

Research on the Psychological Cost of Disaster Victims in Emergency Logistics

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Abstract: Emergency logistics plays a pivotal role in addressing natural disasters and major public health emergencies, serving as a vital support system to ensure social order and the safety of individuals. In recent years, with the deepening of the people-centric emergency management concept, the academic community has increasingly focused on the psychological state of disaster victims during emergency rescue operations and its impact on rescue effectiveness. Building upon the existing research status of emergency logistics, this paper integrates psychological costs into traditional dispatching and location selection models. It analyzes current domestic and international studies on disaster victims' psychology, identifies deficiencies in current emergency logistics that consider psychological costs based on this analysis, and proposes future research directions to advance the development of a more compassionate and precise service model in the field of emergency logistics.

Keywords: Emergency Logistics; Psychological Costs; Prospect Theory; Welfare Economics Principles.

1. Introduction

With the ongoing acceleration of globalization and urbanization, natural disasters and major sudden public health events are increasingly impacting human society. Emergency logistics is crucial in disaster management systems, directly influencing the well-being of disaster victims and societal recovery from such crises. However, traditional emergency logistics research has mainly focused on optimizing material distribution efficiency without considering how a victim's psychological state can impact rescue efforts. The concept of 'disaster victim psychology' encompasses their mental strain and emotional burden during wait times for relief supplies; neglecting these factors could reduce rescue efficiency or lead to secondary social issues. Therefore, integrating psychological costs into emergency logistics decision-making models is theoretically important with practical implications for enhancing overall effectiveness in rescue operations while ensuring comprehensive aid for disaster victims.

2. The Current Research State of Emergency Logistics Research

2.1. The Concept and Characteristics of Emergency Logistics

The concept of emergency logistics was initially articulated by Z.W Ou in 2004, distinguishing it from conventional logistics and focusing primarily on addressing emergency situations such as public health events and natural disasters to ensure the timely provision of essential aid. At its core, this concept aims to maximize response speed while minimizing disaster-induced damage, with the objective of rapidly delivering relief supplies to areas most in need, thereby mitigating the adverse impact of disasters.

The characteristics of emergency logistics are manifested in its exceptionally high demands for speed and efficiency, which starkly contrast with the cost minimization objective of traditional logistics. It necessitates swift coordination of

rescue equipment and supplies, as well as the organization of personnel evacuation during emergencies. This logistical activity exhibits several distinctive features: firstly, it is characterized by suddenness, meaning that disaster events are often unpredictable, requiring the logistics system to be able to swiftly initiate operations; secondly, it is marked by time-critical urgency, emphasizing the imperative need for prompt rescue action due to the critical nature of time in saving lives and minimizing losses; thirdly, it is subject to random demand patterns as the uncertainty of disasters may lead to rapid changes in material type and quantity requirements; finally, it possesses a weak economic orientation where economic benefits are often not the primary consideration in emergency logistics. Instead, greater emphasis is placed on rescue effectiveness and social benefits. These features collectively contribute to the distinctiveness and complexity of emergency logistics.

2.2. Present Research Status

Although Chinese scholars' exploration of emergency logistics commenced belatedly, it has experienced rapid advancement in recent years with notable achievements. A comprehensive review of literature from the past decade reveals a predominant emphasis on enhancing the efficiency and efficacy of emergency logistics. Scholars have adeptly integrated cutting-edge optimization techniques and methodologies to persistently address pivotal challenges within this domain. Presently, research endeavors in China are primarily bifurcated into two focal areas: optimizing routes for emergency material delivery and selecting locations for emergency distribution centers.

2.2.1. Optimization of Emergency Supplies Distribution Routes

(1) Path optimization problems considering uncertain factors

Due to the abrupt and unpredictable nature of natural disasters and public health emergencies, numerous unforeseen challenges may arise during the rescue operations, such as uncertain road accessibility and ambiguous demand

information.

First of all, because natural disasters are extremely destructive, the road conditions in the rescue process will be greatly affected, which will directly affect the decision maker's choice of distribution routes. Therefore, many scholars began to study emergency supplies transportation based on road damage. T.L. He[1] divided post-disaster roads into three types: passable, repairable and impassable. S.S. He [2] emphasized that road repair work should be started immediately after disaster, and proposed a multi-stage road emergency repair vehicle routing problem integrating random repair time when the repair time could not be accurately estimated. Under the background of earthquake research, S.S. Yang[3] conducted a comprehensive assessment of the vulnerability and carrying capacity of roads, and then obtained the impact of road damage on the traffic speed. When the disaster site becomes an "island" and cannot be delivered by ordinary vehicles, helicopters or drones are used for delivery[4].

Secondly, in the process of emergency rescue, due to the suddenness of the incident and the lack of disaster information, the type and demand of materials in the rescue process are uncertain. Therefore, in order to solve this problem, many scholars choose different methods to build models, and the commonly used methods are fuzzy programming, random programming and robust optimization. Fuzzy programming deals with uncertain factors by setting membership function. J. Tan[5] described the uncertainty of demand through triangular fuzzy function, and innovatively constructed a model considering the random failure of supply point caused by secondary disasters, and demonstrated its importance through calculation examples. J.X. Ye[6] took customer demand as a fuzzy variable by triangular fuzzy number, established a fuzzy optimization model based on the credibility theory, and proposed a super-heuristic algorithm to solve the problem. Stochastic programming is to obtain the probability distribution of demand uncertainty by analyzing it. B.R. Cheng[7] et al. assumed that the demand at disaster sites was subject to normal distribution, built a path optimization model under random demand for emergency materials, and verified its rationality. X.X. Zhu[8] constructed a time series analysis model based on case-based reasoning method to predict material demand, and finally the model was fitted and verified with the data of actual cases. Robust optimization is to define the fuzzy parameters of demand by using the interval. W. Xu[9] used interval number and trigonometric function to represent the uncertainty of demand and time respectively, conducted an in-depth analysis of the problem of emergency material distribution with uncertain factors and the problem of emergency vehicle service network scheduling with dual demand, and verified the effectiveness of his method through case tests. J.J. Wang[10] introduced robust optimization methods to address uncertain demand for medical supplies during the epidemic and established an emergency medical supply scheduling model. By comparing the robust optimization model with a deterministic model in the case of Wuhan COVID-19, it was further demonstrated that the former can better handle demand uncertainty problems.

(2) path optimization problems considering demand urgency

After the disaster occurs, due to the type, intensity, duration and geographical location of the disaster and other factors, the degree and way of the impact of each disaster site is often different. This difference directly leads to the significant

difference in the urgency of material needs in different disaster sites. In order to maximize the utility of emergency resources, some scholars construct a path scheduling optimization model considering the urgency of demand.

At present, the vast majority of literature measures the urgency of needs by establishing an evaluation system and applying methods such as TOPSIS, grey relational analysis, and analytic hierarchy process to determine the relative importance of these evaluation indicators, and ultimately calculate the urgency scores of each demand point. The only difference is that the urgency coefficient is applied differently to the objective function. F.Y. Wang[11], X.C. Dong[12], and Z.Q. Fan[13] all utilized the urgency coefficient of demand as a weighting factor, in conjunction with the required quantity of supplies, to formulate an objective function for fairness by minimizing the weighted sum of unmet demand at each disaster site. Y.T. Zheng[14] employed the derived urgency score values to influence the time satisfaction function, which represents a preference for minimizing time. L. Xu[15] integrated the urgency coefficient of demand and the cost of deprivation to express supply delivery priority to points with higher demand urgency by multiplying these two factors. This approach effectively demonstrated both fairness and efficiency in supply allocation. C.Y. Xu[16] proposed a subsidy cost function to prioritize the delivery of high-priority demand points with urgent needs. The cost is solely determined by the urgency of demand and increases in a positive manner. Building on this, Z. Yang[17] introduced the concept of "relative demand urgency" to mitigate the impact of different scales on the target and incorporated it into the subsidy cost function to represent supply delivery without delay.

2.2.2. Selection of Emergency Distribution Center Site

(1) The problem of emergency distribution center location considering facility damage

After a disaster, facility failure is a common occurrence. Once the facility is damaged, the original location model may not be the optimal solution, leading to reduced system service efficiency and weakened response ability during rescue operations, and potentially resulting in a demand gap. Therefore, many scholars have incorporated considerations for facility damage into emergency facility location planning to ensure that the entire logistics system can continue to function effectively after such damage occurs. The primary methods for addressing this issue are stochastic optimization and robust optimization.

In the random optimization study on facility damage, W.S. Yu[18] considered the risk of damage to the existing distribution center and assigned it a probability of being damaged. They established an emergency distribution center location model based on the existing distribution center. Y.M. Guo[19], in their research, took into account the possibility of facility damage and aimed to minimize total cost while maximizing coverage in order to determine the location and allocation quantity of emergency distribution centers. They used a non-dominated genetic algorithm to solve this model problem. In the robust optimization research on facility damage, J.M. Zhu[20] constructed a multi-objective location decision model by considering comprehensive coverage of demand points, increased rescue time due to disaster scenarios, and facility service range. J.P. Wang[21] utilized scenario planning methods to develop a robust facility coverage location model for different grades of railway emergency scenarios with known and unknown facility

damage probabilities, and solved the model using Lingo software. These documents are all based on single-stage robust optimization. However, due to the overly conservative nature of the single-stage robust optimization model, some scholars have opted for a two-stage robust optimization approach in their modeling. In contrast to other literature that assumes a probability of damage, C. Peng[22] introduced binary variables to describe the state of facilities and introduced a risk measure parameter to reflect the impact of interruption. This comprehensive approach considers the risk of facility interruption, material demand uncertainty, and transportation cost uncertainty, leading to the design of a two-stage robust location model. W.Y. Qin[23] utilized uncertain sets to describe the uncertain states of facility damage and demand, constructing a two-stage robust optimization model solved using the Column and Constraint Generation (C&CG) algorithm. B. Du[24] designed a two-stage robust emergency facility location optimization model to achieve effective coordination between pre-location and re-location in response to fluctuations in demand and costs, as well as the uncertainty of facility damage.

(2) The problem of emergency distribution center location considering priorities

In response to natural disasters or sudden public health emergencies, numerous researchers deliberate on the optimal placement of distribution centers based on varying perspectives. Some emphasize demand considerations by prioritizing regions with high demands or urgent requirements in order to guarantee sufficient assistance and provisions for these locales. Consequently, emergency facilities might be situated in densely populated zones, historically susceptible regions prone to calamities, or forecasted disaster-affected areas for swift aid delivery. Conversely, other scholars adopt an emergency-centric approach by prioritizing immediate needs driven by time sensitivity. This inclination could lead decision-makers to select sites capable of reaching disaster-stricken locations at the swiftest pace regardless of their level of demand. In literature focusing on prioritizing needs, S.S. Sun[25] classified all disaster-affected areas based on their demand levels and established a hierarchical evaluation index system for assessing the demands of these areas. This approach took into account the demand levels of the affected areas, as well as rational control over time and cost, in order to optimize warehouse layout. Meanwhile, Q. Zhang[26] considered the urgency of disaster area needs and the emergency response capacity of distribution centers as factors influencing site selection. By incorporating the urgency coefficient of needs into a penalty cost within the total cost of site selection, an algorithmic example verification demonstrated that distribution centers with better emergency response capacities are chosen for disaster areas with higher urgency in relief needs. Y.H. Song[27] considers the uncertainty of supply and demand and the urgency of disaster points, and establishes a multi-mode, multi-stage, multi-objective dynamic location model with fuzzy conditions, based on the literature study of demand-prioritized. For the case of emergency priority, F. Yin[28] will reduce the overall rescue time as the core optimization goal, and applies the 0-1 integer programming method to establish a multi-level coverage emergency facility location model specifically for large-scale sudden events. J. Zhang[29] takes shortening the rescue response time as the optimization goal, while considering the uncertainty of demand and the availability of various vehicle types. Based

on this, a two-stage fuzzy nonlinear model based on multiple scenarios is constructed to solve the location and path planning problems simultaneously, and the model is verified to be superior in terms of storage cost and emergency response time. L. Zhou[30] incorporates the time factor of emergency supplies reaching the demand points into the study, and creates a function of time satisfaction. Based on this, a dual-objective mixed integer programming model is established, combining the overall system cost, and is solved by the immune simulated annealing algorithm.

2.3. Summary of Current Research Status

Based on the literature review above, recent research in the field of emergency logistics has predominantly focused on two key areas: optimizing the distribution routes of emergency supplies to ensure efficient and rapid delivery to points of need, and determining the optimal location for emergency distribution centers to facilitate swift response and coverage during disasters. The research methods employed are diverse, encompassing fuzzy planning, stochastic programming, robust optimization, and various other optimization techniques aimed at addressing uncertainty and urgency issues in natural disasters and public health emergencies. Scholars have not only taken into account practical concerns such as road damage and facility destruction but have also optimized the delivery paths of emergency supplies and selection strategies for distribution center locations from the perspective of demand urgency and priority.

3. The Current Research Status of Emergency Logistics under Psychological Costs

3.1. The Concept of Psychological Cost

The psychological experience of disaster victims primarily refers to the psychological burden and mental stress experienced by affected populations in emergency situations such as natural disasters, accidents, and public health crises due to factors such as shortages of supplies, delayed rescue efforts, and environmental changes. The psychological cost quantifies the psychological experiences of disaster victims through specific methods. During post-disaster evacuation and distribution of relief supplies, this psychological cost not only impacts the mental well-being and emotional state of affected populations but can also influence the overall implementation of disaster relief efforts.

3.2. Present Research Status

As people's living standards improve, incorporating the psychological costs of disaster victims into the decision-making process of emergency logistics is a crucial step in realizing a people-centered approach to emergency management. It also represents an important avenue for achieving the scientific, precise, and humane management of emergencies. Consequently, an increasing number of scholars in the field of emergency logistics are considering the psychological well-being of disaster victims as a factor and employing various methods to quantify their psychological experiences for application in emergency logistics dispatch and location modeling.

A review of current literature on the quantification of psychological costs among disaster victims reveals two main approaches: research on psychological costs based on

prospect theory and research based on welfare economics.

3.2.1. Research on the Psychological Costs of Disaster Victims Based on Prospect Theory

A study of the psychological costs of disaster victims based on prospect theory is an attempt to understand and quantify the psychological reactions of disaster victims during a disaster, as well as their impact on rescue efforts from the perspectives of psychology and behavioral economics. It primarily aims to describe decision-making behavior when facing risk and uncertainty, particularly the irrational characteristics exhibited in evaluating losses and gains. Current research typically involves directly applying or modifying the value function curve in prospect theory to derive the psychological cost function curve for risk perception among affected populations.

C. Ma[31] utilized prospect theory to analyze the risk perception of disaster victims, using the psychological expected time as a reference point to assess their level of risk awareness while waiting for relief supplies. This involved plotting a risk perception curve and establishing corresponding functional expressions. Following the prospect theory, Z.P. Fan[32] conducted a comprehensive value assessment of various emergency scenarios and determined their respective weights within the overall context. Ultimately, this process yielded comprehensive weights for different emergency response plans, enabling prioritization and providing decision-making support. X.P. Wang[33] incorporated behavioral science perspectives into the examination of earthquake emergency supply chains, and utilized prospect theory to establish individual risk perception functions for rescue centers and various decision-makers. This was done in order to assess their levels of material shortages and transportation delay risks. Z.Y. Wang [34] applied prospect theory to analyze public cognitive behavior towards risk during public opinion dissemination, conducting comprehensive research on optimizing emergency scheduling for multiple resource flows in such scenarios. Additionally, she examined decision-maker preferences based on public risk perception and investigated the potential impact of these preferences on forming optimal scheduling solutions. W.L. Yang[35] employed the dissatisfaction degree as a metric for evaluating the rationality of emergency supplies distribution and developed a specialized value function to assess the dissatisfaction emotions triggered by the psychological perception of disaster victims. T. Ning[36], in investigating end-of-pipe logistics, utilized prospect theory to measure customers' psychological perception levels and derived customers' psychological expected perception curves using their anticipated time frames as benchmarks. S.Y. Yin[37] applied prospect theory to quantify the psychological costs incurred by drivers and disaster victims in complex post-disaster scenarios. Decision-makers can then select the most appropriate distribution plan by considering vehicle expenses, driver and victim psychological stress, as well as different rescue stages and specific conditions in disaster areas. Z.W. Gong [38] incorporated prospect theory into scheduling problems, particularly in uncertain environments, by considering the psychological factors of disaster victims and developing a psychological risk perception function to quantify the risk perception of disaster victims when obtaining emergency supplies following a large-scale sudden event.

However, the current application of prospect theory also faces certain issues and challenges. For instance, decision-

makers often encounter uncertainty in emergency logistics path selection, posing a challenge due to their limited rationality in uncertain environments. Therefore, many scholars suggest the adoption of cumulative prospect theory in this context. This theory modifies and enhances the functions within the original theoretical framework to address specific limitations of prospect theory when dealing with probability and uncertainty, especially in managing the cumulative effects of multiple low-probability events.

L.J. Tian et al.[39] employed cumulative prospect theory in modeling user equilibrium within transportation networks by incorporating perceived arrival time values, thereby offering a novel framework for comprehending travelers' decision-making processes. Fang et al.[40] integrated cumulative prospect theory into TOPSIS-based decision-making with demonstrated applicability in real-world scenarios. Building upon cumulative prospect theory, S.Z. Song[41] devised a multi-reference point emergency logistics model utilizing transportation time and path risk as benchmarks to optimize material transport routes and supply locations effectively. Furthermore, J.M. Zhao[42] established psychological reference points for time and volume tailored to diverse needs of drivers and disaster victims while developing an emergency material distribution route optimization model for City W that accounts for personnel's psychological costs through cumulative prospect theory.

3.2.2. Research on the Psychological Costs of Disaster Victims Based on Welfare Economics

The principle of welfare economics provides a foundational framework for policy development and resource allocation in the field of welfare economics, aiming to optimize societal well-being. When applied to addressing the psychological well-being of disaster victims, welfare economics primarily considers costs and equity. In this context, costs refer to societal expenses arising from unequal resource distribution, such as deprivation or scarcity costs. In terms of equity considerations, scholars employ measures like the Gini coefficient, maximum-minimum functions, jealousy and sympathy functions to evaluate fair distribution and develop models for allocating emergency relief supplies.

Holguín (2013) [43] was the first to incorporate the welfare economic principle into the post-disaster humanitarian logistics model, defining the level of suffering experienced by disaster victims as the cost of deprivation. He concluded that the absolute exploitation cost would exhibit an exponential growth trend with increasing waiting time for disaster victims. Cantillo et al. (2017) [44] suggested that after receiving treatment following rescue, disaster victims would experience a linear decline in absolute exploitation costs, indicating that their psychological suffering diminishes linearly upon receiving assistance. Zhu Li et al. (2019) [45] further argued that, following the evacuation of all injured individuals from the disaster area, there is a subsequent exponential increase in absolute deprivation cost when victims are transported to medical centers. J. Gu[46], expanding on the concept of deprivation cost, introduced the innovative notion of "relative deprivation cost" to depict the psychological gap experienced by disaster victims due to disparities in rescue efforts. This led to the proposal of a model that divides post-disaster emergency material distribution into multiple stages with the objective of minimizing psychological and transportation costs while considering dynamic characteristics of rescue demand. Furthermore, L. Xu[15] integrated both "absolute deprivation cost" and "relative deprivation cost" into the

objective function and introduced minimization of transportation costs as an additional goal. This facilitated the development of an emergency material allocation and path optimization model based on demand urgency.

In addition to utilizing the cost of deprivation for economically quantifying the psychological experiences of disaster victims, various methods such as the Gini coefficient, tolerance function, numerical rating scale, and others can also be employed for quantitatively assessing the actual distribution of resources. Through rigorous scientific evaluation and adjustment, these methodologies ensure optimal fairness in resource allocation.

Gutjahr et al.[47] contend that the minimization of deprivation cost model's tendency to generate equilibrium solutions is insufficient to offset the escalating unfairness resulting from rapidly intensifying deprivation. Consequently, the authors opt for the Gini coefficient as a measure of inequality and validate it using illustrative examples. Song et al. [48] devised a tolerance function for refugees to delineate their upper and lower thresholds of psychological resilience, and judiciously allocated resources based on this framework. Wang et al.[49] considered both the nature of supplies and their duration of scarcity as variables, devising a function to quantify disaster victims' perceived costs through a numerical assessment table. This function aims to gauge the perceived costs incurred by disaster victims due to inadequate supplies, constructing an optimization model with the dual objective of minimizing logistics costs and perception-related expenses combined. This model is employed to ascertain optimal sites for emergency shelters and efficient distribution of provisions.

3.3. Summary of Current Research Status

Research on psychological costs in the field of emergency logistics is currently showing a trend towards diversification. Scholars are not only focusing on the psychological experiences of disaster victims in urgent situations, but also attempting to evaluate and optimize emergency logistics decisions through various theoretical frameworks and quantitative methods. Studies based on prospect theory emphasize the psychological responses of disaster victims when facing uncertainty, while those grounded in welfare economics prioritize fairness and efficiency in resource allocation. Both approaches provide a scientific basis for understanding and alleviating the psychological burden of disaster victims, propelling emergency logistics decision-making towards a more compassionate and sophisticated direction. Despite encountering some theoretical and practical challenges, the introduction of cumulative prospect theory and innovative applications of fairness indicators offer new perspectives and tools for addressing these issues. Overall, research on psychological costs is gradually deepening.

4. Insufficient Research on Emergency Logistics under Psychological Costs.

In the realm of emergency logistics research focusing on psychological costs, despite notable progress, there remain significant areas warranting attention. While the current research framework and methodologies have been somewhat established, further deepening and expansion are necessary to comprehensively grasp the intricate impact of psychological costs on decision-making and execution in emergency logistics.

Currently, the majority of research quantifies the

psychological costs experienced by disaster victims through the utilization and refinement of the value function, as exemplified in studies such as that conducted by Yang Wanli et al. While this approach offers an initial framework for comprehending the psychology of disaster victims, it may not fully encapsulate the intricacy and dynamic nature of their psychological state. In real-life disaster scenarios, the psychological condition of victims undergoes continual changes due to factors such as advancements in rescue operations, passage of time, and acquisition of information. This gives rise to a multifaceted process encompassing fear and helplessness transitioning into hope and recovery. Consequently, existing quantification methods may oversimplify these dynamics and fail to comprehensively capture them.

Furthermore, when considering the psychological costs, the majority of scholars focus solely on the perspective of disaster victims and quantify their psychological burdens. While a few scholars like S.Y. Yin and J.M. Zhao have considered the psychological factors of drivers in quantifying these costs, they have overlooked other relevant stakeholders such as decision-makers and rescue personnel, along with their psychological states and emotions. Decision-makers play a crucial role in emergency logistics, where their mental states and decision preferences are vital to the execution of rescue operations. Additionally, rescue personnel face significant psychological pressure during disaster relief efforts; thus, their mental well-being directly impacts the efficiency and effectiveness of rescue missions.

In conclusion, the majority of current research is focused on the short-term phase following disasters, with in-depth analyses of the immediate psychological responses and short-term impacts on disaster victims. However, there is a relative scarcity of research on the long-term psychological recovery process after disasters and its potential impact on long-term emergency logistics. This limitation constrains the long-term applicability value of methods for quantifying psychological costs during post-disaster recovery and reconstruction stages, preventing a comprehensive evaluation of the effectiveness and sustainability of psychological aid and emergency logistics strategies over extended periods. Therefore, enhancing research into long-term psychological recovery mechanisms after disasters holds significant importance for refining methods to quantify psychological costs and improving the overall efficiency of emergency logistics.

5. Conclusion and Prospects

In the context of disaster response, emergency logistics plays a crucial role. Current research primarily focuses on two key areas: optimizing the distribution routes for emergency supplies and determining the optimal locations for emergency distribution centers. To address the uncertainties and urgencies associated with natural disasters and public health crises, researchers have employed a variety of methods including fuzzy planning, stochastic programming, robust optimization, and other advanced optimization techniques. Scholars have not only addressed practical issues such as road damage and facility destruction but have also enhanced delivery routes for emergency supplies and strategies for selecting distribution center locations based on demand urgency and priority. This is aimed at improving efficiency and response speed.

As scholars continue to expand both the breadth and depth of their research efforts, content in this field has become

increasingly diverse while research directions are gradually becoming more refined. Many scholars have directed their focus towards understanding how psychological factors influence rescue outcomes. By incorporating prospect theory and welfare economics into their work, scholars have successfully quantified the psychological costs experienced by disaster victims. These costs are then integrated into decision-making processes within emergency logistics management practices to make them more scientific, precise, and humane.

Looking ahead to future developments in this area of study, it is essential that further research delves deeper into understanding the complexity and dynamics of disaster victims' psychological costs in order to provide a more comprehensive reflection thereof. This will require innovative approaches such as integrating real-time data analysis with machine learning technologies to better capture changes in disaster victims' psychology over time. Furthermore, diversifying perspectives beyond just focusing on disaster victims themselves to include all stakeholders—such as decision-makers and rescue personnel—is critical in forming a multi-dimensional assessment system for evaluating psychological costs. Additionally, long-term recovery of disaster victims' psychology post-disaster should be considered as a focal point for future studies. The aim here would be to assess the sustained impact of emergency logistics strategies over extended periods ensuring that not only short-term assistance is provided but also enabling personal as well as societal comprehensive recovery in the long run. Ultimately through deepening our understanding of psychological costs along with its application within this domain we can ensure that emergency logistics serves disaster victims more effectively thereby promoting social harmony & progress.

References

- [1] T.L. He, W.G. Lou. Solving Emergency Supplies Allocation with Multiple Demand Points Based on Improved Firefly Algorithm [J]. *Journal of Small and Microcomputers*, 2020, 41(6): 1334-1339.
- [2] S.S. He, W.H. Zhu, X.Q. Zhuang. Research on Multi-stage Delivery Path of Emergency Supplies Based on Disaster Repair [J]. *Computer Simulation*, 2016, 33(03): 167-171.
- [3] S.S. Yang. Optimization of Emergency Supplies Distribution Considering Road Reliability in Earthquake Disasters [D]. *China University of Mining and Technology*, 2022.
- [4] Y.L. Tang. Research on the Location-Routing Optimization of Emergency Logistics Considering Road Damage Degree in Earthquake Disasters [D]. *Chongqing University*, 2021.
- [5] J. Tan, W.L. Li, K.K. Liu. An Open-loop Emergency Logistics Vehicle Routing Problem Considering Secondary Disasters [J]. *Systems Engineering*, 2021, 39(02): 61-71.
- [6] J.X. Ye. Research on Vehicle Routing Optimization Problem with Capacity Constraints under Uncertain Demand [D]. *Zhejiang University of Finance and Economics*, 2023.
- [7] B.R. Cheng, X.B. Zhao, Q. Jin. Emergency logistics vehicle routing optimization model and algorithm considering supply shortage [J]. *Computer Applications Research*, 2016, 33(06): 1682-1685.
- [8] X.X. Zhu. Research on Optimization Decision Model of Emergency Materials Distribution in Earthquake Disaster [D]. *Harbin Institute of Technology*, 2017.
- [9] W. Xu. Research on Materials Distribution in Emergency Service Network with Multiple Supply Points and Demand Points [D]. *Zhengzhou University*, 2018.
- [10] J.J. Wang. Research on Emergency Medical Materials Distribution under Uncertain Demand in Epidemic Situation [D]. *Dalian Maritime University*, 2022.
- [11] F.Y. Wang, X.R. Wang, X. He, et al. Emergency Supply Location-Allocation Problem Considering Urgency of Demand and Overall Satisfaction[J]. *Systems Engineering*, 2024, 42(01): 37-50.
- [12] X.C. Dong. Study on Optimization of Emergency Vehicle Routes Considering Urgency of Demand in Major Sudden Events[D]. *Dalian Jiao tong University*, 2022.
- [13] Z.Q. Fan, N.N. Liang, Y.F. Luo, et al. Research on the Three-Level Emergency Supply Allocation Considering Urgency of Demand Differences and Fair Distribution[J]. *Industrial Engineering and Management*, 2024, 29(02): 26-36.
- [14] Y.T. Zheng. Study on Emergency Medical Supply Allocation Considering Supply and Demand Relationship and Urgency of Demand[D]. *Nanjing University*, 2021.
- [15] L. Xu. Research on Emergency Supply Distribution and Route Optimization Considering Residents' Psychological Cost in Sudden Public Health Events[D]. *Chongqing Jiao tong University*, 2023.
- [16] C.Y. Xu. Research on Optimization of Emergency Medical Supply Delivery Routes Considering Urgency of Demand in the Epidemic[D]. *Jiangxi University of Finance and Economics*, 2023.
- [17] Z. Yang. Research on Vehicle Routing Problem of Emergency Logistics Vehicles Considering Urgency of Demand[D]. *Chang an University*, 2018.
- [18] W.S. Yu. Research on the Selection Problem of Emergency Distribution Center Considering Risk of Damage[D]. *Dalian Maritime University*, 2023.
- [19] Y.M. Guo, D.W.Hu, L. Zhu, et al. Modeling Research on Emergency Logistics Facility Location and Allocation Problem Considering Reliability Elements[J]. *China Safety Science and Technology*, 2017, 13(02): 85-89.
- [20] J.M. Zhu. Multi-objective Decision-making Method for Emergency Facility Location under Damage Scenarios[J]. *Systems Engineering - Theory & Practice*, 2015, 35(3): 720-727.
- [21] J.P. Wang. Research on the Uncertainty-Based Scenario-Oriented Railway Emergency Facility Damage Location Planning. Master's thesis, *East China Jiao tong University*, 2018.
- [22] C. Peng. Decision-making on Emergency Medical Service Facility Location under Uncertainty. Master's thesis, *Beijing Institute of Technology*, 2017.
- [23] W.Y. Qin. Research on the Location of Emergency Materials Storage Warehouse Considering Facility Damage and Uncertain Demand. Master's thesis, *Beijing Jiao tong University*, 2023.
- [24] B. Du, H. Zhou. Two-Stage Robust Optimization Model for Emergency Facility Location under Uncertain Environment. *Industrial Engineering*, 2016, 19(05): 45-50.
- [25] S.S. Sun. Research on the Location-Routing Optimization Problem of Emergency Logistics Considering Demand Hierarchy. Master's thesis, *East China Jiao tong University*, 2023.
- [26] Q. Zhang. Research on Emergency Facility Location Considering Differentiation in Major Public Health Events. Master's thesis, *Southwest Jiao tong University*, 2022.

- [27] Y.H. Song, L.F. Wang, L.J. Du, et al. Multi-Mode Transportation Problem of Emergency Materials Distribution Selection under Fuzzy Conditions. *China Safety Science Journal*, 2017, 27(07): 169-174.
- [28] F. Yin, Y.D. Yu Multi-Level Coverage Location Model of Emergency Facilities in Major Sudden Events. *Journal of Science and Technology Engineering*, 2014, 14(21): 302-305.
- [29] J. Zhang, H.X. Zhu, H. Shen, et al. Research on the Location-Routing Problem of Emergency Logistics in Complex Environment. *Journal of Transportation Systems Engineering and Information*, 2023, 23(03): 280-289.
- [30] L. Zhou, Q.P. Li, Li. Location Model and Algorithm of Emergency Materials Storage Warehouse Considering Time Satisfaction. *China Safety Science Journal*, 2023, 33(03): 188-194.
- [31] C. Ma. Research on Optimized Distribution and Dynamic Allocation of Emergency Supplies Based on Psychological Risk Perception of Disaster Victims [D]. Dalian University of Technology, 2012.
- [32] Z.P. Fan, Y. Liu, R.J. Shen. Risk Decision Method Based on Prospect Theory for Emergency Response in Disasters [J]. *System Engineering - Theory & Practice*, 2012, 32(05): 977-984.
- [33] X.P. Wang, X.Y. Yang, T. Yang, et al. Dynamic Traffic Conditions-Based Seismic Supplies Allocation Dynamics Model Considering Decision-Maker's Risk Perception [J]. *Journal of Systems Management*, 2015, 24(02): 174-184.
- [34] Z.Y. Wang, Y.C. Yue. Multi-Resource Flow Emergency Optimization Scheduling Considering Public's Risk Perception in Public Opinion Spread [J]. *Chinese Management Science*, 2016, 24(06): 115-123.
- [35] W.L. Yang. Research on Emergency Supplies Allocation Considering Disaster Victims' Psychological Perception [D]. Chang an University, 2019.
- [36] T. Ning, X.P. Wang, X.P. Hu. Study on Interference Management Method Based on Prospect Theory in End-of-Pipe Logistics [J]. *System Engineering - Theory & Practice*, 2019, 39(03): 673-681.
- [37] S.Y. Yin. Research on Vehicle Routing Optimization for Post-Disaster Emergency Supplies Delivery Considering Personnel's Psychological Cost [D]. Wuhan University of Technology, 2020.
- [38] Z.W. Gong, J.Q. Yang. Multi-Period Emergency Supplies Allocation Uncertainty Planning Model Considering Disaster Victims' Psychological Response [J/OL]. *Chinese Management Science*, 1-17 [2024-07-12].
- [39] L.J. Tian, H.J. Huang, and X. Wang. A static network equilibrium model considering arrival time perception value. *Systems Engineering - Theory & Practice*, 2015, 35(6): 1493-1500.
- [40] C.W. Fang, Y.P. Liang, F. Wu. Hesitant fuzzy TOPSIS multi-attribute decision making method based on cumulative prospect theory[J]. *Journal of Nanyang Institute of Technology*. 2019: 11(6) : 20-23.
- [41] S.Z. Song, Y. Du, Y.Q. Shang, et al. Research on Emergency Supplies Path Selection Based on Cumulative Prospect Theory[J].*Journal of Jilin Engineering Technological Normal University*, 2022, 38(12): 88-93.
- [42] J.M. Zhao. Study on Improving Emergency Supplies Delivery Paths Considering Personnel Psychological Costs in W City[D]. Jiangnan University, 2023
- [43] Holguín-Veras J, Pérez N, Jaller M, et al. On the appropriate objective function for post-disaster humanitarian logistics models[J]. *Journal of Operations Management*, 2013, 31(5): 262-280.
- [44] Cantillo V ,Serrano I ,Macea F L , et al. Discrete choice approach for assessing deprivation cost in humanitarian relief operations[J].*Socio-Economic Planning Sciences*,2018,6333-46.
- [45] L. Zhu, Y. Gong, Y. Xu, J. Gu. Emergency relief routing models for injured victims considering equity and priority[J].*Annals of Operations Research*, 2019, 283(1-2SI): 1573-1606.
- [46] J. Gu. Optimization Research on Dynamic Allocation of Emergency Relief Materials Considering the Psychological Factors of Disaster Victims [D].Nanjing University of Information Science and Technology, 2018.
- [47] Gutjahr W J, Fischer S. Equity and Deprivation Costs in Humanitarian Logistics [J].*European Journal of Operational Research*, 2018, 270(1): 185-197.
- [48] Y.H. Song, Y.H. Song, C.X. Li, et al. Emergency logistics distribution model considering material damage and psychological impact[J]. *Chinese Journal of Safety Science*, 2020, 30(07): 173-179.
- [49] X.W. Wang, W.X. Zhang, Y.G. Yu, et al. Optimization of emergency evacuation site selection and material distribution considering refugee pain perception[J].*Chinese Journal of Management Science*, 2020, 28(12): 162-172.