

Review of Domestic and Foreign Emergency Logistics Research Under Major Emergencies

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Abstract: In recent years, there have been frequent public health emergencies that have brought great harm to people's lives. Among them, major infectious diseases spread rapidly once they break out. They are characterized by a wide range of infections, rapid spread, high degree of mutation and lasting harm, and difficulty in initial control. Based on this, the focus and research on emergency logistics are gradually carried out. Based on previous literatures on emergency logistics, this paper reviews literatures on three research hotspots of emergency logistics, multi-objective optimization, and vehicle routing of emergency materials, hoping to provide some help for future in-depth studies on emergency logistics.

Keywords: Emergency logistics, multi-objective optimization, emergency vehicle routing problem.

1. Introduction

According to the relevant research of scholars from various countries in the field of emergency logistics, it is found that at the beginning, the research on emergency logistics is mainly based on the background of natural disasters, and few studies on the background of public health emergencies such as major infectious diseases. In the past two years since the COVID-19 epidemic lasted, the research on emergency logistics for infectious diseases has gradually aroused high attention. To sum up, most of the existing research on emergency logistics focuses on coping with natural disasters such as floods and earthquakes, while the research and exploration on emergency logistics for infectious diseases are also relatively lacking.

2. Research on Emergency Logistics

In 1992, Carter W N [1] pointed out that logistics activities played a very key role in post-disaster emergency work, and proposed the concept of emergency logistics for the first time, defining it as the reception, storage, distribution and transportation of various disaster relief materials involved in the process of emergency rescue. Aakil MC [2] realized that the optimization model could effectively solve the problem of post-disaster emergency logistics. In the research, taking natural disasters as the background, emergency logistics is studied from three aspects: infrastructure layout, relief material distribution and disaster personnel transportation. Nikbakhsh E and Farahani R Z [3] defined the importance of emergency logistics on the basis of analyzing the classification of disasters, the impact of disasters on the country and the post-disaster management system, compared it with commercial logistics, and established relevant models of site selection, distribution, transportation and inventory. Bozorgi-Amiri A et al. [4] regard the demand, supply, procurement cost and transportation cost of emergency materials as uncertain factors, and take the whole rescue process as the research object. By constructing a mixed integer nonlinear programming model with the least expected total cost, Bozorgi-Amiri et al. [4] solve the problem of location selection and distribution of disaster relief materials

distribution center. When studying emergency logistics, Rezaei-Malek M [5] et al. noted that a certain amount of disaster relief materials should be stored in appropriate places before disaster occurs, so that rescue can be carried out in time after disaster occurs, but most disaster relief materials usually have a certain warranty period. Therefore, an optimization model was built that also considered site selection, inventory and distribution. Li Jing [6] et al. sorted out the concept characteristics of emergency logistics and the problems existing in emergency logistics management, and proposed the emergency logistics support mechanism under the background of natural disasters from the aspects of technical support, financial support and traffic support. Guo Debate [7] analyzed the emergency logistics management system after natural disasters from three aspects: decision command, material reserve and information management, pointed out the existing problems, and combined with the characteristics of emergency logistics, proposed measures to improve emergency logistics management. Yao [8] analyzed the characteristics and process of emergency logistics and the factors that affect the emergency logistics rescue effect, divided the index into two types: ability and benefit, established an index system for evaluating the emergency logistics rescue effect, and then built an evaluation model of rescue effect based on BP artificial neural network. Jing Kang [9] specifically analyzed the imperfect laws and regulations of the emergency logistics support system in the field of transportation, the defects of the command system, the high cost of road transportation, and the imperfect multimodal transportation, and put forward five targeted solutions. Taking earthquake disaster as the research background, Wang Yanyan [10] studied the distribution of emergency materials in emergency logistics. In the construction of the model, multiple objectives, multiple distribution and the demand uncertainty caused by disasters were considered.

3. Multi-objective Planning Emergency Logistics Research

In order to give full consideration to the timeliness and economy in the emergency response process, researchers take multiple objectives as research subjects to realize the planning

of emergency materials distribution. Yao Jiao et al. [11] noticed that emergencies would have a certain impact on the connectivity of urban road network, thus affecting the route selection of emergency delivery vehicles. For this reason, relevant factors affecting the route selection of delivery vehicles were sorted out, and a multi-objective optimization model considering safety and traffic conditions was built. Zhu Jiayang [12] built a dynamic programming model for implementation in emergency scenarios in view of robust policy stability and multi-stage and multi-objective problems. Jiang Yangsheng et al. [13] established a rolling optimization model of material distribution scheme cycle based on the spread model of infectious diseases and the characteristics of point-to-point transportation of medical materials. Tang Donghai et al. [14] focused on the fairness of emergency medical supplies distribution, considered the minimum total transportation time and took the demand satisfaction rate as one of the optimization objectives. Gao Xinyu et al. [15] established a multi-objective and multi-stage location path optimization model in view of the different requirements of decision schemes for cost and rescue efficiency in different stages of emergency rescue. In order to improve the distribution efficiency of emergency materials, Zhang Bukuo et al. [16] converted time satisfaction and cost satisfaction into the same metric, and jointly built a dual goal planning model of three-level distribution based on virtual demand points with the goal of fairness. Liu Changshi et al. [17] comprehensively considered the randomness of emergency vehicle travel time caused by the geographical location and terrain of the disaster relief point, the uncertainty of the emergency material demand at the disaster relief point and the time urgency of emergency material distribution, and built a multi-objective fuzzy LRP optimization model based on opportunity constraint planning, aiming at the shortest total transportation time and minimum total distribution cost of emergency materials. According to the characteristics of the model, a hybrid immune genetic algorithm is designed to solve the problem. He Shanshan et al. [18] built a dual-objective optimization emergency logistics network model to improve balanced slack inventory and reduce total time cost in combination with the transit collaborative distribution mode of public and rail intermodal transport. Ma Lirong et al. [19] designed the ant colony algorithm to solve the multi-objective emergency distribution optimization model with the least number of delivery vehicles and the shortest total driving distance. Cao Cejun et al. [20] fully considered the relationship between survivor satisfaction and risk acceptability in the relief materials dispatching network, and built a double-layer integer programming model that minimized the sum of weighted travel time and maximized weighted perceived satisfaction. Wang Li et al. [21] established a multi-objective coordination optimization model focusing on the balance between distribution fairness and delivery timeliness of disaster sites in emergency rescue. Zheng Xia et al. [22] graded disaster sites and constructed a multi-objective location path optimization model for emergency materials, which covered the largest population, the smallest total rescue cost and the smallest unmet total demand for materials.

4. Research on Vehicle Routing of Emergency Materials

When Polimeni A and Vitetta [23] solve the route

optimization problem of emergency supplies vehicles, they mainly consider the delay time of emergency supplies delivery vehicles and the number of rescuers, and solve the model through dynamic programming and Dijkstra algorithm. Victoria JF [24] et al., taking the vehicle routing problem in the last kilometer of emergency rescue as the research object, reduced the distribution cost and determined the driving route and service time of vehicles by building relevant optimization models. When studying the vehicle routing problem of emergency supplies, Vaz Penna P H[25] et al. took the earthquake as the background, considered the constraints such as vehicle type, distribution times and number of distribution centers, and designed a hybrid heuristic algorithm to solve the problem. Molina J[26] et al established a multi-objective emergency vehicle routing optimization model considering the limited number of vehicles, minimum distribution cost and maximum rescue delay. Keke [27] sorted out the research results of vehicle routing for emergency supplies, identified its characteristics, and built an optimization model based on a single emergency distribution center and multiple supplies with the background of public health emergencies. Zeng Zhengyang [28] et al., taking multi-emergency distribution centers and multi-demand points as research objects, established a vehicle routing model with minimum total waiting time at demand points in order to deliver emergency materials to demand points as soon as possible. In the case of insufficient supply of emergency materials and uncertain demand, Cheng Bilong et al. [29] built a vehicle routing optimization model to minimize total cost (loss cost, vehicle start-up cost and distribution cost) from the perspective of decision makers. Zhang Yuzhou et al. [30] established a model considering total transportation and total delay time as optimization objectives, solved the problem by hybrid genetic algorithm and carried out analysis. Wang Hongbin [31] used fuzzy analytic hierarchy process (AHP) to evaluate the traffic conditions of each road according to the established road traffic condition evaluation system, and built an optimization model to maximize the satisfaction of demand points on this basis. Song Yinghua et al. [32] solved a model that incorporated the driver's psychological cost caused by disasters into the target and considered the event constraints by using an improved genetic algorithm. He Ting [33] et al. built a model based on the novel coronavirus outbreak, focusing on the unique constraints under the epidemic background, and then studied the vehicle routing problem. Kang Bin [34] et al established a more practical emergency vehicle distribution model with single center and multiple distribution points in view of the road damage factors caused by strong destructive disasters in emergencies. Yuan Tao et al. [35] also considered the actual road damage and traffic conditions when establishing the LRP model, and used examples to carry out logistics route scheme planning.

5. Summary of Research Status

To sum up, the existing researches in the field of emergency materials route planning mainly focus on the theoretical system of emergency logistics, the multi-objective planning of emergency logistics and the routing problem of emergency materials vehicles. By combing relevant literature, the existing researches have achieved relatively in-depth research results in the field of emergency logistics. It also provides theoretical basis and research method for emergency logistics distribution planning under the background of major infectious diseases. However, there are still some problems

worth further exploration in the current emergency materials route planning, which are summarized as follows:

(1) Research on the construction of the existing emergency logistics response system mostly focuses on natural disasters, such as the emergency rescue of natural disasters caused by floods and earthquakes, and the types of relief materials organized and distributed by the system cover a wide range, including food, bedding and other necessities of life and professional rescue equipment. Obviously, the kinds of supplies that are lacking after a natural disaster such as a flood are different from the kinds of relief supplies that are needed after a sudden public health event such as a major infectious disease. A large number of demand gaps for emergency supplies generated by major infectious diseases mainly exist in emergency medical supplies, including strain detection reagents and various medical drugs for proper treatment. In the research on the distribution of emergency supplies for daily necessities and professional rescue equipment, the research on the distribution of emergency medical supplies for specific categories, such as emergency medical supplies, has rarely been explored in existing literature. At the same time, as the state attaches more importance to the scientific research on the prevention and treatment of public health emergencies, it also makes the route planning of emergency medical supplies under the epidemic situation more important.

(2) Current studies on vehicle routing for emergency supplies are mainly based on the model itself. Although most of them take into account the impact of road damage and traffic conditions, distribution fairness, survivor satisfaction, etc., on the final rescue effect during emergency distribution, few take into account the impact of the dynamic spread of the epidemic in the epidemic area and the quantity consumption of medical supplies in designated hospitals on the distribution route planning. That is, the consumption of medical supplies can change the conversion rate of infectious diseases to a certain extent, thus making a difference in the spread of the epidemic situation. Most of the models built to study the vehicle routing problem take the total distance traveled by vehicles, the number of vehicles in use, and the carbon emission of vehicles as the objective function, while few studies consider the social cost of the distribution point distribution waiting time. Moreover, in most studies, point-to-point mixed distribution of single or multi-category emergency materials is implemented through established or sited emergency supply networks including logistics transfer centers and other levels.

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