



Analysis and Optimization Research on the Current Situation of Emergency Logistics Based on the Background of Epidemic

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Abstract. The emergency support system is facing significant challenges when dealing with global pandemics. As a critical component of the emergency support system, the emergency logistics system faces severe problems in circulation and supply chain interruption, as exposed during the COVID-19 pandemic. This article provides a deep analysis of the current state of emergency logistics during the pandemic and identifies critical evaluation indicators through enterprise interviews and questionnaires. By combining multiple methods, this study identifies important factors affecting the emergency logistics system and conducts a systematic analysis of its existing problems. A series of improvement measures are proposed, providing useful references for building and improving an effective multidimensional emergency logistics system in China. Therefore, this study has practical significance in enhancing the response capacity and capability of the emergency logistics system in dealing with unexpected events.

Keywords: Logistics management · Emergency logistics · Epidemic

1 Introduction

In the 21st century, various epidemics have occurred frequently around the world, such as the 2003 SARS outbreak, the 2009 H1N1 influenza pandemic, the 2014 Ebola virus outbreak, and the 2020 COVID-19 pandemic, causing enormous economic losses and threatening human lives. Emergency logistics is the physical flow process for meeting the material needs of sudden events, including natural disasters, accidents, public health emergencies, and social security incidents. The emergency logistics system plays a critical role in providing emergency support for the material and personnel needs during sudden events. By providing essential supplies such as medicine and food quickly, emergency logistics can save lives and reduce losses. The level of development and improvement of the emergency logistics system directly determines its ability to provide emergency supplies, and thus, it directly affects the ability to control epidemics. Therefore, it is necessary to improve the emergency logistics system.

2 Characteristics of Emergency Logistics

2.1 Emergence

The sudden nature of an outbreak determines that emergency logistics in such an environment must also be sudden, requiring effective allocation of limited resources under urgent circumstances. The type and quantity of emergency supplies required in the affected area cannot be predicted or planned in advance.

2.2 Uncertainty

The unpredictability of emergency situations, including the timing, intensity, and scope of impact, makes it difficult to estimate the types and quantities of emergency supplies needed in areas affected by sudden outbreaks. The uncertainty of the outbreak itself results in fluctuating demands for emergency supplies in these regions, leading to a state of unpredictability in emergency logistics.

2.3 Efficiency

Emergency logistics require swift and efficient delivery of goods to ensure timely response during critical situations. Failure to deliver emergency supplies in a timely manner can result in an exponential increase in harm, causing incalculable losses to both human lives and the economy. To gain control over such situations, emergency logistics must operate at a pace that exceeds the rate of disease transmission, and ensure that goods are delivered as quickly as possible to minimize losses.

2.4 Unconventionality

In times of crisis, the timeliness of emergency logistics determines the ability of regional logistics to transport a large amount of urgently needed supplies in an extremely short period of time. Thus, traditional logistics organizational mechanisms are not suitable for emergency logistics. Specific emergency logistics mechanisms are usually employed in order to reduce certain steps and adopt relevant measures to increase logistics speed, ensuring timely delivery of emergency supplies to their intended destinations.

2.5 Insufficient Economic Efficiency

Ordinary logistics emphasizes both efficiency and profitability, with economic benefits as the primary goal. However, emergency logistics, with national and governmental intervention and demand, primarily emphasizes logistics efficiency rather than profitability, resulting in weaker economic feasibility.

3 Review of Research

In recent years, due to sudden public health emergencies and natural disasters, the logistics system in China has increasingly faced severe challenges in responding to emergencies, especially during the COVID-19 pandemic. Compared to foreign research, China's research on emergency logistics started later and people's understanding of it is not deep enough, and there are many existing problems. Therefore, it is urgently necessary to accelerate the establishment of a sound emergency logistics system. Some scholars have explored the application of modern information technology such as the Internet of Things and databases in emergency logistics. Jiang Fangtao (2018) proposed the "Internet Plus" emergency logistics model, expounded on the problems of traditional emergency logistics, emphasized the importance of establishing an emergency logistics information exchange system, and analyzed the mechanism by which "Internet Plus" improves the emergency logistics system. Ling Bintao (2019) pointed out in his article that the improvement of emergency logistics supply models can be based on big data, the Internet of Things, and other information technologies, and by constructing an emergency logistics information management platform, reasonably planning logistics networks, scientifically managing materials, and controlling inventory. Zhao Zhenli (2020) pointed out that during the epidemic, China's emergency logistics system lacks unified coordination, and called for the establishment of a unified emergency logistics coordination and command system at all levels composed of logistics-related government departments and industry associations. Some scholars have also discussed the issue of ensuring timely distribution and disaster risk avoidance under the background of emergency logistics by building models and addressing site selection issues. Chen Yudan (2021) focused on the optimization of vehicle dispatch in emergency logistics distribution in a medical context, emphasizing the integrity of drug supply and logistics in public health emergencies, which is helpful in constructing models by considering both sides' characteristics and highlighting the importance of ensuring the timely supply of emergency medical materials. Zhao Qihong (2020), based on a comprehensive consideration of China's national conditions, proposed a basic approach and method for building an emergency logistics management system for major sudden events. Through the above research analysis, it can be seen that people have a certain degree of control over the follow-up arrangements for emergencies, and the level of improvement in emergency logistics systems plays a decisive role. Currently, China's research on emergency logistics focuses more on the application of modern technology and overall path optimization, while there is less research on the specific link of the operation mode, process control, and end distribution of emergency logistics, as well as less analysis of related cases. Therefore, this article, in combination with the problems of emergency logistics end distribution under the background of COVID-19 epidemic prevention and control, selects Xiamen, Putian, and Quanzhou cities in Fujian Province, which have experienced large-scale epidemics, as research areas to conduct in-depth investigations and provide feasible recommendations for the construction of a more sound emergency logistics end distribution system and overall emergency logistics system.

4 Assessment Indicators for Emergency Logistics System Architecture

The emergency logistics information platform serves a primary function of providing precise information for the distribution and rescue of critical materials during epidemic prevention and control. This function includes the entire process from information collection to dissemination.

The emergency logistics operation mode is a system that is tailored to the platform, designed to address challenging issues such as site selection for urban emergency logistics centers, resource allocation, and timely distribution during sudden epidemics. This mode aims to minimize logistics costs, from the aggregation of anti-epidemic materials at the logistics center to their distribution from the supply side to the logistics center.

The emergency logistics command center is a simplified temporary or permanent system. Prior to the outbreak of a public health emergency, a standing command center is established, and in the event of an outbreak, a joint prevention and control leadership group is swiftly established, along with various corresponding institutions for problem resolution.

Emergency logistics resource guarantee is a typical system with both social and economic characteristics. The construction of a sound urban emergency material guarantee platform requires the storage of not only the most common materials but also a complete supply chain framework to ensure supply and a robust reserve system for supply.

Emergency logistics rules and regulations serve the entire system, mainly by establishing regulations for emergency logistics management and improving laws and regulations (Table 1).

Table 1. Assessment Indicators

Level 1 indicators	Level 2 indicators	Level 3 indicators
Emergency logistics system	Rules and Regulations	Integrity
		Standardization
	Operation Model	Distribution scheduling
		Smooth traffic
		Distribution
	Command Center	Pre-arranged planning
		Timeliness
		Organization and coordination
	Information Platform	Collection
		Transmission
Management		

(continued)

Table 1. (continued)

Level 1 indicators	Level 2 indicators	Level 3 indicators
		Application
	Resource Guarantee	Material reserve
		Human resources
		Enterprise level

5 Existing Problems of Emergency Logistics

5.1 Inadequate Legal Framework of Emergency Logistics System

The construction of China's emergency logistics legal system is insufficient, with mostly administrative regulations and provisions, and a lack of specific legal regulations for emergency logistics. Without legal norms and guidelines for logistics enterprises' legal obligations and incentives, logistics companies may become passive or uncooperative, affecting the operational capability of emergency logistics and the rescue tasks in disaster areas. The authority in responding to sudden epidemics needs to be strengthened, as only a few logistics companies voluntarily participated in transporting emergency relief supplies during the outbreak of the COVID-19 pandemic in 2020. Inadequate legal regulations can also lead to a limited spread of emergency logistics knowledge and poor promotion, limited exercises related to sudden public health emergencies, poor coordination between the government and the people, and relatively weak self-defense ability of the public during crisis situations.

5.2 Insufficient Emergency Logistics Response Capability

During outbreaks, the deployment technology of emergency logistics coordination agencies still relies on traditional manual communication modes, which presents issues of timeliness and accuracy. This approach can suffice for small-scale emergency logistics response and management needs, but temporary emergency response operations expose the lack of deep integration between emergency logistics management agencies and logistics service providers. The length of time required for emergency logistics system construction directly affects the government's ability to respond to sudden outbreaks and the ultimate effectiveness of their response.

5.3 Inadequate Construction of Emergency Logistics Information Infrastructure

The channels for information exchange in China's emergency logistics are limited, with low levels of information technology and lack of a unified information dissemination and communication platform. Emergency logistics involves critical elements such as route planning, material supply and demand, and temporary deployment, all of which require timely publication and collection to ensure the authenticity, accuracy, and timeliness of information about the disaster area. Currently, the only credible platform for emergency

logistics information dissemination in China is the government, while other platforms are characterized by mixed messages and lack of instant communication for supply and demand information, resulting in great restrictions in the amount and accuracy of information. For example, the emergency inventory of the Red Cross is severely backlogged, while local hospitals are still experiencing shortages of epidemic prevention and medical supplies. This phenomenon reflects the unsynchronized relationship between emergency material supply and demand, asymmetric information, low matching efficiency and poor accuracy of medical supplies, which in turn affects post-disaster relief work and may lead to greater losses in property, life and health security, and even public panic and social chaos.

5.4 Inadequate Emergency Material Reserve System

Primarily, the process of inventorying emergency materials still relies on manual record keeping and auditing, resulting in untimely updates to specific material information, as well as type and quantity, and therefore yielding low efficiency and high error rates. Additionally, the procurement mode for emergency materials is single-handedly reliant on public tenders. While this may ensure the daily storage of materials, during emergencies, disruptions in the supply chain may result in abnormal procurement tasks, which in turn leads to inadequate emergency material reserves, a lack of material categories, and low-quality supplies.

5.5 Issue of Inefficient End-Point Distribution

During the outbreak of the pandemic, the number of infected people within the region had increased dramatically. Due to quarantine measures, a large number of logistics workers were stranded at home, unable to return to their workstations. This resulted in an exponential increase in demand for logistics services from all sectors of society. Some materials remained stuck in warehouses for over a month, further exacerbating the sharp mismatch between logistics supply and demand, and causing logistics costs to rise significantly above usual levels.

5.6 Hindered Road Transport

During the outbreak of the epidemic, there has been a significant increase in the number of infected individuals within a given region. Due to the quarantine measures, many logistics workers have been stranded at home and unable to return to their work stations. This has resulted in a geometric growth of demand for logistics across all sectors. Some goods have remained in warehouses for up to a month, further exacerbating the conflict between supply and demand for logistical support, as well as raising logistics costs significantly above average.

5.7 Inadequate Hardware Facilities

During the outbreak of the COVID-19 pandemic, most logistics companies experienced a shortage of freight vehicles. Despite the rapid response from the government and

businesses, there was still a shortage of emergency transportation tools. The outdated facilities and equipment in the emergency logistics system were a significant issue. For example, there was a clear shortage of large-scale emergency logistics carrying and loading and unloading equipment, outdated emergency material allocation, packaging, and marking facilities, and limited use of satellite positioning systems, wireless radio frequency identification, and big data technology equipment. The outdated facilities and equipment can result in a slow response time for government and related departments in the storage and allocation of emergency supplies, making it difficult to complete emergency supply distribution tasks in a short period. For instance, during the outbreak of COVID-19 in Wuhan, medical supplies were visibly scarce while aid materials from various regions were piled up in the warehouse of the Red Cross Society of Wuhan due to the outdated facilities and equipment.

5.8 Insufficient Emergency Logistics Personnel

Emergency logistics, as a highly specialized logistics activity, involves a lot of professional knowledge, including the procurement, storage, transportation, and distribution of emergency materials at multiple stages. Emergency organization activities have a wide range of involvement, including multiple levels and departments, requiring broad participation from governments, grassroots community organizations, enterprises, the public, and even the military. The transportation of emergency materials is different from that of ordinary materials. For example, as a special type of rescue goods, medicines have obvious differences from other ordinary goods, with strict requirements for temperature, transportation tools, and storage methods. Without professional emergency logistics management personnel, the professionalism of emergency management departments will be weak, making it difficult to carry out scientific, unified planning and scheduling. In the early stages of the outbreak of the COVID-19 epidemic, the work of the “Red Cross Society” in Wuhan was criticized. After the warehouse was transferred to a professional private logistics enterprise, the speed of material storage and distribution was improved. This situation also indicates that emergency logistics management requires professional personnel to perform professional work. The phenomenon of emergency logistics practitioners being employed without professional training or even without professional backgrounds is common, hence the severe shortage of emergency logistics professionals.

6 Strategies for Enhancing Emergency Logistics

6.1 Improving Emergency Logistics Legislation

Countries such as the United States, Japan, and Germany have successively enacted emergency state laws, but China has not yet formed a complete emergency logistics legal system. Only with laws to follow in the process of emergency logistics response, can the stability of the city’s emergency logistics network be guaranteed to respond quickly, efficiently, and timely under uncertain circumstances. It is necessary to standardize the emergency system response in a legal form. Currently, there is a lack of logistics-specific legislation in our country, but this has been a topic advocated by the academic community for many years.

Firstly, all logistics enterprises should be included in the emergency logistics network to regulate their requisition and command rights in emergency mechanisms.

Secondly, it is very important to educate the public about crisis management. Emergency logistics needs to strengthen cooperation and coordination between the government and the public, and carry out planned and regular emergency logistics propaganda work in accordance with the law.

6.2 Enhancing Emergency Logistics Response Capability

To enhance the emergency logistics response capability, the government should strengthen organization and control, and establish a specialized emergency agency to enable unified command and swift operation of the emergency logistics system. Enterprises should strengthen their professional logistics service capabilities and be able to interface with disaster areas at the terminal. The general public should reduce the waste of social and material resources for rescue efforts based on the orderly action rules established by the government. When responding to emergency logistics demands, introduce network communication technology for information exchange and use big data technology for scheduling and decision-making. A robust emergency plan can also be established to ensure that it can achieve maximum efficiency in handling emergency events and further improve response capability.

6.3 Establishing an Emergency Logistics Information Platform.

Establishing a unified emergency logistics information platform is crucial to enhancing service quality in the big data environment. The emergency logistics information system's main functions include information release and collection, data analysis, emergency order management, and distribution management. The government can rely on existing public information platforms, IT enterprises, and internet logistics service platforms to build partnerships. The timely release of emergency resource demand information helps the government sensibly mobilize and reserve emergency resources, improve emergency response capability, and avoid excessive emergency material inventory. Advanced international technologies such as cloud computing, IoT, and GPS can be introduced to monitor real-time material supply and whereabouts.

6.4 Optimizing the Material Reserve System

Emergency materials must be properly classified and managed with inventory quantities regularly monitored to ensure the rationality of the storage structure and inventory safety. The emergency material reserves must adopt a combination of government and market forces, leveraging the strengths of multiple parties and timely grasping market information to avoid rising prices or inadequate supply. A dynamic storage mechanism with strict inspection of inbound and outbound emergency materials and periodic random checks must be established. While ensuring quantity and quality of material reserves, cost of national material storage must be reduced. Logistic and storage center layouts must be rationally optimized with advanced technologies such as big data and artificial

intelligence to scientifically and standardizedly manage inventory reserves. The modernization, intelligence, and scientific level of storage facilities and equipment must be improved, and contingency plans must be prepared to coordinate emergency logistics links for sudden epidemics, effectively guaranteeing the passage of life.

6.5 Utilizing Intelligent End Distribution Equipment

The rapid application of the new generation of information technologies, such as 5G, big data, cloud computing, and blockchain, effectively supports the use and development of intelligent end distribution equipment, enhancing the overall capability of the emergency logistics system at the operational level, such as unmanned vehicles and unmanned aerial vehicle distribution. In various emergencies, intelligent equipment has an irreplaceable role. It should actively adopt intelligent equipment such as assisted driving, robot sorting, intelligent terminals, and unmanned aerial vehicles. Under the dispatch of information systems such as WMS, TMS, and WCS, intelligent sorting, transportation, and distribution of emergency materials are realized, efficiently enhancing emergency rescue capabilities.

6.6 Rational Optimization of Road Transport

Initiating the system of emergency transport vehicle passes and ensuring easy processing channels while emphasizing urgency, timeliness, safety, and convenience principles are crucial for facilitating the issuance of passes. The emergency management authorities should collaborate with relevant departments to leverage digital technologies to achieve online issuance of passes for smooth online and offline processing. Specialized channels must be established for the expedited passage of vehicles in and out of epidemic-affected regions that hold passes. Considering the urgency of the material, dedicated channels must be set up to ensure rapid transit.

6.7 Refining Hardware Infrastructure Construction

In the construction of logistics parks, emergency logistics warehouses should be reasonably planned and large-scale transportation and loading and unloading equipment should be appropriately increased to meet the needs of logistics in emergencies. At the same time, the number of transport vehicles should be reasonably increased so that public vehicles and transportation tools of other enterprises can be requisitioned during epidemic outbreaks. In addition, new equipment such as satellite positioning systems, wireless radio frequency identification technology devices, big data technology facilities, drones, AGV robots, autonomous trucks, unmanned warehouses, and intelligent express cabinets should be gradually expanded for their application and popularization in the logistics field.

6.8 Improving the Mechanism for Talent Cultivation

To achieve high-quality and efficient formation of professional teams, a collaborative model involving government, universities, enterprises, and industries should be adopted.

The government should promulgate relevant policies for talent cultivation, universities should develop scientific talent cultivation programs, and enterprises and industries should actively participate in talent construction. Most importantly, support should be provided for universities to strengthen emergency logistics talent cultivation, exploring and forming a model of joint cultivation of logistics talent among higher education institutions, research institutes, industry associations, and business, to train a group of emergency personnel with high level and strong professionalism for our country. Establishing emergency management training bases and regularly organizing practical training and exercises for emergency management personnel will equip them with the ability to respond quickly to emergencies. In addition, strengthening on-the-job skills training for emergency personnel, regularly inviting logistics experts and scholars to enhance the business level and emergency response capabilities of emergency management personnel and on-duty employees, should also be emphasized.

7 Conclusions

As the epidemic prevention and control enters a new phase, we must remain vigilant against the potential emergency caused by regional outbreaks. It is imperative that we seize this opportune moment of success in epidemic control to address deficiencies and omissions based on past experiences, prioritize critical indicators that impact emergency logistics, analyze problems, and adopt targeted measures to further enhance the emergency logistics system, and improve its service capabilities to prepare for potential future emergencies.

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