American Journal of Civil Engineering
2024, Vol. 12, No. 4, pp. 144-152
https://doi.org/10.11648/j.ajce.20241204.15

Research Article

A Literature Study of Emergency Material Dispatch Models and Optimisation in the Context of Natural Disasters

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Abstract

The recurrent occurrence of natural disasters has brought into sharp focus the urgent need for the expedient distribution of emergency materials. In the aftermath of a disaster, the swift and precise distribution of essential emergency supplies is of the utmost importance in ensuring the basic survival needs of the affected population are met, minimising the impact of the disaster and maintaining social stability. In order to provide a comprehensive overview of the research progress in the field of emergency supplies dispatching after natural disasters, we employ the knowledge graph analysis software VOSviewer to investigate the optimisation issues pertaining to the emergency supplies dispatching model, taking into account the inherent uncertainty, from a multi-objective standpoint and across a range of algorithms. A total of 375 literature sources were included in the China Knowledge Network database for review. The research objectives, methods and conclusions of the representative literature on hot spots at home and abroad were subjected to analysis. The review examines the research objectives, methodologies and conclusions of the most prominent literature on the subject, both domestic and international, and analyses the current status of research on the scheduling of emergency materials in the context of natural disasters. By synthesising these findings, we aim to identify gaps in existing research and suggest directions for future endeavours to promote a more resilient and effective emergency management system that can respond rapidly to the ever-changing needs of disaster-affected communities.

Keywords

Natural Disasters, Emergency Supplies Scheduling, Vehicle Scheduling, model Optimisation, Research Review

1. Introduction

The recurrence of natural disasters represents a significant risk to human security and the stability of the economic and social order. In light of these challenges, the work of securing emergency supplies is particularly complex. This is due to a number of factors, including the unpredictability of demand, the difficulty of resource deployment and the uncertainty of the transport process. These difficulties necessitate prompt action following an event, utilising on-site data to forecast and evaluate the actual demand for emergency supplies, and formulating scientific and pragmatic material dispatch programmes and transport routes to guarantee the timely and accurate delivery of materials to disaster-stricken areas. The study of emergency material dispatching in the context of natural disasters has both practical and historical

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Received: 7 August 2024; **Accepted:** 21 August 2024; **Published:** 30 August 2024

significance. By undertaking an in-depth examination of the theoretical, methodological and technological aspects of emergency material dispatching, it is possible to enhance the efficiency of disaster response, minimise losses and casualties, and contribute to the mitigation of disasters. The objective of this paper is to provide a comprehensive and systematic review of the research progress, main methods and models in the field of natural disaster emergency material dispatching, both domestically and internationally. In order to achieve this, 31 relevant literature sources have been subjected to detailed analysis. The analysis results reveal the problems existing in the current research on emergency logistics resource scheduling under natural disasters, such as the uncertainty of emergency material demand information, the complexity of multi-objective optimisation model, the insufficient effectiveness and robustness of algorithms, and the insufficient validation of actual data and cases, etc. This paper proposes the solutions and countermeasures to solve the above problems by analysing and summarising the above problems, and also proposes the future research directions and trends.

2. Bibliometric Analysis Study

This paper presents a systematic literature review of the existing research on the topic. Firstly, the topic of the literature review must be determined. This is achieved by selecting relevant literature from the China Knowledge Network database for metrological analysis. Keywords such as emergency supplies, material scheduling, natural disasters, algorithmic models and other pertinent keywords are used to retrieve literature for the paper. Duplicate literature and literature that deviates from the topic of this paper are then eliminated to obtain a preliminary list of papers. The literature in this preliminary list is then combed to obtain the final list of papers. After completion of these steps, a total of 375 relevant journals were obtained. After completion of the aforementioned steps, a total of 375 relevant journal papers were identified.

In a comprehensive analysis of the advancements in the field of emergency material dispatch, the utilisation of the VOS viewer, a sophisticated literature visualisation software, enables a systematic examination of the extensive literature resources amassed from domestic and international sources. The research hotspots, trends and potential associations within the field are revealed through the co-occurrence clustering analysis, which is carried out on the titles and keywords of the literature. This process not only captures the dynamic changes at the forefront of the discipline, but also visualises the complex network structure of emergency material dispatch research through the visual bibliometric mapping illustrated in Figure 1. The research focus on emergency material dispatch is concentrated on several core disaster types. Earthquake disasters, with their sudden onset and destructive impact, occupy a prominent position in the research agenda. Flood disasters are of great concern due to their wide range of impacts and long duration. Typhoon disasters, with their powerful winds and accompanying secondary disasters such as torrential rainfalls and storm surges, have likewise become a focus of research. Additionally, the frequent occurrence of public health events around the globe has led to the emergence of emergency material dispatching under public health emergencies as an indispensable research direction.

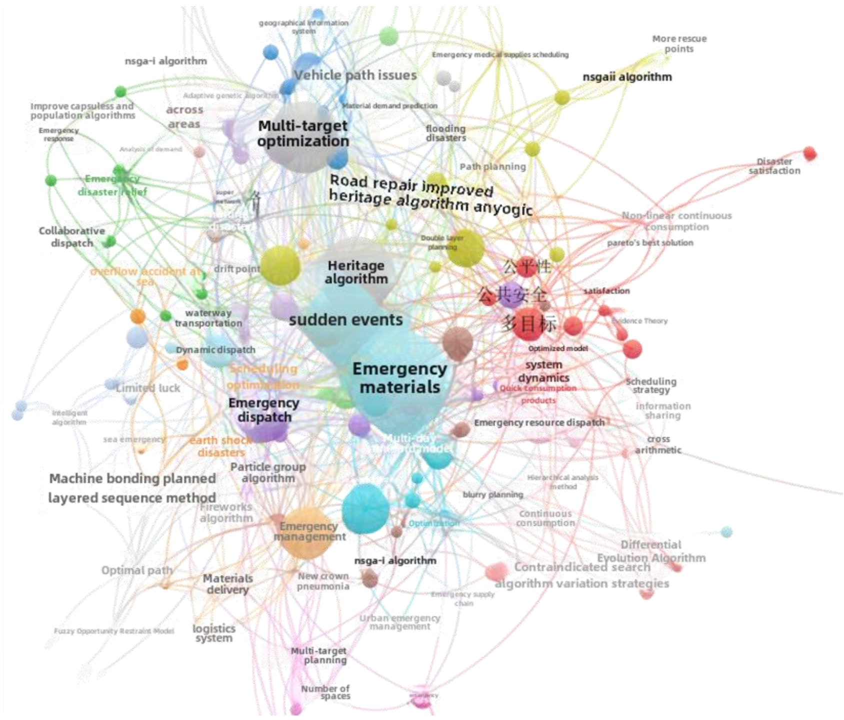

Figure 1. *Map of research hotspots for emergency material dispatch in natural disasters.*

In the field of objective optimisation, research has demonstrated a growing emphasis on the advancement of multi-objective optimisation. This reflects the pressing need among scholars to develop methodologies for simultaneously considering multiple optimisation objectives (e.g., time-efficiency, cost-efficiency, fairness, etc.) in order to achieve comprehensive optimal solutions in the context of complex and dynamic emergency response environments. In order to achieve this objective, it is of particular importance to select and apply suitable modelling algorithms. At present, the genetic algorithm, with its robust global search capability and adaptability, is the dominant approach for solving the path planning problem in emergency material dispatching. The ant colony algorithm, with its optimisation mechanism that emulates the foraging behaviour of ants in nature, demonstrates a distinctive advantage in addressing the intricate path optimisation problem. These two heuristic algorithms are not only widely used individually, but also appear in the research of hybrid algorithms combining the advantages of the two. The aim of this research is to further improve the efficiency and effect of emergency material dispatching through the complementary and fusion of the algorithms.

Furthermore, an analysis of the keyword changes in the bibliometric mapping shown in Figure 2 allows for the observation of the evolutionary trend of the research field of emergency material dispatch. In the initial phase of research, scholars primarily concentrated on fundamental theories, including algorithm design and optimisation, vehicle path planning, and so forth. The objective was to identify the most effective material distribution and transportation solutions through the construction and resolution of mathematical models. However, as research has progressed and the occurrence of natural disasters has increased in frequency, the focus of research has shifted towards more specific areas, such as earthquakes and floods, within the context of the material scheduling problem. These studies have not only concentrated on the efficiency and effectiveness of material dispatch, but have also commenced investigations into the means of guaranteeing the safety of personnel and the security of transport in extreme environments, in addition to the construction of a more resilient and adaptable emergency logistics system.

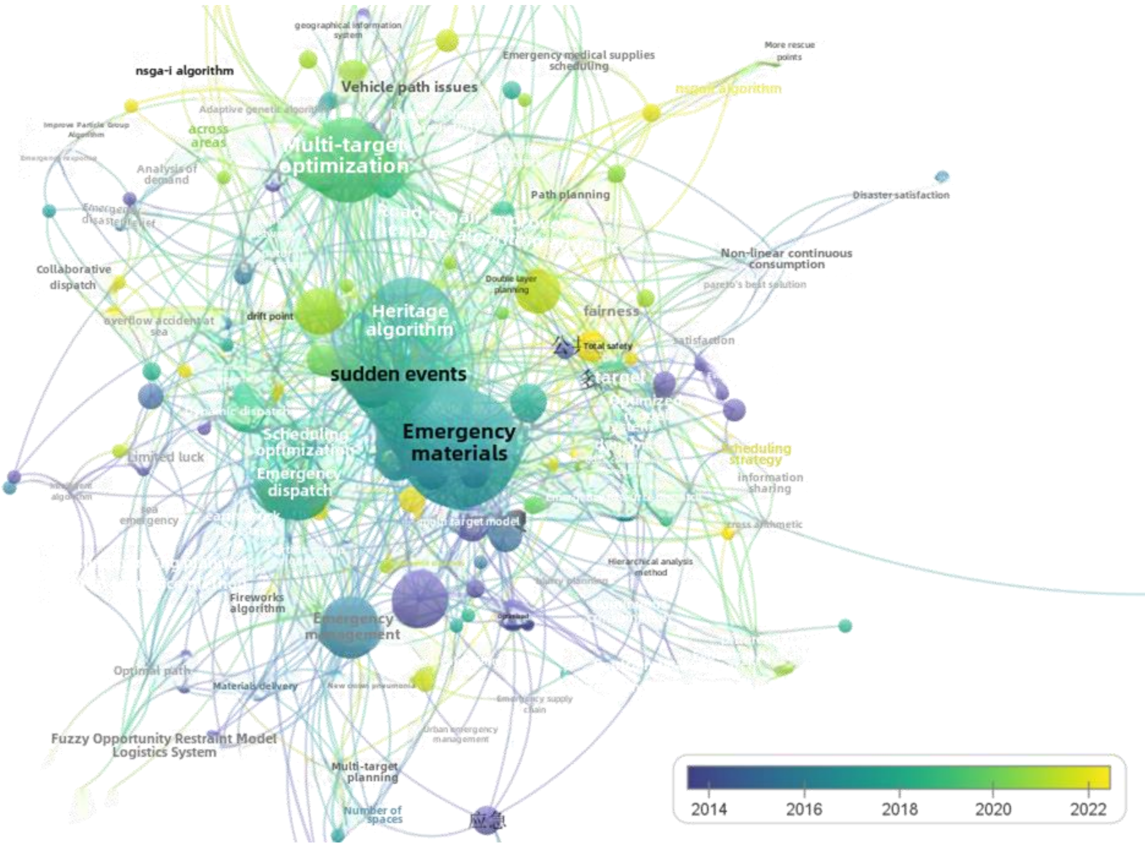

Figure 2. *Trends in research on the movement of emergency supplies in the event of natural disasters.*

The results of the above bibliometric analysis are used to inform a systematic review and overview of the research progress made in the field of emergency material dispatching under different natural disaster scenarios. The review focuses on three key areas: the research objects (e.g., different kinds of natural disasters, objective optimisation, transport network algorithmic models, etc.), the research methods (including heuristic algorithmic models, simulation, etc.), and the main conclusions. Furthermore, this paper offers an exhaustive examination of the advancements made in each domain, while also identifying shortcomings and deficiencies in the extant research. These include the lack of understanding regarding the mechanism of collaborative scheduling of emergency supplies under information uncertainty, the intricate nature of the trade-off between different objectives, and the limitations of the simulation software for validation. The objective is to provide a foundation for further theoretical and practical advancements in the field of emergency supplies scheduling.

3. Study on Emergency Material Movement Under Uncertainty Considerations

The increasing frequency of natural disasters has made the dispatch of emergency materials an indispensable component of the infrastructure required to maintain social stability and public safety. Figure 2 illustrates that uncertainty, demand forecasting, road reliability and other uncertainty factors have been the subject of increasing research attention. In recent years, academics have conducted comprehensive research in this field, particularly incorporating uncertainty factors such as sudden disruptions in the transport network and significant fluctuations in demand into emergency material dispatch models. For instance, Bozorgi-Amiri [1] et al. put forth a multi-objective robust stochastic programming model to address uncertainty in disaster relief logistics, offering a range of optimisation techniques for emergency supplies scheduling to navigate uncertainty.

After the occurrence of an emergency, the information on the material needs of the disaster area is often uncertain, and this uncertainty is mainly manifested in the types and quantities of material needs, because the type and level of the emergency are unknown, and the casualties in the disaster area cannot be accurately accessed, which leads to uncertainty in the process of preparation of the emergency materials, the types and quantities of the emergency materials that should be prepared, and the selection of modes of transport and means of transport. Moreover, the occurrence of natural disasters may lead to road damage, affecting the transport and distribution of materials. Some scholars have proposed corresponding solutions to these uncertainty problems, for example, Meng Dan [2] constructed an emergency material dispatch model under the conditions of uncertain demand and road damage, used the fuzzy opportunity constraint planning theory to analyse and quantify the uncertain demand, and counted the road repair time into the total emergency dispatch time. Wang Yongqi [3], Li Yao [4] Zhang Lin [5] et al. all used the triangular fuzzy number method to represent uncertain variables and transformed uncertainty problems into deterministic problems to solve. Weixuan Liu [6] Robust optimisation theory was introduced to deal with the uncertainty of food material demand. Chen [7] et al. assumed that the demand for supplies at the disaster site follows a normal distribution, which provides a mathematical model for uncertainty in the demand for supplies.

However, these studies may have some limitations in practical application, the first is the limitation of parameter setting and model assumptions, most of the studies often rely on empirical data to determine the key parameters when constructing the emergency material dispatch model, and fail to comprehensively consider the real factors such as capacity constraints, material reserve limitations, dynamic fluctuations in demand, and cyclical scheduling needs, etc., which leads to a large deviation between the modelling assumptions and the This simplified approach leads to large deviations between model assumptions and the complex and changing actual emergency environment, which affects the accuracy and effectiveness of dispatching decisions. In addition, the research also has obvious shortcomings in terms of adaptability and flexibility. In the face of different types of natural disasters and diversified rescue scenarios, it is often difficult for the existing models and algorithms to adapt to the complex and changing emergency needs. Finally, the insufficient ability to cope with complex environments and the challenges of data quality and real-time are also one of the problems that need to be solved by the current research. In practical applications, the dispatch of emergency supplies may be affected by a variety of complex factors, such as road damages, traffic control, and weather changes.

Some scholars have also considered other uncertainty problems based on the uncertainty of demand forecasting and transport process, for example, Hu Zhongjun [8] Considering the uncertainty of disaster occurrence and material supply, an improved GM (1, 1) dynamic prediction model based on grey system theory is proposed to predict the number of disaster-affected population and then estimate the demand for emergency materials, and in the multi-source distribution optimization method, the impact of real-time traffic information update on the distribution scheme is considered, and hybrid genetic algorithm embedded with taboo search is designed. Fan Youlong. [9] The uncertainty of unit material transport cost is considered, and a multi-objective model is established to deal with the situation where the demand, transport time and unit material transport cost are all uncertain, and the interval number is used to express the possible transport time range, and the triangular fuzzy number is used to express the uncertainty of the cost. Yan-Yan Wang. [10] Considering the uncertainty of disaster information, interval numbers and triangular fuzzy numbers are used to describe the uncertainty of material supply and demand, and the fuzzy information is transformed into a deterministic problem to be solved through the deterministic transformation method.

Wang Fuzhi [11] et al. Considering the different demand and urgency of materials at the disaster sites, there is also uncertainty, and the urgency coefficient is derived by defuzzification using the evaluation index data, and the urgency-based fairness model is constructed. Sun [12] Considering the uncertainty in the timing of emergencies and traffic flow, a one-dimensional cloud model was used to predict the traffic flow and transform it into a road congestion index, and the NSGA-II algorithm was also improved to solve the model by means of crossover and mutation operations, which were modified in the algorithm to adapt to the actual road network and traffic conditions.

Although these scholars in the consideration of road transport and demand uncertainty based on research and analysis, but there are still some shortcomings, for example, the existing model in response to emergency events in the dynamic response to changes in demand and the adjustment of the inadequacy of the model needs to be enhanced to adapt to real-time changes in the ability to respond to the actual emergency response often need to dispatch a variety of materials at the same time, which increases the complexity of the problem and difficulty in solving, the existing model This increases the complexity of the problem and the difficulty of solving it, and the existing models mostly focus on the dispatch of a single material, which is difficult to meet the actual needs. The speed of information updating in disaster response has an important impact on the effectiveness of the model, and the existing models still do not consider the information updating mechanism and frequency sufficiently. A variety of factors in the disaster environment intertwine to affect the distribution of materials, such as weather, secondary hazards, etc., and the interactions between these factors need to be further considered by the model in a comprehensive manner.

In general, most of the models are still under deterministic assumptions, but under actual emergency conditions, the demand information is often inaccurate, and it is difficult to carry out precise calculations of material demand, which can only be estimated according to approximate conditions in most cases, which may lead to a large range of data errors and variations. Secondly, real-time data dependence and difficulty in acquiring are also key factors restricting the in-depth development of emergency material scheduling research. In practical applications, the acquisition and updating of these data often face many challenges, such as unreliable data sources, delayed data transmission, and insufficient data processing capabilities, which affects the real-time and accuracy of scheduling decisions. In addition, the absence of a compensatory transport mechanism is also an important shortcoming of current research. During the dispatch of emergency supplies, some disaster sites may not be able to obtain the required supplies in a timely manner for a variety of reasons, and the absence of such a mechanism affects the continuity and integrity of the emergency response.

4. Research on the Application of Goal Optimisation to the Problem of Scheduling Emergency Supplies

In natural disaster events, it is crucial to dispatch emergency supplies quickly and efficiently, and it is found through the research trend map of emergency supplies dispatch in Figure 2 that the objective optimisation problem occupies a large proportion, with multi-objective optimisation being the focus of the research.

In the objective optimisation scholars have different choices of objectives, some scholars have established single-objective models to cope with emergency material dispatch under different disasters, and single-objective models are generally models with the objectives of least time-consuming, lowest dispatch and transport costs, and maximum satisfaction rate. Among them, the least time-consuming is one of the core objectives. In disaster events, time is life, and the speed of material dispatch is directly related to the efficiency of rescue operations and the life safety of people in the disaster area. For example, Ghaffari [13] et al. proposed a mixed-integer programming model for the emergency supply chain scheduling problem in disaster relief operations, with the objective of minimising the total weighted completion time, and developed a particle swarm optimisation (PSO) algorithm to solve the large-scale problem. Tao Yu-Min [14] A BP neural network prediction model based on case-based reasoning and grey correlation analysis is proposed, and an emergency supply scheduling model with the objective of minimising the total system loss is constructed based on this network. Shasha Yang [15] An earthquake emergency material distribution method considering road reliability was studied, and an emergency material dispatch optimisation model was built with the objective of minimising the total delivery time to optimise the problem of emergency material dispatch for earthquake disasters. However, single-objective planning usually focuses on only one optimisation objective, such as minimising transport time, minimising cost, etc. However, in emergency material dispatching, it is often necessary to consider multiple objectives at the same time, such as time efficiency, cost-effectiveness, and resource utilisation, etc. Single-objective planning ignores the trade-off relationship between these objectives, which may result in a reduction of the overall efficiency. Secondly, single-objective planning is often based on a series of simplified assumptions when modelling, such as constant demand for materials, unlimited transport capacity, stable traffic conditions, etc. However, in the actual situation, these assumptions are often difficult to be established, and they do not accurately reflect the actual situation, leading to irrationality in the scheduling plan.

In order to overcome these shortcomings, researchers have gradually turned to multi-objective optimisation methods to consider various objectives and constraints of emergency material dispatch more comprehensively, with the main objectives including minimising transport time, minimising transport cost and maximising the satisfaction of the affected sites, etc. By means of complex algorithms and advanced mathematical methods, they search for solutions to reach an optimal balance between these objectives. This model can not only improve the overall efficiency of emergency material dispatching, but also maximise the social benefits with limited resources.

A number of scholars have worked on developing a multi-objective emergency material scheduling model with the core objective of minimising scheduling cost and scheduling time. For example, Zhang Lin [5] et al. constructed a multi-hazard site oriented intelligent dispatch model for emergency supplies under uncertain conditions with the objectives of minimising emergency dispatch cost and dispatch time. Sun [12] et al. explored the emergency logistics scheduling problem under the uncertain conditions of the time of emergency events and the traffic flow predicted through the cloud model, and proposed a bi-objective optimisation model based on the minimisation of the transport time and the minimisation of the transport cost. Bozorgi-Amiri [1] et al. proposed a multi-objective robust stochastic programming model for the uncertainty problem in disaster relief logistics, which provides a variety of optimisation methods to cope with uncertainty in emergency material scheduling. Ding [16] et al. proposed a grey interval number based multi-supply point-multi-demand point emergency material scheduling model by considering the effect of road reliability and targeting the time cost and transport cost, which effectively dealt with the uncertainty of post-disaster relief information in their study. Chen Weijiong [17] et al. explored the feasibility and effectiveness of introducing horizontal transfer methods in disaster-stricken points, and constructed a secondary scheduling model aiming at the shortest time and the lowest cost. However, in emergency material dispatching, only considering dispatching cost and time cannot fully satisfy the diversified needs of different emergency points, while ignoring the importance of fair distribution of resources.

Recognising that it is not enough to consider cost and time alone, scholars have begun to take other important factors such as satisfaction, fairness and road reliability into account, and these new objectives have not only increased the complexity of the models, but also their applicability and flexibility in practical applications. For example, Li Qiaoru [18] et al. investigated the impact of road reliability on multi-objective emergency dispatching after an earthquake, and Wang Jingjing [19] studied multi-objective emergency dispatch optimisation based on road damage, and they both proposed multi-objective optimisation methods to minimise the longest vehicle travel time, maximise the minimum vehicle travel path reliability, and minimise the unsatisfied demand for supplies. Li Yao [4] Aiming at the problem of uncertain scheduling time due to uncertain demand and damaged road network, the problem is solved with an improved ant colony algorithm with the objectives of maximising the rescue utility of emergency supplies and minimising the scheduling cost. Song Xiaoyu [20] et al. constructed a multi-emergency point, multi-rescue point and multi-stage emergency material dispatch model with the objectives of minimising the total dispatch cost and maximising the emergency point satisfaction, and designed a hybrid multi-objective particle swarm algorithm for solving the multi-objective optimisation problem. Xia Zhang [21] et al. considered maximising the actual demand rate of each affected point, minimising the cost of transporting emergency supplies and the risk of vehicle transport, and used the non-dominated sorting genetic algorithm with elite strategy (NSGA-II) to solve the established multi-objective planning model.

In summary, in multi-objective optimisation, there may be conflicts between different objectives, for example, there may be trade-offs between cost minimisation and time minimisation, and additional trade-off strategies are required to resolve these conflicts. In order to accurately assess and trade-off multiple objectives, more data and information inputs are required, which puts higher demands on the accuracy and reliability of the data and increases the difficulty of model implementation. In addition, when dealing with rapidly changing contingency environments, multi-objective optimisation models must respond and adapt quickly to new conditions to enable immediate strategy optimisation.

5. Research on the Application of Optimisation Algorithms to the Problem of Scheduling Emergency Supplies

When responding to emergencies, emergency material scheduling model is the key to ensure that the materials can be delivered to the affected area in a timely and effective manner, as can also be seen through the hotspots of research on emergency material scheduling in Figure 1, researchers have used a variety of algorithms to solve the model, of which 42 out of the 375 papers analysed for the natural disaster emergency material scheduling problem in bibliometric analysis have used genetic algorithms, for example, the Zhou [22] et al. applied an improved genetic algorithm to solve the multi-period dynamic emergency resource scheduling problem. Wang Fuzhi [11] et al. used a multi-objective genetic algorithm to solve the problem. Jingjing Wang [19] Minimising the longest vehicle travel time, maximising the minimum vehicle travel path reliability, and minimising the unsatisfied system supplies as the objectives were solved using the second-generation non-dominated sorting genetic algorithm (NSGA-II). Hu Zhongjun [8] Taking the three-level multi-source distribution system as the research object, the mathematical model based on maximising the level of fair distribution satisfaction was constructed, and the hybrid genetic algorithm embedded with taboo search was designed to solve the problem. Seventeen articles adopted the ant colony algorithm, for example, Jinqiu Li [23] By constructing an optimisation model that integrates the fire spreading trend and the matching of material supply and demand, and applying the discrete bee colony algorithm to solve the problem, a new solution is provided for material dispatching in forest fire emergency rescue. Li Yao [4] Aiming at the problem of uncertain scheduling time due to demand uncertainty and road network damage, methods such as fuzzy number theory and path reliability analysis were used to model and quantify the problem, and an optimization model was proposed and the ant colony algorithm was improved to solve the problem. Some other researchers have used particle swarm algorithms, for example, Ghaffari [13] et al. proposed a mixed integer programming model for the emergency supply chain scheduling problem in disaster relief operations and proposed a particle swarm optimisation algorithm to solve the large-scale problem. Xiaoyu Song [20] et al. designed a hybrid multi-objective particle swarm algorithm for solving a multi-objective optimisation problem and constructed an emergency supply scheduling model with multiple emergency response points, multiple exit points and multiple phases.

Heuristic algorithms such as genetic algorithms and ant colony algorithms are widely used, can effectively improve the scheduling efficiency, optimize the scheduling scheme and deal with uncertainties in emergency material dispatching, and their principles are based on certain rules or strategies to guide the search process and ensure the effectiveness and reliability of the algorithms through the characteristics of iterative search for the optimal, combination of randomness and determinism as well as global convergence, and some researchers have also upgraded such heuristic algorithm is upgraded, for example, Feng [24] et al. designed a Solomon insertion heuristic algorithm (SIHA) for determining the optimal route for emergency resource dispatching, which considers not only the distance but also the time dimension in the heuristic process. Heuristic algorithms such as genetic algorithms and particle swarm optimisation algorithms have some shortcomings, although they have high efficiency and better search capability in solving optimisation problems. For example, heuristic algorithms may concentrate on a small region of the solution space too early in the search process, causing the algorithm to converge to the local optimal solution rather than the global optimal solution early. Moreover, the performance of heuristic algorithms often depends on the setting of algorithm parameters, such as crossover rate, mutation rate, particle velocity, etc., but finding the optimal parameter combinations often requires a lot of experiments and adjustments.

In response to the limitations of heuristic algorithms, some scholars have designed hybrid algorithms, which are able to provide efficient and high-quality solutions in complex and changing environments, and have a wide range of applications in the fields of emergency material dispatching, logistics and supply chain management. For example, Zhang [25] et al. proposed a rescheduling model for rescheduling vehicle paths after a disruption that occurs at a specific time and lasts for a certain period of time, and constructed a hybrid algorithm combining Ant Colony Optimisation (ACO) and Scattered Search (SS) to solve the recovery problem. Qing [26] An emergency logistics and distribution vehicle scheduling model based on time division is proposed and optimised by combining genetic algorithm and ant colony algorithm. Yongqi Wang [3] A multi-objective optimisation model for concurrent distribution and scheduling of multiple emergency supplies oriented to multiple stockpiling points and multiple distribution points is constructed, and a hybrid intelligent algorithm based on 2D NSGA-II and ant colony optimisation is designed to solve this complex combinatorial optimisation problem. Xiaowen Xiong [27] A multi-species fair LRP model and a hybrid heuristic algorithm are developed for fair scheduling of multi-species demand of post-earthquake emergency medical rescue supplies. Yuan Ruiping [28] et al. constructed a multi-stage multimodal scheduling framework for emergency supplies according to the characteristics of different stages of emergency rescue, and proposed a hybrid heuristic algorithm combining genetic algorithm and simulated annealing, which enhanced the local search capability and global search characteristics of the algorithm. Koyi Zhang [29] et al. designed a hybrid algorithm (HGADP) based on the fusion of genetic algorithm and dynamic programming algorithm for the optimal decision-making research of natural disaster emergency supplies dispatching in mountainous areas based on truck-UAV collaboration. Ren [30] et al. proposed a multi-period dynamic scheduling method that considered the degree of urgency and connectivity reliability and used a hybrid genetic algorithm to solve a single-objective model.

Although some studies have verified the effectiveness of the algorithm through simulation, for example, Tao Yumin [14] Taking some data of Yushu earthquake as an example, Li Yao [4] Setting up the simulation algorithm to solve the case with the 2008 Wenchuan earthquake as background, Shasha Yang [15] Simulation using Anylogic software, Li Chengxin [31] et al. drew a trend chart of fire spread degree-total forest tree prediction and a real-time simulation chart of total forest tree under fire spread, but there is relatively little data and case validation in practical applications, and the lack of actual data validation may lead to the algorithm performing less well than expected in real scenarios, and the results may be inaccurate, which needs to be combined with practical tests, theoretical analyses, and experts' The results may not be accurate and need to be evaluated comprehensively by combining various factors such as practical tests, theoretical analysis and experts' experience.

From the above literature analysis, it can be further concluded that although the existing algorithmic models have made some progress in improving the efficiency of emergency material dispatching, there are still some problems that need to be solved. For example, algorithms such as hybrid algorithms and heuristic algorithms still have room for improvement in solving efficiency and accuracy, and future research needs to develop new algorithms or improve existing algorithms to improve their global search capability, convergence speed and solving accuracy. In addition, existing research focuses on vertical material deployment, while the potential of horizontal material deployment has not yet been given full play, and researchers should consider how to break information silos and optimise the material deployment process between nodes of the same level. Finally, emergency material dispatching lacks an intelligent information platform, and future research should focus on developing an information system that can realise real-time data updating and rapid response to demand. Through the in-depth exploration and practical application of these research directions, the response speed of emergency material dispatching and the rationality of resource allocation can be significantly improved, providing a solid logistic guarantee for effectively responding to all kinds of emergencies.

6. Summary and Outlook

Through an in-depth analysis of the above literature, it can be seen that the research on vehicle dispatch optimisation in the field of emergency supplies focuses on three core aspects: firstly, the construction of the emergency supplies dispatch model under the consideration of uncertainty, secondly, the analysis of dispatch optimisation based on the multi-objective perspective, and thirdly, the optimisation of the emergency supplies dispatch model under different algorithms. Although the research on emergency material dispatch optimisation has made some progress, there are still many challenges and problems in terms of uncertainty of demand information, complexity of multi-objective optimisation models, insufficient effectiveness and robustness of algorithms, and insufficient verification of actual data and cases.

With the continuous progress of science and technology and the continuous improvement of emergency management needs, how to use advanced technology to improve the efficiency and accuracy of emergency material dispatching, and build a more perfect and efficient emergency management system is still a key breakthrough direction in the future. It is hoped that the review research in this paper can provide reference for the research in related fields, promote the research on emergency material dispatching to a higher level, and contribute to the construction of a better society.

Abbreviations

GM	Grey Model
NSGA-II	Non-Dominated Sorting Genetic Algorithm II
PSO	Particle Swarm Optimization
BP	Back Propagation
SIHA	Solomon's Insertion Heuristic Algorithm
ACO	Ant Colony Optimization
SS	Scatter Search
LRP	Logistics Resource Planning
HGADP	Hybrid Genetic Algorithm Dynamic Programming

Author Contributions

Zhou Ruoqi: Conceptualization, Data curation, Formal Analysis, Investigation, Software, Visualization, Writing – original draft, Writing – review & editing

Duan Manzhen: Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing – review & editing

Conflicts of Interest

The authors declare no conflicts of interest.

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