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Research Status and Prospect of Medical Material Scheduling

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Abstract: *When sudden public health events broke out, the demand for medical materials surged, so there were some problems such as lack of materials and low efficiency of medical materials transportation. This paper collects the literature related to medical material scheduling at home and abroad, mainly summarizes the location of medical emergency material warehouse and emergency medical material scheduling model, points out the areas that can be improved in the process of medical material scheduling in China at present and the direction that can be studied in the future, and puts forward several measures to improve it, so as to enhance the national emergency support capacity and better deal with major public health emergencies.*

Keywords: *Medical material dispatching; Mathematical model; Intelligent optimization algorithm*

1. Introduction

After the outbreak of public health emergencies, the growing number of infected people and limited medical resources have formed a sharp conflict, and the first-line relief materials are often in short supply. In disaster emergency decision-making, the allocation and scheduling of emergency relief supplies (ASERS) is an important link in carrying out emergency rescue, and it is the basis for dealing with emergencies and carrying out disaster relief.[1]. Emergency materials are necessary to deal with public health emergencies, and reasonable material scheduling can effectively reduce the adverse effects of sudden disasters. Coping with public health emergencies is a race against time. After the outbreak, the release of material information is not timely, the emergency logistics capacity is insufficient, and the supply and demand information is biased, which seriously affects the prevention and control of public health emergencies. The scheduling of medical materials is a very important issue in public health emergencies, and how to use scarce emergency materials where they are most needed is particularly important.

This paper intends to think and study from two aspects: one is to summarize the papers related to medical material scheduling; Second, aiming at the problems existing in current medical dispatch, the medical material dispatch mechanism has been improved. It can improve the response speed and ability of the emergency system when the country faces public health emergencies, and provide reference for the country to face public health emergencies in the future.

2. Emergency medical supplies scheduling model

After the outbreak of public health emergencies, it is very important to study the relevant strategies to deal with public emergencies. The reserve of emergency materials can provide sufficient material security and effectively deal with various emergencies, so scholars at home and abroad have done a lot of research on emergency materials and vehicle scheduling. In 1998, List et al.[2]Emergency problem is introduced into the transportation optimization model of radioactive dangerous goods for the first time, which lays the foundation for the study of emergency resource scheduling.

2.1 Emergency Warehouse Location Problem

At present, few scholars in China discuss the location of emergency rescue warehouse, and establishing emergency warehouse is one of the important means to deal with sudden disasters. During the pandemic, the great demand for materials, insufficient emergency supplies and unreasonable emergency facilities planning reflect the importance of emergency warehouse decision-making. Bo Chen

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Wang, Qi Yuan Qian and others.[3]A mixed integer programming (MIP) model based on time cost under uncertain conditions is proposed to solve the problem of emergency warehouse location and distribution. The disadvantage is that some data in the paper are generated according to uniform distribution, which is not in line with the actual situation. Qianqian Liu, Churan Lin[4]Taking the epidemic situation as the research material, this paper puts forward an intelligent dispatching assistant decision-making method for emergency medical materials, and applies computer simulation technology to construct an evaluation system of emergency medical materials transportation scheme based on urban geographic information data. By comparing the location of distribution centers, the optimal distribution scheme can be obtained. In the case of insufficient transportation capacity, increasing distribution vehicles can effectively improve transportation efficiency.

2.2 Emergency medical supplies scheduling model

When a sudden pandemic breaks out, it is very important to take correct and effective measures and deliver medical materials quickly and accurately in the process of emergency rescue. In order to solve the emergency dispatch problem of medical materials under public health emergencies, Hu Xiaowei, Song Lang and others[5]A dynamic distribution model of emergency medical materials is established with the maximization of weighted demand satisfaction rate as the main goal and the minimization of vehicle travel distance as the secondary goal. The model also gives an automatic calculation method when data is missing, which is more operable. However, this document only considers the confirmed situation of the distribution center, and the dynamic distribution of emergency medical materials with uncertain distribution center can be further discussed in the future. Xiaojia Wang,Zhizhen Liang[6]With the goal of the highest system service rate, markov decision processes (MDP) model is established, which shows how to dispatch limited emergency medical supplies in the dispatching center to achieve the best service efficiency of the whole system. However, the model does not consider the restrictions of personnel flow and vehicle peers in closed environment. Yudan Chen[7]The dual-objective vehicle scheduling model, which aims at the shortest delivery time and the highest customer satisfaction, optimizes the delivery vehicle scheduling in the transportation and distribution of emergency materials, so that medical materials can arrive in a short time and play their greatest role, and improve the rescue efficiency in emergency situations. Wang Fuyu, Tang Tao and others.[8]A multi-objective optimization model is constructed with the goal of maximizing the satisfaction of victims, minimizing the total cost and considering the fairness of distribution. SEIR is used to predict the number of infected people in the disaster area and calculate the urgency of material demand in the disaster area. And Zhang Li, Zhang Huizhen and others.[9]The entropy weight method is used to determine the urgency of demand points, and a multi-objective model is constructed with the goal of maximizing the fairness of emergency material distribution and the shortest total distribution path on the basis of urgency.

At the beginning of a sudden pandemic, there will be problems such as insufficient transport efficiency in the distribution center. In order to effectively solve the problem of emergency materials scheduling and improve the utilization rate of emergency materials, Zhang Guangsheng[10]This paper summarizes the basic process and existing problems of emergency material dispatching, analyzes the supply-demand path and rescue timeliness of emergency material dispatching system, constructs an efficient, timely and low-cost dynamic dispatching model of emergency material dispatching system, and simulates the model based on the shortest path problem of multi-source time and Floyd-Warshall algorithm. Wu Ke, Song Yinghua and others[11]Considering the situation of multiple emergency material distribution centers and emergency material demand points, a complete emergency delivery vehicle scheduling model is constructed with the goal of minimum number of delivery vehicles and minimum delivery routes, and a time window is added to the model, so that emergency materials can be delivered within the time required by each demand point. Jia Liu, Jinyu Bai and others.[12] Aiming at calculating the shortest transportation time from any distribution center to any hospital and the corresponding route, and calculating the medical materials transported to each hospital by each vehicle (the best distribution scheme of medical materials can be obtained), this paper puts forward a distribution model of medical materials scheduling in major public health emergencies. To solve this model, they propose a multi-dynamic programming algorithm combining multiple separate dynamic programming operations, which realizes the rapid update of distribution schemes when the number of vehicles changes. The limitation of this model is that it is not suitable for the situation with a large number of hospitals.

2.3 Special Medical Material Scheduling Model

At the beginning of public health events, the problem of medical materials scheduling under the

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condition of insufficient medical materials is a special transportation problem. The protective equipment in stock can't meet the increasing demand, so we must make good use of these scarce and critical resources. Chen Feng, Ding Wenlong and others[13]Based on the actual situation of insufficient supply of medical materials during the epidemic period, combined with the different needs of medical materials in various medical points, a dual-objective optimal scheduling and distribution model of medical materials considering material delay loss and logistics cost was established by using optimization theory and method. Compared with the single-objective model, the double-objective model proposed in the literature is more in line with the actual situation. In order to distribute relief materials to the people in a timely and efficient manner, Fu-Sheng Chang, Jain-Shing Wu and others.[14]A multi-objective genetic algorithm (GSMOGA) based on greedy search is proposed, which can adjust the allocation of available resources, dynamically adjust the distribution plan of each supply point according to the demand of material demand points, and automatically generate various executable emergency material scheduling schemes for decision makers. The results generated by GSMOGA can be used to determine the resource availability of each demand point and the resource quantity of supply points. Reze Sakiani, Abbas Seifi et al.[15]Mentioned the redistribution of materials, some areas have surplus inventory, while others have insufficient inventory. They established an operational mathematical model of dynamic distribution and redistribution of disaster relief materials considering the different characteristics of disaster relief materials, and proposed a novel simulated return algorithm to solve the model. The model manages the inventory of different nodes and different periods, and it is also responsible for arranging the vehicle route for transporting materials in the first phase. This model can't update the solution in real time, and we can study it in this direction in the future. Bryan P.Bednarski, Akash Deep Singh and others.[16]They also noticed the problem of medical supplies redistribution in COVID-19. They studied how reinforcement learning and deep learning models can promote the near-optimal redistribution of medical supplies. They proposed a powerful data preprocessing pipeline and a redistribution algorithm that can be applied on a large scale.

None of the above documents takes into account the shortage of vehicles for transporting materials during the epidemic period. During the epidemic period, there will be a shortage of vehicles for transporting emergency materials due to the measures of city closure and traffic control. Therefore, timely and effective medical materials scheduling has become the key point to carry out the work of fighting the epidemic. In the actual material scheduling process, we should make decisions according to the real-time traffic conditions. Wang Xuping, Ma Chao and others[17]According to the demand of emergency materials dispatching, the route selection of rescue vehicles and the distribution of emergency materials are comprehensively decided under the condition of limited transportation capacity. The solution space of the problem is reduced by hierarchical solution strategy. Finally, the dynamic scheduling scheme of materials under the condition of extreme shortage of rescue vehicles is obtained. In view of the uncertainty and complexity of traffic flow in the process of medical materials transportation, Huang Chengning, Li Juan and others[18]A graph neural network is proposed to solve the problem of material scheduling time series prediction. He Tilong, Lou Wengao[19]This paper studies the emergency material scheduling problem from multiple rescue points to multiple demand points under three kinds of road damage conditions, establishes a model with the goal of minimizing the total material loading time and the minimum consumption cost, and solves the model with an improved moth extinguishing algorithm.

2.4 Cold Chain Drug Transportation Scheduling Model

Sorting out the above literature found that they are all aimed at the research of routine medical material scheduling. In the emergency demand, cold chain drugs have become important materials, and these special transportation schedules have also increased. Yun Yang, Changxi Ma et al.[20]Aiming at the problem of cold chain emergency materials distribution path optimization with multi-demand centers and soft time windows, a multi-dimensional robust optimization model is proposed to minimize the cost and maximize the robustness, and the model is solved by a hybrid algorithm combining Pareto genetic algorithm and improved grey relative analysis (IGRA). Most of the existing studies focus on the path optimization under the condition of separation of cold chain and emergency factors, while only some studies focus on both cold chain and emergency factors. And Yuhe Shi, Zhenggang He[21]Different from the above scholars, they innovatively studied the optimization of medical material distribution after natural disasters from the perspective of interference management, and established a disturbance management model of medical material distribution from two dimensions: time and cost.

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3. Using improved NSGA-IIMedical material scheduling problem solved by algorithm

For multi-objective problems, NSGA-II Algorithm solution[22]. Zhang Guofu, Wang Yongqi and others put forward a method based on two-dimensional NSGA-II Hybrid intelligent search algorithm with ant colony optimization[23], which is used to solve the multi-objective optimization model of multiple storage points, multiple release points and multiple emergency relief materials. Xue Xingqun, Wang Xuping and others constructed a non-dominated sorting hybrid evolutionary algorithm with elite strategy according to the idea of random domain search mutation and hierarchical crossover.[24]Under the condition of limited transportation capacity, the optimization model with the shortest average waiting time and the lowest total cost of emergency network as the goal is solved. Ren Hui, Wang Dongyu[25]According to the characteristics of chromosome coding, a new genetic operator is proposed to improve NSGA-II Algorithm, and apply it to the emergency material reserve model based on cloud service and considering expected deployment. Liu Yang, Zhang Guofu and others.[1]Put NSGA-II Extended to two-dimensional integer vector coding, based on NSGA-II And the shortest transit time from each storage point to each distribution point is given by ant colony optimization. Wang Fuyu, Zhang Kang[22]NSGA-II with adaptive mechanism Algorithm, and applied to the optimization model with the goal of minimizing the average waiting time for rescue at the disaster site and minimizing the cost of emergency material scheduling. Chen Gang, Fu Jiangyue and others.[26]Considering the fairness of material distribution, this paper constructs a multi-objective optimization model with the minimum total weighted jealousy value and the lowest total logistics cost as the goal, and designs a new coding method and genetic operator for NSGA-II The algorithm is improved and the model is finally solved. Yuhe Shi,Yun Lin[27]People use drones for the delivery of medical materials, which can break the restrictions of ground transportation, shorten the delivery time and realize non-contact delivery. In this paper, a dual-objective mixed integer programming model is proposed for multi-path UAV location routing problem, with the operating cost and UAV travel time as the best objectives. A modified NSGA-II containing double codes is designed in the literature.Apply it to this model. In major public health emergencies, the rapid and accurate distribution of medical materials through new technologies is an important field of future research.

4. Conclusion and prospect

Nowadays, the research on medical material scheduling is increasing, which shows that the problem of medical material scheduling is still a research hotspot. With the development of the times, the research on medical material scheduling has more and more social value. By combing the relevant literature at home and abroad, we have the following findings:

(1) Chinese scholars are increasingly rich in the research content of medical material scheduling problem, from just using a single algorithm to solving the model now using multiple algorithms or improved optimization algorithms to solving the model.

(2) Foreign scholars have considered the special emergency medical supplies scheduling, such as the transportation of cold chain emergency supplies, and the use of drones to distribute emergency supplies when land transportation is limited. Domestic scholars still need to explore related research.

In a word, the research on emergency medical material scheduling in China has achieved fruitful results, but it can not be ignored that there are still many problems to be solved urgently, and the research on emergency medical material scheduling is not comprehensive. In the follow-up study, we can consider establishing emergency warehouses in cities to shorten the transportation time and cost of emergency materials and improve transportation efficiency. We can also consider other ways to distribute medical materials when land transportation is limited, as well as some transportation problems for cold chain drugs, which plays an important role in the actual emergency medical materials scheduling.

In the process of collecting literature, I also found out how to investigate the problems existing in the process of medical material scheduling and the ways to solve them from the perspective of the positioning of medical material scheduling. The scheduling of emergency materials involves many departments and links, so a coordinated and efficient command and coordination mechanism is needed.[28]. There should be more specific measures in this regard, as follows:

(1) Improve the emergency deployment and guarantee system of medical materials: We can set up a reasonably laid-out emergency material reserve area, optimize the material reserve structure, and expand the types and scale of the reserve materials.

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(2) Assign materials according to the degree of risk and the stock of materials: according to the risk level assessment, update the emergency materials classification and reserve catalogue in a timely and dynamic manner, and scientifically adjust the quantity of materials reserves.

(3) Control and distribute medical materials by classification.

Sudden public health incidents are large in scale and latent, so the demand for materials is more urgent. It is very important to build an efficient command and coordination mechanism and improve the national emergency support capability.

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