluation index system, and made an empirical study on the social network rumor management strategy to verify its effectiveness [113]. The proposed strategies in this article are mainly based on the research achievements of policy regulations and literature, which may have certain limitations in terms of empirical evidence and practical applications. The rumor governance

strategies proposed have not been validated and refined in practice, which could lead to potential deviations in strategy and application.

Future improvements and optimizations could be considered in the following aspects.

- (1) Expand the data sources by including policy regulations from other countries and literature data from other databases. This will enhance the universality and representativeness of rumor governance research.
- (2) Conduct empirical research and practical implementations. Consider the inclusion of empirical research on governance projects, actions, and plans related to rumor management and conducting empirical studies and pilot projects in a local government, to assess the effectiveness of the governance strategies proposed in this research. This will also help identify potential problems and challenges encountered in practical applications and allow for timely adjustments and improvements.

6. Conclusion

By integrating policy regulations and scientific research literature, this study utilized the lifecycle model to analyze the development status of rumor policy regulations and scientific literature. It was found that the research on rumor policies and regulations predates the research on literature, and both are in a period of refinement. The number of policies and literature has become stable after a period of explosive growth. It is anticipated that future research on rumor governance will achieve a very mature level. Through the extraction of high-frequency words in the field and cluster analysis, combined with the crisis cycle model, it was identified that both policy regulations and scientific literature focus on the three stages of prevention, monitoring, and governance in rumor governance research. Through coordinated analysis, the deficiencies and shortcomings of existing research were identified. To address these issues, strategies and suggestions for rumor governance were proposed, including strengthening media promotion, promoting multi-stakeholder collaboration, supporting technological research and development, implementing parallel monitoring and reporting, emphasizing targeted governance, and providing timely evaluation and feedback. These strategies and suggestions aim to improve the collaborative mechanism of rumor governance. It is anticipated that this study can provide scientific guidance and references for the theory and practice of rumor governance, as well as offer effective ideas and suggestions for the construction and improvement of a coordinated rumor governance system.

Data availability statement

The dataset used and analyzed during the current study are available in Mendeley Data at <http://doi.org/10.17632/6m356t8vby.1>.

Ethics declarations

Review and/or approval by an ethics committee was not needed for this study because [this study does not contain any studies with human participants performed by any of the authors].

Informed consent was not required for this study because [this study does not contain any studies with human participants performed by any of the authors].

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CRediT authorship contribution statement

Jianbo Zhao: Writing – review & editing, Methodology, Conceptualization. **Huailiang Liu:** Supervision, Resources, Project administration, Investigation, Conceptualization. **Haiping Dong:** Visualization, Methodology. **Weili Zhang:** Validation, Resources. **Jige Xin:** Writing – original draft, Resources. **Xuan Zhou:** Writing – original draft, Software. **Zhen Wang:** Software, Data curation. **Xiaojin Zhang:** Writing – review & editing. **Xinyuan Ren:** Validation, Resources. **Shanzhuang Zhang:** Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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