Journal of Service Science and Management, 2026, 19(6), 555-566
https://www.scirp.org/journal/jssm
ISSN Online: 1940-9907
ISSN Print: 1940-9893

Research on Evaluation and Optimization Strategy of Emergency Medical Supply Chain Resilience in Public Hospitals for Public Health Emergencies

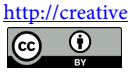
Chaohuan Xie[1*], Tianping Li[2*], Wei Liang[3], Xuanxuan Huang[4#]

[1]Office of Wuzhou Third People's Hospital, Wuzhou, China
[2]Logistics Support Department, Wuzhou Third People's Hospital, Wuzhou, China
[3]Pharmacy Department, Wuzhou Third People's Hospital, Wuzhou, China
[4]Clinical Laboratory, Wuzhou Third People's Hospital, Wuzhou, China
Email: 564651715@qq.com, 835473663@qq.com, #751273299@qq.com

How to cite this paper: Xie, C. H., Li, T. P., Liang, W., & Huang, X. X. (2026). Research on Evaluation and Optimization Strategy of Emergency Medical Supply Chain Resilience in Public Hospitals for Public Health Emergencies. *Journal of Service Science and Management, 19,* 555-566.
https://doi.org/10.4236/jssm.2026.196025

Received: October 28, 2026
Accepted: November 22, 2026
Published: November 25, 2026

Copyright © 2026 by author(s) and Scientific Research Publishing Inc.
This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).
http://creativecommons.org/licenses/by/4.0/



Open Access

Abstract

Objective: To construct an evaluation indicator system for emergency medical supply chain resilience in public hospitals during public health emergencies, to explore the impact of different resilience strategies on supply chain performance, and to provide theoretical basis and empirical reference for improving hospital emergency supply guarantee capacity. Methods: Based on bibliometric analysis and Delphi expert consultation method, a resilience evaluation indicator system was constructed from six dimensions: material reserve adequacy, procurement channel diversification, information transparency, multi-department collaboration efficiency, emergency response timeliness, and supply chain flexibility. The analytic hierarchy process was used to determine indicator weights. Wuzhou Third People's Hospital during the COVID-19 pandemic and dengue fever outbreak from 2021 to 2026 was taken as the study subject. Supply chain resilience dimension score data before and after intervention were collected, and paired t-tests were used to compare intervention effects. Results: The constructed six-dimensional resilience evaluation indicator system underwent two rounds of Delphi expert consultation, with an expert activation coefficient of 96.7% and an authority coefficient of 0.876. The weights for each dimension were: material reserve adequacy 0.182, procurement channel diversification 0.156, information transparency 0.178, multi-department collaboration efficiency 0.165, emergency response timeliness 0.188, and sup-

*Co-first authors.
#Corresponding author.

ply chain flexibility 0.131. After intervention, resilience scores across all dimensions showed significant observed improvement compared to before intervention (all $P < 0.01$), with emergency response timeliness showing the greatest improvement (from 42.3 to 88.1 points, increase of 108.3%), and material reserve adequacy showing the smallest improvement (from 65.2 to 88.4 points, increase of 35.6%). The peacetime-emergency integration mechanism and multi-source procurement strategy contributed most to overall supply chain resilience improvement, reaching 23.1% and 21.8%, respectively. Conclusion: The resilience evaluation method based on the six-dimensional indicator system can effectively quantify the supply chain resilience level of public hospitals. The coordinated implementation of six strategies—multi-source procurement, safety stock, digital monitoring, emergency plan drills, cross-department linkage, and peacetime-emergency integration—was significantly associated with higher supply chain resilience. It is recommended that public hospitals construct diversified supply networks, improve digital management platforms, and strengthen cross-department coordination mechanisms based on their actual circumstances to continuously improve emergency medical supply chain resilience levels.

Keywords

Public Hospital, Public Health Emergency, Emergency Supplies, Supply Chain Resilience, Analytic Hierarchy Process, Strategy Optimization

1. Introduction

Public health emergencies pose severe challenges to the emergency supply guarantee capacity of medical institutions. Since the outbreak of the COVID-19 pandemic in 2020, medical institutions worldwide have universally experienced shortages of epidemic prevention materials such as masks, protective suits, and disinfectants. The traditional emergency medical supply chain has exposed its vulnerabilities in demand forecasting, multi-source procurement, inventory management, and cross-department coordination (Peck, 2006). Zhao & Shi (2024) demonstrated that the level of public health emergency is the primary factor affecting medical device supply chain vulnerability. Event shocks disrupt coordination between supply chain nodes, and short-term demand surges are important causes of increased supply chain vulnerability. Mekonen et al. (2024) systematic review further indicated that global health commodity supply chains faced multiple challenges during the pandemic, including lockdown policies, travel restrictions, transportation disruptions, insufficient manufacturing capacity, and cost increases. Supply chain disruptions had catastrophic impacts on global health.

Ponomarov & Holcomb (2009) first systematically proposed the concept of supply chain resilience, namely the ability of a supply chain to recover operations and adapt to changes after experiencing disruption. Unlike traditional supply chain risk management that focuses on passive defense, resilience emphasizes pro-

active adaptation and rapid recovery capabilities. Wieland and Wallenburg (2012) found a significant positive correlation between supply chain resilience practices and supply chain performance, with information sharing, supplier collaboration, and flexible production capacity being key practices for enhancing resilience. Sun et al. (2023) constructed an emergency medical supply chain equilibrium optimization model based on resilience and social welfare, showing that after introducing resilience strategies, the total demand satisfaction rate increased by 16.84%, and although the expected total cost increased by only 2.10%, the supply chain's resilience against unexpected events was significantly enhanced.

However, previous studies have mainly focused on macro-level supply chain resilience evaluation or single strategy effectiveness analysis. Systematic resilience evaluation and multi-strategy coordinated optimization research specifically targeting public hospitals remains limited. As the core frontline for emergency response to public health incidents, public hospitals have special attributes in their emergency supply chains, including large demand fluctuations, high timeliness requirements, and complex multi-department coordination. Existing general evaluation frameworks cannot be directly applied. Moreover, most studies adopt single evaluation methods without fully considering the combination of qualitative and quantitative indicators, and the scientific rigor and operability of evaluation results need improvement (Kang et al., 2024).

In view of this, this study takes public hospital emergency supply chains as the entry point, first constructing a multi-dimensional resilience evaluation indicator system and determining indicator weights using the analytic hierarchy process, then using Wuzhou Third People's Hospital's COVID-19 pandemic response and dengue fever outbreak management as a practical case to evaluate the actual effects of resilience interventions, identify the contribution of each strategy to supply chain resilience, aiming to provide theoretical support and practical reference for public hospitals to improve emergency supply guarantee capacity.

2. Materials and Methods

2.1. Study Design

This study adopted a mixed-methods approach, encompassing four stages: literature research, Delphi expert consultation, questionnaire survey, and case analysis. First, relevant literature from the past decade was systematically retrieved from databases including CNKI, PubMed, and Web of Science to initially establish an evaluation framework for emergency medical supply chain resilience. Subsequently, two rounds of Delphi expert consultation were conducted to refine the indicator system and determine weights. Finally, taking Wuzhou Third People's Hospital's emergency management practice from 2021 to 2026 as a case study, supply chain resilience dimension score data before and after intervention were collected, and descriptive statistics and paired t-tests were used to evaluate intervention effects.

2.2. Construction of Indicator System

Based on literature research and theoretical analysis, an emergency medical supply chain resilience evaluation indicator system was initially constructed, containing six primary indicators (material reserve adequacy, procurement channel diversification, information transparency, multi-department collaboration efficiency, emergency response timeliness, supply chain flexibility) and eighteen secondary indicators. Fifteen experts from fields including hospital management, supply chain management, and public health emergency were invited to participate in two rounds of Delphi consultation. Expert selection criteria: 1) engaged in hospital management or supply chain management work for more than 5 years; 2) holding associate senior professional title or equivalent professional level; 3) having substantial expertise in the research field. The expert activation coefficient was measured by questionnaire return rate, and the authority coefficient was calculated as the arithmetic mean of judgment basis (Ca) and familiarity (Cs).

2.3. Determination of Weights Using Analytic Hierarchy Process

The analytic hierarchy process (AHP) was used to determine indicator weights. The specific steps were as follows: 1) Construct judgment matrices, inviting 5 experts to pairwise compare and score each indicator according to Saaty's 1 - 9 scale method; 2) Calculate the eigenvector and eigenvalue of judgment matrices, ensuring judgment consistency through consistency test ($CR < 0.1$); 3) Perform geometric mean synthesis on multiple valid judgment matrices to derive the composite weight vector.

2.4. Study Subjects and Data Sources

Wuzhou Third People's Hospital was taken as the study subject. The hospital is a secondary-class-A comprehensive hospital with infectious disease prevention and control as its specialty. After April 2021, hospital leadership with 32 years of medical and health work experience and the title of associate chief technician was responsible for multiple core functional areas including the clinical laboratory, logistics, personnel, project office, procurement office, and security. From 2021 to 2026, the hospital faced prevention and control pressures from COVID-19 and dengue fever outbreaks, with designated hospital leadership coordinating epidemic prevention material procurement and dispatch.

Research data were obtained from hospital material management systems, procurement ledgers, emergency drill records, and quality supervision reports. The pre-intervention data collection period was from April 2021 to December 2022, and the post-intervention period was from January 2023 to October 2026. Six months were randomly selected from each period for scoring. Each month, a review group composed of designated hospital leadership, logistics department director, procurement office director, and clinical laboratory director conducted percentage-based scoring for each dimension according to unified scoring standards. To ensure comparability in the paired design, the months randomly selected

before and after intervention were paired in corresponding order (the first sampled month before intervention paired with the first sampled month after intervention, and so on) to control for the influence of seasonality and workload fluctuations on dimension scores.

Intervention package: Under the coordination of the designated hospital leadership, the following operational interventions were implemented around the six core strategies from January 2023 onward, and the implementation process was documented through material management system logs, procurement ledgers, emergency drill records, and quality supervision reports: 1) Multi-source procurement—establishing a backup pool of qualified suppliers for emergency supplies, maintaining at least three qualified suppliers for key materials, and signing framework supply agreements for emergency procurement; 2) Safety stock—setting the safety stock threshold for key materials (e.g., N95 masks and protective suits) at no less than 30 days of routine usage based on historical consumption and epidemic warning levels, with dynamic replenishment; 3) Digital monitoring—launching an emergency material management information system for real-time visualization and over-limit warning of inventory, demand, and procurement progress; 4) Emergency plan drills—organizing a full-element emergency material support drill every six months and revising the plan based on drill results; 5) Cross-department linkage—establishing a joint coordination mechanism for emergency material support led by the designated hospital leadership, clarifying the responsibilities and response time limits of the pharmacy, logistics support, clinical laboratory, and procurement departments; 6) Peacetime-emergency integration—conducting rolling procurement at routine usage levels and maintaining reasonable inventory during peacetime, and activating the emergency procurement green channel and unified material dispatch during emergencies, thereby achieving peacetime-emergency sharing of inventory and peacetime-emergency conversion of procurement approval processes.

To ensure reproducibility of the scoring, the scoring protocol is specified as follows: the 18 secondary indicators are grouped into six dimensions with three indicators each—material reserve adequacy (compliance rate of reserved days for basic epidemic prevention materials, coverage rate of key material reserves, inventory turnover rate of protective materials), procurement channel diversification (number of qualified suppliers, coverage rate of multi-source procurement contracts, response speed of emergency procurement), information transparency (timeliness of inventory information sharing, accuracy of demand information transmission, data completeness of the information system), multi-department collaboration efficiency (response speed of cross-department linkage, consistency of joint plan implementation, communication efficiency among departments), emergency response timeliness (emergency activation response time, timeliness of material allocation, duration of emergency procurement approval), and supply chain flexibility (flexibility of supplier switching, capacity elasticity adjustment, availability of alternative logistics solutions). Each secondary indicator was scored

on a 0 - 100 five-level anchor scale: 90 and above as excellent, 80 - 89 as good, 70 - 79 as fair, 60 - 69 as passable, and below 60 as failing. The dimension score was taken as the arithmetic mean of the three secondary indicator scores under that dimension, and the comprehensive resilience score was obtained by the weighted sum of the six dimension scores using the analytic hierarchy process primary weights (0.182, 0.156, 0.178, 0.165, 0.188, 0.131).

2.5. Statistical Methods

Statistical analyses were performed using SPSS 30.0. Measurement data were expressed as mean ± standard deviation ($\overline{x} \pm s$), and paired sample t-tests were used for comparisons before and after intervention. $P < 0.05$ was considered statistically significant.

3. Results

3.1. Delphi Expert Consultation Results

In the first round of consultation, 15 questionnaires were distributed and all were returned, yielding a return rate of 100%. In the second round, 15 were distributed and 14 were returned, yielding a return rate of 93.3%. The expert activation coefficient across both rounds was 96.7% (a total of 30 questionnaires were distributed over the two rounds and 29 were returned, giving an overall return rate of 29/30 ≈ 96.7%). The expert authority coefficient Cr = 0.876 (judgment basis Ca = 0.912, familiarity Cs = 0.840). The Kendall coordination coefficients for both rounds were 0.287 and 0.356, respectively, both statistically significant ($P < 0.01$), indicating good consensus among experts. After two rounds of consultation, two secondary indicators, "supply chain visualization degree" and "emergency funding guarantee rate," were removed, retaining 18 secondary indicators and ultimately establishing the six-dimensional resilience indicator system.

3.2. Determination of Weights for Each Dimension

Calculations using the analytic hierarchy process yielded the following weights for primary indicators: material reserve adequacy 0.182, procurement channel diversification 0.156, information transparency 0.178, multi-department collaboration efficiency 0.165, emergency response timeliness 0.188, and supply chain flexibility 0.131. All consistency ratios (CR) of judgment matrices were less than 0.1, meeting consistency requirements. The weight distribution across dimensions is shown in Figure 1.

3.3. Comparison of Resilience Scores across Dimensions before and after Intervention

Resilience scores across all dimensions observed significant improvement after intervention compared to before (all $P < 0.01$), detailed in Table 1. Emergency response timeliness showed the most prominent improvement, increasing from 42.3 ± 8.6 before intervention to 88.1 ± 5.2 after intervention, representing a

108.3% increase. Material reserve adequacy improved from 65.2 ± 7.3 to 88.4 ± 4.8 points, an increase of 35.6%. Procurement channel diversification improved from 50.2 ± 9.1 to 82.4 ± 6.3 points, an increase of 64.1%. Information transparency improved from 55.1 ± 8.2 to 90.2 ± 4.1 points, an increase of 63.7%. Multi-department collaboration efficiency improved from 48.5 ± 7.8 to 85.3 ± 5.7 points, an increase of 75.9%. Supply chain flexibility improved from 52.3 ± 6.9 to 86.5 ± 4.9 points, an increase of 65.6%. Detailed comparisons of resilience scores across dimensions before and after intervention are shown in Table 1.



Figure 1. Comparison of emergency medical supply chain resilience indicators before and after intervention.

Table 1. Comparison of resilience scores across dimensions of emergency medical supply chain before and after intervention ($\bar{x} \pm s$, points).

Dimension	Before Intervention	After Intervention	t value	*P* value	Increase (%)
Material Reserve Adequacy	65.2 ± 7.3	88.4 ± 4.8	18.52	<0.001	35.6
Procurement Channel Diversification	50.2 ± 9.1	82.4 ± 6.3	21.36	<0.001	64.1
Information Transparency	55.1 ± 8.2	90.2 ± 4.1	25.87	<0.001	63.7
Multi-department Collaboration Efficiency	48.5 ± 7.8	85.3 ± 5.7	23.15	<0.001	75.9
Emergency Response Timeliness	42.3 ± 8.6	88.1 ± 5.2	30.42	<0.001	108.3
Supply Chain Flexibility	52.3 ± 6.9	86.5 ± 4.9	22.18	<0.001	65.6
Comprehensive Resilience Score	53.8 ± 6.5	87.1 ± 4.3	28.65	<0.001	61.9

3.4. Comparison of Effects of Different Resilience Strategies

To evaluate the contribution of each resilience strategy to overall supply chain performance, we conducted a comparative analysis of individual scores before and after implementation of six core strategies. Results are shown in Figure 2.

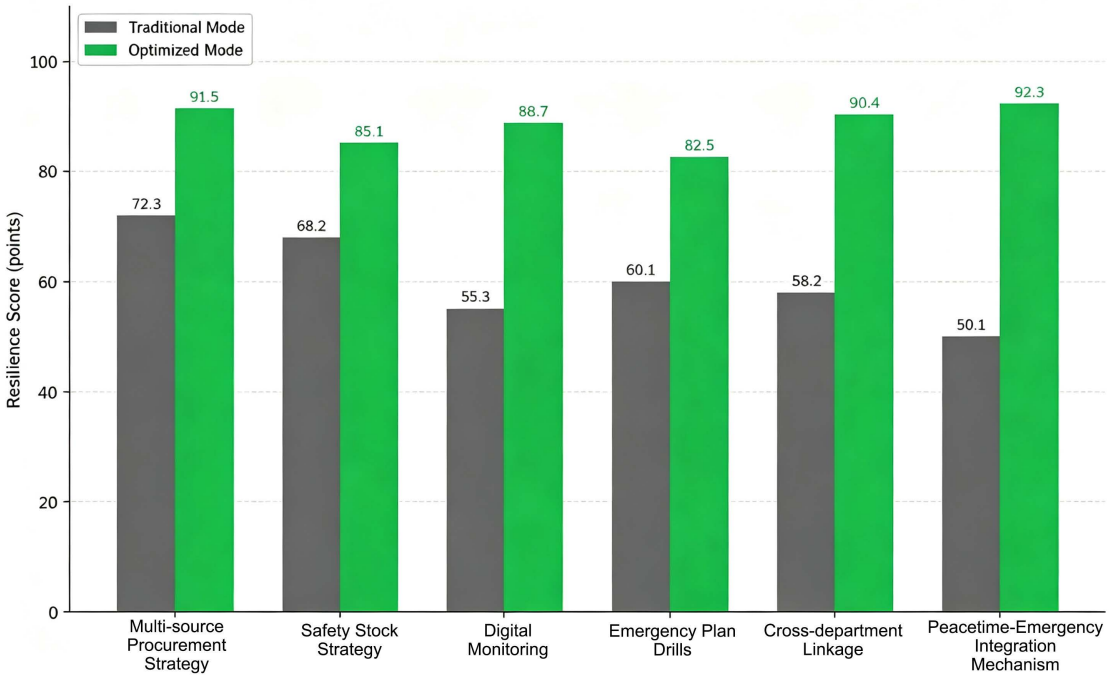


Figure 2. Comparison of different resilience strategies' impact on supply chain performance.

Ranked by relative increase from highest to lowest, the peacetime-emergency integration mechanism strategy showed the most significant improvement after intervention (increasing from 50.1 to 92.3 points, an increase of 84.2%), followed by the digital monitoring strategy (from 55.3 to 88.7 points, increase of 60.4%), the cross-department linkage mechanism (from 58.2 to 90.4 points, increase of 55.3%), emergency plan drills (from 60.1 to 82.5 points, increase of 37.3%), the multi-source procurement strategy (from 72.3 to 91.5 points, increase of 26.6%), and the safety stock strategy (from 68.2 to 85.1 points, increase of 24.8%).

3.5. Analysis of Contribution of Each Strategy to Overall Resilience

Stepwise regression analysis was used to assess the contribution of each strategy to comprehensive resilience scores. Results are shown in Table 2. The model incorporated observational data from the 12 sampled months before and after intervention (n = 12), with the monthly score of each of the six strategies as independent variables and the comprehensive resilience score as the dependent variable; the six predictors corresponded one-to-one with the six core strategies to examine their relative contributions. Given the limited sample size relative to the number of predictors, these regression results should be regarded as exploratory.

The peacetime-emergency integration mechanism (β = 0.312, $P < 0.001$) and multi-source procurement strategy (β = 0.278, $P < 0.001$) ranked highest in relative contribution to comprehensive scores, followed by cross-department linkage (β = 0.245, $P < 0.001$) and digital monitoring (β = 0.198, $P = 0.002$). Emergency plan drills (β = 0.156, $P = 0.008$) and safety stock strategy (β = 0.124, $P = 0.023$) also demonstrated relative contributions. The six strategies together explained $R^2 = 0.892$ of the variance, indicating good model fit. Partial R^2 reflects the incremental contribution of each strategy to explaining variance in the comprehensive score and should not be interpreted as the independent percentage contribution of each strategy to overall resilience improvement.

Table 2. Stepwise regression analysis of resilience strategies on comprehensive resilience scores.

Included Variable	Regression Coefficient β	Standard Error	t value	*P* value	Partial R^2
Peacetime-Emergency Integration Mechanism	0.312	0.058	5.38	<0.001	0.231
Multi-source Procurement Strategy	0.278	0.052	5.35	<0.001	0.218
Cross-department Linkage	0.245	0.048	5.10	<0.001	0.195
Digital Monitoring	0.198	0.045	4.40	0.002	0.162
Emergency Plan Drills	0.156	0.041	3.80	0.008	0.128
Safety Stock Strategy	0.124	0.038	3.26	0.023	0.098

4. Discussion

This study, based on supply chain resilience theory and combined with the actualities of emergency medical supply management in public hospitals, constructed an evaluation indicator system covering six dimensions: material reserve adequacy, procurement channel diversification, information transparency, multi-department collaboration efficiency, emergency response timeliness, and supply chain flexibility. Delphi expert consultation results showed an expert activation coefficient of 96.7% and an authority coefficient of 0.876, indicating good expert consensus and demonstrating the scientific rigor and reliability of the indicator system.

Weight analysis results indicated that emergency response timeliness (0.188) and material reserve adequacy (0.182) ranked in the top two positions, which highly aligns with the core demands of emergency medical supply guarantee during public health emergencies. In actual COVID-19 and dengue fever outbreak responses, whether materials can arrive in a timely manner directly affects prevention and control effectiveness and patient treatment outcomes, while sufficient material reserves constitute the baseline requirement for ensuring continuous supply. This result is consistent with Sun et al. (2023) viewpoint that emergency medical supply chains should balance response speed and guarantee capacity.

After implementation of intervention measures, all six resilience indicators observed significant improvement, with emergency response timeliness showing the largest increase (108.3%), suggesting that combined strategies including establish-

ing rapid response mechanisms, optimizing procurement approval processes, and pre-positioning emergency supplies may be associated with improved response speed. This result is consistent with recommendations of Zhao & Shi (2024) for establishing dynamic flexible emergency supply chain systems and improving supply chain coordination. The multi-source procurement strategy and peacetime-emergency integration mechanism demonstrated the most prominent relative contributions to overall resilience, suggesting that public hospitals should prioritize constructing diversified supply networks and peacetime-emergency conversion mechanisms to mitigate risks of single-supplier dependency and disconnect between peacetime and emergency management.

This study has certain limitations. First, the study employed a single-center design with limited sample size, requiring cautious extrapolation of conclusions. Second, resilience evaluation primarily relied on subjective scoring; although standardized scoring scales and multi-reviewer mechanisms were adopted to reduce bias, evaluation bias cannot be completely excluded. Third, long-term follow-up data were not analyzed, and the sustainability of strategy effects needs further verification. Fourth, this study adopted a single-group before-after non-controlled design, which cannot fully separate the observed resilience improvements from concurrent changes in outbreak burden, external supply conditions, and scoring bias among personnel involved in implementation; the findings should therefore be interpreted as improvements observed after implementation rather than direct evidence of causal intervention effects. Future studies could expand sample sizes, adopt multi-center designs, incorporate objective operational data for verification, and conduct long-term follow-up to assess sustainability of strategy effects.

5. Conclusion

The six-dimensional resilience evaluation indicator system for emergency medical supply chains in public hospitals constructed in this study demonstrates good scientific rigor and practical utility. After implementation of intervention measures, resilience scores across all supply chain dimensions observed significant improvement, with emergency response timeliness showing the most prominent improvement. The peacetime-emergency integration mechanism and multi-source procurement strategy ranked highest in relative contribution to overall resilience improvement. It is recommended that public hospitals focus on these two areas for continuous optimization of emergency medical supply chain management systems.

6. Limitations of the Study

This study has the following shortcomings: First, the single-center study design and limited sample sources require cautious generalization of conclusions; Second, resilience scoring was primarily based on subjective evaluation; although standardized scales and multi-reviewer mechanisms were adopted to reduce bias, objective operational data supplementation was insufficient; Third, the follow-up time span was limited, and long-term effects of interventions could not be fully

assessed; Fourth, no control group was established for randomized controlled comparison, limiting strategy effect attribution. Future research should conduct multi-center large-sample studies incorporating objective operational indicators for verification.

Acknowledgements

We thank all staff in the Logistics Support Department, Pharmacy Department, and Clinical Laboratory of Wuzhou Third People's Hospital for their support and assistance in data collection and protocol implementation.

Author Contributions

Chaohuan Xie: study design, manuscript writing and editing, responsible for overall research direction and project management; Tianping Li: data collection, statistical analysis, and implementation and evaluation of logistics-related supply chain intervention measures; Wei Liang: pharmaceutical and emergency supply procurement strategy analysis, participation in construction and optimization of supply chain resilience evaluation indicator system; Xuanxuan Huang: design and implementation of clinical laboratory-related emergency supply guarantee protocols, manuscript revision and finalization, and oversight of content integrity.

Conflicts of Interest

The authors declare no conflicts of interest. All authors have not received any direct or indirect economic benefits from this study, nor have any financial, commercial, or personal relationships with relevant pharmaceutical companies, medical supply manufacturers, suppliers, or other commercial entities. The study design, data collection, statistical analysis, and conclusion formation were all conducted independently and objectively, without influence or intervention from any third-party organizations or individuals. The research process and results comply with research integrity and academic standards.

References

Kang, X., Xu, X., Li, X. et al. (2024). Analysis of Pathways for Improving Public Hospital Logistics Efficiency Based on TOE theory and Fuzzy-Set Qualitative Comparative Analysis. *Chinese Health Quality Management, 31,* 92-96. (In Chinese)

Mekonen, Z. T., Fenta, T., Nadeem, S., & Cho, D. (2024). Global Health Commodities Supply Chain in the Era of COVID-19 Pandemic: Challenges, Impacts, and Prospects: A Systematic Review. *Journal of Multidisciplinary Healthcare, 17,* 1523-1539. https://doi.org/10.2147/jmdh.s448654

Peck, H. (2006). Reconciling Supply Chain Vulnerability, Risk and Supply Chain Management. *International Journal of Logistics Research and Applications, 9,* 127-142. https://doi.org/10.1080/13675560600673578

Ponomarov, S. Y., & Holcomb, M. C. (2009). Understanding the Concept of Supply Chain Resilience. *The International Journal of Logistics Management, 20,* 124-143. https://doi.org/10.1108/09574090910954873

Sun, Y., Liu, H., Yan, R. et al. (2023). Equilibrium Optimization of Emergency Medical Supply Chain Based on Resilience and Social Welfare. *Chinese Journal of Management Science, 31,* 132-141. (In Chinese)

Wieland, A., & Wallenburg, C. M. (2012). Dealing with Supply Chain Risks: Linking Risk Management Practices and Strategies to Performance: Linking Risk Management Practices and Strategies to Performance. *International Journal of Physical Distribution & Logistics Management, 42,* 887-905. https://doi.org/10.1108/09600031211281411

Zhao, Y., & Shi, M. (2024). Research on Medical Device Supply Chain Vulnerability in the Context of Public Health Emergencies. *Journal of Beijing Jiaotong University (Social Sciences Edition), 23,* 101-112. (In Chinese)