Constructing a Theoretical Framework for Emergency Intelligence Support Systems for Major Epidemic Prevention and Control: A Case Study of COVID-19 Response Postprint

Authors: Cao Zhenxiang, Chu Jiewang, Guo Chunxia

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Abstract

[Purpose/Significance] Through analyzing the emergency information support system oriented towards COVID-19 epidemic prevention and control, this study aims to provide recommendations for epidemic response and the improvement of the national emergency management system.

[Method/Process] The study outlines the characteristics of emergency information, analyzes the deficiencies in emergency information support work during epidemic prevention and control, and constructs an emergency information support system as well as a multi-knowledge-subject collaborative emergency information support think tank.

[Result/Conclusion] The key content and operational mechanism of the emergency information support system are elaborated from five aspects: support objects, support processes, organizational structure, information subjects, and information workflow.

Full Text

Preamble

Construction of a Theoretical Framework for an Emergency Intelligence Security System for Major Epidemic Prevention and Control—Taking the COVID-19 Epidemic Prevention and Control as an Example

Cao Zhenxiang[1], Chu Jiewang[2], Guo Chunxia[2] [1] School of Economics, Anhui University, Hefei 230000 [2] School of Management, Anhui University, Hefei 230000

Abstract: [Purpose/Significance] By analyzing the emergency intelligence security system for COVID-19 epidemic prevention and control, this study offers recommendations for epidemic response and for improving the national emergency management system. [Method/Process] The paper outlines the characteristics of emergency intelligence, analyzes deficiencies in emergency intelligence security work during epidemic prevention and control, and constructs an emergency intelligence security system and a multi-knowledge-subject collaborative emergency intelligence security think tank. [Result/Conclusion] The key contents and operational mechanisms of the emergency intelligence security system are explained from five aspects: security targets, security processes, organizational structure, intelligence subjects, and intelligence workflows.

Keywords: emergency intelligence; security system; epidemic prevention and control; COVID-19; think tank **Classification Number:** G250 **DOI:** 10.13266/j.issn.0252-3116.2020.15.010

Over the past decade, global public health emergencies have occurred frequently, causing significant damage to social production and people's lives. The emergence of COVID-19 in 2019, with its unprecedented spread speed and harmfulness, plunged most countries into pandemic panic, making the strengthening of epidemic emergency management systems an urgent priority. During the outbreak, Chinese governments at all levels and media outlets timely reported epidemic developments, proactively pushed information about epidemic trends and local conditions to the public, fully utilized intelligent information technology to assist in epidemic screening and tracking, and actively provided information and technical support for medical treatment and epidemic prevention and control, fundamentally achieving transparent epidemic information and smooth communication of epidemic-related intelligence. Under China's strong emergency prevention and control measures, the epidemic gradually eased, and the nation began resuming work and production, with people's lives gradually returning to normal. Although China's emergency prevention and control effects were remarkable, certain problems and deficiencies also existed, posing new requirements for the government's handling of public health emergencies. Xi Jinping pointed out: "We must address the shortcomings and deficiencies exposed in this epidemic response, improve the national emergency management system, and enhance our capacity to handle urgent, difficult, and dangerous tasks" [1].

Emergency intelligence has always been a hot research topic in the intelligence science community. Current academic research on emergency intelligence for sudden incidents mainly focuses on: theoretical foundations of emergency intelligence [2-3]; emergency intelligence research based on smart cities, big data, cloud computing, and Internet of Things technologies [4-6]; emergency intelligence research for different fields and cases [7]; emergency intelligence research from multiple perspectives [8-9]; and problems and improvement suggestions for emergency intelligence management [10-11]. Yao Leye et al. believe that emergency intelligence is effective information that addresses problems and uncertainties to support decision-making and action plan formulation during the

information flow process of emergency management for sudden incidents [12]. Guo Hua et al. [5] point out that intelligence work has real-time and integrative characteristics, and built an urban emergency management intelligence platform through information resource planning methods. Tang Mingwei et al. [7] divided the emergency intelligence system into four levels: early warning linkage, network public opinion control, risk assessment, and crisis identification and warning, and conducted case analysis through real public security events. Guo Lusheng et al. [9] constructed a "situation-demand" emergency intelligence requirement analysis model based on domain analysis and ontology perspectives to obtain intelligence requirement information through emergency domain research. Lin Xi et al. [11] discovered through research that China's emergency intelligence faces problems such as imperfect laws and regulations, backward intelligence talent teams, unsound intelligence resource systems, and unsmooth intelligence networks, and proposed corresponding suggestions based on these findings. Scholars have conducted research on emergency intelligence from different perspectives and reached insightful conclusions. However, it is not difficult to find that research on emergency intelligence for specific major sudden incidents is still relatively scarce.

Major public health emergencies have sudden and group characteristics. The core of public health emergency management is emergency decision-making and prevention and control, while in-depth mining and analysis of epidemic-related data resources is a prerequisite for effectively implementing emergency decisions and prevention and control. Therefore, research on emergency intelligence security systems for major public health emergencies has certain practical significance. Emergency intelligence security plays an important role in epidemic prevention and control, capable of extracting key intelligence needed by the government and the public from massive information resources, timely assisting in handling hidden dangers brought by major epidemic events, providing direction for epidemic prevention and control, guiding the public to actively fight the epidemic through correct intelligence and public opinion, ensuring scientific prevention and control, and providing new ideas for precise policy implementation. This study, from the perspective of the COVID-19 epidemic prevention and control event, constructs an emergency intelligence security system for epidemic prevention and control, with the aim of promoting the modernization of emergency management capabilities and improving the emergency management level of major epidemic events, which also has certain guiding significance for China's epidemic emergency intelligence research.

2 Characteristics of Emergency Intelligence for Epidemic Prevention and Control

For the construction of an emergency intelligence security system for epidemic prevention and control, it is first necessary to clarify the current characteristics of epidemic emergency intelligence to serve as construction principles. Epidemic emergency intelligence needs to include the following six characteristics:

(1) **All-source**: Information related to sudden epidemics is multi-source and heterogeneous, including causes, characteristics, impacts, network public opinion information, and prevention and control resource information [13]. Sufficient and effective emergency intelligence is more conducive to the government formulating scientific and effective emergency decision-making plans and prevention and control measures.

(2) **Real-time**: Real-time refers to intelligence on the real-time status and development trends of COVID-19 epidemic prevention and control. COVID-19 spreads rapidly and causes enormous harm and losses to society. Based on this, Chinese society must quickly understand and timely control this emergency event, which requires real-time monitoring of epidemic changes, scientific analysis of the sources and spread speed of the epidemic, real-time response and resource scheduling to prevent further damage to society.

(3) **Predictive**: Emergency intelligence needs to be predictive and forward-looking, that is, based on past and existing epidemic intelligence data, using scientific methods and means to predict epidemic changes within a certain period in the future. This helps relevant functional departments fully understand and recognize the development direction of the epidemic and make scientific decisions and prevention and control measures.

(4) **Precision**: Precision means that in epidemic prevention and control, emergency intelligence must highly accurately reflect the objective situation of the epidemic to play an important role in the prevention and control of governments at all levels and organizations.

(5) **Coordination**: Emergency intelligence requires information linkage among industry and information technology, medical and health, transportation and other departments to form multi-source data monitoring and sharing related to the epidemic, such as roads, communications, and medical care.

(6) **Evaluative**: For this epidemic, governments at all levels need to timely assess the harm and losses caused by the epidemic to provide a basis for recovery and restoration, bring social development back on track, and provide a theoretical basis for future emergency management.

3 Deficiencies and Reflections on Emergency Intelligence Security Work in Epidemic Prevention and Control

The outbreak of COVID-19 has attracted global attention. This sudden disaster has brought many reflections to humanity, and its spread speed and prevention and control difficulty have plunged countries worldwide into bottlenecks in emergency management. From the perspective of emergency intelligence security, this paper aims to clarify the deficiencies in China's COVID-19 epidemic prevention and control, and improve these deficiencies through the emergency

intelligence security system constructed later, with the hope of strengthening scientific research on emergency management, deepening intelligence involvement, and enhancing the ability to quickly respond and efficiently prevent and control future public health emergencies.

3.1 Identify Emergency Intelligence Security Targets and Encourage Full Participation in Crisis Governance

Current social informatization is increasing exponentially, and no one can stay out of it. COVID-19 epidemic prevention and control is by no means carried out solely through system construction and legal monitoring. The suddenness and complexity of this epidemic caused its impact to expand rapidly. The ambiguity and absence of emergency intelligence security targets directly affect the level of epidemic prevention and control management, which is specifically reflected in three aspects: The role of intelligence in epidemic prevention and treatment has been neglected, information dissemination and updating lag behind, emergency management cannot respond to epidemic development in a timely manner, and epidemic prevention and control cannot adapt to changes in people, finances, materials, and environment brought by the epidemic. During the epidemic development process, due to inadequate intelligence publicity, untimely intelligence delivery, certain ambiguity and ambiguity in intelligence content, and the inability of emergency prevention and control to meet users' multi-faceted intelligence needs, intelligence recipients (mainly the public) have weak prevention awareness. Even when the epidemic situation was severe, some people ignored lockdown and home isolation orders, causing great difficulties for prevention and control work. Practice has proven that under the rapid development of the epidemic, the government and relevant departments' epidemic prevention and control efforts are limited and cannot manage every detail of epidemic prevention and control.

Therefore, the emergency intelligence security system must clarify the question of "who is the target of intelligence security." Some scholars believe that traditional emergency intelligence serves decision-making, with the main purpose of supporting emergency decision-making for sudden incidents. However, under the current epidemic prevention and control, the general public also needs relevant intelligence knowledge for epidemic prevention and control. Because under the rapid development of the epidemic, relying solely on the power of the government and relevant departments is difficult to achieve efficient and rapid response. The strength of the entire public must be mobilized to achieve social-wide epidemic prevention and control linkage. Only by relying closely on the people can we win the battle against the epidemic. Therefore, constructing an intelligence security system for epidemic prevention and control must include both government and relevant organizations and the general public as security targets, breaking through the deficiencies of traditional intelligence security targets.

3.2 Align Security Processes with Prevention and Control Work to Improve Emergency Response Timeliness

COVID-19 is a major test. To submit a satisfactory answer sheet, we must pay close attention to every checkpoint. The development of an epidemic has a certain evolution process and life cycle, and rapid and accurate emergency response is an important weapon to successfully deal with the entire life cycle of epidemic development. As a basic element in the emergency response process, the efficiency, accuracy, and scientific nature of intelligence play a vital role. If the emergency intelligence security process cannot be smoothly connected with prevention and control work, it will increase the difficulty of emergency prevention and control and material management. From the incubation, outbreak, and spread periods of this epidemic, there are four main problems: When COVID-19 first appeared in the public eye, due to the small number of cases and the lack of monitoring, analysis, and early warning of factors and signs of the epidemic, the number of infected people surged during the Spring Festival.

When the epidemic broke out, prevention and control preparations were obviously insufficient, people panicked and fled, epidemic areas were chaotic, and hospital medical resources were strained. During the spread stage, the epidemic crisis continued to expand and develop, rural areas had weak prevention and control awareness, the market experienced some chaos, and ordinary people had difficulty seeking medical treatment, increasing the difficulty of epidemic prevention and control. The emergency intelligence workflow is incomplete and unsound, lacking systematic, cyclical, and continuity characteristics.

The epidemic is constantly changing and developing, which requires intelligence to provide security for epidemic prevention and control at different stages of epidemic evolution. Therefore, the emergency intelligence security system must be effectively connected with the four stages of epidemic prevention and control: early warning, preparation, implementation, and conclusion. It must conduct rapid and flexible intelligence security transformations for epidemic development and build a complete and effective intelligence workflow to conduct more targeted epidemic prevention and control emergency intelligence security.

3.3 Break Down Information Barriers, Achieve Coordinated Linkage, and Promote Rapid Response Between Levels

In major public health emergencies, emergency management capabilities can truly demonstrate a country's governance capacity and level. Emergency intelligence plays an intellectual support role in emergency management, providing true and reliable information for the entire emergency management process and serving as the basic basis for emergency prevention and control. However, traditional single and scattered emergency intelligence cannot quickly respond to multi-domain sudden incidents. At this time, a major epidemic prevention and control emergency intelligence team with multi-knowledge-subject collaboration can provide more scientific and targeted epidemic prevention and control interpretations. Several issues in the COVID-19 epidemic also need attention:

Traditional intelligence security mainly relies on knowledge intelligence experts for intelligence collection, analysis, and application. However, under COVID-19, emergency intelligence involves a broad scope, and single intelligence experts cannot meet the multi-faceted needs brought by the epidemic. The lack of intelligence skills in emergency teams and slow reactions and inadequate measures are important reasons for improper emergency management in this epidemic, which requires focusing on whether staff knowledge and skills are complete. Weak epidemic analysis capabilities led to insufficient attention in the early stage of the epidemic and inability to stop the epidemic in time. Insufficient intelligence analysis capabilities and lack of in-depth development of data information. After the COVID-19 outbreak, relying solely on the power of government or organizational institutions cannot achieve effective epidemic prevention and control. Social organizations, enterprises, and the public should all participate in epidemic prevention and control to provide useful information and intelligence.

When the epidemic enters a rapid spread period worldwide and multiple countries declare a state of emergency, the infectiousness and harmfulness of COVID-19 pose a great threat to social stability. In this severe situation, the efficient operation of organizations in various regions is the key way for intelligence to exert its value. This epidemic reflects some internal organizational problems, mainly manifested in three aspects: The role positioning of decision-making and executive agencies is unclear. In the early stage of epidemic development, there were relatively sharp problems, such as adhering to traditional emergency management models, missing the best opportunity for epidemic prevention and control, and being unable to accurately position themselves in the new environment according to epidemic development. Although Chinese society has undergone long-term information construction, due to the independent operation of information systems in different regions, departments, and organizations, information barriers exist between departments. In the data collection stage, various channels and departments cannot achieve monitoring information sharing and exchange, leading to difficulty in data sharing, incomplete intelligence data collection, high information transmission delays, and resistance to epidemic monitoring work. Horizontal coordination of organizational work is difficult, making it hard to achieve rapid intelligence flow. The linkage mechanism is not sound, and internal organizational agencies experience problems such as unequal functional powers and responsibilities, functional redundancy, blurred division of labor, and multiple leadership during the epidemic period.

Therefore, it is necessary to clarify under what organizational structure intelligence security can maximize its role. This requires constructing an organizational structure that adapts to both epidemic prevention and control and intelligence security. This organizational structure must first clearly define the work responsibilities, scope, and authority of each functional department. Second, it must enable rapid horizontal and vertical organizational response. Third, it must effectively solve data transmission and intelligence sharing problems between various subjects, thereby achieving coordinated linkage of emergency or-

ganizations and ensuring two-way rapid and effective dissemination of epidemic prevention and control intelligence.

3.4 Build a Multi-knowledge-subject Collaborative Mechanism to Ensure Effective Epidemic Prevention Work

In traditional emergency intelligence systems, the main producers of emergency intelligence are intelligence security agencies or comprehensive emergency intelligence security platforms, and some directly use the emergency intelligence system as the producer of emergency intelligence. However, whether this is feasible in practice is questionable. Since the outbreak of COVID-19, intelligence has mainly served the prevention and control decisions of the government and relevant departments and the prevention and control behaviors of the public. The main work of think tanks is to use research results to promote user decision-making and judgment, which coincides with the purpose of emergency intelligence security. In addition, think tanks have experts and scholars from various disciplines and fields, which can make up for the shortcomings of single intelligence experts, enhance the technical capabilities of emergency intelligence teams, and better use wisdom and talent to research and judge epidemic development, providing effective intelligence products for epidemic prevention and control. Therefore, to improve the efficiency and scientific nature of epidemic prevention work analysis, it is necessary to build an emergency intelligence security think tank with multi-knowledge subjects as the main body, assisted by experts in the intelligence field, to achieve multi-domain and all-round expert collaboration, and supply intelligence to government and public demanders.

When the epidemic involves all fields of Chinese society, relying solely on intelligence security agencies for intelligence security shows great limitations, and think tanks can precisely make up for these limitations. Therefore, this study believes that the emergency intelligence security system is an improvement on the traditional emergency intelligence system. How to provide security for epidemic prevention and control, its core is the intelligence security think tank established for epidemic prevention and control. The emergency intelligence security system can be understood as the combination of the emergency intelligence system and think tank security coordinated by multi-knowledge subjects, and is the intelligence behavior and process to promote emergency decision-making and prevention and control.

4 Emergency Intelligence Security System for Major Epidemic Prevention and Control

4.1 Theoretical Foundation and System Construction

Based on the above analysis of the deficiencies in current epidemic prevention and control intelligence security and how intelligence security should be improved, in order to more clearly understand the specific goals and content settings of the emergency intelligence security system for major epidemic preven-

tion and control, it is necessary to summarize and analyze its various modules and elements, and then support the current emergency management work of COVID-19 prevention and control through the system. At present, academia has not formed a unified framework concept for the emergency intelligence security system, and the construction methods for emergency intelligence systems are also diversified. Some scholars construct systems from the basic processes of knowledge management, namely information collection, processing, analysis, and dissemination [14-15], while others construct systems from the content [16] and forms [7] of security.

It is generally believed that the basic concepts of a sudden incident intelligence system mainly include four aspects: intelligence organization, intelligence workflow, intelligence technology, and tools [17]. Usually, internal system construction, forms, and information resource management are key factors in forming an efficient intelligence organization; scientifically reasonable process design reflects an effective response strategy process for dealing with sudden incidents in the emergency system. The arrival of the information age has given rise to various emerging intelligent technologies, providing key technical support for improving the efficiency and quality of emergency systems. In addition, Ma Feicheng pointed out that intelligence should have three dimensions: first, intelligence is a kind of knowledge; second, intelligence is an action; third, intelligence provides organizational security [18]. The construction of an emergency intelligence security system needs to take the basic concepts of the emergency intelligence system and the basic dimensions of intelligence as construction principles.

Most scholars in emergency intelligence systems analyze data and directly support emergency decision-making, neglecting the security role of "think tanks (brain trusts)," while think tank security is the "bridge" connecting intelligence results and users. Because the development goal or mission of think tanks is pragmaticism that influences policy-making, which is to use research results to support government decision-making and public policy [19]. Moreover, in major epidemic prevention and control, intelligence security is not only about supporting epidemic decision-making and prevention and control, but also about bringing true and credible intelligence reports and products to society and the public. Traditional intelligence security agencies have relatively single talent knowledge levels and technical security means, with intelligence analysis experts as the main body. A large number of think tanks gather many outstanding talents from different fields, which intelligence security agencies cannot match. When the epidemic involves all fields of Chinese society, relying solely on intelligence security agencies for intelligence security shows great limitations, and think tanks can precisely make up for these limitations. Therefore, this study believes that the emergency intelligence security system is an improvement on the traditional emergency intelligence system. How to provide security for epidemic prevention and control, its core is the intelligence security think tank established for epidemic prevention and control. The emergency intelligence security system can be understood as the combination of the emergency intelligence system and think tank security coordinated by multi-knowledge subjects, and is the

intelligence behavior and process to promote emergency decision-making and prevention and control.

Based on this, the emergency intelligence security system for major epidemic prevention and control is an organic whole that: takes China's epidemic prevention and control intelligence needs as guidance; based on the epidemic evolution cycle; uses the multi-knowledge-subject collaborative major epidemic prevention and control emergency intelligence think tank alliance as the main body of intelligence security; conducts real-time transmission, storage, and analysis of epidemic-related data and information; produces, archives, and shares intelligence on this basis; and provides intelligence security for the incubation, outbreak, spread, and recovery periods of major epidemics through a coordinated and linked emergency intelligence security organizational structure. It provides intelligence solutions for government agencies, the military, medical and health institutions, etc., to support the decision-making behaviors of decision-making subjects and promote the effective and stable implementation of various prevention and control measures. It also provides high-quality epidemic prevention and control intelligence knowledge for the media and the public to maintain social stability and public safety. At the same time, security targets need to provide timely information feedback to the multi-knowledge-subject collaborative think tank alliance based on the effectiveness of intelligence security, thereby optimizing intelligence (see Figure 1 [Figure 1: see original paper]). Correspondingly, this paper analyzes from five aspects: security targets, security processes, organizational structure, intelligence subjects, and intelligence workflows.

Figure 1 Emergency Intelligence Security System for Major Epidemic Prevention and Control

4.2 Security Targets

The occurrence of COVID-19 concerns the entire Chinese society, and no one can stay out of it. Similarly, the security targets of the emergency intelligence security system are not limited to the single subject of the government, but also include social organizations, medical and health systems, military systems, and the public. The effective operation of a rapid response intelligence security system requires continuous reception of information from the outside world, processing and sorting, and outputting intelligence needed by intelligence users. At the same time, under changing epidemic conditions, prevention and control subjects update intelligence through mutual information resource sharing, enabling the intelligence security system to develop and improve in an orderly direction through continuous information reception and intelligence output. Starting from both active intelligence acquisition and passive intelligence acceptance, security targets can be divided into two categories: One is government and its functional departments, the military, medical and health systems, and other agencies that actively obtain intelligence. They are the decision-making and executive agencies for dealing with epidemic events and the main body for handling epidemic events. Therefore, these organizations need to rely on intelligence for

active decision-making and overall command in the emergency intelligence security system, and need to invest human and material resources in data collection and analysis, and organize relevant domain scholars for information interpretation and decision-making consultation. The other is social organizations, the public, and media that passively accept intelligence. When they passively receive epidemic prevention and control intelligence, they can flexibly and quickly respond, conduct certain early warning and prevention, organize mobilization, and timely feedback the intelligence they collect, thereby compensating for the deficiencies and shortcomings of government and other organizations in the work of the intelligence security system, and better contributing to major epidemic prevention and control.

4.3 Emergency Intelligence Security Process

The evolution of an epidemic is the same as the life cycle of a sudden incident, mainly divided into four stages: incubation period, outbreak period, spread period, and recovery period [20]. Correspondingly, the emergency intelligence security process can also be divided into four stages: epidemic prevention and control early warning, epidemic prevention and control preparation, epidemic prevention and control implementation, and epidemic prevention and control conclusion, as shown in Figure 2 [Figure 2: see original paper]:

Figure 2 Emergency Intelligence Security Process Based on Epidemic Evolution

4.3.1 Epidemic Prevention and Control Early Warning Stage In early December 2019, COVID-19 patients had already appeared in Wuhan, but due to the small number of cases, it was not easily detected and did not receive attention. If factors and signs of the epidemic could have been monitored and warned at this time, the epidemic could have been more effectively prevented and controlled. Therefore, in the early warning stage, the most important thing for the emergency intelligence security system is to build a professional intelligence monitoring and early warning platform, improve the basic information database related to the epidemic, conduct real-time monitoring and effective early warning of possible epidemics through cross-departmental and cross-regional collaboration, discover potential epidemic risks in advance, and regularly form monitoring reports so that relevant emergency departments can understand possible epidemic situations in real time and conduct timely epidemic prevention and control preparation.

4.3.2 Epidemic Prevention and Control Preparation Stage In this stage, the epidemic begins to gradually expand and break out, and the epidemic event has attracted widespread social attention from being unknown. The negative impacts of the epidemic have begun to gradually emerge. Therefore, the most important thing for emergency intelligence security in the preparation stage is to assess and grade the infectiousness and destructiveness of the

epidemic to provide more targeted intelligence support for epidemic prevention and control. At this time, single intelligence experts can no longer meet the needs of epidemic prevention and control, and it is necessary to build a collaborative emergency intelligence security team of experts from different fields for prevention and control preparation.

4.3.3 Epidemic Prevention and Control Implementation Stage After the epidemic breaks out, the crisis it generates continues to spread and expand. During this period, if the epidemic spread cannot be effectively controlled, it will cause huge social crises. In addition to causing public health damage, it will also cause derivative harm, causing huge damage to the economy, politics, social stability, and medical health. Currently, the COVID-19 epidemic has already caused severe disruption to the global economy and markets, and has also increased panic among the public. The duration of this period mainly depends on the effectiveness of epidemic prevention and control implementation. If epidemic prevention and control can be implemented timely and comprehensively, the spread period will end more quickly, and vice versa. Therefore, the most important thing for emergency intelligence security in the implementation stage is to conduct real-time monitoring and rapid analysis of emergency data, generate intelligence products to support epidemic decision-making and prevention and control and the formulation of emergency plans, provide correct and effective epidemic prevention and control knowledge to society, and continuously adjust prevention and control plans according to epidemic changes.

4.3.4 Epidemic Prevention and Control Conclusion Stage Entering the recovery period, the epidemic has begun to be effectively controlled, the harm caused to society is gradually decreasing, social order begins to recover, and public life gradually returns to normal. Therefore, in the conclusion stage, the emergency intelligence security think tank first needs to rely on an intelligence team mainly composed of medical and health experts to conduct analysis and demonstration of the epidemic, determine whether the epidemic crisis can be lifted, and report the intelligence to government departments for decision-making. Then, it should evaluate the effectiveness of the intelligence security work for this epidemic prevention and control, and improve the epidemic prevention and control plan to optimize and perfect the intelligence security work. Finally, it should timely release relevant experience intelligence of this epidemic prevention and control to the public to provide theoretical guidance for future mass prevention and control.

4.4 Organizational Structure

To build an intelligence security system that operates in real-time for epidemic prevention and control, it is necessary to design an effective organizational structure that clarifies the functional composition and hierarchical division of different departments within the organization. The organizational structure of the intelligence security system for epidemic prevention and control must have five

characteristics: Flat structure: A flat organizational structure can promote the rapid flow of intelligence within the system, facilitate intelligence exchange between horizontal departments, and thus realize the security function of intelligence. Clear functional division: Epidemic emergency intelligence security at the same level can only be the responsibility of a single department, and multiple leadership and blurred division of labor cannot occur. Separation of "administration" and "technology": Emergency intelligence work involves professional and technical issues and requires relative independence. The ultimate purpose of separating "administration" and "technology" is to strengthen the relative independence of professional personnel in specific prevention and control functions and minimize interference from administrative departments in professional technical work. Collaborative cooperation: Because epidemic prevention and control is a comprehensive project, collaborative cooperation between the government and relevant organizations and the emergency intelligence security organization can effectively slow down and prevent the epidemic.

When an epidemic occurs, how to achieve data transmission and intelligence sharing among various subjects in the intelligence security system is particularly important. Currently, China has built a State Council joint prevention and control mechanism for COVID-19, with working groups for epidemic prevention and control, medical treatment, scientific research, publicity, and logistics support, adopting a centralized management model to form an effective joint force for epidemic prevention and control [21]. Based on this, this study divides the organizational structure of the emergency intelligence security system into horizontal and vertical parts:

(1) **Vertical Organizational Structure** (see Figure 3 [Figure 3: see original paper]): The emergency management system generally adopts a three-level structure of national-provincial-local. To match the emergency management system, the intelligence security system also sets up a three-level organizational structure, with the core being the national high-end intelligence security think tank, provincial intelligence security think tank, and local intelligence security think tank, corresponding to the State Council joint prevention and control mechanism, provincial COVID-19 epidemic prevention and control headquarters, and local COVID-19 epidemic prevention and control headquarters.

(2) **Horizontal Organizational Structure** (see Figure 4 [Figure 4: see original paper]): Based on a flat organizational structure, the emergency intelligence security think tank only manages epidemic intelligence. Administratively, it belongs to the epidemic prevention and control headquarters, but its work is relatively independent. In specific practice, the epidemic prevention and control headquarters is mainly responsible for management work such as epidemic prevention and control, medical relief, scientific research, epidemic publicity, and logistics support. The epidemic prevention and control headquarters conveys policy orientation, intelligence needs, and key work content to the emergency intelligence

security think tank. The responsibility of the emergency intelligence security think tank is to conduct data transmission and intelligence sharing with functional departments under the epidemic prevention and control headquarters and enterprises and social organizations, use the professional technical advantages of the think tank to integrate and analyze emergency data, and provide core emergency intelligence security for the epidemic prevention and control headquarters in real time, share professional domain intelligence with relevant organizations and enterprises, and share basic intelligence with the public. The government and functional departments, enterprises, social organizations, and the public provide intelligence feedback to the think tank based on the actual use of intelligence, promoting the improvement and innovation of intelligence work, thereby forming an organizational system for coordinated linkage of data transmission and intelligence sharing.

Through the combination of horizontal and vertical structures, it not only ensures the tightness of the organization and controls the quality of intelligence transmission and security, but also facilitates the rapid and effective dissemination of epidemic prevention and control intelligence to all levels, promotes rapid response at all levels, and has certain dynamic and flexible characteristics.

5 Multi-knowledge-subject Collaborative Emergency Intelligence Security Think Tank

5.1 Basic Framework of Think Tank Alliance

The core of the emergency intelligence security system for major epidemic prevention and control is the construction of an emergency intelligence security think tank. As problems in the economy, politics, medical care and other fields brought by the epidemic continue to emerge, the Chinese government also faces pressure from epidemic prevention and control decision-making, planning, implementation, and evaluation, and urgently needs more external wisdom support. Building an emergency intelligence security think tank for major epidemics is an important means and method to promote the Party and government to conduct scientific decision-making and effective prevention and control in response to the epidemic. Zhang Jianian pointed out that the intelligence work of think tanks determines their intelligence functions, because the scientific research of think tanks is built on the basis of data collection, integration, and analysis in relevant fields, and is the basis for think tank knowledge innovation and decision support, as well as an important support for think tank research work [22]. Therefore, the emergency intelligence security think tank generates intelligence products through multi-level effective development of epidemic-related data, and then implements intelligence in epidemic prevention and control strategies and measures and other practical actions.

For major epidemics, a single expert or scholar cannot conduct comprehensive analysis, and it is not practical to redeploy experts and scholars to build an

epidemic prevention and control think tank institution. Therefore, the most effective method is to aggregate and coordinate the advantageous elements of existing think tank institutions to build a think tank alliance. A think tank is a closely connected and division-of-labor cooperative system. In the emergency intelligence system for the current COVID-19 epidemic prevention and control, as the supplier of emergency decision-making and prevention and control plans, the think tank alliance needs to be mainly composed of medical field expert think tanks, supplemented by university think tanks, civilian think tanks, Party, government, and military think tanks, social science academies, and intelligence security agencies, to conduct collaborative work for intelligence security, forming a network collaborative open system. This can promote multi-knowledge-subject alliances, multi-level epidemic knowledge sharing and integration, and promote the integration, division of labor, and collaboration of knowledge and wisdom resources, thereby maximizing the value of experts, as shown in Figure 5 [Figure 5: see original paper]:

Figure 5 Basic Framework of Multi-knowledge-subject Collaborative Think Tank Alliance

5.2 Workflow Design of Emergency Intelligence Security Think Tank Alliance

Ma Feicheng pointed out that the intelligence cycle mainly includes five stages: planning and direction—correct collection and reporting—information storage and processing—information analysis and production—intelligence dissemination [18]. Under the situation of epidemic prevention and control, intelligence work needs to be more refined, comprehensive, and orderly. Therefore, by combining the actual situation of the current epidemic, this study constructs a conceptual framework for the workflow of the emergency intelligence security think tank for major epidemic prevention and control (see Figure 6 [Figure 6: see original paper]). The workflow mainly includes nine levels: requirement analysis, data sources, data transmission, data storage, intelligence analysis, intelligence production, intelligence archiving, intelligence sharing, and intelligence feedback. These processes are actually a cyclical and repetitive process.

Figure 6 Intelligence Security Workflow

5.2.1 Requirement Analysis Meeting users' emergency intelligence needs is the initial purpose of building an emergency intelligence security think tank. Therefore, the first step in the think tank workflow is to clarify users' intelligence needs. Because the epidemic is constantly changing and epidemic prevention and control methods are constantly changing, intelligence needs are also constantly updated. If users cannot obtain urgently needed intelligence products, then emergency intelligence security will inevitably fail, leading to the invalidation of emergency intelligence security work. Therefore, the following questions need to be clarified: The target of intelligence security; The form, content, and quantity requirements of intelligence products; The time requirements

for providing intelligence; Intelligence already mastered by users; Other personalized needs. This requires intelligence staff to continuously communicate with the government, medical and health systems, etc., to grasp their decision-making, prevention and control, scientific research, and technical intelligence needs.

5.2.2 Data Sources After understanding users' intelligence needs, it is necessary to determine the sources and composition of data. All data that can promote epidemic emergency prevention and control should be regarded as data sources for emergency intelligence. Currently, the main bodies of epidemic prevention and control can be divided into five categories: Government departments and relevant organizations. Currently, 32 departments have established the State Council joint prevention and control mechanism, and the data owned by these departments belongs to the data needed for emergency intelligence. State-owned enterprises, such as State Grid and mobile operators, which have data on core infrastructure such as electricity, transportation, and communications. Public institutions, such as hospitals, universities, and TV stations, which have data on health care, scientific research and education, and broadcast media. Private enterprises, such as Alibaba and Baidu, which have massive user data and Internet data. Social organizations, such as charities, associations, and federations, which have data on social assistance and personnel information. Before data collection, data sources should be determined according to different intelligence needs.

5.2.3 Data Transmission After determining data sources, data transmission and sharing only need to be conducted between data source departments and the think tank alliance. The most important thing in the data collection stage is to achieve data transmission. As pointed out above, the problem with data transmission is that public basic data is undertaken, constructed, and managed by different departments, and there is no data sharing and exchange between their databases and management information systems. This also leads to difficulty in effectively collecting and aggregating data in emergency prevention and control.

Therefore, it is necessary to establish and improve the big data management system of the emergency intelligence security system, build unified data formats and data standards, and construct a foundation for data sharing among departments within the system to ensure data standardization, consistency, and usability. Strengthen the construction of data security guarantee mechanisms, and clarify the scope of data security responsibilities and specific requirements for data transmission, sharing, and opening between the think tank alliance and the government and relevant organizations. At the same time, it is necessary to strengthen the guidance and coordination of the joint prevention and control mechanism and the COVID-19 epidemic prevention and control headquarters, provide unified access ports for different departments and organizations, convert unstructured data into standardized data, thereby achieving the integration of

multi-source heterogeneous data, and build a large environment for emergency intelligence security data based on epidemic prevention and control.

5.2.4 Data Storage After data transmission, it is necessary to clean and eliminate redundancy from the data. Preprocessing work improves data quality and effectiveness. After determining target data, extract and synthesize data within the target range, identify important relationships and related entities between data, correlate and aggregate cleaned data, and finally store it in different databases according to different data types in a standardized structure. To enable cleaned data to be stored in databases in accurate and appropriate formats and exert their true value, two points should be ensured in the storage database: first, the persistence of storage infrastructure and the stability of storage capacity; second, the scalability of access interfaces to facilitate user queries and analysis of big data [23]. In the big data environment, emergency security think tanks can cooperate with cloud storage service providers, use cloud storage technology to preserve emergency data, and integrate data resources into cloud storage space. Using cloud storage can not only integrate resources but also effectively unify the data storage structure of think tanks, thereby promoting the effective conduct of think tank data storage work.

5.2.5 Intelligence Analysis Unprocessed data and information are ineffective. Collected data and information must be analyzed and processed before they can be utilized by the government and relevant organizations and the public. Therefore, after obtaining massive epidemic-related data, how to conduct effective intelligence analysis becomes the core content of intelligence security. Emergency intelligence analysis is an activity in which emergency intelligence experts select appropriate data mining methods and analysis tools to conduct in-depth processing, integration, evaluation, and analysis of currently available epidemic-related data and information, thereby mining out emergency intelligence with practical utilization value, and ultimately supporting epidemic prevention and control in different fields.

Traditional emergency management data analysis methods only roughly organize simple statistical data and then rely on relevant emergency management personnel to identify and judge based on their own practical experience, lacking in-depth mining. However, with the rapid development of current information technology, data mining and analysis technologies are constantly innovating, with knowledge modeling, network analysis, big data technology, artificial intelligence technology, etc., all emerging. Data analysis needs to focus more on multi-source data fusion, promoting data analysis from causal analysis to correlation analysis and knowledge discovery, from model fitting to data mining, from logical reasoning to association rule formulation [24].

Data analysis is the core of the multi-knowledge-subject collaborative think tank intelligence security process for major epidemic prevention and control, but intelligence security targets are more concerned about whether the analysis

results can be reasonably explained. Otherwise, it is difficult to make security targets understand and be convinced, and may even mislead them. Therefore, by introducing visualization technology, human-computer interaction technology, and data provenance technology to enhance data interpretation capabilities, it helps security targets understand the results.

5.2.6 Intelligence Production Intelligence production refers to the intelligence products obtained after data collection and analysis. Intelligence products are knowledge outcomes produced by think tank experts and scholars based on solid theoretical foundations and practical knowledge combined with the actual epidemic situation. The intelligence production of think tanks is generated through innovative research on major issues concerning the overall situation of the epidemic and response to epidemic prevention and control, which can support and lead prevention and control during epidemic development, and promote the formation of new ideas and concepts for epidemic prevention and control. The content and carriers of intelligence production for major epidemic prevention and control are diversified. The content covers fields closely related to the epidemic, such as economy, society, and medical health, including social security situation intelligence, epidemic development trend intelligence, personnel flow intelligence, epidemic prevention and control suggestion intelligence, etc. The carriers include research consultation reports, papers and books, briefings and newsletters, and other forms. Intelligence production mainly includes seven levels: "data, analysis, evaluation, judgment, conclusion, suggestion, and matters needing attention," and in special cases, "prospects and model construction" can also be added [25]. Intelligence production needs to be concise, clear, objective, and complete, and should provide rigorous, logical arguments and analysis.

5.2.7 Intelligence Archiving After forming intelligence through data analysis and mining, for the convenience of intelligence sharing, it is necessary to classify and archive intelligence according to different types. Classification is usually conducted from aspects such as the security field, intelligence category, intelligence content, and intelligence level of intelligence. Emergency think tanks can set up special intelligence databases and general intelligence databases to timely respond to various sudden incidents. For example, according to the use of intelligence, intelligence databases can be classified from scientific research, disease prevention and control, material management, etc., or divided into decision-making intelligence databases, case intelligence databases, classification model databases, intelligence method databases, etc., according to different intelligence types. By providing precise intelligence for different fields, it shortens intelligence transmission time, improves the accuracy of intelligence extraction and the work efficiency of management personnel, and fully exerts the value of emergency intelligence. Staff within the think tank system can retrieve various intelligence in think tanks according to user needs or their own needs under the condition of following the principle of equal rights and responsibilities, thereby conducting the next step of intelligence sharing.

5.2.8 Intelligence Sharing Intelligence products are an important window for government departments and the public to understand epidemic prevention and control intelligence, and also the most effective way for think tanks to exert their intelligence security functions. The government and relevant organizations generally obtain think tank intelligence production through direct collaborative cooperation, while non-confidential intelligence production can be timely opened and shared with the public through networks, media, and other channels to achieve publicity and guidance purposes, thereby enhancing social attention to epidemic prevention and control and the influence of intelligence. Currently, the most authoritative intelligence release model is the press conference of the State Council joint prevention and control mechanism, which regularly releases various intelligence related to the epidemic to the public, enabling the public to understand the epidemic in a timely manner and enhancing the government's guiding role. Many Internet platforms also actively leverage their own advantages to assist in epidemic intelligence sharing. For example, the "Healthy China" WeChat public account of the National Health Commission launched a "COVID-19 Science Popularization Knowledge" special topic, actively promoting epidemic-related intelligence knowledge to the public, helping the public understand the epidemic from aspects such as epidemic dynamics and epidemic protection, and has received good social response [26].

5.2.9 Intelligence Feedback Because intelligence has the attribute of knowledge, it has a life cycle from knowledge production to decline, reflecting the objective laws in the process of knowledge generation, diffusion, and utilization [27]. The epidemic is constantly changing and developing, and intelligence needs to have dynamic, real-time, accurate, and scientific characteristics, and needs to continuously innovate and optimize to match the real-time epidemic prevention and control. Therefore, it is necessary to build a long-term and flexible emergency intelligence feedback mechanism to better serve epidemic prevention and control decision-making. Intelligence feedback is both the end point and the starting point of the emergency intelligence security life cycle. Intelligence feedback can be mainly divided into three parts: Emergency intelligence security effectiveness feedback: including intelligence security evaluation, intelligence product content feedback, etc.; Emergency intelligence work feedback: including intelligence processing process evaluation, intelligence carrier model evaluation, intelligence sharing channel evaluation, etc.; Data source feedback: including data reliability and validity, intelligence conversion rate, etc. In addition, intelligence feedback needs to be targeted, timely, and continuous, so that staff of the emergency intelligence security think tank can make real-time improvements to security work through intelligence feedback.

Public health emergencies are usually complex and long-term, and the emergency intelligence security system for epidemic prevention and control plays an important supporting role in multi-source real-time monitoring of the epidemic, medical treatment, and information linkage. The emergency intelligence security system in this study is built on the basis of combining the emergency

intelligence system and think tank security, clarifying that the multi-knowledge-subject collaborative emergency intelligence security think tank is the core of intelligence security and the intellectual support for emergency decision-making. By clarifying emergency security targets, integrating emergency intelligence into the specific process of epidemic evolution, and providing intelligence security for major epidemic prevention and control through a reasonable organizational structure, it provides more scientific and reasonable epidemic prevention and control guidelines for responding to public health emergencies. However, it should be noted that the ultimate purpose of the emergency intelligence security system is not simple theoretical model construction, information collection, and intelligence analysis, but to continuously improve and innovate through deepening intelligence involvement for specific sudden incidents, thereby promoting the improvement of China's emergency intelligence security capabilities and achieving rapid response of intelligence security when dealing with major epidemic prevention and control.

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Author Contributions:

Cao Zhenxiang: Responsible for overall framework design, literature collection, and paper writing; Chu Jiewang: Responsible for paper review, polishing, and revision; Guo Chunxia: Responsible for topic selection and later paper revision guidance.

Construction of a Theoretical Framework for an Emergency Information Security System for Major Epidemic Prevention and Control—Taking COVID-19 Epidemic Prevention and Control as an Example

Cao Zhenxiang[1], Chu Jiewang[2], Guo Chunxia[2] [1] School of Economics, Anhui University, Hefei 230000 [2] School of Management, Anhui University, Hefei 230000

Abstract: [Purpose/significance] To analyze the emergency information security system for COVID-19 epidemic prevention and control, and make suggestions for epidemic response and improving the national emergency management system. [Method/process] The characteristics of emergency information were outlined, and the shortcomings of emergency information security work in epidemic prevention and control were analyzed. Based on this, an emergency information security system and an emergency information security think tank coordinated by multiple knowledge subjects were constructed. [Result/conclusion] The key contents and operation mechanism of the emergency information security system were explained from five aspects: security target, security process, organizational structure, information subject, and information workflow.

Keywords: emergency information; security system; epidemic prevention and control; COVID-19; think tank

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