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Optimization of Emergency Logistics Service Capacity in the Context of COVID-19

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Abstract:

Emergency logistics plays a vital role in the prevention and control of COVID-19. However, after the outbreak of COVID-19, there is a certain degree of deficiency in the capacity of emergency logistics. Aiming at the existing problems, this paper analyzes the characteristics of emergency logistics and the advantages of intelligent logistics technology. On this basis, the three links of emergency supplies raising, dispatching and transportation are analyzed emphatically, explore the comprehensive use of modern logistics information technology in each link in order to realize the wisdom and improvement of the whole process of emergency logistics, then the service capacity of emergency logistics is optimized from three dimensions of ensuring efficient collection of emergency materials, promoting reasonable dispatch of emergency materials and ensuring intelligent transportation of emergency materials. Through the research on the optimization of emergency logistics capacity in order to improve the emergency logistics material supply security system, support services were provided to effectively respond to sudden disasters such as COVID-19.

Keywords*: COVID-19 outbreak, Intelligent logistics, Emergency logistics, Optimization.*

I. INTRODUCTION

The outbreak of COVID-19 in 2020 is the most serious human infectious disease since the global influenza pandemic in 1918. It is also the most serious public health emergency since World War II. Its complexity and arduousness are unprecedented, and the impact on world economy and social development is unprecedented. How to deal with the public health crisis caused by COVID-19 epidemic quickly and effectively and how to reduce the social loss caused by COVID-19 epidemic has aroused common concern around the world. Whether the emergency management system composed of emergency logistics service capacity and emergency logistics support capacity can play its due role in the response to COVID-19, it is directly related to whether the emergency relief materials and rescue workers can be arranged in time, and whether the victims of the epidemic can be rescued quickly. The ability of emergency logistics services determines the effectiveness of COVID-19 relief to a large extent; therefore, in the context of COVID-19, all regions should do a good job in the management of emergency logistics services and improve the capacity of emergency logistics services, which has become the key link to effectively respond to COVID-19.

Throughout the operation of emergency logistics in the COVID-19 epidemic prevention and control this

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time, it can be seen that the structure of the logistics operation system, such as the mismatch between supply and demand, the link and the configuration of elements, has been disrupted in various regions. In the face of the sudden logistics demand for epidemic prevention, such problems as delayed response, mismatch between supply and demand and low improvement are presented [1]. In the face of the impact of COVID-19, it has become an urgent task to improve the prevention and control system of major epidemics and the national and regional public health emergency management system. In the epidemic prevention and control, supplies such as protective clothing and masks for medical equipment are frequently in short supply, which reflects the glaring weakness of the emergency supply system in various regions; therefore, the emergency material guarantee should be regarded as an important part of the construction of the emergency management system in each region. Emergency logistics has the characteristics of fast response speed and concentrated material demand. The emergency logistics service needs the coordination of all links to respond quickly and effectively, this puts forward the higher request to the emergency logistics capability, intelligent logistics based on big data, Internet of things, cloud computing and other modern information technologies provides new ideas for the improvement of emergency logistics capacity. Intelligent logistics can use relevant information technologies to effectively integrate information and play a role in the process of information collection, analysis and application of emergency logistics, so as to improve the response speed and the emergency improvement of logistics services.

The above analysis shows that emergency logistics is related to the management ability of COVID-19 crisis. How to effectively integrate and apply the relevant technologies of smart logistics is the key to improve the emergency logistics capacity. The optimization of emergency logistics service capacity can better improve the emergency management system of various countries and regions, and effectively reduce the serious threat of sudden public health crises such as COVID-19 to the safety of people's lives and property; therefore, this study has important theoretical significance and application value.

II. LITERATURE REVIEW

After the outbreak of COVID-19, many scholars studied and analyzed the problems existing in the emergency logistics of various regions in the material guarantee of COVID-19, and put forward some guiding suggestions from the perspective of top-level design to improve the emergency logistics system and enhance the emergency logistics capacity in the future. Zhu pointed out that after the outbreak of COVID-19, problems such as blocked transport channels and poor deployment of emergency supplies occurred in the transportation guarantee of emergency supplies in various places [2]. Salman and Yücel studied the adverse effects of emergencies and other disasters on traffic in disaster areas. They use system models to predict accessibility between supply points and demand points, which will help to make more effective decisions about the location of emergency facilities [3]. In addition to the problems in the transport channels and allocation of emergency supplies, Zhang et al. further pointed out that the shortage of medical supplies is widespread and the transport improvement of emergency supplies needs to be improved [4]. After the outbreak of COVID-19 in China, most regions were in short supply of supplies such as masks, disinfectant, protective clothing, and aid to Hubei could not be delivered in time. Some regions even experienced shortages of daily supplies. To some extent, the above problems indicate that China still has shortcomings in the emergency transportation system when the epidemic breaks out. Therefore, it has become an important

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topic of current research to carry out related research on emergency transportation system to improve its emergency response capacity in emergency times and improve the transportation of emergency materials and related personnel.

In the suggestions to improve the emergency logistics system and enhance the emergency logistics capacity, many scholars believe that information is a key link to improve the emergency logistics capacity. Liu pointed out that all technical means should be used as far as possible to improve the true accuracy of demand data, to achieve protective sharing of information and data under the principle of confidentiality, and to make timely, full and targeted public disclosure, so as to reduce the material hoarding caused by panic and hoarding of goods in all links. In addition, information sharing should be used to reduce information distortion and distortion, so that the emergency supply chain can minimize the oxtail effect caused by the uncertainty of demand and supply. True, accurate and highly shared information is not only an important condition for matching supply and demand of emergency supplies, but also an important decision support factor for each link of emergency logistics [5]. In terms of emergency supplies demand forecasting, Yang et al. consider the outbreak after the disaster in the high degree of uncertainty and limited distribution of information, put forward must be made before the outbreak of disaster location decision in advance, developed a disease before the static and dynamic multiphase dynamic post-disaster emergency supplies due to a distributed robust optimization model [6]. Zhan et al. adopted a new decision-making framework, replacing the traditional disaster relief logistics actions with periodic sequential actions including demand point positioning and distribution, and establishing a dynamic optimization model to solve the phenomenon of incoordination between supply and demand [7]. Prak and Teunter established a dynamic time-varying demand model, which is suitable for demand distribution and parameter estimation of different inventory models. Through case analysis, they proved that the model can effectively save money [8]. In terms of emergency logistics network design, Khayal et al. constructed a network traffic model with cost minimization method [9]. Against the background of the spread of the epidemic, Liu and Zhang built an interactive coordination and optimization model for the dynamic ordering and distribution of medical resources between the hospital distribution center and suppliers [10]. Zokaee et al. built a three-level emergency relief logistics model consisting of supplier relief distribution center and affected area, and analyzed the influence degree of uncertain parameters on the solution [11]. Liu et al. put forward a stochastic model of post-disaster rescue logistics, which can help managers determine the initial deployment of emergency resources after a disaster [12]. In view of the spread of smallpox and other epidemics, Dasaklis et al. built an emergency logistics supply chain management model in the context of mass vaccination [13]. Taking the shortest distance of emergency logistics network as the optimization goal and the supply and demand capacity as the constraint condition, Boonmee et al adopted heuristic algorithm to establish a mathematical programming model and studied the location of facilities for humanitarian post-disaster relief [14].In terms of epidemic emergency logistics, the existing theoretical research achievements include not only the research on the design of emergency supplies dispatching network in an outbreak environment, but also the research on the dynamic distribution of emergency supplies in an outbreak environment. Research on the dynamic allocation of emergency supplies mainly focuses on how to dynamically allocate limited emergency supplies in the context of an outbreak to obtain the optimal relief effect, such as the prevention and treatment of HIV epidemic with a fixed government budget [15]. distribution of emergency supplies in the context of H1N1 [16], optimization of the distribution of anti-influenza drugs in the context of influenza

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diffusion [17]. In view of the Ebola epidemic in West Africa, Buyuktahtakin et al. put forward the optimal location allocation model for emergency resource use [18]. Early application of operational research optimization methods in the prevention and control of epidemic outbreaks or infectious diseases can also be referred to Brandeau's review article [19].

To consummate the epidemic data sets collected digital standard, and promote the data sharing and common, need joint medical emergency monitoring analysis of epidemic prevention and control of virus traceability expert of the resource allocation, make joint outbreak of digital collection standard data sets, is advantageous for the large data comprehensive analysis and data quality check data cleaning and information extraction, and then realize social network survey statistics Integration and sharing of multi-source data such as transportation network, express delivery network, high-speed network, video surveillance network, communications network, Internet and satellite network. Information sharing and application in emergency logistics rely on big data, Internet of things, cloud computing and other smart logistics related technologies. Sun et al. emphasized the importance of intelligent logistics and other modern information technology in the optimization of emergency logistics capacity, and pointed out that intelligent logistics technology should be used to realize the integrated sharing and in-depth application of emergency materials information, so as to improve the emergency logistics [20]. The optimization of emergency logistics capability requires the integration of supply and demand information in multiple links of material raising, dispatching and transportation, the dynamic adjustment of material supply and deployment scheme, and the realization of automatic and intelligent transportation, so as to improve the logistics capability of emergency materials [21].

In summary, existing studies have proposed some strategic solutions and strategies for the problems existing in emergency logistics after COVID-19, but lack specific plans and application paths. In addition, among the existing research results, researches on the optimization of emergency logistics capacity mostly focus on a certain aspect of the emergency logistics link, instead of optimizing from the overall perspective, the optimization scheme design is rarely carried out from the perspective of smart logistics [22]. The improvement of emergency logistics capability needs to consider all links of raising, dispatching and transportation of emergency supplies. Intelligent logistics based on big data, Internet of things and cloud computing technology, can effectively integrate information of all links of emergency logistics, carry out intelligent optimization and application, and expand the improvement space of emergency logistics capability. This paper will explore from the above two aspects, and strive to improve the theoretical system of emergency logistics and comprehensively enhance the capacity of emergency logistics.

III. MAJOR PROBLEMS IN EMERGENCY LOGISTICS: ANALYSIS BASED ON COVID-19

The outbreak of COVID-19 is a major test of the emergency logistics capacity of all regions. In this sudden public health crisis, China's emergency logistics has exposed the following problems.

3.1 Emergency Supplies are Not Collected Efficiently

In the early stage of COVID-19 prevention and control, the demand for emergency supplies is highly

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concentrated and the supply gap is large. On the one hand, information of emergency supplies and emergency capacity is vague, and some materials do not meet the use standards. On the other hand, due to the information asymmetry and information lag in the process of the development of the epidemic, the supply of materials is not flexible enough to meet the needs of the development of the epidemic, which leads to the phenomenon that some enterprises produce too many personal epidemic prevention supplies and the supply of special medical equipment is insufficient.

3.2Imbalance of Emergency Supplies Dispatching

The COVID-19 epidemic lasted for a long time, affected a wide range of areas, and caused a high level of damage. Given the shortage and uneven distribution of emergency supplies, the difficulty in deploying emergency resources is high, and the problem of delayed and mismatched supplies has occurred from time to time. In the early stages of the epidemic, the overall supply of emergency resources fell short of the demand, the severity of the epidemic varied among regions, and the resources support was skewed toward the worst-hit areas. In this context, there is a serious shortage of epidemic prevention and medical supplies in some non-key and local disaster-affected areas. At the same time, affected by factors such as the lag in updating and following up the information of donations, social donations provide less assistance to.

3.3The Transport Capacity of Emergency Supplies is Insufficient

After the outbreak of COVID-19, the main problems in the transport of emergency supplies are as follows: lack of flexibility in the selection of transport routes; tracking and monitoring of transport status of emergency supplies; and low automation and intelligence in the transport process. The existence of the above problems reduces the timeliness of the transport of emergency supplies, and it is difficult to dynamically obtain the transport process of emergency supplies, thus unable to flexibly adopt emergency plans. In the process of dealing with the epidemic, the need to invest more manpower has increased the risk of infection of logistics workers.

IV. EMERGENCY LOGISTICS CAPACITY OPTIMIZATION BASED ON INTELLIGENT LOGISTICS

4.1The General Framework of Emergency Logistics Capacity Optimization

Emergency logistics is characterized by sudden and unpredictable demand, randomness, time constraint and urgency, and joint participation of economic government and market. Compared with ordinary logistics, emergency logistics lays more emphasis on the ability of rapid, efficient, accurate matching and dynamic response of logistics. Emergency logistics tries to realize its logistics benefits through logistics improvement. The realization of the improvement of emergency logistics depends on the comprehensive utilization of information in all links of the collection, deployment and transportation of emergency supplies. Therefore, logistics information is an important breakthrough in the optimization of emergency logistics capacity. Logistics information helps to accurately obtain, analyze and apply emergency supplies, and relevant technologies of intelligent logistics provide technical support for this. Intelligent logistics makes use of

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modern information technologies such as the Internet of Things, big data, cloud computing, intelligent hardware and software, sensors and sensor network. Intelligent logistics can obtain information in the process of circulation and make decisions for information analysis, so that goods can be tracked and managed in real time from the source. This mode has thinking perception learning the ability to reason and judge and solve some problems in logistics by oneself can realize the information flow faster than the physical flow. Through the fine, dynamic and scientific management of intelligent logistics, the logistics system has the characteristics of automation, visualization, controllability, intelligence, network and flexibility. Therefore, the optimization of emergency logistics capacity will start from the three links of emergency supplies raising, dispatching and transportation, and analyze how to use intelligent logistics technology to integrate logistics information, so as to realize the rapid, efficient, accurate matching and dynamic response capacity of emergency logistics. The overall framework of emergency logistics capacity optimization is shown in Fig 1.

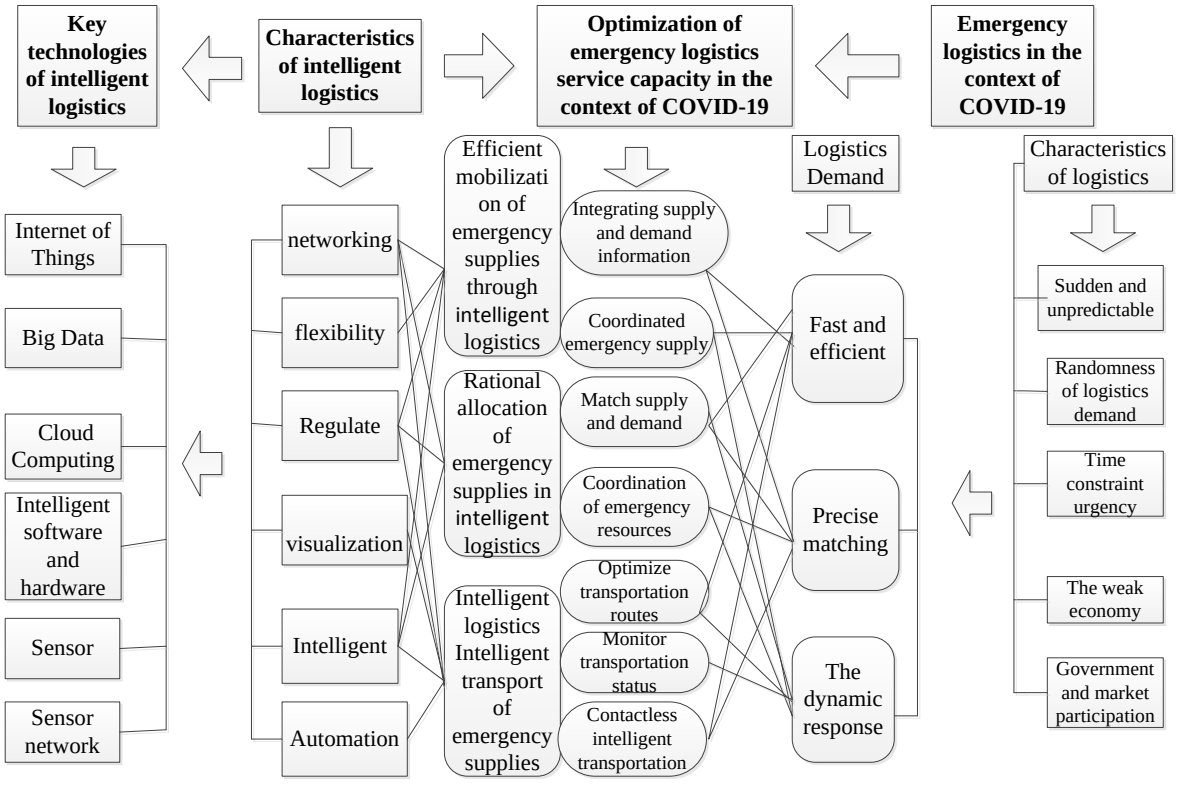

Fig 1: Overall framework of emergency logistics capability optimization

4.2Efficient Collection of Emergency Supplies Based on Intelligent Logistics

The relationship between supply and demand for emergency supplies and its information flow are shown in Fig 2.

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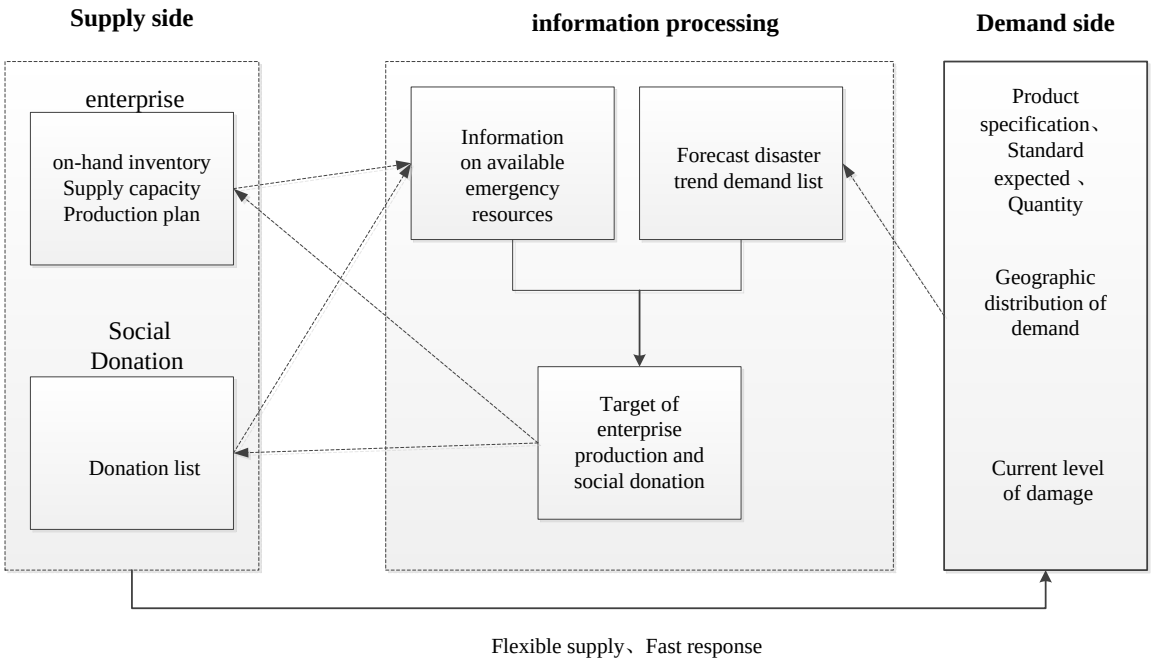

Fig 2: Emergency supplies mobilization

4.2.1 Integrating supply and demand information

It is a prerequisite for emergency logistics to obtain the information of supply and demand of emergency supplies rapidly and accurately. To the supply side, it is necessary to clarify the existing inventory of emergency supplies, emergency supply capacity, upstream supply information and other information of the supply chain for the production of emergency supplies. For the disaster-affected demand side, it is necessary to provide the product specifications, standards and expected quantity of emergency supplies as well as the disaster-affected location and other information for the reference of suppliers. Compared with traditional logistics, smart logistics has obvious advantages, which can collect supply and demand information in a more efficient and timely manner. The use of big data technology cloud computing information technology can achieve a high degree of information sharing. After the demand information is determined, the relevant supplier can be quickly identified through mass data processing and data calculation in the cloud computing center, and the future production plan of emergency supplies can be arranged according to the demand forecast information on the basis of clear existing supply situation. At the same time, demand for information sharing in the materials supply chain. All participating subjects can understand the whole production plan and implementation schedule. The upstream enterprise in a timely manner to understand the demand of downstream supplies manufacturing enterprises information and timely production supply plan. Downstream enterprises can quickly match to production materials haven't cooperation of suppliers, and can be put into production in time, implement related for emergency supplies .The whole chain synchronization and the overall improvement of the supply chain. In addition, the social donation is also an important source of emergency supplies, through the collection and processing technology of cloud computing data after the demand of information more system accurately and timely, is advantageous to the donor specific donor

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object Donation channel and donations standards, provide emergency supplies, and that can be used to reduce due to demand information fuzzy time and human and material costs.

4.2.2Coordinated emergency supply

After the outbreak of COVID-19, the needs of the victims for various supplies are not constant. With the implementation of the prevention and control plan and the change of the conditions of the affected people, the demand for various materials will increase and decrease dynamically. Big data and cloud computing technology can be used to identify such changes, and demand prediction can be made based on the existing information combined with the development trend of COVID-19. The processed demand information will be transmitted to the material supplier, who will make production and operation plans according to the orders. This flexible emergency supply mode relies on the circulation and transmission of production information within the supply chain system, and at the same time, it also needs timely feedback of external demand information. And intelligent logistics makes it possible to accurately analyze and share demand information. Information is no longer transmitted in a single line between upstream and downstream suppliers. Networked data sharing enables all participants in the whole process to obtain the operational objectives of this link at any time. This means that all the internal elements of the supply chain system can have a keen perception and rapid response to the demand changes of external emergency supplies, and adjust the relationship between each other accordingly, so as to keep the whole supply chain system in a relaxed and moderate operation state. In this mode, emergency supplies related supply chain upstream and downstream enterprises is no longer an isolated units, more like a integration of large factory, can effectively avoid the data island and bullwhip effect caused by the disorder Lagging production, enhance the response speed of the changes on demand for emergency supplies, and realize flexible supply of emergency logistics.

4.3Reasonable Dispatch of Emergency Supplies Based on Intelligent Logistics

The supply and demand relationship of emergency supplies scheduling and its information flow are shown in Fig 3.

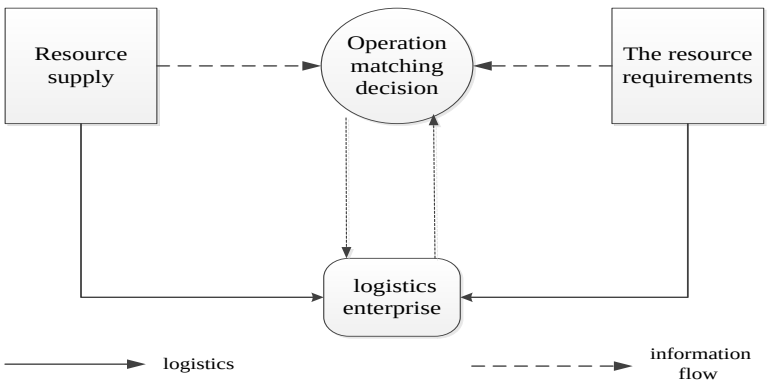

Fig 3: Emergency material scheduling

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4.3.1Match supply and demand

The traditional emergency logistics usually adopts the centralized command mode. The demand information of disaster victims and the supply information of suppliers cannot be directly matched. Instead, the decision is made in the command center after passing the information layer by layer, which increases the matching time between supply and demand and causes the possibility of decision lag to a certain extent. Intelligent logistics through the Internet of things terminal sensor technology, can achieve physical interconnection machine interconnection and human-machine interconnection, the biggest advantage of the Internet of things technology is comprehensive access to information, with the help of a large-scale integrated sensor network and terminal to collect vast amounts of information, and upload information to the cloud storage, the status of suppliers and demanders can accurately transmitted to the information management platform. The data of the information management platform can achieve intelligent matching through the big data cloud computing technology, thus reducing the loss caused by personal decision-making mistakes. In this mode, the demand information of the disclosing party and emergency supplies the supplier has the function of organization feedback operation, each participant is direct input nodes of information processing platform, and information processing platform can directly from the original data to synchronize operations, use of networked information feedback and processing automation and intelligent matching precision. This decentralized information collection and processing method of emergency supplies supply and demand greatly shortens the information transmission path, avoids the information distortion in the hierarchical transmission process of information, and improves the matching accuracy and improvement of supplies supply and demand.

4.3.2Coordination of emergency resources

In addition to the matching of supply and demand, the scheduling of emergency materials also includes the scheduling of emergency vehicles and personnel, the selection of centralized supply center of emergency materials, and the overall arrangement of emergency resource priority in the case of resource shortage. In intelligent logistics activities, the built-in sensing equipment of the transport vehicle can transmit the position and loading status of the vehicle to the information management platform. The information management platform will carry out intelligent matching between the transport vehicle and the material supply station, and transmit the matched transport target to the terminal vehicle through the Internet of Things technology. In this way, the vehicles participating in emergency dispatching can be allocated to clear transport tasks, while avoiding the empty vehicles caused by unreasonable allocation and reducing the queuing time waiting for transport materials. In addition, the location of emergency materials centralized supply center is also an important factor affecting the speed of material allocation. In the public health crisis with shortage of materials, the suppliers of materials are scattered. Emergency materials usually need to be deployed across regions, and social spontaneous relief materials are also distributed in a decentralized manner. Therefore, centralized supply transfer stations can improve the material dispatch. Big data and cloud computing technology can be used to analyze and predict the high incidence points of material transit, so as to complete the best location. The outbreak of acute public health crisis is often accompanied by early prevention and control of the condition of the shortage of emergency resources, in accordance with the scale of the resource allocation priority setting is key step to realize the overall loss minimum, priority setting is

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not only to consider the current disaster situation, and the forecast of the development trend for the future crisis, big data and cloud computing technology to precise calculation Reasonable forecast, make the best resource allocation plan.

4.4Intelligent Transportation of Emergency Supplies Based on Intelligent Logistics

The task and route adjustment process of emergency supplies transportation are shown in The task and route adjustment process of emergency supplies transportation are shown in The task and route adjustment process of emergency supplies transportation are shown in Fig 4.

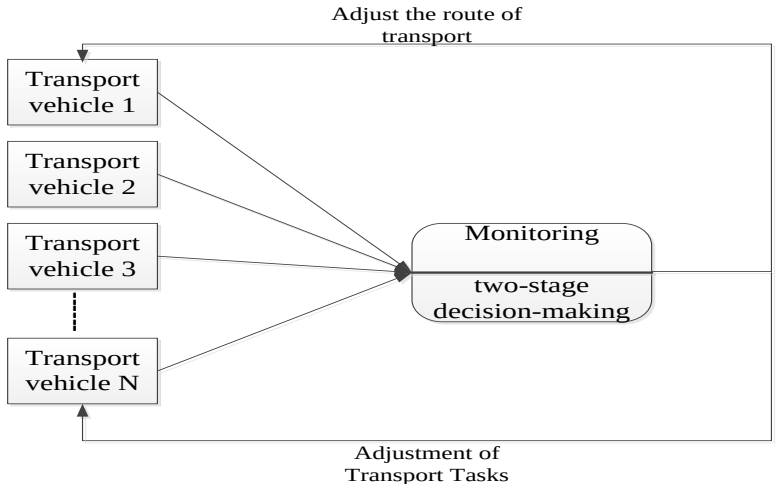

Fig 4: Transport of emergency supplies

4.4.1Optimize transportation routes

Path optimization is a common problem in logistics and transportation. Different from the path optimization in economic activities, emergency logistics has weak economy, and it pays more attention to the optimization of transportation path speed and less to the realization of logistics cost optimization. In the process of intelligent material transportation, the sensor and sensor network technology of the Internet of Things can collect the road flow information; transmit it to the information management platform for visual translation. Meanwhile, the relevant transport vehicle positioning and transport tasks are also synchronized on the management platform. The information management platform uses the data processing technology to develop the transportation path and transportation scheme according to the input information and the optimized path is transmitted to the transportation vehicles through the Internet of Things devices. With the help of intelligent logistics technology, vehicle positioning, vehicle interactive flow management and optimal path selection and other functions in the transportation process can be realized in an orderly manner. Transport vehicles is not spontaneously choose the shortest path to improve transport speed, but after considering the same time other vehicle routing and is expected to road traffic information, such as scientific arrangement transport path, then this greatly reduces the road congestion caused by diversified transport path decisions, guarantee the transportation improvement and transportation process Predictability

4.4.2Monitor transportation status

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Dynamic monitoring of emergency materials transportation status is an important means to accurately trace the source of emergency materials and timely adjust the transportation plan and material supply plan. Intelligent logistics technologies such as RFID sensors, sensor networks and the Internet of Things can be used to locate emergency vehicles in real time and obtain the visual status of emergency supplies. Information management platform can not only use this information to optimize transport scheme of emergency supplies, and to predict material delivery time, and combining the material demand information to the secondary supply plan adjustment, so as to ensure the supply of emergency supplies can change according to the demand of the rapid response, realize information faster than the material. Visual monitoring method can achieve the accuracy of emergency supplies, starting from the emergency supplies to transport links, all materials status will be recorded and stored: material is provided by which supplier or social rescuer shall be the responsibility of the company undertake transport vehicles and personnel list In road goods and materials of the transit center and transportation line material storage locations, the distribution status and final flow direction of materials. Emergency supplies can be tracked and located in real time, and problem supplies can be accurately traced, so as to ensure the safety and control of emergency supplies.

4.4.3 Contactless intelligent transportation

In the material transportation activities after the COVID-19 epidemic, the adoption of automatic and intelligent transportation mode can not only improve the productivity and reduce the error rate, but also reduce the use of personnel and guarantee the life safety of transportation personnel. In intelligent logistics, physical logistics makes use of artificial intelligence RFID technology, video perception technology, positioning technology, sensor technology, bar code recognition and scanning technology to form an Internet of Things network system, which can realize intelligent command and automatic operation in the links of storage, handling, sorting, transportation, and assembly. In the whole transportation process, people are no longer the executor of transportation instructions. The operation instructions are stored in the machine and equipment as the set program, and the emergency supplies are fully automated transportation through the intelligent equipment. This fully automatic and intelligent transportation mode can maximize the optimization of transportation process and improve transportation. At the same time, contactless transportation also reduces the possibility of accidental casualties.

V. CONCLUSIONS AND PROSPECT

Emergency logistics plays a vital role in sudden public health crises such as COVID-19. In view of the main problems in the emergency logistics of various places in the COVID-19, combining the characteristics and advantages of intelligent logistics and the needs of emergency logistics, this paper focuses on the material mobilization and dispatch the optimization scheme of emergency logistics capacity based on intelligent logistics in the context of COVID-19 was studied and analyzed. First, intelligent logistics was used to ensure the efficient collection of emergency supplies and realize the integration of supply and demand information and flexible supply of emergency supplies. Second, use intelligent logistics to promote the reasonable dispatch of emergency supplies, and realize the matching between supply and demand of supplies and the overall planning of emergency resources; Third, the use of intelligent logistics to ensure the

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intelligent transportation of emergency supplies, to achieve the optimization of the transportation path, the monitoring of the transportation state and the automatic intelligent transportation.

This paper focuses on the theoretical discussion on the optimization of emergency logistics capacity in the context of COVID-19, and the application cases and empirical analysis of intelligent logistics technology in the field of emergency logistics are the topics to be further studied in the future. It should be noted that to improve the logistics support capacity of emergency supplies and promote the deep application of intelligent logistics technology in the field of emergency logistics requires the multi-participation of enterprises and government researchers, as well as the cutting-edge technology of legal and policy infrastructure It relies on the national system and mechanism for prevention and control of major epidemics, and looks forward to the further improvement of the emergency management system in public health crises such as COVID-19.

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