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Research on Intelligence Intervention and Fusion Models in Emergency Management of Sudden Incidents: Postprint

Authors: Liu Jianzhun, Tang Peiwen, Shi Mi, Liu Chunlei, Yan Yaojun

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Abstract

[Purpose/Significance] This study aims to explore efficient intervention models of intelligence in the field of emergency management for sudden incidents, thereby achieving the objectives of ensuring personnel safety, reducing property losses, and mitigating negative social impacts.

[Method/Process] This study employs lifecycle theory to temporally divide the emergency intelligence response system into three phases: pre-incident early warning, during-incident control, and post-incident loss mitigation, adopting different intelligence intervention strategies according to distinct developmental stages, thereby forming a framework structure that progresses from social membrane perception and early warning, to reducing information entropy of sudden incidents, and ultimately enhancing social resilience. This paper emphasizes the synergistic cooperation effect between intelligence flow and technology flow, breaking through academic domain barriers between senior intelligence core personnel and scientific research technical staff, to construct a system that “inputs timely and accurate latest intelligence, and outputs effective and targeted technical solutions.” It utilizes social membrane theory to filter routine safety information and transmit suspicious sudden incident information; employs the entropy reduction principle to decrease the disorder and chaos of on-site intelligence; and leverages the hexagonal elastic equilibrium theoretical model to enhance social resilience, strengthening resistance and recovery capacity when facing sudden incidents.

[Results/Conclusion] The adoption of intelligence intervention in the field of emergency management for sudden incidents significantly accelerates the processing speed of emergencies and improves efficiency and accuracy. Future research will employ empirical methods such as big data and computer simulation to verify the correctness and universality of the model, and further refine the

study of intelligence intervention models suitable for different types and spatiotemporal contexts of emergency management for sudden incidents.

Full Text

Research on Intelligence Intervention and Fusion Model in Emergency Management

Liu Jianzhun¹, Tang Peiwen¹, Shi Mi¹, Liu Chunlei², Yan Yaojun¹

¹School of Economics and Management, Tianjin Polytechnic University, Tianjin 300387 ²School of Computer Science and Technology, Tianjin University, Tianjin 300350

Abstract

[Purpose/Significance] This study aims to explore an efficient intelligence intervention model in the field of emergency management to ensure personnel safety, reduce property losses, and minimize negative social impacts. **[Method/Process]** Employing lifecycle theory, this research divides the emergency intelligence response system into three temporal stages: pre-warning, in-process control, and post-loss stopping. Different intelligence intervention strategies are adopted according to each developmental stage, forming a framework that proceeds from social membrane perception and early warning, through reducing information entropy of emergencies, to ultimately improving social resilience. This paper emphasizes the synergistic cooperation between intelligence flow and technology flow, breaks through academic barriers between senior intelligence personnel and scientific research technicians, and constructs a system of “inputting timely and accurate latest intelligence while outputting effective and targeted technical solutions.” Social membrane theory is utilized to filter routine safety information and transmit suspicious emergency information; the entropy reduction principle is applied to decrease disorder and chaos at emergency scenes; and the hexagonal elastic equilibrium theory model is employed to enhance social resilience and strengthen resistance and recovery capabilities in facing emergencies. **[Result/Conclusion]** The application of intelligence intervention in emergency management significantly accelerates emergency response speed and improves efficiency and accuracy. Future research will employ empirical methods such as big data and computer simulation to verify the model’s correctness and universality, and further refine intelligence intervention models suitable for different types and spatiotemporal contexts of emergency management.

Keywords: emergency management; intelligence intervention and fusion; lifecycle theory; information entropy; social membrane

1. Introduction

In today's society of continuous technological and economic development, social contradictions and emergencies emerge endlessly, making research in emergency management both urgent and imperative. Intelligence intervention and support are essential throughout emergency management processes including pre-warning, in-process control, and post-loss stopping. Comprehensive intelligence work also facilitates decision-making and judgment by social authorities. However, due to the uncertainty of intelligence and difficulties in its quantification, coupled with China's pyramid-shaped intelligence system structure, a gap often exists between high-level core personnel and researchers in higher education institutions. Both sides lack deep understanding of each other's fields, creating a bottleneck in collaboration between intelligence holders and technical processors that urgently needs resolution. Therefore, this study, based on life-cycle theory, investigates strategies and methods for intelligence intervention at different stages of emergency management, builds bridges between intelligence flow and information flow, and strengthens collaboration between intelligence core personnel and technical personnel.

2. Literature Review

Using CNKI (China National Knowledge Infrastructure) as the source database and core intelligence journals as the literature source, we conducted searches matching keywords and themes including “emergency,” “emergency management,” and “intelligence intervention” for the period 2010-2018. By December 3, 2018, 507 relevant documents were retrieved. After cleaning and standardization, 468 documents met the requirements. Using knowledge mapping tools, we established a keyword co-occurrence map for intelligence intervention in emergency management (see [Figure 1: see original paper]), where larger node areas indicate research frontiers and priorities. The map shows that emergencies, online public opinion, emergency management, emergency decision-making, microblogging, intelligence systems, and big data are hotspots and frontiers in this field.

Building on our research theme and focusing on literature retrieval and organization, we visualized current research hotspots to quantitatively understand research trends. Through further focused literature review, we identified substantial foundational work by several researchers. Jiang Xun et al. proposed reconstructing the emergency response knowledge base into a cluster comprising common-sense knowledge, factual experience knowledge, and operational reasoning knowledge based on the demand characteristics of three user groups: the public, rescue personnel, and decision-makers [1]. Li Yang and Li Gang argued for combining intelligence engineering concepts with smart city construction, using smart emergency response as the “subject” and intelligence engineering as the “predicate” to improve urban emergency management processes and construct a smart emergency intelligence system architecture [2]. Cao Yujie and Li Gang suggested that massive intelligence data accompanying emergencies cre-

ates obstacles for decision-making information utilization, necessitating a big data fusion framework and path oriented toward the full decision-making process to provide reference for actual decision-making information screening and analysis [3]. Liu Chunnian and Zhang Lingyu combined engineering thinking with WSR system methodology to propose a WSR three-dimensional structure for engineering thinking-based emergency information source credibility research systems, thereby improving emergency information source quality and emergency management capabilities [4]. Su Xinning and Zhu Xiaofeng proposed three emergency intelligence system theoretical models based on lifecycle theory from organizational, intelligence content, and emergency decision-making perspectives, providing theoretical foundations for future research on intelligence systems across different domains, types, and stages [5]. Zeng Ziming et al. proposed constructing a public health emergency intelligence system architecture centered on public health data intelligence to achieve intelligent control of public health emergencies [6]. Xu Xukan et al. proposed constructing a “form-feature-decision” three-level emergency intelligence fusion framework based on big data, emergency decision-making, resource and problem dual drivers, and intelligence analysis methods [7]. Ci Yutong et al. introduced intelligence supervision concepts into emergency management to further ensure emergency work quality and improve decision-making effectiveness [8].

These scholars, from perspectives such as smart cities, knowledge base clusters, engineering thinking, lifecycle theory, and public health data, conducted necessary correlation analyses between emergency management decision-making and intelligence concepts, demonstrating interdisciplinary characteristics while illustrating the social value and significance of intelligence theory systems. However, direct research on intelligence intervention and fusion in emergency management remains relatively scarce. This paper builds upon these scholars’ research foundations for deeper exploration.

3. Theoretical Foundation for Intelligence Intervention in Emergency Management

Intelligence intervention depends on fundamental functions of prediction, monitoring, and remediation, inserting into and intervening in the entire emergency management process (early warning, process control, and loss stopping). Emergency management at all stages requires intelligence support and coordination, including intelligence signal capture, intelligence analysis, intelligence consulting services, and intelligence technical systems. Intelligence work is extremely important in social emergency management: through intelligence sources, primary intelligence undergoes necessary processing, analysis, and integration into intelligence reports that serve decision-making and judgment by social authorities. Intelligence intervention in emergency management represents an important field of social science and intelligence science research and practice, as well as a result of interdisciplinary integration. Moreover, intelligence’s value manifests in blocking negative chain reactions through precise information collection

and analysis, and further refining intelligence to serve on-site commanders can significantly enhance emergency response capabilities.

Based on lifecycle theory, emergencies can be temporally divided into three developmental stages: pre-event, in-event, and post-event. Different emergency response systems correspond to different actual development stages, requiring different intelligence intervention and utilization methods. Stage-specific refinement enhances the targeting and utilization of cutting-edge technologies, demonstrating the high importance and necessity of intelligence intervention in emergency management.

4. Basic Principles Analysis

4.1 Connotation of the Intelligence Intervention System in Social Emergency Management The intelligence intervention system in social emergency management can timely capture various danger signals, achieve real-time dynamic monitoring and early warning, and run through the entire process of emergency occurrence and development, providing intelligence coordination support for decision-makers to enhance their handling capabilities. This system integrates sociology and intelligence science theories, aims at disaster reduction and loss stopping, uses intelligence content as support, and applies modern intelligence analysis and processing technologies throughout all stages of the emergency management lifecycle.

- (1) The intelligence intervention system employs social membrane theory for pre-event perception and early warning, uses entropy reduction to quickly and accurately filter effective information, and applies the hexagonal elastic equilibrium theory model to improve social resilience. In 1998, R. Heath proposed the 4R theory, which states that the crisis lifecycle comprises four stages: Reduction, Readiness, Response, and Recovery [9]. The “social membrane” structure introduces the membrane concept from engineering—used to filter and disperse substances—into social sciences, constructing an indicator framework for perceiving and warning about emergencies to prevent or reduce their scale. The entropy reduction principle requires minimizing the entropy value of direct intelligence from the scene during analysis, i.e., immediately organizing and screening collected intelligence to identify effective information and eliminate useless information, reducing disorder and chaos while improving information utilization orderliness. R. Prasanna emphasized in 2017 the importance of intelligence information intervention in fires, suggesting that basic components of intelligence information systems could build advanced conceptual architectures for fire emergency response role systems [10]. The hexagonal elastic equilibrium theory model comprises six elements—survival security, economic support, social distribution, social control, social psychology, and external environment—enabling measurement of social stability status and calculation of social risk values to identify appropriate countermeasures for improving social resilience. Social resilience includes resis-

tance and recovery, measuring a region's ability to maintain status quo during emergencies and timely restore it afterward.

- (2) Achieving intelligence-technology integration depends on collaboration between high-level intelligence personnel and technical researchers. In the intelligence intervention emergency management system, intelligence information is divided into different lifecycle stages. Based on existing knowledge bases and the established "social membrane" structure, current development situations are perceived and identified, with cooperation and coordination between intelligence holders and technical personnel serving as providers and receivers of intelligence analysis and technical processing, enabling rapid transmission and exchange of intelligence flow and information flow.

4.2 Basic Functions of the Intelligence Intervention and Fusion Model

In the emergency management intelligence intervention system, we divide the emergency response process into stages according to time and development progress. Pre-warning, in-process control, and post-loss stopping correspond to different stages of the intelligence intervention model, achieving fusion and rapid response between intelligence and technology.

- (1) **Systematicness.** Considering the integrity of intelligence flow and information flow during intervention and the interdisciplinary nature of intelligence science and emergency management, we established the intelligence intervention model based on systematic principles, providing theoretical guidance for information exchange and circulation between core intelligence personnel and technical processing personnel.
- (2) **Fusion.** To break communication bottlenecks between high-level core personnel and research technicians, enabling better intelligence-technology integration for more efficient emergency processing and reduced losses and negative impacts, the model achieves rapid, accurate intelligence input and timely output of targeted solutions. It strengthens exchanges between senior intelligence personnel and technical researchers, accelerating the fusion of timely intelligence with cutting-edge technology.
- (3) **Entropy Reduction Principle.** Due to the uncertainty and randomness of emergencies, intelligence collected from first scenes is relatively chaotic and disordered. The entropy reduction process requires timely screening of effective information and elimination of useless information during analysis. The model first applies intelligence methodology to detection and identification in emergencies, then sequences, transforms, and fuses primary intelligence to improve utilization and reduce disorder.
- (4) **Synergy.** The combination of intelligence intervention with emergency management theories, methods, and cutting-edge technologies is significant for timely and efficient emergency processing. The model employs collaborative design principles, enabling each module to cooperate and

achieve “1+1>2” effects, particularly emphasizing synergy between timely, accurate intelligence and advanced research technology.

- (5) **Sharing and Updating Principles.** With rapid social development and accelerating knowledge renewal in the internet big data era, we must continuously share and update knowledge resources. The model’s emergency management knowledge base applies the sharing principle, using previous research experiences and achievements in current emergency situations to minimize harm. Post-event experiences and lessons are recorded in the knowledge base to provide effective guidance for future emergencies.
- (6) **Social Resilience.** Resilience includes resistance and recovery—the ability to maintain original status during emergencies and restore it afterward. Given the frequency of recent emergencies, relying solely on post-event recovery is insufficient. The hexagonal elastic equilibrium theory model should be used to improve social resilience long-term through survival security, economic support, social psychology, social control, social security, and external environment aspects.
- (7) **“Social Membrane” Early Warning.** Introducing the selectively permeable membrane structure concept from natural sciences into humanities and social sciences constructs a “social membrane” that filters safety information while identifying and transmitting suspected emergency information as a pre-warning tool. Applied in continuous daily monitoring, it enables simulation analysis through pre-set indicators and data processing to prevent emergencies.

5. Integrated Model Design for Intelligence Intervention and Fusion in Emergency Management

5.1 Design Principles The intelligence intervention and fusion model in emergency management integrates intelligence flow and technology flow, dividing emergency development stages according to lifecycle theory to better respond to emergency prediction, early warning, and evolution. It bridges primary intelligence held by high-level core personnel with advanced technology held by researchers, synergizing their respective expertise to achieve rapid, accurate information input and timely, targeted solution output. Following entropy reduction principles, it reduces disorder in first-hand scene intelligence, blocks potential social public opinion and other negative chain reactions, accelerates emergency processing, and facilitates decision-making by social authorities. The “social membrane” structure is introduced in the pre-warning stage, and the “hexagonal elastic equilibrium theory model” is applied in the post-loss stopping stage to formulate more targeted social stability countermeasures adjustable during post-event reconstruction. The overall integrated model is shown in [Figure 2: see original paper].

Traditional emergency management measures in sociology have consciously considered intelligence and intelligence science theories, but rarely utilize intelli-

gence's predictive and early warning functions, failing to prevent emergencies at the 萌芽 stage. For instance, when responding to highway emergencies, management departments only focused on comprehensive assessment of emergency response capabilities, establishing evaluation indicator systems and weights to obtain final ratings [11], but lacked daily intelligence collection and analysis, resulting in incomplete monitoring and failure to follow up on latest information. In university emergencies, management departments used questionnaires to understand students' views and suggestions on emergency handling [12], obtaining direct feedback but still failing to achieve effective pre-warning without intelligence support. This study utilizes intelligence fusion, transformation, and the established emergency management model, fully leveraging intelligence's timeliness and early warning capabilities to detect future scenarios and development dynamics, supporting accelerated emergency response and minimizing social impact.

5.2 The Integrated Model In this model, lifecycle theory segments intelligence intervention in emergency management into three stages: pre-warning, in-process control, and post-loss stopping, with different strategies and methods applied at each stage to form a complete process from prevention through handling to knowledge resource updating. The model employs collaborative theory to break barriers between high-level core intelligence personnel and university research technicians, combining intelligence flow and technology flow to build a system that inputs timely, accurate intelligence and outputs targeted emergency response solutions, reducing adverse social impacts and protecting lives and property. The entropy reduction principle decreases disorder in first-hand scene intelligence data, using sequencing, transformation, and fusion—referencing the three intelligence dynamics theories (sequencing theory, transformation theory, and fusion theory) that focus on information, knowledge, and intelligence processing [13]—to filter effective intelligence and construct an emergency decision-making intelligence system. The “social membrane” perception and early warning system is combined with hexagonal elastic equilibrium theory to improve social resilience from six aspects: survival security, economic support, external environment, social control, social psychology, and social distribution, enhancing regional resistance and recovery capabilities.

5.2.1 Pre-warning Stage This stage is the early warning period before emergencies occur, representing the daily management state of intelligence work. Since emergencies inevitably have internal causes, generally resulting from combined internal and external contradictions and hidden dangers that accumulate over time until quantitative change leads to qualitative change, intelligence intervention advantages must be fully utilized to collect effective information, conduct comprehensive daily monitoring, and provide early warning and monitoring to identify and resolve potential triggers, thereby reducing emergency probability and scale and nipping them in the bud.

In the pre-warning stage, computer and big data simulation technologies and

existing knowledge bases can construct a “social membrane” structure for filtering and identifying emergencies. Based on established emergency management knowledge bases, relevant indicator systems are summarized, information and data are collected and processed, and risk factors are evaluated. The selective permeability function of the “social membrane” filters safety information while identifying and transmitting suspicious emergency information for subsequent monitoring and processing. When daily monitoring triggers certain indicators, timely judgments can be made based on existing knowledge and experience to adjust situations and avoid or reduce emergency probability and scale. To improve the reliability and accuracy of this filtering process, knowledge bases must be continuously updated, and simulation system maintenance and construction must be performed daily to check system operation and efficiency, achieving pre-event information early warning.

Additionally, this stage requires continuous, extensive intelligence collection from multiple channels, closely monitoring and reviewing regional and event security through “large-scale review” combined with “small-detail monitoring.” Intelligence personnel focus on intelligence collection, processing, and monitoring. Through multi-channel, multi-dimensional, multi-period long-term monitoring based on emergency knowledge resources, the system immediately enters warning processing upon perceiving suspected emergency information, resolving emergencies during the incubation period to prevent large-scale outbreaks.

5.2.2 In-process Control Stage This stage is the control period after emergencies have occurred, representing the emergency processing state of intelligence work. Since most current emergencies cannot be completely prevented during pre-warning, the efficiency and methods of in-process control directly affect final social harm. Correct, efficient solutions that strictly control emergency evolution prevent escalation to uncontrollable levels, truly protecting lives and property while reducing negative public opinion impacts. M. Granatt proposed in 2004 the need to build effective public communication systems for public threat emergencies and use risk communication to develop appropriate crisis management strategies [14], reducing public insecurity and social opinion, benefiting social stability and post-event negative impact control and image reconstruction.

In the in-process control stage, intelligence providers and emergency receivers must collaborate to fuse intelligence flow and technology flow, constructing an emergency decision-making intelligence system that uses timely, accurate intelligence to output targeted technical solutions for effective emergency development control. Latest scene information is input to intelligence providers, processed and screened by high-level core intelligence personnel, then transmitted to receivers. Core research technicians must output targeted emergency response solutions based on rapid response requirements, forming an emergency decision-making intelligence system. Following entropy reduction principles, useless intelligence is eliminated while effective intelligence is retained, reducing informa-

tion disorder and improving targeting and ordering. Intelligence methodology sequences, transforms, and fuses scene information to improve utilization.

Additionally, total quality management and PDCA process management establish a rigorous, scientific, and efficient quality evaluation system centered on emergency processing results and efficiency. Using the PDCA cycle structure (Plan, Do, Check, Act), comprehensive implementation and timely feedback ensure strict management control of emergency operations, guaranteeing efficiency and quality under effective control.

5.2.3 Post-loss Stopping Stage This stage is the loss-stopping period after emergencies, representing the evaluation and reflection state of intelligence work. After emergency processing, the design and implementation process and all adopted methods and strategies require feedback and supplementation. The emergency decision-making intelligence system and overall emergency processing should be reasonably evaluated and improved, with experiences and lessons learned updated and supplemented into the emergency management knowledge base to provide guidance and reference for future emergencies. During post-event reconstruction, the hexagonal elastic equilibrium theory model evaluates construction stability and future risk avoidance capabilities to support more effective, targeted countermeasures.

In the post-loss stopping stage, the hexagonal elastic equilibrium theory model should be daily applied to improve regional resistance and recovery. This model uses six indicators—survival security, economic support, social control, social psychology, social distribution, and external environment—to assess social stability and calculate social risk values. During the recovery period, targeted policy adjustments improve system operation efficiency. The model reflects mutual influence and constraint among six factors (six sides). Some factors directly affect each other, while others indirectly influence; some are strongly correlated at times and weakly at others, intertwining to form an organic whole. Real-time assessment using these six indicators during post-event stages monitors social stability, enabling high attention to suspicious information that might trigger secondary emergencies.

Intelligence personnel must objectively and impartially evaluate strengths and weaknesses in post-event restoration and feedback, continuing strengths while correcting weaknesses. Feedback and updating mechanisms should be established to achieve resource knowledge sharing, timely feedback evaluation, and management repair experience, with original knowledge systems promptly updated. This enables intelligence core personnel and research technicians to use latest knowledge achievements, break academic field barriers, and better prepare for future emergency prevention, control, and processing, achieving intelligence flow-technology flow synergy and constructing more reasonable, targeted emergency intelligence response systems.

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