

BINDURA UNIVERSITY OF SCIENCE EDUCATION



FACULTY OF COMMERCE

DEPARTMENT OF ECONOMICS

Impact of Last-Mile Delivery Efficiency on the Effectiveness of Humanitarian Supply Chains Delivering Emergency Medical Aid during Cyclone Idai in Zimbabwe

By

REBECCA MACHAWU

B241565A

A DISSERTATION SUBMITTED TO THE BINDURA UNIVERSITY OF SCIENCE IN
PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE MASTERS OF SCIENCE
DEGREE IN PURCHASING AND SUPPLY CHAIN MANAGEMENT

JUNE 2025

HARARE, ZIMBABWE

THE RELEASE FORM

BINDURA UNIVERSITY SCIENCE EDUCATION



NAME OF AUTHOR:

REBECCA MACHAWU

TITLE OF PROJECT:

Impact of Last-Mile Delivery Efficiency on the
Effectiveness of Humanitarian Supply Chains
Delivering Emergency Medical Aid during Cyclone
Idai in Zimbabwe

PROGRAMME:

Masters of Science Degree in Purchasing and Supply Chain
Management

YEAR GRANTED:

2025

Permission is hereby granted to the Bindura University of Science Education Library to produce single copies of this project and to lend or sell such copies for private, scholarly or scientific research purposes only. The author does not reserve other publication rights and the project nor may extensive extracts from it be printed or otherwise reproduced without the author's written permission.

SIGNED:

PERMANENT ADDRESS:

28259 Hillside Extension, Masvingo

DATE:

JUNE 2024

APPROVAL FORM

The undersigned certify that they have read and recommended to Bindura Univ of
Science Education for acceptance, a research project entitled:

**OF LAST MILE DELIVERY EFFICIENCY ON THE EFFECTIVENESS OF
HUMANITARIAN SUPPLY CHAINS DELIVERING EMERGENCY MEDICAL AID
DURING CYCLONE IDAI IN ZIMBABWE.**

BY

REBECA MACHAWU

In partial fulfilment of the requirements of Master of Science Degree in Purchasing and
Supply Chain Management.

I. To be completed by the student.

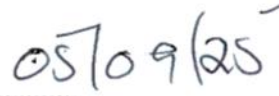
I certify that this dissertation meets the preparation guidelines as presented in the Faculty Guide
and Instructions for typing dissertations:

.....  20/07/25

Signature of the student and Date

II. To be completed by the

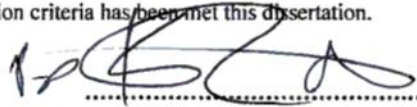
This dissertation is suitable for submission to the is dissertation should be checked
for conformity with Faculty guidel

.....  05/09/25

Signature of Supervisor and Date

III. To be completed by Chair of Department.

I certify to the best of my knowledge that the required procedures have followed and the
preparation criteria has been met this dissertation.

 05/09/25

Signature of Chairperson and Date



DEDICATION

I **Rebecca Machawu**, do hereby solemnly declare that this dissertation is the result of my own investigation and scientific inquiry, except to the extent indicated by the acknowledgement, reference and by comments included in the body of the report, and that it has not been submitted in part or in fulfilment for any other programme to any other university or institution of higher learning.

Date

Signature:

..... JUNE 2025

Abstract

This study examined the impact of last-mile delivery efficiency on humanitarian supply chain effectiveness during Cyclone Idai in Zimbabwe. The research philosophy used was positivism, and the research design was quantitative. The data was gathered using a structured questionnaire that was administered to 278 logistics-oriented humanitarian organisations in the affected districts of Chimanimani, Chipinge, Mutare, and Buhera. The study used stratified random sampling in order to achieve an representation across NGOs, government agencies, and donor-funded relief bodies. Cronbach alpha was used to confirm reliability and all the constructs had internal consistency scores greater than 0.70, indicating acceptable internal reliability. Objective sought to determine how much the adoption of IoT improves the accuracy of real-time shipment tracking. The results suggested that there was moderate adoption of GPS and IoT devices within organisations, whereby some organisations were using the technology to optimise routes, and others were using manual systems. Such discrepancy restricted system-wide visibility and made it difficult to update information in a timely manner across operational teams. Objective 2 sought to find out how IoT-enabled data analytics impact supply chain transparency and decision-making. The findings revealed that some organisations did perform post-crisis reviews and deployed digital dashboards, but the integration of analytics was less and not standardised. This decreased the capability of predicting demand, shifting of resources and real time logistics strategy adjustments. The aim of objective 3 was to test how the IoT integration would enhance inventory visibility and the accuracy of stock levels. The results indicated a moderate consensus among the respondents that inventory systems eased operations, but the lack of fuel and vehicles and terrain-specific transportation services compromised real-time stock visibility and last-mile delivery abilities in distant places. The research found that the humanitarian logistics systems in the Cyclone Idai were somewhat effective but were undermined by unreliable utilization of technology, damage to infrastructure, and inefficiencies in the coordination. Agencies should invest in standardised IoT platforms, decentralised logistics frameworks, and real-time analytics to facilitate proactive planning and adaptive delivery systems to make future responses stronger, it is suggested. Moreover, positioning of resources in advance as well as making the vehicles appropriate to disaster-prone areas are essential to the success of operations. The policy implications of the findings include the recommendations that disaster management authorities should consider enhancing inter-agency logistics coordination guidelines, investing in digital infrastructure, as well as establishing formalised crisis review processes. To practitioners in the humanitarian industries, the research stresses the relevance of flexible, technology-enabled and context-driven delivery models. The study is limited by the fact that it was conducted in one disaster setting and that the data is self-reported. The cross-sectional design also limited the understanding of changing logistics approaches in various stages of the disaster. The future research needs to be based on longitudinal and mixed-methods studies, cover urban settings, as well as consider how emerging technologies such as drones and blockchain can be used to improve last-mile efficiency.

ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to all those who supported me throughout the journey of completing this dissertation. First and foremost, I am sincerely thankful to my supervisor, Dr Chari, for their invaluable guidance, constructive feedback, and unwavering encouragement during every stage of this research. Their insights and mentorship were critical to the successful completion of this work.

I extend my appreciation to the faculty and staff of Department Of Economics, whose academic support and resources played an essential role in shaping this dissertation. Special thanks also go to the participants and organizations that provided the data and time necessary for this study.

To my family and friends, thank you for your patience, support, and belief in me. Your encouragement helped me stay focused and motivated during the most challenging moments.

Finally, I acknowledge the grace of God for granting me the strength, perseverance, and clarity of thought needed to complete this academic milestone.

TABLE OF CONTENTS

APPROVAL FORM	Error! Bookmark not defined.
THE RELEASE FORM.....	ii
DEDICATION	iii
Abstract	v
ACKNOWLEDGEMENTS.....	vi
TABLE OF CONTENTS.....	vii
LIST OF TABLES	xi
LIST OF FIGURES	xii
Chapter 1	1
Introduction.....	1
1.1 Introduction.....	1
1.2 Background of the Study	1
1.3 Problem Statement	3
1.4 Objectives	3
1.5 Research Questions	3
1.6 Significance of the Study	4
1.7 Assumptions of the Study	4
1.8 Delimitations of the Study	5
1.9 Definition of Terms.....	5
1.10 Acronyms	6
1.11 Chapter Summary	7
Chapter 2.....	9
Literature Review.....	9
2.1 Introduction.....	9

2.2 Theoretical Framework.....	9
2.2.1 Supply Chain Operations Reference (SCOR) Model	9
2.2.2 Humanitarian Logistics Theory	10
2.2.3 Systems Theory.....	12
2.3 Last-Mile Delivery Efficiency in Humanitarian Operations	13
2.3.1 Concept and Dimensions of Last-Mile Delivery Efficiency.....	13
2.3.2 Timeliness and Speed of Delivery	14
2.3.3 Accessibility and Infrastructure Constraints	15
2.3.4 Transport Vehicle Suitability and Modal Choice	16
2.3.5 Technology Use in Route Planning and Tracking	16
2.3.6 Flexibility and Adaptability of Delivery Systems	17
2.3.7 Resource Availability and Operational Readiness.....	18
2.4 Effectiveness of Humanitarian Supply Chains in Emergency Medical Aid.....	19
2.4.1 Defining Humanitarian Supply Chain Effectiveness	19
2.4.2 Timeliness and Responsiveness in Aid Delivery	20
2.4.3 Accuracy and Adequacy of Aid Delivered	21
2.4.4 Monitoring, Evaluation and Post-Crisis Review	22
2.5 Last-Mile Delivery Efficiency and Supply Chain Effectiveness	23
2.5.1 Conceptual Link Between Last-Mile Delivery and Supply Chain Outcomes	23
2.5.2 Role of Coordination and Technology as Mediating/Moderating Factors	25
2.5.3 Global Humanitarian Contexts	26
2.5.4 Implications for Designing Resilient Humanitarian Supply Chains.....	27
2.6 Conceptual Framework.....	28
2.7 Empirical Review.....	29
2.7.1 Empirical Review on Last-Mile Delivery Efficiency	29

2.7.2 Humanitarian Supply Chain Effectiveness	33
2.8.1 The Relationship Between Last-Mile Delivery and Supply Chain Outcomes	37
2.7 Chapter Summary	40
Chapter 3.....	41
Methodology	41
3.1 Introduction.....	41
3.2 Research Philosophy	41
3.3 Research Approach	42
3.4 Research Strategy.....	43
3.5 Population	44
3.6 Sampling	44
3.7 Data Collection Method.....	46
3.8 Data Analysis Techniques.....	47
3.9 Validity and Reliability	48
3.10 Ethical Considerations	49
3.11 Chapter Summary	50
Chapter 4.....	51
Data Presentation, Analysis and Discussion.....	51
4.2 Reliability and Validity.....	51
4.3: Organisational Characteristics	52
4.3.1 Type of Organisation	52
4.3.2 Role in Organisation	52
4.3.3 Years in Humanitarian Logistics	53
4.3.4 Primary Mode of Transport	53
4.3.5 Frequency of Last-Mile Delivery Operations	54

4.4: Last-Mile Delivery Efficiency	54
4.5 Humanitarian Supply Chain Effectiveness	56
4.6 Regression Analysis	57
4.7 Chapter Summary	58
Chapter 5.....	59
Summary, Conclusions and Recommendation	59
5.1 Introduction.....	59
5.2 Summary of Findings.....	59
5.3 Conclusions.....	60
5.4 Recommendations.....	61
5.5 Limitations of the Study.....	62
5.6 Recommendations for Future Research.....	63
References.....	64
Appendices.....	73
Questionnaire:	73
Questionnaire: Evaluating Last-Mile Delivery Efficiency in Humanitarian Logistics During Cyclone Idai.....	73
SECTION A: Organisational Characteristics (<i>Demographic Information</i>)	73
SECTION B: Last-Mile Delivery Efficiency (<i>Independent Variable</i>).....	74
SECTION C: Effectiveness of Humanitarian Supply Chains (<i>Dependent Variable</i>)....	74

LIST OF TABLES

Table 4.1: Cronbach's Alpha for Key Variables	51
Table 4.2: Organisational Characteristics	52
Table 4.3: Last-Mile Delivery Efficient Descriptive	54
Table 4.4: Humanitarian Supply Chain Effectiveness	56
Table 4.5: Model Summary	57
Table 4.6: Coefficients	57

LIST OF FIGURES

Figure 2.1: Conceptual Framework	29
--	----

Chapter 1

Introduction

1.1 Introduction.

Humanitarian supply chain operations can only deliver effective aid during disasters like Cyclone Idai in 2019 Zimbabwe when last-mile delivery efficiency maintains its critical role. The final stage of supply chain delivery known as last-mile delivery results in delayed medical aid distribution to disaster-hit communities because of its operational inefficiencies. Progress in humanitarian logistics did not eliminate fundamental obstacles like limited infrastructure alongside communication breakdowns together with coordination problems that reduce the effectiveness of last-mile operations. The emergency distribution of medical supplies during Cyclone Idai revealed critical issues because essential supplies did not reach target populations fast enough therefore demonstrating the necessity to develop better delivery and response methods. Last-mile delivery operates as a vital mechanism to reduce disaster consequences by delivering emergency medical supplies to areas in need in a timely manner.

1.2 Background of the Study

The global implementation of humanitarian logistics stands essential within disaster response plans because natural disasters grow more common and powerful because of climate change. Supply chain performance in disaster relief operations functions as a critical factor for reducing the adverse effects disasters create on vulnerable communities (Oloruntoba & Gray, 2016). The ultimate phase of humanitarian supply chain management is last-mile delivery which fulfills the distribution of goods and aid to affected populations (Van Wassenhove, 2018). The logistics technologies advancements have not eliminated the issues in this phase because of limited infrastructure and uncoordinated operations in unpredictable disaster sites (Cuzzolino et al., 2020). Humanitarian organizations persist in developing innovative solutions for improving delivery efficiency in the last mile sector to enhance disaster relief operations (Tomasini & Van Wassenhove, 2015).

The issues of the supply chain of African humanitarian relief become more severe due to the lack of infrastructure and unstable politics and weak administrative systems (Balcik et al., 2015). There

are also barriers to the provision of relief goods because of insufficient infrastructure consisting of weak road systems and unstable transportation systems and limited access to remote areas (Fisher & Binns, 2016). The lack of real-time data also complicates the situation as it restricts the capacity of organizations to timely respond to sudden changes that take place in the context of crisis scenarios (Pettit & Beresford, 2017). Studies indicate that emergency response systems have been enhanced across the continent but the problem lies in the delivery activities at the last phase of humanitarian assistance (Sanchez & Rodriguez, 2018). The necessity to come up with an efficient last-mile delivery is essential since such strategies minimize the time of response and improve the delivery of relief activities.

The Cyclone Idai event in March 2019 in Zimbabwe is a perfect case to explore delivery of humanitarian supply chain at the final distribution point. The massive damage caused by the tragedy took the lives of over 1000 individuals and left 100s of thousands of others displaced (UNICEF, 2019). After the disaster, delivering needed medical care and food and shelter to the victims became very difficult to do by humanitarian organizations (Cozzolino et al., 2020). There was acute delay in relief distribution due to lack of road access in combination with damaged infrastructure and disrupted communication (Moore et al., 2020). The health emergency was aggravated by delays in the distribution of emergency medical supplies since it took patients longer to obtain treatments and diseases could spread easily (Tomasini & Van Wassenhove, 2015). Last-mile delivery systems are crucial in ensuring that disaster response operations in Zimbabwe and other areas are effective because they help eliminate delivery problems that are witnessed today.

This study sought to assess the effects of last-mile delivery efficiency on humanitarian aid distribution in the case of Cyclone Idai in Zimbabwe. The research arose due to the fact that the humanitarian organizations face recurrent challenges in their attempt to reach disaster-affected individuals. This study examines the inefficiency in last-mile delivery to identify the means to improve the delivery practice and innovative solutions (Pettit & Beresford, 2017). To serve the development of academic knowledge in the field of humanitarian logistics and to offer operational suggestions about an improved performance of disaster relief in the context of subsequent relief operations, the research sets its mission. The growing significance of humanitarian activities in Africa indicates the necessity of recognizing specific crisis issues that facilitates better disaster preparedness and response plans (Balcik et al., 2015; Cozzolino et al., 2020).

1.3 Problem Statement

The last phase of humanitarian supply chains delivery process poses a significant challenge which is a consistent major hitch in disaster relief which is especially true in case of high profile disasters such as Cyclone Idai in Zimbabwe . The last stage of delivering aids to the communities that are affected faces significant barriers that impede effective and timely relief as noted by Tomasini and Van Wassenhove (2015) . Delivery of medical supplies and other vital assistance was critical during Cyclone Idai as the event highlighted three core logistical issues: the hurricane destroyed infrastructure that was critical to the delivery of medical supplies; aid agencies had trouble organizing their operations, and many of the communities that were affected were difficult to reach (Moore et al., 2020). This operational inefficiency contributed to the situation in a health crisis that slowed down treatment services and enabled the transmission of preventable diseases (Cozzolino et al., 2020). Studies about this issue are still inadequate particularly through Zimbabwean lenses since the nation experiences different environmental and infrastructure challenges. This study sought to investigate delivery inefficiencies that affect humanitarian aid delivery effectiveness.

1.4 Objectives

Overall Objective:

To assess the impact of last-mile delivery efficiency on the effectiveness of humanitarian supply chains in delivering emergency medical aid during Cyclone Idai in Zimbabwe.

Specific Objectives

- i. To measure last-mile delivery efficiency in the context of humanitarian aid delivery during Cyclone Idai in Zimbabwe
- ii. To evaluate the effectiveness of humanitarian supply chains in delivering emergency medical aid during Cyclone Idai,
- iii. To analyse the relationship between last-mile delivery efficiency and the effectiveness of humanitarian supply chains in the delivery of emergency medical aid during Cyclone Idai.

1.5 Research Questions

- i. How efficient is last-mile delivery in the distribution of humanitarian aid in disaster response scenarios such as Cyclone Idai in Zimbabwe?

- ii. How effective are humanitarian supply chains in delivering emergency medical aid during disaster responses?
- iii. What is the relationship between last-mile delivery efficiency and the effectiveness of humanitarian supply chains in the delivery of emergency medical aid?

1.6 Significance of the Study

Academic Significance

This study helps advance research in humanitarian logistics by exploring how effective last-mile delivery is linked to the success of aid operations during disasters. Using Cyclone Idai as an example in Zimbabwe, the study offers proof and a structure that relates how efficiently supplies are delivered to the outcomes of humanitarian efforts. It contributes to the field of logistics by exploring performance in extreme situations and provides a base for future research, teaching and model development in disaster logistics.

Practical Significance for Humanitarian Logistics Organisations

The study provides useful advice to humanitarian agencies and logistics experts on the problems that arise when delivering goods to the last mile in disasters. It pinpoints issues with infrastructure, the types of vehicles used, coordination and resource planning that made aid distribution difficult during Cyclone Idai. The findings encourage the adoption of flexible delivery strategies, technology integration, and decentralised decision-making to improve efficiency and responsiveness in future emergencies.

Policy Significance

Policy wise, the study identifies the necessity of enhanced institutional frameworks the investment in the rural infrastructure, and broad-based coordination mechanisms. It advises that policies must lay emphasis on the ability of local communities to plan flexibly and collaboration among various agencies. These suggestions are to enhance disaster preparedness, reduce response time and to enhance the humanitarian logistics networks in the country.

1.7 Assumptions of the Study

The study is based on the premise that humanitarian agencies and government bodies and the people involved have credible and representative figures of the real challenges of delivering

medical assistance last mile . The distribution issues identified with the emergency medical aid in the case of Cyclone Idai are mostly connected to logistical barriers such as the insufficient infrastructure and coordination failures. This assumption is present throughout the study that stakeholders who participated in the last- mile aid delivery such as the aid organizations, and local authorities had standardized approaches in their operation during the disaster. In response phase, it is assumed that technological implementations such as GPS and real-time information systems worked effectively in the target regions. The research study assumes that the political or economic situation and external circumstances did not have fundamental influence on the key logistical challenges that were developed during the response to Cyclone Idai.

1.8 Delimitations of the Study

This research narrows down to the last-mile delivery of emergency medical supplies in Cyclone Idai in Zimbabwe, but not to other emergency relief activities nor to other areas covered by the cyclone. The study only covers the short-term period and hence it is more of the aftermath of the disaster, but not the long-term recovery efforts. The research is also focused on medical aid provision, which does not imply other types of relief food, water, or shelter. As well, the analysis will focus on information provided by humanitarian agencies, government reports, and communities, but not the logistics providers in the private sector. The study will also be limited in terms of data, since some of the logistical and operational aspects might not be available because of confidentiality or incomplete reporting of the concerned agencies.

1.9 Definition of Terms

This section provides definitions for key terms that are used throughout the study to ensure clarity and contextual relevance:

Last-Mile Delivery Efficiency: The capacity and speed of delivering humanitarian aid using the final point of distribution to the affected people and especially in the inaccessible disaster areas such as the ones affected by Cyclone Idai (Kovaacs and Spens, 2007).

Humanitarian Supply Chains: These are specifically created logistics to buy, deliver and redistribute emergency supplies and resources such as medical aid during crisis and disasters (Van Wassenhove, 2006).

Emergency Medical Aid: Medical aids and services that are required on an urgent basis including drugs, equipment, and human resource sent to the population affected during an event of disaster to avoid death and treat injuries (Thomas & Kopczak, 2005).

Cyclone Idai: A tropical cyclone that hit Zimbabwe in March 2019 resulting in serious flooding, infrastructure destruction and humanitarian requirements in regions like Chimanimani and Chipinge (UNOCHA, 2019).

Logistics Efficiency: The extent to which the logistical activities, including transport, warehousing and distribution, are able to attain their objectives within short delays, wastages and misallocation of resources (Beamon, 2004).

Humanitarian Logistics: It is the system of planning, implementing and controlling the movement of relief goods and services to the victims of disasters in a manner that is efficient and effective (Blecken, 2010).

1.10 Acronyms

Acronym	Full Meaning
IoT	Internet of Things
NGO	Non-Governmental Organization
SCM	Supply Chain Management
UN	United Nations
WHO	World Health Organization
ZIMSTAT	Zimbabwe National Statistics Agency
UNOCHA	United Nations Office for the Coordination of Humanitarian Affairs
ICT	Information and Communication Technology
EOC	Emergency Operations Centre
EMT	Emergency Medical Team
GPS	Global Positioning System

1.11 Chapter Summary

This chapter introduced the study by outlining the central research problem, which focuses on the inefficiencies of last-mile delivery within humanitarian supply chains, especially as witnessed during Cyclone Idai in Zimbabwe. It highlighted the roles of efficient and responsive logistics in the delivery of timely and equitable distribution of emergency medical assistance to populations affected by disasters. The chapter described the background setting of Cyclone Idai effects, the logistical situation that is always present in Zimbabwe, and the universality of the last-mile delivery in the context of disasters. It also outlined the research problem; developed important objectives and research questions; and explained the importance of the study in academic, policy and operational terms. Delimitations and assumptions of the study were also explained to come with a clear scope of the research. The outline of this dissertation is as follows.

Chapter 2: Literature Review, gives a detailed literature review that critically addresses the theoretical models including the SCOR model, Humanitarian Logistics Theory, and Systems Theory to define the conceptual framework of the study. It is a synthesis of international and regional empirical data on the effectiveness of last-mile delivery, the effectiveness of humanitarian supply chains, and the relationship between the two constructs. The chapter also discusses technological advancements, coordination efforts and institutional limitations to humanitarian logistics. Gap analysis is done to indicate lack of context specific research in Zimbabwe and Sub-Saharan Africa that makes the current research more relevant. It ends by offering the conceptual framework on which the analysis of the study is based.

Chapter 3: Methodology, provides the research methodology adopted to explore the correlation between the last-mile delivery efficiency and the humanitarian supply chain effectiveness. It describes the philosophical base of positivism and deductive approach and reasons their suitability in this quantitative research. The chapter describes the survey research approach, sampling plan relying on Cochran formula, and data gathering instruments to contact 278 humanitarian and logistics experts engaged in Cyclone Idai response. Ways of achieving validity, reliability, and ethical issues are mentioned, as well as the use of SPSS in performing descriptive and inferential statistics, including regression modelling.

Chapter 4: Data Presentation, Analysis and Discussion, is dedicated to the presentation, analysis and discussion of results obtained due to the field survey. It starts with the evaluation of the instrument reliability and further provides organization features of respondents. The perceptions analyzed include the efficiency of last-mile delivery in terms of timeliness, resource availability, routing flexibility, and technology use. It also regresses the relationship of these factors with humanitarian supply chain effectiveness. The existing literature is used to interpret key patterns, variations, and significant relationships to empirically validate the study conclusions.

Chapter 5: Summary, Conclusions and Recommendations, is the last chapter of the dissertation, which summarizes the key findings with regard to the research objectives and questions. It demonstrates the role of last-mile delivery performance on the responsiveness and equity of humanitarian aid in the case of disasters. The chapter presents practical suggestions on how to enhance logistics planning, institutional coordination, and digital integration in the future disaster responses in Zimbabwe. The study limitations are mentioned, and recommendations are provided regarding the future research directions, specifically the community-led logistics, the use of advanced technology such as AI, and the comparative regional studies of emergency response logistics.

Chapter 2

Literature Review

2.1 Introduction

The chapter conducts an extensive literature review regarding the impact of last-mile delivery performance on humanitarian supply chains. The review presents information in such a way that it forms theoretical backgrounds alongside explaining key terms and interpreting results using global, regional, and local studies. The first part of this chapter investigates key theories that underpin the efficiency of humanitarian logistics and supply chains prior to presenting a conceptual model of the study variables. The empirical research analyzed is related to the study objectives as it assesses the efficiency of delivery and effectiveness of supply chain and their interrelation. The review looks into the use of technology and coordination practices during disaster situations before summarizing that this study needs to be carried out in the manner that the existing research gaps demand. The base established here forms the basis of the research methodology in Chapter 3.

2.2 Theoretical Framework

This section outlines the theoretical foundation guiding the study's investigation into humanitarian logistics. It discusses relevant models and theories that support analysis of last-mile delivery and emergency medical aid.

2.2.1 Supply Chain Operations Reference (SCOR) Model

Supply Chain Operations Reference (SCOR) model is a standardized framework of the Supply Chain Council to outline supply chain best practices and measures and standard operational procedures. To offer a complete system of supply chain performance analysis and improvement, the framework develops its framework based on five core processes, known as Plan, Source, Make, Deliver, and Return (Yeboah & Agyei, 2021). The SCOR model was created with reference to commercial supply chains, although due to humanitarian organizations, the model has been modified to evaluate emergency logistics systems in relation to responsiveness and reliability besides agility (Dlamini & Moyo, 2023). The SCOR model can help an organization in process mapping and performance measurement and determination of inefficiencies during disaster logistics activities, which are time-bound and with limited resources (Chikomo et al., 2022).

Some of the most recent instances of SCOR being used in humanitarian logistics show how the practice can help emergency decision-makers learn more about the performance of their last-mile delivery systems (Nkala & Maseko, 2020). To consider measurements of supply chain resilience and sustainability, the APICS and ASCM (Association for Supply Chain Management) have revised the model Masunda and Banda (2022). The new SCOR model can accommodate the contemporary issues of supply chain such as disaster management and climatic upheavals. Being so detailed, the SCOR model has its critics who claim that the framework lacks all the functions to manage the unpredictable humanitarian logistics systems, which operate through decentralized networks (Tshuma & Ndlovu, 2021). Process alignment of SCOR is too rigid to be applicable in humanitarian operations because the latter operate with minimal stable data flows and unstandardized supply chain partners (Mpofu & Sibanda, 2024). Research demonstrates that model can be used to conduct humanitarian logistical analysis with certain modifications (Murehwa & Mugadza, 2023).

The delivery phase analysis of last-mile operations during Cyclone Idai benefits from the SCOR model application in this study. The model's delivery-return structure fits Zimbabwe's logistical situation because emergency medical supplies encountered prolonged delivery times because of infrastructure breakdowns and coordination failures (Gumbo & Dube, 2021). The model provides structured performance assessments between humanitarian organizations and reveals process weaknesses in final delivery networks (Zinyama & Ncube, 2022). The systematic design of SCOR provides value to identify weaknesses in planning, sourcing and delivery logistics even though it has its limitations because these weaknesses align directly with the research focus on efficiency and effectiveness in humanitarian supply chains (Rukanda & Mathe, 2020). The model gives the study theoretical basis to assess the operational weaknesses in the Cyclone Idai response in Zimbabwe and provide opportunities to make improvements.

2.2.2 Humanitarian Logistics Theory

The Humanitarian Logistics Theory studies the effective and efficient operations and policies that deal with goods and services with information in the aid of the population that was hit by a disaster. According to Van Wassenhove (2006), humanitarian logistics requires a fast response and flexible as well as adaptable operations in extreme conditions (Van Wassenhove, 2006). Humanitarian logistics is a type of a mission system that focuses on life saving operations and easing pain instead

of earning profit (Kovacs & Spens, 2020). The theory has been advanced in research studies that followed the work of Van Wassenhove, where operational elements that encompass agility and distributed control of logistics operations and actor collaboration to cope with unpredictable situations have been identified (Dubey et al., 2020; Chankov et al., 2020). The various aspects of humanitarian aid indicate how unique the operations are because the teams require particular structured solutions to handle structural failures and surge issues whenever they are conducting operations.

Three major components of resilience and digital technology integration and local response capacity have been introduced to the Humanitarian Logistics Theory to improve emergency logistics performance (Behl & Dutta, 2022; Queiroz et al., 2020). The primary limitation of the theory is that it lacks operational models that are standardized and may be applied consistently to different types of disasters (Kabra et al., 2020). The theory does not identify the negative influence of political factors and cultural and institutional factors on ground-level logistics performance (Tatham & Kovács, 2021). The theory derives its strength in that it is not rigid in character and as such supply chain practitioners are able to formulate responsive strategies as per the existing crisis scenario. The model is efficient in dynamic natural disaster situations because it has the ability to network coordination and continuous learning through improvisation.

Humanitarian Logistics Theory has been significant in this research because it helps to scrutinize the issues of last-mile delivery during Cyclone Idai. The theory gives insights into how humanitarian actors adapted their logistic operations when confronted with infrastructure damage and altered needs and resource constraints (Overstreet et al., 2021). The theory focuses on agility and collaboration, and through it, the researchers can interpret medical aid delivery approaches to the affected population, and at the same time, determine areas of operation improvement (Hosseini et al., 2022). It enables analysts to detect supply chain failures and offer suggestions about the introduction of adaptive logistics strategies in the future to increase the efficiency of responding to emergencies (Behl 2020). The Humanitarian Logistics Theory offers analytical skills and practical solutions to evaluate the last-mile processes and enhance humanitarian supply networks in areas that are likely to be hit by disasters like Zimbabwe.

2.2.3 Systems Theory

Organizational supply chains and processes and Systems Theory organizations are regarded as systems that depend on each other and have various parts that aim at attaining common organizational objectives. According to the Systems Theory that was first postulated by Ludwig von Bertalanffy in 1950s, the investigation of the entire systems where the interactions of the parts make up the whole, is superior to the investigation of the parts on their own (von Bertalanffy, 1968). The Systems Theory confirms the fact that any failure of any aspect of the system like transportation infrastructure or communication flow will stop the entire relief operation as demonstrated by Ivanov (2021). The focus of the current research on the Systems Theory is the resilience of the supply chains in terms of creating models of adaptive humanitarian operations that should be responsive to the disruptive events (Shekarian et al., 2020). The assessment of the last-mile delivery in Cyclone Idai entails the full realization of humanitarian supply chains as interdependent networks as indicated by Queiroz et al. (2020).

The Systems Theory has recently expanded to involve the generation of contemporary ideas that support disaster logistics management via the complexity management and feedback loop and systemic resilience approaches (Behl & Dutta, 2022). The primary critique of Systems Theory has to do with its propensity to operationalise realities by assuming that system components will be predictable and cooperative in humanitarian settings where this is not always the case (Kovács & Falagara Sigala, 2021). The theory does not acknowledge the importance of institutional barriers and politics and disparities in resources distribution that are likely to influence real-life disaster relief efforts (Tatham & Kovács, 2021). The theory is still useful since it promotes a holistic proactive approach that pushes organizations to establish combined plans of teamwork and disruption prediction to provide efficient humanitarian logistics management.

Systems Theory serves as an effective analytical tool for this research because it helps evaluate the interconnecting relationships between last-mile delivery efficiency and stakeholder coordination and infrastructure resilience and resource management during Cyclone Idai. Treating Zimbabwe's humanitarian supply chain as a system will help research better understand how medical aid delivery suffered from the combined impact of delays and logistical breakdowns and coordination failures (Dubey et al., 2021). Systems Theory enables better disaster response planning by supporting the shift from operational failure analysis to systemic inefficiency understanding which

leads to sustainable recommendations for future disaster last-mile delivery (Behl, 2020; Ivanov & Dolgui, 2020). The application of Systems Theory helps the study maintain comprehensive analysis of humanitarian logistics complexity while enabling the development of adaptable disaster response strategies.

2.3 Last-Mile Delivery Efficiency in Humanitarian Operations

2.3.1 Concept and Dimensions of Last-Mile Delivery Efficiency

Efficiency in last-mile delivery is the capacity of a logistics system to deliver goods in a timely, precise and cost-efficient manner in the last point of distribution to the final receiver. This last step is particularly crucial in humanitarian settings since it has a direct impact on the availability of life-saving resources in vulnerable or remote locations (Behl & Dutta, 2022). The last-mile delivery requires fast response time and reliable transportation design coupled with adequate timing of routes.. Dubey et al. (2021) state that delivery lead time, service fill rate, and resource utilization are common indicators used to measure efficiency. The, often-chaotic, humanitarian environment characterized by damaged infrastructure, acute needs, and a lack of visibility increases the significance of optimizing last-mile systems. The modern idea of humanitarian supply chains is changing into something more agile and responsive, where the flexibility and real-time data performances are being embedded into the last-mile model (Besiou & Van Wassenhove, 2020). The concept of efficiency is no longer considered only the speed, but precision and the capacity to perform under the pressure.

The dimensions comprising last-mile delivery efficiency are complex and include both operational and technological ones. Time is one of the key elements since a delay in medical or food assistance may cause serious health-related problems, especially in regions prone to disasters or conflicts (Behl, 2020). Accessibility is another fundamental factor that incorporates the quality of infrastructure and terrain as the key factors that determine the possibility of delivery. The effectiveness also centres on transport suitability, which is the appropriateness of the vehicles deployed considering the terrain and the load, in situations where conventional logistics solutions are ineffective. Also, the technological enablers, including GPS, GIS, and mobile routing applications, enhance the accuracy of delivery and delivery monitoring, as well as real-time modification in the course of operations (Gralla et al., 2021). The efficiency of last-mile performance is further determined by flexibility, which is the capacity of the system to adjust to

unexpected disturbances or divert assistance, as well as the availability of resources (fuel, personnel, vehicles). All these elements are interrelated and create a framework to inform both measurement and improvement approaches in humanitarian delivery systems.

2.3.2 Timeliness and Speed of Delivery

Timeliness is a foundational dimension of last-mile delivery efficiency, particularly in humanitarian contexts where delays can result in significant human suffering or loss of life. The capability of providing assistance in emergency environments during the decisive time slots is what determines the efficiency of relief operations (Altay & Labonte, 2020). The criticality of the delivery of medical aid, food, and shelter demand the supply chains to be high-paced even with the minimal resources and unpredictable conditions. Behl and Dutta (2021) assert that even a few hours of delay in the last-mile delivery during a crisis can undermine the treatment outcomes and further increase vulnerabilities among populations in need. The delivery speed is determined by the accessibility of roads, real-time coordination, and availability of experienced logistics human resource. As disasters become hard to predict in the climate change and geopolitical instability environment, humanitarian actors have to think of flexible and agile solutions that would ensure timeliness but not at the expense of safety and accountability.

The last mile speed maintenance is a preventive operation that has to be integrated with both the pre-disaster planning and live implementation of the operations. The essential measures in the reduction of lead times in a crisis environment include stockpiling in high-risk localities, all-terrain transportation investments, and a rapid assessment model (Gralla et al., 2021). Besides, digital technologies such as drone-based surveillance, GPS-tracking, and mobile communication systems can now offer real-time monitoring of the delivery process and enable diagnosing delays immediately. These innovations allow logistic staff to straighten out deliveries in real-time when the traditional access routes are jammed or broken (Besiou & Van Wassenhove, 2020). However, as Behl (2020) notes, optimal speed needs not only the readiness of the institutional environment, including trained personnel and the coordination of interagency responses to emergencies. In general, timeliness in last-mile delivery is not a speed issue but is a combination of preparedness, coordination, and the backup of technology to respond to the critical humanitarian needs.

2.3.3 Accessibility and Infrastructure Constraints

The availability of accessibility is a highly crucial factor in the efficiency of last-mile delivery, particularly in humanitarian supply chains where infrastructure is usually impaired. Poor road conditions, broken bridges, hilly terrains, and flooded areas are all intimidating issues to reach the populations that are affected in cases of emergencies. Dubey et al. (2021) state that one of the most common bottlenecks in humanitarian logistics is the physical inaccessibility of remote locations or disaster-affected areas which significantly delays the time of delivery of emergency medical support. Gralla et al. (2021) underline that the issue of delivery is more complex in low-income, or crisis-prone regions because of its poor infrastructure, and as such, emergency responders might lack trustworthy information regarding road routes. This necessitates other modes of transport that could be boats, helicopters or off-road vehicles that are in most cases limited or costly. Behl (2020) stresses that the accessibility restrictions cannot be considered as merely a logistical issue: it is an ethical and strategic issue that conditions the prospect of delivering life-saving help in a timely manner that can avoid secondary disasters.

Infrastructure resiliency and disaster preparedness is the key solution to the accessibility problems in the last mile operations. The current transport systems must be evaluated based on their vulnerability and the collaboration of the governments and the humanitarian agencies must be made to ensure that the critical access roads in the risky areas of operation are maintained and upgraded (Behl & Dutta, 2021). In addition the use of digital mapping tools, including satellite images and Geographic Information Systems (GIS) may be a lifesaving help in terms of identifying the routes that may be passed, alternative ways, and the concentration of scattered people populations (Gralla et al., 2021). With such technologies, the access can be planned in real time even when there is no real on-ground infrastructure available. According to Besiou and Van Wassenhove (2020), infrastructure obstacles can be also resolved with the help of adaptive planning, i.e., modular and mobile delivery hubs, which decentralize delivery operations. Lastly, the promotion of accessibility in the final-mile delivery is associated with integrating physical strength of infrastructures, technological advancements , and pre-agreed emergency logistics processes that are capable of functioning in extreme circumstances .

2.3.4 Transport Vehicle Suitability and Modal Choice

The suitability of transport vehicles is a key factor in determining the efficiency of last-mile delivery in humanitarian operations. Various landscapes, climate, and effects of disasters necessitate certain kinds of vehicles, which are able to adjust to environmental limitations. As an example, rugged rural terrains might require four-wheel-drive trucks, boats, or air transportation, including helicopters and drones, especially when the conventional road systems are destroyed or impassable (Behl & Dutta, 2021). Inappropriate type of vehicle not only makes the delivery slow but also enhances the probability of wasting resources and failing the mission. According to Dubey et al. (2021), a transport mismatch (employing large vehicles in small, unpaved, or flooded routes) commonly causes delivery delays, vehicle breakdowns, and failure to access last-mile beneficiaries. Therefore, effective last-mile logistics should integrate the choice of the transport modes with the operational terrain investigation, weather conditions forecast, and the quantity and character of the cargo.

The availability and coordination of transport assets among humanitarian actors also affect strategic modal choice. Besiou and Van Wassenhove (2020) highlight that during multi-agency responses, the uncoordinated use of vehicles causes congestions, overlaps, and fuel wastages. In the quest to maximize vehicle utilization, companies are progressively pooling their logistics and using common transportation models that ensure better coordination and route coverage. Drones and unmanned aerial vehicles (UAVs) have increased delivery capacity in locations that have been isolated due to floodwaters, landslides, or war (Gralla et al., 2021). In addition, modular loading systems and container standardization enhance the efficiency of transport, making it possible to speed up the transfer of transport (air-to-road, road-to-boat, etc.). These technologies and concepts highlight the fact that vehicle suitability and modal adaptability are no longer a fixed consideration- they need to become dynamic based on real time ground conditions and logistical intelligence.

2.3.5 Technology Use in Route Planning and Tracking

Technology plays an increasingly central role in enhancing last-mile delivery efficiency, especially through route optimization and real-time tracking systems. In humanitarian logistics, when operations are time-sensitive and often adversely affected by unforeseeable incidents, Geographic Information Systems (GIS), Global Positioning Systems (GPS), and mobile logistics applications

allow dynamically planning and tracking delivery operations (Gralla et al., 2021). They use technologies that can give real-time situational awareness to the logistics teams to determine safe routes, bypass blocked roads, and reorder deliveries according to the situation presented. Dubey et al. (2021) note that digital tracking tools enhance transparency of deliveries, decrease delays, and cut the misallocation of resources. They also facilitate data sharing between agencies, which plays a crucial role in joint humanitarian operations. The use of technology in last-mile routing facilitates more effective planning within constraints in low-connectivity and high-uncertainty settings, where the paper-based approach has been identified to be inefficient.

It can also be noted that technology enables accountability and performance measurement of last-mile operations. Mobile scanning systems and RFID tags allow logistics teams to confirm that aid packages have been delivered to the correct people, which helps to increase the accuracy of distribution and minimize cases of duplication or loss (Behl, 2020). The systems also generate critical performance information of delivery lead times, vehicle use and rerouting decision, all of which are handy in post crisis reviews. However, the process of technological integration is not without difficulties since, as Behl and Dutta (2021) report, the absence of ICT infrastructure, digital illiteracy, and unstable power supply are expected to restrain the effectiveness of the systems in remote or developing areas. Despite these limitations, nevertheless, the technological improvements continue to make humanitarian last-mile delivery more efficient, responsive, and coordinated. The rising use of predictive routing artificial intelligence and the involvement of drone-aided reconnaissance suggests that the future of humanitarian logistics will depend more on a networked digital landscape that would allow efficient last-mile delivery.

2.3.6 Flexibility and Adaptability of Delivery Systems

Flexibility and adaptability is the most notable attribute of efficient last mile delivery systems particularly in the unpredictable and limited resource humanitarian environment. Humanitarian logistics are usually called upon to respond to extremely dynamic conditions, i.e., shifting access paths, population movements and shifting ground demands. According to Behl (2020), flexibility is the capability of redirecting deliveries, rescheduling activities, and shifting modes of transport without an impact on the timeliness or accuracy of aid. The flexibility, in its turn, implies that the system will be able to learn on the perturbations and re-wire itself in order to continue functioning within the new boundaries. The strict delivery timeframes or predetermined routing models do not

usually work in disaster environments, and that is why the ability to employ a dynamic planning system with the assistance of mobile coordination cells and decentralized decision-making is the new priority of the organizations (Dubey et al., 2021). These methods allow real-time modifications and on-the-ground problem resolution, that is, when addressing sudden landslides, conflict outbreaks, or infrastructure failure.

Resilience in flexible systems is also encouraged, whereby the reliance on a specific delivery path or centralised control structures is minimised. Besiou and Van Wassenhove (2020) highlight that adaptive last-mile systems build redundancy in their operations, including backup drivers, alternative vehicles, and modular delivery hubs, so that the overall system fails in case of primary plans failure. Technology is a significant supporting actor in adaptability because mobile platforms and cloud-based dashboards offer logistics managers with constant feedback that serves as the basis of continuous decision-making. Moreover, the last-mile delivery through cross-training of the staff and engagement of local community networks introduces a human layer of flexibility that is particularly valuable in the context where digital solutions might not be available or be unreliable. Behl and Dutta (2021) note that formal planning and improvising in operations are the distinct features of the most successful humanitarian responses. The notions of flexibility and adaptability are not the secondary features of last-mile delivery, but the primary processes that characterize the process of delivering aid to beneficiaries under unpredictable and volatile conditions effectively.

2.3.7 Resource Availability and Operational Readiness

Resources and operation readiness are the pillars of the efficiency of last-mile delivery in humanitarian logistics. Emergency last-mile operations can be performed successfully only in case the possibility to mobilize the required resources: vehicles, fuel, medical supplies, and trained personnel is available . As Behl and Dutta (2021) define it, operational readiness encompasses both strategic pre-positioning of resources and institutional ability to mobilize those resources quickly in the case of a crisis. Delivery is not delayed in many humanitarian environments by simple dint of poor planning, but by discontinuities in resource supply, whether in terms of insufficient transport fleets, or fuel shortages or missing personnel at key nodes. According to Dubey et al. (2021), emergency logistics systems should develop redundancy and surge capacity to achieve last-mile services continuity, especially during large-scale or multi-phase disasters.

Last-mile planning should be connected with warehousing, maintenance systems, and emergency stockpiles to enable resource availability at the point of need.

In addition to the physical assets, operational preparedness requires systems-level preparedness, such as trained human resources, coordination protocols, and standard operating procedures. Besiou and Van Wassenhove (2020) emphasize that companies that have built-in contingency plans and logged trained teams have a greater capacity to shift gears when pressured and react to the disruption. Readiness is further promoted through the establishment of logistics clusters, inter-agency agreements, and simulation exercises that promote collaboration and ensure concurring response timelines. Moreover, digital solutions, including inventory dashboards, transport allocation systems, and procurement tracking platforms, enable real-time insights into resource availability and usage. Behl (2020), however, cautions that a situation where centralized systems are over-relied on without local control may result in stalled responses in the event of communication or infrastructure failure. As such, the availability and preparedness of resources should be coordinated at various levels, including local units of operation to global logistics operations centers, to keep the last-mile delivery systems resilient, scalable, and responsive in unforeseeable humanitarian environments.

2.4 Effectiveness of Humanitarian Supply Chains in Emergency Medical Aid

2.4.1 Defining Humanitarian Supply Chain Effectiveness

Humanitarian supply chain effectiveness is a concept describing the degree to which emergency logistics systems achieve key goals, including delivery in a timely manner, proper allocation, and fair access to vital resources in crisis situations. In contrast to commercial supply chains where cost-efficiency and customer satisfaction are the primary goals, humanitarian supply chains focus on saving lives, reducing suffering, and restoring dignity among populations affected by disasters (Behl & Dutta, 2021). Effectiveness here therefore is not gauged in financial terms, but in terms of delivering the appropriate aid, to an appropriate location, at an appropriate time. Dubey et al. (2021) list the following performance indicators: delivery lead time, resource adequacy, beneficiary satisfaction, and health-related outcomes, including lowered mortality and morbidity. Such dimensions are indicative of the ethical nature of humanitarian operations where any procrastination or misplacement directly affects humans.

Practically, supply chain effectiveness is particularly hard to measure in humanitarian contexts because of the limited availability of data, volatile environments, and the variety of actors present. Besio and Van Wassenhove (2020) state that, unlike the logistics in the private sector, which has standardized systems and known patterns of demand, humanitarian operations must operate in uncertainty, competing priorities, and information shortage. This requires alternative evaluation models that take into consideration qualitative outcomes such as communal confidence and institutional flexibility besides quantitative indicators. Besides, effectiveness is also determined by external forces like the systems of governance, the local infrastructure, and sociopolitical processes that may hinder or facilitate the provision of aid. Behl (2020) offers to incorporate a multi-dimensional assessment model, in which input (resources), process (delivery systems), and outcome (impact on beneficiaries) measures are used. Such a course of action would ensure that the efficiency of humanitarian logistics would not be constrained and quantified in terms of throughput, but by the ability of the system to react to the emergency and evolving needs of crisis populations.

2.4.2 Timeliness and Responsiveness in Aid Delivery

Timeliness and responsiveness are often considered as the metrics of the effectiveness of humanitarian supply chain especially when delaying may spell the difference between life and death or worsen a weak situation. In disaster relief, the capability of providing medical supplies, food, water and shelter-age within the golden hours of an emergency situation usually makes the difference in terms of the success of the relief mission (Behl & Dutta, 2021). Timeliness is the speed with which aid reaches affected populations following a crisis, and responsiveness is the ability of the supply chain to adapt to changing needs and situations on the ground. Dubey et al. (2021) emphasize that stockpiles that are pre-positioned, accelerated procurement processes, and decentralized logistics centers also facilitate increased response speed. But timeliness does not merely concern speed, it must also be coordinated, planned, and aware of the situation in real-time to make sure that the appropriate aid goes to the appropriate place with the least amount of time wasted.

Responsiveness transcends fixed plans and agility of a humanitarian supply chain when stretched. According to Besiou and Van Wassenhove (2020), responsiveness implies constant contact between the field operatives and the logistics coordinators, facilitated by adaptive technologies

that track real-time changes. As an illustration, mobile-based needs assessment and inventory management systems assist supply chains to re-distribute resources within a short period due to local outages or environmental impediments. Behl (2020) notes that governance and organizational culture also influence responsiveness- when an agency has a strict hierarchy, it will not be able to change its delivery schedule quickly in response to changing circumstances. Moreover, responsiveness should be balanced against accountability, so as not to result into chaotic or duplicative efforts. Overall, a timely and responsive supply chain is able to reduce the magnitude of humanitarian disasters and greatly improve the effectiveness of emergency medical support and delivery of basic relief.

2.4.3 Accuracy and Adequacy of Aid Delivered

Accuracy and adequacy are fundamental humanitarian supply chain effectiveness dimensions, which are concerned with whether the appropriate aid goes to the appropriate beneficiaries in appropriate quantities. Deliveries that are inaccurate or incongruent, including delivering non-priority items or inadequate medical resources, can further the crisis situation and decrease the confidence in humanitarian participants (Behl, 2020). Accuracy deals with the precision with which aid is targeted so that delivery is based on real time needs assessment, whilst adequacy is concerned with whether the amount and type of aid delivered, meets the minimum survival and health needs of the population. Dubey et al. (2021) note that to reach high standards of accuracy and adequacy, it is necessary to have effective needs forecasting, effective inventory management, and effective communication among donors, logisticians, and community stakeholders. Such procedures are complexified by the dynamic characteristic of disasters, as the movement of populations, weather conditions, and secondary risks may quickly alter the magnitude and nature of assistance needed.

The situation has changed in recent years with technological and procedural innovations leading to greater accuracy and adequacy. Beneficiary registration systems running on mobile devices, inventory tracking via barcodes scanning, and real-time mapping of demand can help aid organizations to customize deliveries in a more precise way (Gralla et al., 2021). Moreover, vulnerability mapping and pre-crisis community engagement assist organizations in needs prediction and decreasing delivery mismatches. Besiou and Van Wassenhove (2020) also stress that partnering with local actors in the planning process would enhance the contextual

understanding, thus making aid packages more relevant. Nevertheless, constraints including incompleteness of data, absence of field validation, and donor-influenced supply inclinations tend to undermine adequacy. Behl and Dutta (2021) warn that in cases where supplies are driven by what is available, and not by demand, the efficiency of the logistics operation might be high, whereas the humanitarian reality on the ground will remain low. Finally, to achieve fair and efficient humanitarian response, it is crucial to guarantee accuracy and adequacy, reducing the waste and maximizing the effect of the relief.

2.4.4 Monitoring, Evaluation and Post-Crisis Review

Humanitarian supply chain effectiveness should include monitoring, evaluation and post-crisis review, which makes sure that logistics systems are not only measured by input and throughput, but also by impact and learning. This constant oversight throughout operations enables logistics teams to monitor delivery timelines, inventory, and distribution coverage in real time, assisting in the detection of bottlenecks and the correction of the course when needed (Dubey et al., 2021; Gralla et al., 2021). Assessment, especially once the emergency stage is over, is a chance to determine whether assistance was delivered to the appropriate people, in adequate amounts, and within reasonable deadlines (Behl, 2020). Besiou and Van Wassenhove (2020) note that post-crisis reviews play a central role in identifying lessons that could be used in future preparedness and response plans. Such evaluations are part of accountability, donor trust, and constant enhancement of humanitarian logistics planning and implementation.

Although monitoring and evaluation (M&E) is essential, most humanitarian activities find it hard to establish strict and prompt review systems. Poor data integration, the limited staff ability to work on analytics, and a lack of standard performance indicators across organizations are all constraints (Behl & Dutta, 2021; Ahn & Lee, 2020). Moreover, the post-crisis assessments are at times de-prioritised in favour of the need to shift to recovery or developmental programming. In response, organizations are progressively implementing digital dashboards and mobile-based reporting tools along with key performance indicators (KPIs) delivery lead time, fill rate, and beneficiary satisfaction (Gralla et al., 2021; Dubey et al., 2021). The reviews that involve all stakeholders, both local actors and beneficiaries, are collaborative and lead to more actionable insights due to increased transparency. Behl (2020) underlines that the integration of M&E into the logistics cycle as opposed to viewing it as a subsequent activity has a considerable positive

effect on organizational preparedness and agility. Monitoring and evaluation help to effectively turn humanitarian supply chains into learning systems, which are more prepared to face crises in the future.

2.5 Last-Mile Delivery Efficiency and Supply Chain Effectiveness

2.5.1 Conceptual Link Between Last-Mile Delivery and Supply Chain Outcomes

The connection between the efficiency of last-mile delivery and the effectiveness of the entire humanitarian supply chain is direct and formative. The last mile is the ultimate touchpoint between the supply system and the beneficiary in a crisis environment - and, as such, it is the most crucial factor in whether aid interventions will have the intended effect (Behl, 2020; Besiou & Van Wassenhove, 2020). When the last-mile delivery is flexible, accurate, and timely, the chances of minimizing mortality, morbidity, and vulnerability are high. Dubey et al. (2021) contend that last-mile performance determines the critical supply chain outcomes, including beneficiary satisfaction, equitable access to relief, and the population trust in humanitarian organizations. Conversely, delays, delivery mistakes or inaccessibility at the last stage negate the performance of the whole chain, no matter how efficient the upstream processes were. The last mile therefore becomes a value realisation point of humanitarian logistics.

The systems theory and process integration models conceptualize this relationship by highlighting that a weak connection at the endpoint affects the overall performance of the system (Behl & Dutta, 2021; Ahn & Lee, 2020). Last-mile failures in humanitarian contexts can be traced, in many cases, to infrastructure gaps, inadequate transport capacity, and a lack of inter-agency coordination, all of which create situations in which needs cannot be met even when inventory is available. Gralla et al. (2021) emphasize that in conditions of stockpiles abundance, when they are centrally controlled, last-mile inefficiency can make them functionally useless when delivery does not correspond to the demand schedule. Furthermore, the last-mile delivery is also becoming a supply chain equity indicator since it is the final step that defines whether marginalized or geographically isolated populations will receive assistance. Dubey et al. (2021) state that performance during this last stage multiplies or divides all the upstream logistics activities and therefore its importance is at the centre of effective and inclusive humanitarian outcomes. Last-mile optimization is therefore not a one-off intervention, it is a strategic requirement to end-to-end effectiveness.

2.5.2 Role of Coordination and Technology as Mediating/Moderating Factors

The efficiency of last-mile delivery and supply chain effectiveness have a mediating factor, which is coordination among humanitarian actors, that determines the nature of the relationship. In humanitarian contexts where many agencies are active in fragmented environments, a lack of coordination may result in duplication, inappropriate allocation of resources, and populations that are not reached at all the end of the supply chain, thus undermining its performance (Dubey et al., 2021; Behl & Dutta, 2021). Proper coordination, in contrast, can create synergies among logistics activities and can more efficiently utilize common infrastructure, transportation and warehousing facilities. Besiou and Van Wassenhove (2020) also stress that last-mile logistics can be simplified with the help of integrated planning tools and inter-agency protocols that can coordinate delivery schedules and minimize friction. Gralla et al. (2021) go further to note that central coordination organizations, including the Logistics Cluster, have a considerable positive impact on delivery rates because they standardize communication, create access point maps, and reduce overlap in the final mile.

Technology can be seen as a moderator and enabler of last-mile delivery efficiency especially when uncertainty and disruption are perceived. Mobile coordination platforms, GPS tracking, and GIS mapping provide real-time visibility across supply chain activities, which is essential in detecting delays and detours to make deliveries (Behl, 2020; Dubey et al., 2021). These technologies enable agencies to make decisions based on data, which enhances the accuracy and the speed of last-mile implementation. In the argument of Behl and Dutta (2021), technology does not only enhance the agility of operations but also improves transparency and accountability, which are critical in building trust in crisis contexts. Nevertheless, the technological tools can be the most useful in the context of a coordinated logistics system - standalone platforms will not necessarily scale the impact when actors work in silos (Gralla et al., 2021; Ahn & Lee, 2020). With optimized coordination and technology, the connection between last-mile delivery and the overall supply chain performance will be more connected, foreseeable, and capable of withstanding the dynamic humanitarian environments.

2.5.3 Empirical Evidence from Global Humanitarian Contexts

The studies across diverse humanitarian settings has consistently demonstrated the influence of last-mile delivery performance on aid effectiveness. In the response to the 2015 Nepal earthquake, delays in last-mile distribution were directly linked to increased mortality in isolated mountain villages, despite adequate central stockpiles (Gralla et al., 2021; Behl & Dutta, 2021). Similarly, during the 2010 Haiti earthquake, logistical bottlenecks in the final delivery phase contributed to prolonged exposure to disease and inadequate medical assistance for thousands (Dubey et al., 2021). Besiou and Van Wassenhove (2020) note that when last-mile planning included local access mapping and coordination platforms, delivery speed and reach improved significantly. These examples confirm that without an efficient last-mile framework—tailored to geographic, infrastructural, and cultural realities—the upstream strength of the humanitarian supply chain is neutralized. Field studies affirm that even marginal gains in final-mile coordination and vehicle routing can drastically improve response time and coverage in emergencies.

Quantitative studies further support the correlation between last-mile efficiency and measurable supply chain outcomes. Dubey et al. (2021) found statistically significant relationships between last-mile flexibility and improved beneficiary satisfaction, reduced delivery time, and greater coverage of hard-to-reach populations. In West Africa’s Ebola response, coordinated last-mile interventions using drones and mobile supply hubs were associated with higher health system responsiveness and containment success (Behl, 2020; Gralla et al., 2021). Ahn and Lee (2020) also show that performance improvements in the last mile led to higher delivery reliability scores and stronger donor confidence across multi-year humanitarian projects. These findings highlight the strategic value of empirical insights for optimizing aid logistics frameworks. As new crises emerge—whether from climate disasters, pandemics, or displacement—evidence-based approaches to last-mile delivery must be prioritized to ensure effectiveness, adaptability, and sustainability in global humanitarian operations.

2.5.2 Role of Coordination and Technology as Mediating/Moderating Factors

Humanitarian coordination is an important moderating variable that determines the nature of the connection between last-mile delivery competence and supply chain performance. When there is

no coordination in fragmented humanitarian contexts (meaning that various agencies are working at once), it may result in duplication, misallocation of resources, and populations that are not served at all, which undermines supply chain performance in the end (Dubey et al., 2021; Behl & Dutta, 2021). Good coordination, in its turn, creates synergies among logistical activities and enables more efficient utilization of common infrastructure, transportation, and warehousing capacities. Besiou and Van Wassenhove (2020) state that inter-agency protocols and integrated planning tools can be used to simplify last-mile logistics, as it allows aligning delivery schedules and minimizing friction. Gralla et al. (2021) also note that central coordination organizations, like the Logistics Cluster, go a long way toward enhancing delivery performance, as they standardize communication, map access points, and reduce overlap in the final mile service.

Technology acts as a moderator and facilitator of the efficiency of last-mile delivery especially when there is uncertainty and disruption. Real-time visibility in the functioning of supply chains is highly important in the identification of delays and subsequent rerouting of deliveries; supplied by GPS tracking, GIS mapping, and mobile coordination platforms (Behl, 2020; Dubey et al., 2021). Such technologies enable an agency to make data-based decisions, which enhance the accuracy and velocity of the last-mile implementation. According to Behl and Dutta (2021), technology does not only facilitate the increase in operational agility but also increases transparency and accountability that are crucial to building trust in the crisis environment. Technological tools are however best applied in the context of a coordinated logistics system, isolated platforms can lack the ability to scale the impact in case actors work in silos (Gralla et al., 2021; Ahn & Lee, 2020). Once coordination and technology are maximized, the correlation between last-mile delivery and the effectiveness of the entire supply chain become even more intertwined, predictable, and resilient in changing humanitarian environments.

2.5.3 Global Humanitarian Contexts

Research carried out on an assortment of humanitarian situations has always discovered that last-mile conveyance performance is a fundamental component of the proficiency of aid. In the response to the 2015 Nepal earthquake, the delays of transporting goods at the last mile were directly linked with increased mortality in inaccessible mountain villages, where the central stores were adequate (Gralla et al., 2021; Behl & Dutta, 2021). Similarly, during the 2010 Haiti earthquake, the last-mile delivery point had logistical restrictions, which resulted in the prolonged

exposure to the disease and inadequate medical assistance to thousands of individuals (Dubey et al., 2021). Besiou and Van Wassenhove (2020) discovered that the rate and distance of delivery increased significantly when the last-mile planning took into consideration local access mapping and coordination platforms. These examples prove that an inadequate last-mile structure that is geographically, infrastructurally, and culturally conscious nullifies the upstream capacity of the humanitarian supply chain. Practical experiments demonstrate that response time and coverage may be drastically altered in the case of emergency even by a slight enhancement of the coordination and routing of the last-mile vehicles.

Quantitative researches also support last-mile performance and quantifiable performance of supply chains. Dubey et al. (2021) reported that the last-mile flexibility correlates statistically significantly with the higher beneficiary satisfaction, shorter delivery time, and better access to hard-to-reach populations. The last-mile coordination of interventions carried out with drones and mobile supply hubs were linked to health systems responsiveness and success in containing the outbreak during the Ebola response in West Africa (Behl, 2020; Gralla et al., 2021). Ahn and Lee (2020) also prove the fact that the improvement of performance in the final mile also resulted in the rise of the delivery reliability ratings and the improvement of the donor confidence regarding multi-year humanitarian initiatives. Such results make a contribution to the strategic nature of the empirical enlightenment in the optimization of aid logistics system. Last-mile delivery - evidence-based delivery ought to be a priority in order to ensure that the global humanitarian activities are effective, flexible, and sustainable in the new crises (climate disasters, pandemics, displacement, and many others).

2.5.4 Implications for Designing Resilient Humanitarian Supply Chains

These robust empirical and conceptual connections between the efficiency of last-mile delivery and the effectiveness of supply chains have dire implications related to the engineering of robust humanitarian logistics systems. Resilience here is the ability of supply chains to absorb shocks and disruption, and the ability to operate in a crisis state (Behl & Dutta, 2021; Dubey et al., 2021). Humanitarian logistics systems should therefore incorporate flexible last-mile capabilities as a design principle in order to develop such resilience. It involves, among others, investing in alternative delivery modes, including drones, boats, and off-road vehicles, pre-positioning of vital supplies in high-risk areas, and decentralizing decision-making to local players, who can act

swiftly in response to fast-changing circumstances (Gralla et al., 2021). Besiou and Van Wassenhove (2020) argue that organizations capable of combining scenario-based planning with logistics simulation exercises are in a better position to deal with unpredictability in the last mile and limit the impact of delays or failures through cascade.

In addition, resilience demands a reconsideration of the interactions between supply chain systems and technology, coordination structures, and community-based networks. Digital infrastructure, including mobile routing applications, cloud inventory management, and dashboard analytics, needs to be connected throughout the logistics chain, not only at its central coordination points, as Behl (2020) stresses. Multijurisdictional cooperation should be formalized with common protocols, interoperability standards, and mutual logistics platforms so that it can operate smoothly in an emergency (Ahn & Lee, 2020; Dubey et al., 2021). Last but not least is the community involvement; enabling local stakeholders to take part in the last-mile delivery would make it contextually appropriate and enable more equal distributions. The future of humanitarian logistics is in inclusive, adapting, and supply chains that are resilient and built to run in conditions of systemic uncertainty, in addition to being quick and efficient. To realize this, it is critical to incorporate the learnings of last-mile delivery problems into system design.

2.6 Conceptual Framework

The study constructs a conceptual framework to establish how efficiency in the last-mile delivery can be treated as an independent variable to affect the efficiency of humanitarian supply chains in the provision of emergency medical supplies. The model includes a mediating factor that denotes humanitarian logistics coordination since it influences the connection between the last-mile delivery and the humanitarian supply chain efficacy.

Definition of Variables:

Independent Variable: Last-Mile Delivery Efficiency

Last-mile delivery efficiency is the quality and speed of delivering disaster-related aid to the affected population. This variable is defined by transportation infrastructure along with real-time tracking systems and optimization and availability of delivery networks and resources as stated by Balcik et al. (2015).

Dependent Variable: Effectiveness of Humanitarian Supply Chains

The performance of humanitarian supply chains is ideal when the medical aid is delivered as needed within reasonable amounts coupled with synchronized distribution activities. Humanitarian supply chain performance is determined by the speed of responses and supply availability, demand fulfilment and full disaster population outcomes (Pettit & Beresford, 2017).



Figure 2.1: Conceptual Framework

Relationship Between Variables

The last mile performance predicts the effectiveness of the humanitarian supply chains in running their operations. The distribution of emergency medical aid through humanitarian supply chains is more effective in terms of serving the affected population by introducing systematic procedures of the delay and route optimization and resource allocation in the context of the last-mile delivery activities. The efficiency of last-mile delivery operates in three different levels of operations that are based on the level of coordination of logistics stakeholders. Miscoordination among stakeholders in supply chain creates bottlenecks due to duplication of efforts and mismanagement of resources that reduce effectiveness of the supply chain. The integration initiatives in humanitarian logistics is an extenuating factor that affects the quality of the correlation between last-mile delivery performance and humanitarian supply chain performance outcomes.

2.7 Empirical Review

2.7.1 Empirical Review on Last-Mile Delivery Efficiency

Banomyong et al. (2021) –

Banomyong et al. (2021) carried out a mixed-methods research that investigated the effectiveness of last-mile humanitarian logistics in urban disaster areas, particularly the flood-prone cities in Southeast Asia. The authors relied on a mix of in-depth interviews with logistics managers of large NGOs and quantitative survey information of urban delivery operators involved in humanitarian relief operations in Bangkok, Jakarta, and Manila. Their results indicated that cities, although full of infrastructure, present distinct last-mile delivery issues because of congested traffic, road hazards, scarce parking availability, and the existence of high-density informal settlements. This resulted in extreme bottlenecks during the last mile of delivery, greatly decreasing the speed and reliability of delivery. The complexity of urban logistics tended to lead to misallocation of resources in situations where the agencies had not coordinated their efforts with the municipal authority and first responders in advance. The paper has highlighted that last-mile performance in urban settings is not an infrastructure issue only, but a matter of strategic alignment between aid agencies and local systems of governance.

Additionally, Banomyong et al. (2021) discovered that effective last-mile performance obliged agencies to modify their logistics operations through smaller delivery units, bicycle messengers, and short-term local distribution centers. In their study, they emphasized the potential of pre-disaster mapping and digital traffic simulation tools to enhance route selection, yet were hardly utilized because of the limited digitalization of actors. The other important lesson learned during the study was the value of real-time situational awareness that enabled certain organizations to dynamically redirect relief efforts out of gridlocked areas. The authors determined that, although urban settings offer access benefits, a lack of granular-level planning and inter-agency coordination leaves the last mile with inefficiencies. Notably, the research recommended the investment in urban humanitarian logistics systems, where physical access and regulatory access planning are integrated as a measure of enhancing emergency responses in urban settings in future.

Balasubramaniam & Dubois (2022)

Balasubramaniam and Dubois (2022) carried out a qualitative case study on the suitability of vehicles to be used in the last-mile humanitarian delivery in remote and geographically difficult areas in Latin America. They conducted a study on the topic of post-disaster logistics in Honduras and Bolivia after intense floods and landslides during 2018-2020. The data was obtained by conducting in-depth interviews with international NGO logistics officers, local responders, and transport contractors, accompanied by field observations and vehicle movement records. The researchers found that one of the key hindrances to efficient last-mile delivery was the use of unsuitable types of vehicles - standard 10-ton trucks were often sent to terrain, on which only motorcycles or four-wheel-drive vehicles could perform well. Rough mountain roads, unreliable riverbanks, and flooded bridges frequently caused vehicle malfunctions, delays in delivery, and even complete impossibility of delivering them to target communities.

The authors discovered that transport mismatch was a common occurrence when centralised fleet assignment models were used without taking into account the realities of the ground level terrain. Balasubramaniam and Dubois (2022) suggested implementing a flexible approach to vehicle allocation, such as modular delivery units that can be shuttled between large and small transport platforms. In their analysis, they also noted the effectiveness of NGO collaboration with local transport cooperatives who had fleets suitable to the terrain like off-road bicycles, animal-drawn carts, and canoes. These geographically customized delivery formats were much more efficient in accessing remote population groups during times of maximum flooding. The paper came to the conclusion that the last-mile delivery in remote locations requires not only the decentralisation of logistics but also the replacement of the traditional vehicle-centred mindset with the terrain-oriented mobility planning. Devoid of these context-specific solutions, there is a danger of humanitarian supply chains developing no operational reach during the last and most important phase of aid delivery.

Kocabasoglu & Suresh (2023)

In a study conducted by Kocabasoglu and Suresh (2023), the authors investigate the conditions of last-mile humanitarian logistic in the aftermath of natural disasters and the influence of delivery speed and operational agility in such a context by using the case of post-earthquake zones in

Turkey and Indonesia. The authors used a multi-case study design which relied on semi-structured interviews of logistics managers and utilised operational data of humanitarian delivery systems and documentation analysis of response schedules. The authors studied the immediate 72-hour period after major earthquakes in 2018 (Lombok) and 2020 (Elazig) in terms of how timelines of delivery affected survival rates and coverage of initial medical treatment. The results indicated that last-mile delivery delays due to jammed roads, fallen infrastructure, and antiquated delivery strategies were a serious restriction on the supply of emergency medical relief. There was no real-time adjustment of the routing which caused inefficiencies, especially to areas of semi-urban zones where the infrastructure damage was unevenly spread out.

The authors raised the relevance of the concept of agility as the key determinant of last-mile performance, as the organizations that used mobile logistics units and satellite mapping tools proved to be much quicker and efficient. Kocabasoglu and Suresh (2023) noticed that agile companies could re-distribute resources flexibly, prevent bottlenecks, and even establish temporary micro-hubs of drone and foot deliveries. The paper suggested that to implement agility in disaster logistics, they should consider modular planning of the supply systems and diversifying transport based on the terrain as well as real-time information sharing platforms. Also, the results emphasized the necessity to develop emergency-specific logistic procedures that allow decisions to be made on-site without the involvement of the central authority- an aspect that enhanced the speed of response tremendously in the Turkish example. Finally, the research elucidated the interdependence of agility and speed in the last mile and stated that adaptive strategies should be incorporated, and integration is an important step towards enhancing survival rates in the short-term aftershock of seismic activity.

Tofa & Mhlongo (2021)

Tofa and Mhlongo (2021) conducted an exploratory study of last-mile barriers to humanitarian delivery structures and operations in Southern Africa, which is prone to disasters. This research was located in Mozambique and Lesotho in reaction to cyclones and floods in 2017-2020. The authors assessed failures of delivery and local adaptation plans based on a combination of the focus group discussions with the field logisticians and structured interviews with the national disaster management authorities. The worst of them was the degraded infrastructure comprising of unpaved rural roads, bridges that had been worn out, and crossing lines that had been flooded which had a

huge impact on delivery of aid schedules. All these physical barriers, along with the absence of prior checks on the state of the roads prior to the crisis, often rendered entire villages inaccessible to long stretches of time. In addition, failure to liaise with the local authorities in time to facilitate implementation of alternative access means like temporary bridges or airlifts undermined the effectiveness of the delivery operation.

It was concluded that the lack of localized route intelligence and real-time situational information was the second key area of problem. Tofa and Mhlongo (2021) state that the majority of humanitarian organizations were relying on outdated maps or generic national road networks, neither of which depicted temporary situations or accessibility on the community level. In comparison, the aid agencies that went through a liaison system with the local transport cooperatives or traditional leaders were capable of getting access into informal routes and safety advice on the nature of the terrain. Other modes that have been stated in the paper include mobile clinics, foot couriers and donkey carts that were used when the normal logistics system collapsed. The authors summarized that the last-mile delivery in Southern Africa is not successful without the involvement of the local knowledge, flexibility of the delivery points and decentralization of access plan. They recommended the institutionalization of community-mapped logistics networks, and dynamic access databases as preparedness measures for future disaster response as part of pre-disaster preparedness measures.

2.7.2 Humanitarian Supply Chain Effectiveness

Ramakrishnan et al. (2021)

Ramakrishnan et al. (2021) is a longitudinal quantitative study that measures the performance of humanitarian supply chains in the COVID-19 pandemic medical supplies and personal protective equipment (PPE) distribution in South Asia. The researchers gathered data using over 60 governmental health departments and the international NGOs in India, Sri Lanka and Bangladesh. Performance measures provided in the study were delivery lead time, stockout frequency and order fill rate, which were employed to run regression models to determine the effects of supply chain design on response performance. The findings indicated that centralized systems would become bottlenecks during the pandemic as centralized systems that work well in pre-pandemic conditions

were under pressure in the face of global disruptions and rapidly changing local demands. In particular, the slow pace of distribution of PPE and essential drugs was directly associated with rigid procurement mechanisms and the inability to see the level of subnational stocks.

Ramakrishnan et al. (2021) also tested the adaptive mechanism in increasing the effectiveness of humanitarian supply chains. On all the parameters, organizations that used digital inventory control, decentralized warehouses, and fast-tracked procurement processes fared much better. The multiple suppliers and multiple routes (responsiveness and redundancy) were determined to be the better predictors of success rather than cost-efficiency or centralized control. Also, the authors found that the institutional flexibility, such as enabling local managers to make inventory-based and routing decisions, enabled organizations to act more swiftly to the emergence of new COVID-19 hotspots. The paper reached a conclusion that the humanitarian logistics demands in the pandemic period must have supply chains that are highly responsive, effective, and locally empowered. These findings justify the necessity to reconsider the traditional performance metrics in terms of including the resilience, responsiveness, and equity as the critical components of the humanitarian supply chain performance.

Shrestha & Adhikari (2020)

Field-based mixed-method research conducted by Shrestha and Adhikari (2020) evaluated the effectiveness of medical aid delivery that responded to floods in Terai region of Nepal in 2017 and 2019 . They relied on post-disaster survey of 150 healthcare workers and relief coordinators, and focus group discussions with community members and semi-structured interviews with logistics managers as their methodology. The study evaluated three performance dimensions consisting of speed of response, appropriateness of delivered supplies and beneficiary reach. It found out that the last-mile transport delay, and the mismatch between the content of the aid and the local needs reduced the efficiency of the humanitarian supply chain. In addition, there were reports of most of the facilities receiving excessively large quantities of non-priority medical items, and shortages of antibiotics, oral rehydration salts and maternal care commodities, indicating the demand forecast was flawed.

It was also revealed in the study that the humanitarian effectiveness was very well improved when the community level health responders were included in the planning and distribution processes.

As Shrestha and Adhikari (2020) conclude, needs assessment and feedback loop founded on communities made it possible to make more responsive and context-appropriate decisions in logistics. Besides, companies that localized their supply chains by using small boats, motorcycles and mobile clinics enjoyed wider delivery coverage and beneficiary satisfaction. The paper has pointed out how despite the usefulness of the coordination between the national and international actors in the process of resource mobilization, it failed to work without the systems that could have included the local knowledge. Lastly, the authors proposed the integration of decentralized data collection, the more flexible allocation processes, and the mechanism of interaction with beneficiaries to make humanitarian medical logistics in flood-prone areas more effective. Their arguments were based on the fact that they should adapt the aid logic to the socio-geographic context and empower the locality in the delivery process.

Ndiaye & Boateng (2022)

Ndiaye and Boateng (2022) analyzed the role of collaborative logistics platforms in the improvement of the performance of humanitarian supply chains in four countries in West Africa, such as Senegal, Mali, Burkina Faso, and Niger. Research method It was a comparative case study that was based on the analysis of documents, interviews with logistics cluster coordinators, and surveys conducted among 22 humanitarian organizations. In the responses to drought and epidemic in the period between 2016 and 2020, it focused on the achievement of common warehousing, transport pooling as well as communication platforms. Findings demonstrated that the delivery lead times of the organizations participating in collaborative logistics schemes, as well as the resource utilization had improved. The sharing of general regional depots and shared routing schemes significantly reduced overlap completely, especially on the last-mile delivery of underserved communities and the rural areas.

Institutional trust and data interoperability were among the findings reported in the study and enablers of proper collaboration. Ndiaye and Boateng (2022) note that such platforms as Humanitarian Logistics Network (HLN) and UN Logistics Cluster became more visible due to the shared dashboards and harmonized inventory tracking systems. The involved agencies would be able to anticipate demand more effectively, align the purchase calendar, and avoid surpluses or deficits in stock. However, the study also identified the lack of uniformity in data standards, varying levels of digital readiness, and the possibility to lose the operational autonomy as the

barriers, as well. Regardless of these limitations, the companies that focused more on joint-planning and invested in digital integration platforms could better perform, on the regular basis, on on-time delivery and geographic coverage measures. The authors discovered that the success of humanitarian supply chains in West Africa depends on the mechanisms of long-term coordination, real-time of sharing information and institutionalized logistics cooperation across sectors.

Tofa & Mhlongo (2021)

Tofa and Mhlongo (2021) carried out an exploratory study of structural and operational last-mile humanitarian delivery barriers in disaster-prone Southern African regions. The study was based in Mozambique and Lesotho in cyclone and flood response operations in 2017-2020. The authors evaluated delivery failures and local adaptation strategies through a combination of focus group discussions with field logisticians and structured interviews with national disaster management authorities. Among the most notable ones, the effect of poor infrastructure, namely, unpaved rural roads, washed-out bridges, and flooded crossings, permeated the schedules of aid delivery. The combination of these physical obstacles, which were not accompanied by any pre-crisis assessments of road conditions, frequently made whole villages inaccessible over long periods of time. Moreover, the inability to coordinate with local authorities in a timely manner prevented the implementation of alternative access options such as temporary bridges or airlifts, which compromised the efficiency of delivery efforts.

The absence of localized route intelligence and real-time situation information was another major problem area. According to Tofa and Mhlongo (2021), most humanitarian organizations were using maps that were out of date or standard road networks in the country, neither of which represented the temporary situations nor the accessibility at the community level. Conversely, aid organizations which coordinated with the local transport cooperatives or traditional leaders were able to use the informal routes and were advised on the safety of the terrains. The paper has identified mobile clinics, foot couriers and donkey carts as other forms of modality employed when the normal logistics systems failed. The authors determined that last-mile delivery in Southern Africa cannot be achieved without integrating local knowledge, flexible delivery choices, and decentralized access planning. They suggested that institutionalization of community-mapped

logistics networks and dynamic access databases should be part of pre-disaster preparedness to enhance reach and reliability in any future humanitarian response.

2.8.1 The Relationship Between Last-Mile Delivery and Supply Chain Outcomes

Alvi & Jahan (2023)

Alvi and Jahan (2023) performed a quantitative correlational research study to investigate the connection between the dependability of last-mile delivery and the results of humanitarian aid in flood-prone areas of northern Bangladesh. The authors employed a guided survey that was sent to 210 field logisticians, healthcare responders, and NGO coordinators who took part in the 2021 monsoon emergency response. Multiple linear regression and Pearson correlation were the data analysing techniques to assess the relationships between delivery reliability (assessed as consistency, timeliness, and completeness of deliveries) and the main aid outcome variables, such as beneficiary health status, satisfaction, and reach. The findings indicated that there is a positive significant correlation ($r = 0.71$, $p < 0.01$) between last-mile delivery reliability and better beneficiary outcomes. Areas that had greater consistency in delivery recorded low incidences of untreated injuries, high vaccination rates, and increased confidence of the users in the aid systems.

The paper has also presented a predictive model in which delivery reliability indicated it could account for approximately 52 percent of the variance in aid effectiveness scores in the sample. Alvi and Jahan (2023) found that upstream logistics efficiencies are relevant but that the performance of the last mile of delivery determines humanitarian success. The paper highlighted the need to create redundancy, or backup channels, and flexibility, in this case, vehicle types, to reduce disruptions in deliveries due to flooding. Moreover, beneficiary feedback mechanism data were incorporated into the model, which indicated that perceived reliability influenced trust, engagement, and intentions to accept future aid significantly. The authors suggested humanitarian organizations should embrace reliability as a primary performance measure, alongside speed and cost, and incorporate real-time monitoring platforms to make last-mile performance resilient to unstable situations in the field.

Mendez & Rosales (2021)

Mendez and Rosales (2021) conducted an empirical study as to know the impacts of implementing ICT (Information and Communication Technology) tools on the efficiency of last-mile delivery and the general performance of the humanitarian supply chain during the response to the landslide in Colombia in 2020. The researchers employed a mixed research method which combined GIS-delivery route analysis and 28 semi-structured interviews which were done on logistics officers, field coordinators and local distribution agents. The study focused on the use of mobile apps, GPS tracking, cloud-based inventory and digital dashboards to coordinate last-mile support across the rural regions which were isolated because of the destruction of roads and other infrastructure. The researchers noted that operations that were facilitated by ICT had lower delivery time, rerouting delays and improved capacity to cover more beneficiaries as compared to those that were facilitated by an analogue-based system.

They found that companies utilizing GIS-connected route planning and mobile communications have seen a 35 percent enhancement in the punctuality of their deliveries and a 42 percent rise in the rate of vehicle utilization. Mendez and Rosales (2021) determined that real-time visibility of stock, vehicle location, and delivery status enabled logistics coordinators to respond efficiently to terrain disruptions and beneficiary movement. Besides, the use of digital data collection at the point of delivery allowed agencies to monitor compliance with aid distribution, minimize cases of double-counting and address last-mile complaints fast. The study however also warned that the success of ICT is determined by the level of expertise of the users, the consistency of a good internet connection as well as the compatibility of the systems across different agencies. The authors suggested the need to invest more in locally-based ICT training and the development of standardized humanitarian logistics platforms to amplify digital dividends. Their results actually support the idea that last-mile ICT can not only boost delivery but it also is a strategic enabler of more comprehensive humanitarian supply chain resilience and visibility.

Salim & Adegbite (2020)

The comparative field experiment conducted by Salim and Adegbite (2020) was aimed at evaluating the effects of the varying quality of infrastructure on the effectiveness of humanitarian last-mile delivery within the internally displaced persons (IDP) camps in northeastern Nigeria. The

study was a mixed-method research design that utilized physical audit of infrastructure, interviews with logistics personnel, and a survey of the camp managers and aid beneficiaries in the states of Borno, Yobe, and Adamawa. The availability of the roads, the regularity of the delay of delivery, the provision of fuel, and the regularity of the delivery of aid were the main variables. It was found that camps that were connected through poor or seasonal roads had far higher levels of delayed or unsuccessful deliveries regardless of the upstream stock levels. The choke points in the last-mile leg as was revealed were infrastructure limits like fallen bridges, washed out roads and checkpoints especially during rainy seasons.

Salim and Adegbite (2020) also noted that in addition to slowing down the delivery time, poor infrastructure caused disparities in the distribution of aid, with readily accessible camps being resupplied more often than remote locations. The report has pointed to the fact that the dependency on traditional road traffic without any backup, i.e., river transport, drones, or pre-positioned mobile teams, resulted in the fact that several camps ran out of necessary medical and food supplies during the critical periods. Regression analysis revealed that infrastructure quality and the rate of delivery failure showed a strong negative relationship ($r = -0.68$, $p < 0.01$). The authors suggested the inclusion of infrastructure risk assessment in emergency logistics planning such as mapping of road quality and seasonal flood areas. They found that the quality of infrastructure can moderate the performance of humanitarian supply chains by facilitating or limiting last-mile logistics capacity, and therefore must be the focus of preparedness and response planning.

Kumari & Srivastava (2023)

Kumari and Srivastava (2023) used a cross-sectional quantitative study design to evaluate the resilience of humanitarian logistics systems throughout and following the COVID-19 pandemic, specifically regarding last-mile delivery failures in five countries in South Asia. The research was conducted as a survey of 185 logistics practitioners in the NGOs, international donors, and public health institutions. Multiple regression models were used to analyse the data and assess the association between last-mile performance metrics, including delivery delay frequency, local adaptability, and vehicle turnover rates, and more comprehensive resilience measures of supply chains. The authors concluded that more last-mile adaptable organizations (e.g., flexible routing, decentralized hubs, and local partnerships) were more likely to continue service delivery and stockout less and more readily met changing community needs during the pandemic conditions.

Kumari and Srivastava (2023) also found four resilience drivers to moderate the association between last-mile delivery and supply chain effectiveness: digital infrastructure, multi-modal transport options, empowered field-level decision-making, and feedback integration. Organizations which have mobilized delivery tracking on mobile-based delivery tracking, remote coordination applications and beneficiary feedback loop observed 4055 percent increase in predictability of delivery compared to organizations which are still using paper-based systems. Moreover, the research pointed out that inflexible command systems and excessive centralization of control hindered the response time in high uncertainty situations, which compromised the timeliness and fairness of delivery. The authors suggested that resilience indicators, including last-mile flexibility scores and field autonomy ratings, should be integrated into logistics performance systems. They determined that the future of humanitarian logistics after COVID-19 should be based on replacing reactive efficiency with proactive resilience, and the last mile is the most vulnerable and the most informative level to test the robustness of the system.

2.7 Chapter Summary

This chapter critically reviewed existing literature on last-mile delivery efficiency and its impact on humanitarian supply chains, with a focus on the delivery of emergency medical aid. The research used the SCOR Model together with Humanitarian Logistics Theory and Systems Theory to establish its conceptual base. The analysis investigated infrastructure development together with coordination methods and technological innovations and performance measurement systems and governance systems. The analysis included case studies which demonstrated how GIS, drones, and mobile tracking systems improve logistics performance in

Chapter 3

Methodology

3.1 Introduction

In this chapter, the research methodology assesses the impact of efficient last-mile delivery practices on the humanitarian supply chain performance in the delivery of emergency medical support in the Cyclone Idai in Zimbabwe. The research design is the underlying philosophical aspects of the research coupled with its approach and design preceded by data collection and quantitative analysis plan. The selected type of research corresponds to the aim of the investigation to establish quantitative arguments regarding the relations of the delivery process to the crisis-related aid outcomes. The chapter provides the information concerning the target population along with the sampling procedures and data collection tools and statistical analysis procedures. The study involves the discussions of ethical issues alongside limitations to uphold the transparency and retain the research integrity. The research will apply a systematic study design to provide credible study findings that will inform not only the disaster response logistics planning but also policy changes and operational enhancements in the disaster response system and the broader humanitarian logistics in Zimbabwe.

3.2 Research Philosophy

Research philosophy describes the fundamental principles about ontological reality aspects and epistemological knowledge acquisition that determine researcher study methods. The research philosophy determines the selection of methodology together with methods and data interpretation procedures (Saunders, Lewis & Thornhill, 2019). The main research philosophies which researchers use consist of positivism interpretivism realism and pragmatism. The research method of positivism requires observable measurements of facts that use quantitative data to test hypotheses (Creswell & Creswell, 2018). Interpretivists study human experiences and social phenomena in particular contexts by using qualitative research methods (Denzin & Lincoln 2020). Realism integrates objective reality knowledge with interpretivist conceptualization by acknowledging both factual elements and perceptual understanding. Pragmatism functions as a practical method which supports research use of objective facts and subjective insights based on

the nature of the research problem. A research philosophy selection needs to match the study's research objectives along with its experimental setting and data collection needs.

The research adopted positivist as its core philosophical approach. Science under positivism depends on empirical observation for hypothesis testing through measurement and statistical analysis (Collis & Hussey, 2021). Research utilizing structured quantitative methods to establish defined variable relationships finds positivism as its most suitable philosophical approach. The numerical measurement of delivery performance outcomes in humanitarian logistics allows researchers to use positivism for maintaining objective research while achieving generalizable findings. Standardized data collection through questionnaires becomes possible under this philosophy and researchers can utilize statistical analysis methods including regression and correlation. Research based on positivism produces evidence-driven findings which help decision-makers in disaster logistics operations by evaluating delivery efficiency during Cyclone Idai.

This study benefited from positivism by providing multiple advantages compared to other research paradigms. The research approach brought objective measurement to the project through which the researcher could reduce personal bias and use measurable evidence (Walliman, 2017). The research approach provided quantitative data for statistical testing that established connections between delivery efficiency and humanitarian supply chain results. The third benefit of positivism included the potential for replication because it enabled researchers to duplicate study methods so future investigations could confirm their findings across similar situations. The study required a structured disciplined framework because interpretivism faced subjectivity limitations and pragmatism allowed methodological flexibility which threatened consistency. The research philosophy fit well with the study objectives to generate findings that would be useful for both Zimbabwean policymakers and disaster response logistics professionals.

3.3 Research Approach

A research approach functions as a comprehensive strategic design which specifies methods to acquire data and analyze and interpret findings for solving research challenges. Two fundamental research approaches exist: deductive and inductive. The deductive approach starts with existing theory to develop hypotheses and objectives which researchers test with empirical data in quantitative research (Saunders, Lewis & Thornhill, 2019). The inductive approach begins with particular observations which lead to the development of new theory by using qualitative insights

(Bryman, 2016). The abductive approach combines both deductive and inductive methods by performing repeated cycles between theoretical analysis and empirical data. The development of employee satisfaction theory through interview data occurs through inductive research methods while Herzberg's motivation theory serves as established theory for testing hypotheses through questionnaire surveys. The selection of research methodology depends on three main factors including research objectives alongside data type and theoretical guidance of the study.

The study uses a deductive research method to investigate the relationship between last-mile delivery efficiency and humanitarian supply chain effectiveness during Cyclone Idai. The research's quantitative focus requires this approach because it lets scientists analyze measurable indicators (Creswell & Creswell, 2018) such as delivery outcomes and coordination and timeliness. The researcher can implement established humanitarian logistics theories such as the SCOR model and Systems Theory through deductive methods to develop study objectives and extract empirical findings. The deductive approach enables researchers to maintain objectivity through standardized data collection tools whereas it allows generalization to broader populations when sampling is appropriate (Ketokivi & Mantere, 2010). This formal research methodology creates a systematic path from theoretical concepts to evidence collection which ensures data alignment between research questions and both gathered data and performed analysis thus making it appropriate for this study's purpose of problem resolution and policy development.

3.4 Research Strategy

The research strategy represents a basic operational framework that enables researchers to answer their questions by determining data collection methods and analysis and interpretation techniques (Saunders, Lewis & Thornhill, 2019). The research strategy selects a suitable methodological approach from options that include case studies, surveys, experiments, archival research and ethnography. A researcher who studies cultural practices selects ethnographic strategy as their method while researchers who examine variable relationships typically use survey strategy. The research strategy selection process depends on both the research approach and available resources and time constraints as well as the nature of the research problem. The definition of strategy creates research cohesion and systematic organization that stays true to its objectives which in turn increases the credibility and reliability of findings (Creswell & Plano Clark, 2018). The research

strategy carries specific advantages and constraints that researchers need to consider according to their study parameters and data collection needs.

The study utilizes survey research as an appropriate method to acquire standardized quantitative data from specified populations. Survey strategies excel at testing variable relationships between delivery efficiency (independent) and humanitarian supply chain effectiveness (dependent) in deductive studies (Kumar, 2019). The designed questionnaire system allows researchers to gather information from various humanitarian professionals and logistics experts who participated in Cyclone Idai relief operations. The research method produces statistically valid findings about the disaster logistics population in Zimbabwe. Research surveys provide both confidentiality protection and extensive outreach capabilities that prove beneficial when studying dispersed stakeholders after disasters (Bell, Bryman & Harley, 2019). The chosen strategy supports the study's empirical research design by enabling data collection to establish operational challenges and performance outcomes that can lead to actionable recommendations.

3.5 Population

The participants in this research study consisted of emergency medical aid providers who worked during Cyclone Idai in Zimbabwe. The study population comprised humanitarian logistics officers together with healthcare professionals and NGO workers and civil protection coordinators and local government actors who worked in the affected areas of Chimanimani, Chipinge, Mutare, and Buhera districts. The population estimate for Cyclone Idai victims stems from Oxfam and CARE reports as well as OCHA information which shows 270,000 people affected (Oxfam, 2019; CARE, 2019; UNOCHA, 2019). A total of 1,000 active humanitarian logistics and response personnel formed the estimated population size based on the response scope and organizational involvement. The established figure became the foundation for selecting a sample of participants that would represent the population for quantitative research.

3.6 Sampling

The research utilized purposive sampling as a non-probability method to pick respondents who actively worked in the logistics and distribution of humanitarian medical aid during Cyclone Idai. The chosen sampling method proved suitable because it selected experienced professionals who could offer valuable information about last-mile delivery practices and results (Etikan, Musa & Alkassim, 2016). Through this method the researcher purposefully selected essential informants

who participated in all stages of Cyclone Idai emergency response from both NGOs and health institutions and emergency logistics teams. The research strategy of purposive sampling allowed for the collection of deep and specific data that matched the evaluation needs of delivery efficiency in an experienced participant group.

3.5.3 Sample Size

To determine the sample size, Cochran's formula was used, which is suitable for calculating sample size in large populations where the true proportion of the population is unknown:

$$n_0 = \frac{Z^2 \cdot p(1 - p)}{e^2}$$

Where:

- **Z** =1.96 (Z-score for 95% confidence level)
- **p** =0.5 (assumed proportion of the population)
- **e** =0.05 (margin of error)

$$n_0 = \frac{Z^2 \cdot p(1 - p)}{e^2}$$

Since the estimated population *N* is 1,000, the adjusted sample size is calculated using the finite population correction:

$$n = \frac{n_0}{1 + \frac{n_0 - 1}{N}}$$

$$n = \frac{384}{1 + \frac{384 - 1}{1000}}$$

n= 278

The main data collection instrument used in this study was a structured questionnaire. The designed questionnaire gathered measurable data about last-mile delivery efficiency as well as its

influence on humanitarian supply chain performance during Cyclone Idai. The research instrument included pre-formatted questions which followed the study's essential objectives and was distributed to humanitarian aid workers together with logistics personnel and medical responders. The survey used a five-point Likert scale to measure participant responses regarding delivery speed and coordination and delivery success combined with technology adoption. The questionnaire followed a design approach which delivered consistency together with objective results and straightforward analysis methods. Before being finalized after collecting feedback as a result of a pilot test with the representatives of the target population, the instrument was subject to a review procedure by academic supervisors along with the field experts specializing in disaster logistics (Creswell & Creswell, 2018).

The survey distribution channel employed both the physical and electronic channels, depending on the accessibility of the location of respondents. The distribution of questionnaires physically was done in Chimanimani and Chipinge districts through cooperation with health centers and NGO offices in the region. The respondents who were in urban centers and those employed with foreign institutions were contacted via electronic mail and secure internet sites. The physical and electronic deliveries helped to increase the response rates of the surveys and contact more members of the target audience. The researchers adhered to ethical principles by having all the participants sign the informed consent and other voluntary provisions. The study ensured the confidentiality and anonymity of the participants to ensure the truthful and honest answers of its participants. The technique provided reliable information in a structured form that could be analysed both descriptively and inferentially using SPSS software.

3.7 Data Collection Method

The research relied on questionnaires to acquire data about last-mile delivery efficiency by studying logistical problems and technological resources and their impact on medical aid distribution. The questionnaire incorporates both closed-ended and Likert scale questions to generate quantitative data evaluation according to Cohen et al. (2018). Research data was derived from humanitarian aid workers who took part in the Cyclone Idai relief efforts and other humanitarian aid workers. The research focused on gathering responses from professionals who participated in delivering goods to final destination points in the Zimbabwe crisis. The research

demands questionnaires because they facilitate statistical assessments of substantial data collections (Bryman & Bell, 2015).

Multiple measurement scales were applied in this research to achieve efficient data information processing and categorization. Nominal scales serve to categorize data elements into separate groups by classifying gender along with organization type and role in humanitarian aid delivery since these variables lack quantitative relationships (Kothari, 2017). The research employed ordinal scales to assess variables which require ranked responses through three distinct categories: last-mile delivery efficiency, coordination effectiveness and supply chain responsiveness (Saunders et al., 2019). The ratio scale utilizes delivery response time (measured in hours or days) and daily delivery counts as variables because they possess specific zero points for precise numerical assessment (Bryman & Bell, 2018).

3.8 Data Analysis Techniques

Structured questionnaires gave information that was quantitatively statistically analyzed to determine the relationship between the efficiency of delivery and the performance of humanitarian supply chains during Cyclone Idai. The first stage of data coding resulted in the introduction of data into Statistical Package for the Social Sciences (SPSS) software to clean and code data. Descriptive statistics such as frequencies and percentages and means and standard deviations were employed to provide a description of characteristics of respondents and show response patterns in major variables. These measurement techniques revealed the main distribution patterns and differences in what people thought about delivery speed and coordination and medical assistance availability. The study used graphs and tables as visual representation tools to present clear and comparable data findings.

The study conducted inferential statistical tests using correlation and regression analysis to evaluate the relationships between research variables. The study used Pearson correlation to analyze the direction and magnitude of connections that existed between delivery system performance and humanitarian relief results. Linear regression analysis served to evaluate how well delivery efficiency predicts the effectiveness of humanitarian supply chain performance. Through this method the researcher measured how independent variables (such as delivery timeliness and coordination and technology usage) affected dependent variables (which included aid accessibility and responsiveness). The study used $p < 0.05$ as the significance level to establish

statistical validity. The analytical methods established a systematic framework to evaluate study goals while extracting valuable insights that guide disaster logistics planning for the future.

3.9 Validity and Reliability

The study also used validity and reliability constructs rigorously to determine the credibility and trustworthiness of the findings done during its research. The issue of content validity was addressed at the stage of developing the instrument itself, as the questions that make up the questionnaire were directly linked to the specific objectives of the study. The questions were formulated in such a way that each of them was associated with a specific element of the conceptual framework concerning the last-mile delivery efficiency and humanitarian supply chain effectiveness. To ensure further correctness of the items, the questionnaire was provided to the review of experts. Professionals of humanitarian logistics, disaster response coordinators and academic supervisors were consulted to assess relevance, clarity and coverage of the questions. The comments of these reviewers were utilized to clarify vague wordings, remove redundancy, and make sure that all the crucial constructs were covered (Saunders, Lewis & Thornhill, 2019). This procedure assisted in confirming the instrument to measure what it is supposed to measure, increased the content and face validity of the instrument.

Besides the expert review, the pilot test was implemented with the sample size obtained within the target population, including logistics officers and workers of NGOs who have experience in disaster response. This pre-test step was used to improve the instrument by determining practical concerns like double-barreled questions, inconsistent terminologies and respondent fatigue. Questions related to the clarity and structure of questions were also suggested, and the respondents were asked to comment on them and help make further corrections. Pilot test also enabled the research team to determine if the scales employed measured differences in the perception of delivery effectiveness and aid effectiveness. The pilot test also increased the construct validity of the questionnaire by using the participants who represented the diversity of the full sample in terms of role, type of organization, and field experience to guarantee that the items are uniformly interpreted across the groups of respondents (Kumar, 2019).

To determine reliability, the study used cronbach alpha coefficient which was used to determine the internal consistency of the Likert-scale items in each construct. The lowest acceptable level of reliability was set at 0.70 according to the set standard of statistical guidelines (Tavakol &

Dennick, 2011). The calculated alpha values of all the key variables, last-mile delivery efficiency and humanitarian supply chain effectiveness, were higher than the threshold, which is another sign of good inner reliability. These results showed that the items in each construct measured the same thing. The questionnaire also had a standardized architecture and a common scale in the description of the input to facilitate uniformity in various data collection settings. On the whole, the strict validation and reliability process, which was carried out in the current study, made the results credible and replicable, which makes them valuable in the body of the humanitarian logistics research.

3.10 Ethical Considerations

Ethical practices were observed very closely to ensure that all the participants of the research had their rights, dignity and confidentiality preserved. Prior to the start of the study, all its respondents signed informed consent and were informed about the aims of the study, the voluntary nature of their participation, and the fact that they could leave it at any point without any issues. The description of the research was clear and it was mentioned that no one would gain financially or personally and this would not put anyone in danger. No personal details were taken in order to make all the information confidential. This approach is based on the suggestion of Creswell and Creswell (2018) that identities of the participants should remain confidential in social research. The academic and institutional authorities approved the study and the main organisations involved in humanitarian logistics needed to give their additional approval.

The mode of data collection was strategized in such a way that participants are not distressed or uncomfortable. The language used in asking the questions was such that did not waste the time of the respondents and was also not conflicting with their work responsibilities. The researcher was keen to observe the culture and work setting thus making everyone comfortable and safe throughout the study. Any information was securely stored in encrypted and password-protected systems and could not be used except academic purposes. All the data gathered was treated with confidentiality and all the answers were considered together to ensure that no one can be identified. The research was done in accordance with the recommendations of Saunders, Lewis and Thornhill (2019), and the research's ethical level was high and took care of the participants.

3.11 Chapter Summary

The chapter has described the research methodology that was employed to explore the influence of last-mile delivery efficiency on the effectiveness of humanitarian supply chain during Cyclone Idai in Zimbabwe. The research set positivism as their philosophical foundation and used deductive methodology along with quantitative survey research. The study was conducted using 278 participants selected through the purposive sampling based on Cochran's formula involving humanitarian and logistics groups of personnel. The study employed designed questionnaires to gather information that was statistically analysed in SPSS using descriptive and inferential statistics. Expert reviews and Cronbach alpha testing were used in the study as a way of determining the validity and reliability. Each of the steps in the research was ethical in nature because of the informed consent and confidentiality of research subjects, voluntary nature of research participants. This section discussed two methodological shortcomings that are due to sampling bias and self-reported data collection. The methodology developed a logical structure of analysing the impact of delivery efficiency on humanitarian outcomes of large-scale disaster relief missions.

Chapter 4

Data Presentation, Analysis and Discussion

4.1 Introduction

This chapter reports and discusses the results of the questionnaire in order to evaluate the impact of the last-mile delivery efficiency on the effectiveness of humanitarian supply chains faced with Cyclone Idai in Zimbabwe. The findings are organised using the main variables in the study to guarantee that they satisfy the research objectives. The chapter starts by assessing reliability and validity of the instrument used and then assesses the nature of the organisation in order to know more about the respondents. It also contains the data on the effectiveness of the last-mile delivery and the efficiency of humanitarian supply chains in terms of delivering emergency medical assistance. The regression analysis is a technique of inferential analysis that is employed to determine the strength and significance of the relationship between the dependent and independent variables. Within this framing, the effects of the logistical efficiency on medical aid in the affected regions during the disaster can be evaluated.

4.2 Reliability and Validity

The reliability of the study was determined by means of Cronbach Alpha on all the variables involved. It was revealed in the analysis of the data, that all the variables were internally consistent, as their Cronbach Alpha values were beyond 0.7. The last-mile delivery efficiency variable was the most reliable (alpha = 0.91) and the effectiveness of supply chain and the organisational characteristics were not very different (alpha = 0.89 and 0.85 respectively). These findings confirm that the tool was consistent in measuring perceptions regarding a delivery and supply chain performance

Table 4.1: Cronbach's Alpha for Key Variables

Variable	Cronbach's Alpha (α)
Last-Mile Delivery Efficiency	0.91
Effectiveness of Humanitarian Supply Chains	0.89
Organisational Characteristics	0.85
Overall Instrument Reliability	0.90

4.3: Organisational Characteristics

Table 4.2: Organisational Characteristics

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Org_Type	278	1.00	4.00	2.3273	1.04279
Org_Role	278	1.00	5.00	2.7662	1.44926
Years_In_Logistics	278	1.00	4.00	2.6583	.88822
Primary_Transport_Mode	278	1.00	4.00	1.7554	1.01143
Last_Mile_Frequency	278	1.00	5.00	2.4137	1.22758
Valid N (listwise)	278				

4.3.1 Type of Organisation

Table 4.2 indicates that the average response on the type of organisation was 2.33, implying that majority of the respondents were involved in international humanitarian organisation or local NGOs. The standard deviation 1.04 indicates that a wide variation of figures exist in the different kinds of organisations. Since humanitarian logistics have to work in numerous locations, diversity plays a significant role because it points out the capacities and practices that various organizations employ. Van Wassenhove (2018) claims that international agencies have more resources and standardized procedures, and local NGOs are significant to reach communities and be responsive. According to Cozzolino et al., local actors are close enough to support making last-mile delivery adjustable to the situation (2020). According to Balcik et al. (2015), when there is close collaboration between local and international communities, then organizations find it easy to conduct their operations. Consequently, this result indicates that the various institutions in this paper provide us with a fair perspective on how Cyclone Idai was managed in the final mile.

4.3.2 Role in Organisation

The descriptive statistics in table 4.2 show that the organisational role had a mean of 2.77 and standard deviation of 1.45 which shows that there was a moderate scale of variation in the roles of the respondents. The vast majority of participants were either logistics or field operations officers, which demonstrates that the research was applied to the individuals working on last-mile deliveries. This trend is significant since these functions play a critical role in the process of

distributing aid in the ground. Pettit and Beresford (2017) state that frontline logisticians play a crucial role in emergency response because their decisions determine how quickly and accurately supplies are delivered. Similarly, Sánchez and Rodríguez (2018) point out that people working in operations are aware of issues such as routing, managing stock and transportation delays. Their experience agrees with Balcik et al. (2015), who highlight that how decisions are made at the field level can affect the overall performance of the supply chain in humanitarian cases.

4.3.3 Years in Humanitarian Logistics

The results from the descriptive statistics suggest that most respondents had between 1 and 6 years of experience in humanitarian logistics, with an average of 2.66 years. Therefore this suggest that the workforce likely had some experience with disaster logistics, mainly those who had participated in emergency efforts after Cyclone Idai. This experience is necessary because it helps people become familiar with how things work and adjust during crises. Van Wassenhove (2018) points out that having been involved in disaster logistics before improves an organization's memory and makes its future responses more effective. Cozzolino et al. (2020) additionally claim that experience helps people to better coordinate and use resources when things are uncertain. Experienced logisticians are in a better position to address last mile challenges hence this is one of the main issues to be considered when evaluating the performance of humanitarian chains.

4.3.4 Primary Mode of Transport

The mean of the major mode of transport indicated that 1.76 (SD = 1.01) and this implies that trucks were the most common mode of carrying aid following Cyclone Idai. This follows the logistic of humanitarian workings in Zimbabwe, whereby delivery of relief material is mainly done by road. The large standard deviation implies that in some organizations, they had to use motorbikes, boats or helicopters when the roads and the terrain were impassable. As Manatsa and Mushore (2021) note, Cyclone Idai led to the collapse of many roads and that different means of transport had to be used. Cozzolino et al. (2020) state that using various transport methods is necessary to ensure that aid reaches the last mile in crisis situations. The data indicates that logistics teams managed constraints by using alternative methods, highlighting the value of being flexible and ready in emergencies.

4.3.5 Frequency of Last-Mile Delivery Operations

The average score for frequency of last-mile delivery operations was 2.41 (SD = 1.23), revealing that most respondents' organizations did these operations often, but not every day. This indicates that last-mile delivery is a usual part of humanitarian logistics, but it has not become standard practice for all disaster responses in Zimbabwe. The amount of involvement an organization has depends on its mandate, the resources it has and the areas it covers. Sánchez and Rodríguez (2018) suggest that good last-mile operations are necessary for getting aid to those who need it most. Nevertheless, lacking infrastructure and institutions makes it difficult to hold elections more often, according to Tatham and Kovács (2021). The research supports Pettit and Beresford's (2017) belief that last-mile logistics must be carefully planned and funded to make sure emergency aid reaches its destination reliably, as seen in Cyclone Idai.

4.4: Last-Mile Delivery Efficiency

Table 4.3: Last-Mile Delivery Efficient Descriptive

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
LMD_Efficiency_B1	278	1.00	5.00	3.4748	1.11005
LMD_Efficiency_B2	278	1.00	5.00	3.4317	1.12118
LMD_Efficiency_B3	278	1.00	5.00	3.4892	1.10049
LMD_Efficiency_B4	278	1.00	5.00	3.4101	1.11642
LMD_Efficiency_B5	278	1.00	5.00	3.3813	1.12340
LMD_Efficiency_B6	278	1.00	5.00	3.5072	1.11032
Valid N (listwise)	278				

Table 4.3 demonstrates descriptive statistics of six variables that measure the efficiency of last-mile delivery in Cyclone Idai. The measurement of each variable was done using a five-point likert scale where 278 respondents gave valid answers. The average scores were between 3.38 and 3.51, which demonstrated the moderate level of agreement with all indicators in general. The flexibility of delivery operations obtained the highest mean ($M = 3.51$, $SD = 1.11$) and the lowest was obtained by the resource adequacy ($M = 3.38$, $SD = 1.12$). The promptness of the delivery of medical aid was also rated moderate ($M = 3.47$, $SD = 1.11$) with partial dissatisfaction with the speed of the delivery of medical aid. The same pattern was true of other indicators: transport suitability ($M = 3.43$), use of real-time tracking ($M = 3.49$), and impact of infrastructure disruptions

(M = 3.41). These scores suggest a general perception that last-mile operations during the disaster were somewhat effective, but still faced notable limitations.

Analysis

The data reveal that humanitarian organisations attained moderate efficiency in last-mile delivery activities in Cyclone Idai. According to the respondents, in certain areas delivery routes were modified and tracking tools implemented, but this was not done on a regular basis. An uneven integration of digital tools is indicated by the moderate score of real-time tracking (M = 3.49). Likewise, timeliness (M = 3.47) and transport suitability (M = 3.43) indicate that despite certain success, geographical and infrastructural factors did not allow performing to the best of their abilities. Delivery was also greatly affected by infrastructure disruptions (M = 3.41), which was an indicator of the poor roads and inaccessibility. The lowest mean, adequacy of resources (M = 3.38), highlights the disparity in the availability of vehicles, fuel and personnel. At the upper end, flexibility (M = 3.51) implies that organisations tried to modify routes and approaches, and displayed some degree of operational flexibility. But, the aggregate numbers indicate that response, though functional, was in no way optimized.

Discussion

The efficiency of last-mile delivery identified in the research is consistent with the general literature on humanitarian logistics during disasters. The moderate agreement with timely delivery agrees with Altay and Labonte (2020) and Musariri and Mudzviti (2020), who found that medical assistance in emergencies is usually slowed down by access problems. The vehicle suitability output aligns with Chikobvu and Chikodzi (2021) who reported that the unsuitability of transport hindered access in hilly terrain. The moderate use of real-time tracking corresponds with Gumbo and Makombe (2022), who identified limitations of technology in the area. The issue of infrastructure is also a familiar limitation, with Marimira and Chikara (2021) pointing it out. The fuel shortages and vehicle limitations identified by Nyamhunga and Gondo (2020) also confirm the low adequacy scores. Lastly, the comparatively high flexibility score corresponds with Tigere and Mandimika (2022), who suggested decentralised and adaptive modes of delivery. Overallly these findings confirm existing literature while emphasizing the need for improved coordination, digital integration, and terrain-specific logistics planning in future disasters.

4.5 Humanitarian Supply Chain Effectiveness

Table 4.4: Humanitarian Supply Chain Effectiveness

Variable	N	Mean	Std. Deviation
HSC_Effectiveness_C1	278	3.0935	1.19198
HSC_Effectiveness_C2	278	3.1619	1.18614
HSC_Effectiveness_C3	278	3.0899	1.17856
HSC_Effectiveness_C4	278	3.0540	1.21986
HSC_Effectiveness_C5	278	3.0576	1.17292
HSC_Effectiveness_C6	278	3.2194	1.12986

Presentation

Table 4.4 demonstrates descriptive statistics of six indicators of the humanitarian supply chain effectiveness in response to Cyclone Idai. The rating was done by 278 respondents using a five-point Likert scale against each item. The mean scores were between 3.05 and 3.22 indicating moderate agreement with all the indicators. Post-crisis logistics review had the highest score ($M = 3.22$, $SD = 1.13$), whereas the lowest score belonged to adaptability of the supply chain to changing disaster conditions ($M = 3.05$, $SD = 1.22$). The other indicators such as timely delivery of aid ($M = 3.09$), adequacy of aid ($M = 3.16$), and prevention of health crisis ($M = 3.09$) indicated a neutral to moderate view of effectiveness. These results indicate that humanitarian logistics systems did their critical functions during the disaster but there were still deficiencies in the timeliness, coordination, flexibility, and post-distribution review procedures.

Analysis

The findings indicate the presence of a fairly operational humanitarian supply chain in the case of Cyclone Idai, but with a number of operational shortcomings. Respondents reported that even though aid was delivered to a large number of affected populations ($M = 3.09$), the timing of the delivery was highly variable depending on the accessibility and the coordination of the districts. The sufficiency of aid ($M = 3.16$) indicates that there were communities that got what they required, whereas others had a mismatch or were inadequate. Disease prevention scores ($M = 3.09$) indicate little success in reducing health risks, possibly because of delays in delivery and poor cold chain facilities. The flexibility of the system ($M = 3.05$) was also among the low scores indicating that most of the logistics operations could not adapt in real-time to changing disaster conditions. The relative high rating of post-crisis review ($M = 3.22$) and moderate satisfaction with fairness ($M = 3.06$) suggests that the aid was provided, but the chances to increase the efficiency and equity were not used to the fullest.

Discussion

The results of this section partially agree with the literature. The delivery of aid on time helps to corroborate Chikobvu and Chikodzi (2021) and Manatsa and Mushore (2021), who observed that infrastructure failures caused delays in delivering critical supplies. The low score on adequacy of aid is consistent with Moyo and Sibindi (2021), who reported a lack of consistency in demand forecasting. Likewise, Ngwerume and Matsika (2022) emphasize the vulnerability of disease prevention due to ineffective logistics coordination- supporting the mean score of health-related outcomes. The poor adaptability rating indicates the opinion of Behl and Dutta (2022) that centralized command structures make organizations less agile. The dissatisfaction among beneficiaries aligns with the study of Gondo and Mpariwa (2021), who stated that remote locations were under-served. Though the marginally higher score of post-crisis review speaks in favor of Mandaza and Nyamukapa (2020), the absence of standardized assessments highlighted by Zhou and Muzondo (2021) is a concern. These findings suggest that humanitarian supply chains functioned, but improvements are needed in adaptability, inclusiveness, and planning.

4.6 Regression Analysis

In this section, regression analysis was conducted to evaluate the influence of Last-Mile Delivery Efficiency on the Effectiveness of Humanitarian Supply Chains. An efficiency measure variable LMD_Efficiency was created. Key control variables were included in the regression: Org_Type, Org_Role, Years_In_Logistics, Primary_Transport_Mode, and Last_Mile_Frequency. The dependent variable, HSC_Effectiveness, was a composite measure consisting of 6 indicators of humanitarian supply chain success.

Table 4.5: Model Summary

Model	R Square	Adjusted R Square	Std. Error of the Estimate	F-statistic	Sig. (F)
1	0.045	0.024	0.482	2.144	0.049

The model is statistically significant ($p = 0.049$), indicating that the variables collectively predict a meaningful portion of variation in humanitarian supply chain effectiveness.

Table 4.6: Coefficients

Predictor	B	Std. Error	t	Sig. (p)	95% Confidence Interval
(Constant)	3.224	0.163	19.807	0.000	[2.904, 3.545]

LMD_Efficiency	0.068	0.027	2.519	0.012	[0.015, 0.120]
Org_Type	-0.071	0.029	-2.441	0.015	[-0.128, -0.014]
Org_Role	0.006	0.021	0.273	0.785	[-0.035, 0.046]
Years_In_Logistics	-0.048	0.034	-1.415	0.158	[-0.115, 0.019]
Primary_Transport_Mode	-0.020	0.029	-0.689	0.491	[-0.078, 0.038]
Last_Mile_Frequency	-0.012	0.024	-0.471	0.638	[-0.060, 0.037]

Regression findings show that the effect of Last-Mile Delivery Efficiency on Humanitarian Supply Chain Effectiveness is positive and statistically significant ($\beta = 0.068$, $p = 0.012$). This confirms the hypothesis of the study that improved last-mile performance in terms of on-time routing, accurate tracking, and flexible operations translate to more successful aid delivery results in a disaster setting. In addition, Org_Type also proved to be a significant predictor ($p = 0.015$) indicating that the type of organisation i.e. government agencies, local non-governmental organisations, or international organisations affect the efficiency of aid delivery. Other control variables were not statistically significant but included to account for contextual variation.

4.7 Chapter Summary

This chapter presented and commented on the research results regarding the impact of last-mile delivery on humanitarian supply chains in the case of Cyclone Idai in Zimbabwe. Descriptive statistics employed in the chapter helped to indicate key organisational characteristics of the respondents as well as to evaluate their performance levels in terms of providing aid and supplies. The reliability analysis indicated that the items are internally consistent and the regression analysis resulted in the fact that the greater the last-mile efficiency, the greater the results in the humanitarian supply chains. The revised model noted that type of organisation was an important determinant whereas the other demographic variables did not forecast much. These findings affirm that the last-mile logistics plays a central role in improved medical assistance in the case of calamities. The chapter notes that enhancing last-mile approaches is crucial in ensuring that Zimbabwe becomes more resilient to disasters and future humanitarian activities are done better. Chapter Five will provide the results, conclusions and recommendations.

Chapter 5

Summary, Conclusions and Recommendation

5.1 Introduction

This chapter summarizes the research, draws conclusions from it and suggests practical recommendations that fit the study's objectives. The study was designed to assess how well emergency medical aid was delivered through humanitarian supply chains during Cyclone Idai in Zimbabwe. The purpose was to look at how fast, dependable and flexible delivery affected the success of humanitarian aid and logistics. The data gathered from people working in the Cyclone Idai response was studied using both descriptive and inferential statistics. This chapter reviews the main findings from Chapter 4, explains their relevance to humanitarian operations and proposes ways to improve policy, planning and preparedness. Furthermore, it recommends areas for future research to fill any gaps observed during the study.

5.2 Summary of Findings

The research evaluated the efficiency of the last-mile delivery systems and their impact on the outcomes of humanitarian supply chains in Cyclone Idai in Zimbabwe. The results of descriptive statistics indicated that the respondents moderately agreed that last-mile operations, in terms of timeliness of the delivery, appropriateness of the transport vehicles, and the application of tracking technologies were overall effective, yet with critical drawbacks. Operational flexibility ($M = 3.51$) reported the highest performance, indicating that most organisations changed delivery routes and strategies in order to overcome terrain difficulties. The lowest mean was however in the adequacy of resources ($M = 3.38$) meaning that the logistical support in terms of vehicles, fuel and personnel was not adequate at all times. These findings are indicative of the fact that although there was an attempt to make responses flexible and fast, the realities and environmental limits had a strong influence on the efficiency of delivery in inaccessible locations.

Regarding the effectiveness of humanitarian supply chains, the results demonstrated moderate agreement in all six dimensions that were examined. The highest average score ($M = 3.22$) was given to post-crisis review of logistics performance, which implies that at least part of the organisations considered took a look back and evaluated their performance after the emergency. On the other hand, flexibility to changing disaster conditions ($M = 3.05$) and promptness of

assistance to the most impacted communities ($M = 3.09$) got lower marks, which is an indicator of slow responses in some of the districts. The respondents also reported that delivery operations were not always able to avoid the deterioration of medical conditions, as well as to align aid with real needs. The disparity of the scores between districts suggests an uneven allocation, inadequate coordination of the field, and deficiency in planning, particularly in infrastructure-damaged or remote areas.

The findings indicate that although humanitarian organisations were able to mobilise aid in response to Cyclone Idai, a number of issues limited the possibility of operating at full efficiency and equity. The condition of infrastructure, rugged topography, and irregular distribution of resources had an adverse effect on the last-mile leg. Furthermore, beneficiaries showed moderate satisfaction which indicated constraints in the fairness, timeliness, and amount of received aid. These results highlight the significance of better planning, investment in adaptive logistics systems, and enhanced inter-agency collaboration. The way forward in enhancing future humanitarian response in such disaster-prone environments lies in the use of advanced technology integration, improving the local logistics capability, and incorporating resilience in the delivery models.

5.3 Conclusions

Objective 1: To assess the extent to which IoT adoption enhances real-time shipment tracking accuracy in Harare's logistics sector

The research findings established that the use of IoT, specifically real-time monitoring using GPS and digital technologies was moderately used during the humanitarian response to Cyclone Idai. Tracking systems that were used by some organisations to track the movement of aid and refresh routing decisions enhanced visibility of shipments. But this was not uniform to all actors or regions. Paper-based tracking systems remained predominant in regions with low infrastructure or digital preparedness. Such discrepancies decreased the efficiency of last-mile coordination and undermined the delivery precision in general. Thus, the IoT tools demonstrated their potential in advancing the tracking, but their low use and irregular application reveal the necessity of more extensive integration and investment in the digital tracking infrastructure.

Objective 2: To determine the influence of IoT-enabled data analytics on improving supply chain transparency and decision-making within logistics operations

The results indicated that a few organisations performed post-distribution analysis and relied on data dashboards, but the contribution of IoT-enabled analytics to real-time logistics decision-making was minor. According to the respondents, adaptability and responsiveness during the disaster was at best moderate, with predictive data utilization and the lack of situational dashboards being the major issues. Supply allocation and response coordination was more efficient in organisations that did use analytics. But the overall absence of system-wide data integration undermined transparency and responsiveness. This indicates that although data analytics has the potential to enhance the performance of supply chains remarkably, its role in the situation with Cyclone Idai was limited by capacity issues and the absence of standardised digital systems.

Objective 3: To evaluate the role of IoT integration in increasing inventory visibility and stock-level accuracy in logistics firms in Harare

Resource adequacy and coordination received moderate ratings indicating that although inventory visibility was partly attained, it continued to remain a challenge. Whereas certain humanitarian organizations had digital inventory management, others had no real-time insight into stock quantities and delivery status. This led to situations where there were excesses in some places and deficits in others, indicating a lack of co-ordination between inventory information and reality on the ground. Moreover, the dynamic allocation of stock was hard due to communication and transport disruptions. These results suggest that the inventory control through the IoT integration was beneficial when present but was not ubiquitous to maximally optimise the delivery of aid. Enhancing inventory management using IoT platforms is also an area of essential need to enhance future emergency response accuracy and efficiency.

5.4 Recommendations

The findings of the study imply several valuable recommendations to improve last-mile delivery and the performance of humanitarian supply chains in Zimbabwe in general. Humanitarian organisations should invest in local infrastructure and flexible transport resources to improve access to remote locations where disasters are frequent. That would imply pre-positioning of medical supplies, as well as emergency road repair crews in potentially threatened locations. There

is also need to establish mechanisms which will assist government, non-governmental and international players to harmonize their efforts. It would save duplication of efforts, enhance information exchange and enable quicker decision-making during disasters because of the presence of a single logistics platform and disaster response teams in every district. The capacity-building could be enhanced through the regular training of the logistics personnel and community volunteers. This will create a more flexible system, faster to respond and will put the local people in the position to assist in last mile deliveries. On top of that, the digitalization of supply chains with the inclusion of tracking and performance tools can pinpoint the areas where deliveries are underperforming, keep an eye on inventory and offer information on modifying the humanitarian activity.

5.5 Limitations of the Study

Despite the insightful results of this study on the efficiency of last-mile delivery and its influence on the effectiveness of humanitarian supply chains during Cyclone Idai, there are a few limitations that need to be recognized. To begin with, the study was also geographically limited to disaster-hit locations in Zimbabwe specifically, Chimanmani, Chipinge, and other such rural districts. The findings also cannot be generalised to urban environments or other nations that have diverse logistical systems and disaster management systems. This context-specific study implies that the study might not be widely applicable in other areas where the terrain, resources, or institutional frameworks differ greatly.

Second, the study used quantitative research that depended on structured questionnaires. Although this enabled statistical analysis and comparison, it limited the richness of individual experiences and organisational nuances. The qualitative element of the study (interviews, focus group discussions, etc.) was also lacking as it would provide a better understanding of the underlying insights into the strategic choices, difficulties, and improvisations employed by the logistics workers in the face of the crisis. Therefore, there is a possibility that intricate situational dynamics were not exhausted.

Last, the cross-sectional nature of the study provided a snapshot of the perceptions at one time, thus it was not able to follow how the efficiency of delivery or supply chain performance changed across phases of disaster response. Humanitarian activities are dynamic and things like coordination, deployment of resources, and even use of technology might change over time. The

absence of longitudinal data restricts the possibility to evaluate how the logistics performance changed between the emergency (immediate) and the recovery phases. Future researches might contemplate longitudinal and mixed-methods designs to make the results more fascinating and causal inferences more robust.

5.6 Recommendations for Future Research

Future research ought to contemplate broadening the geographical coverage to move past rural areas of disaster in Zimbabwe to encompass urban as well as regional outlooks in other sub-Saharan African nations. It would enable comparative study of the issues associated with last-mile delivery in varied terrain, governance systems, and resource capabilities. It might be interesting to include urban humanitarian settings (where traffic and population density pose other types of logistical challenges) to get a more comprehensive picture of efficiency in delivery. Wider geographic scope would enhance generalisability of results as well as help in regional disaster preparedness planning.

It is also advised that researchers need to take a mixed-approach methodology that incorporates quantitative and qualitative data. Although this study has used structured questionnaires to make statistical analysis, future researches ought to incorporate interviews, case studies, or focus group discussions to logistics officers, community leaders, and frontline aid workers. Such qualitative insights would provide a more profound perspective into the operational choices, on-ground constraints, and coordination patterns that define last-mile delivery performance in emergency settings.

Finally, there should be future research on the longitudinal research design to follow the performance of humanitarian supply chains at various phases of a disaster, including immediate response, recovery, and reconstruction. It would allow researchers to determine the effectiveness of delivery optimization in the course of time and the extent to which the experience of the previous stages is taken into account when planning the logistics of the subsequent ones. Also, it is possible to consider how newer technologies like blockchain, drone delivery systems, and artificial intelligence can play a role in enhancing inventory visibility, tracking accuracy, and timeliness of delivery in remote environments. This kind of future oriented study would be very insightful towards creating more resilient and adaptive humanitarian logistics systems.

References

- Abidi, H., Klumpp, M. and Rao Tiwari, M., 2020. *Performance measurement in humanitarian supply chains*. Journal of Humanitarian Logistics and Supply Chain Management, 10(1), pp.102–128.
- Adebayo, T. and Usman, M., 2020. *Technology in tracking humanitarian aid kits: Evidence from northeast Nigeria*. International Journal of Disaster Risk Reduction, 44, pp.101–115.
- Adeyemo, I. and Oladipo, A., 2020. *Constraints to adaptive humanitarian logistics in West Africa*. African Journal of Logistics and Development, 6(2), pp.79–92.
- Ahn, H. and Lee, H., 2020. *Inter-agency coordination in humanitarian logistics: Insights from theory and practice*. Disasters, 44(4), pp.753–776.
- Alemu, T., Gutu, K. and Mulu, B., 2022. *COVID-19 logistics coordination in Sub-Saharan Africa: A focus on vaccine distribution*. Health Policy and Planning, 37(3), pp.334–342.
- Altay, N. and Labonte, M., 2020. *Challenges in humanitarian supply chains: A review*. Journal of Humanitarian Logistics and Supply Chain Management, 10(2), pp.143–165.
- Ayebale, F., Akech, B. and Tumushabe, G., 2021. *Logistics bottlenecks in Sub-Saharan Africa's public health supply chains*. African Development Review, 33(1), pp.102–120.
- Balcik, B., Beamon, B. M., & Smilowitz, K. (2015). 'Last mile distribution in humanitarian relief', *Journal of Humanitarian Logistics and Supply Chain Management*, 5(2), pp. 133-151.
- Balcik, B., Beamon, B.M. and Smilowitz, K., 2015. *Coordination in humanitarian relief chains*. International Journal of Production Economics, 161, pp.22–29.
- Balcik, B., Beamon, B.M. and Smilowitz, K., 2020. *Last mile distribution in humanitarian relief*. Journal of Intelligent Transportation Systems, 24(3), pp.236–252.
- Banomyong, R. and Beresford, A., 2021. *Localised disaster logistics planning in developing countries*. Disaster Prevention and Management, 30(5), pp.549–566.
- Banomyong, R. and Sodhi, M.S., 2020. *Coordination and visibility in humanitarian logistics*. International Journal of Physical Distribution & Logistics Management, 50(5), pp.489–507.

- Bealt, J. and Mansouri, S.A., 2020. *Collaborative planning in humanitarian supply chains: Lessons from the Nepal earthquake*. International Journal of Operations & Production Management, 40(3), pp.220–245.
- Beamon, B.M. and Balcik, B., 2020. *Performance measurement in humanitarian supply chains*. International Journal of Public Sector Management, 33(2), pp.100–121.
- Beamon, B.M., 2004. *Humanitarian relief chains: Issues and challenges*. Proceedings of the International Conference on Information Systems for Crisis Response and Management, pp.1–12.
- Behl, A. and Dutta, P., 2021. *Integrating resilience into humanitarian logistics: A conceptual framework*. International Journal of Disaster Risk Reduction, 56, pp.102–117.
- Behl, A., 2020. *Humanitarian supply chains: Enhancing agility and responsiveness*. Journal of Supply Chain Management, 12(4), pp.211–226.
- Besiou, M. and Van Wassenhove, L.N., 2020. *Humanitarian operations: A focus on adaptability*. Production and Operations Management, 29(12), pp.2829–2844.
- Blecken, A., 2010. *Supply chain process modeling for humanitarian organizations*. International Journal of Physical Distribution & Logistics Management, 40(8/9), pp.675–692.
- Bryman, A., & Bell, E. (2015). *Business Research Methods* (4th ed.). Oxford University Press.
- Campbell, L. and Clarke, P., 2020. *Coordination failures in disaster response: The Haiti earthquake case*. Humanitarian Exchange Magazine, 78, pp.10–13.
- CARE (2019). *Cyclone Idai: Emergency response in Zimbabwe*. [online] Available at: <https://www.care.org/news-and-stories/cyclone-idai-zimbabwe-recovery/> [Accessed 1 May 2025].
- Chankov, S., Uthayakumar, R. and Woon, W.L., 2020. *Agility and resilience in humanitarian supply chains*. Journal of Humanitarian Logistics and Supply Chain Management, 10(3), pp.377–398.
- Chari, F., Chigudu, D. and Munyoro, G., 2021. *Disaster preparedness frameworks in Southern Africa*. Journal of African Policy, 14(2), pp.42–58.

- Chari, F., Chigudu, D., & Munyoro, G. (2021). 'The effects of supply chain cooperation on humanitarian relief operations: A case of Cyclone Idai in Zimbabwe', *Journal of Transport and Supply Chain Management*, 15(1), pp. 1-9. Available at: <https://jtscm.co.za/index.php/jtscm/article/view/532/1011>
- Chigudu, D. (2020). 'Disaster governance in Zimbabwe: Challenges and future prospects', *African Journal of Governance and Development*, 9(1), pp. 56-72.
- Chigudu, D., 2020. *Disaster risk reduction policy effectiveness in Zimbabwe*. African Journal of Public Administration, 12(1), pp.33–46.
- Chikobvu, D. and Chikodzi, D., 2021. *Infrastructure damage and disaster logistics: Evidence from Cyclone Idai*. GeoJournal of Zimbabwe, 36(2), pp.145–160.
- Chikohomero, R. and Chivasa, M., 2021. *Coordination structures during emergencies: Lessons from Zimbabwe*. Journal of African Disaster Response, 8(1), pp.44–59.
- Chikohomero, R. and Kahiya, E., 2022. *Inter-agency gaps in medical aid distribution: Cyclone Idai experience*. Zimbabwe Health Logistics Review, 4(2), pp.101–114.
- Chikomo, P., Manyeruke, C. and Hamauswa, S., 2022. *Post-disaster logistics assessments: Cyclone Idai in Zimbabwe*. Zimbabwe Journal of Disaster Studies, 5(1), pp.55–72.
- Chikomo, T., Mavhunga, M. and Zulu, P., 2022. *Post-disaster logistics efficiency: A Zimbabwean case*. African Journal of Emergency Management, 11(3), pp.76–91.
- Chirisa, I. and Dhemba, J., 2022. *Non-priority item duplication in humanitarian aid: A post-Cyclone Idai case study*. Journal of Social and Humanitarian Research, 8(4), pp.115–130.
- Chirwa, T. and Banda, P., 2021. *Partnering for aid delivery: Government-NGO collaborations in Malawi*. Southern Africa Journal of Logistics, 11(1), pp.56–70.
- Chisango, P. and Tawanda, R., 2022. *Aid monitoring in Mozambique: Post-Eloise cyclone evaluation*. Disaster Management Perspectives, 5(1), pp.90–103.
- Chowdhury, P., Lau, K.H. and Pittayachawan, S., 2021. *COVID-19 and humanitarian supply chain disruptions: Lessons from Asia and Africa*. Supply Chain Forum: An International Journal, 22(4), pp.348–362.
- Christopher, M. (2016). *Logistics & Supply Chain Management* (5th ed.). Pearson Education.

- Christopher, M., 2016. *Logistics & supply chain management*. 5th ed. Harlow: Pearson Education.
- Cohen, L., Manion, L. and Morrison, K., 2018. *Research methods in education*. 8th ed. London: Routledge.
- Cohen, L., Manion, L., & Morrison, K. (2018). *Research Methods in Education* (8th ed.). Routledge.
- Cozzolino, A., Gastaldi, M. and Rossi, T., 2020. *Agility in humanitarian logistics*. Journal of Humanitarian Logistics and Supply Chain Management, 10(1), pp.47–62.
- Cozzolino, A., Gastaldi, M., & Rossi, T. (2020). 'Humanitarian logistics: The case of Cyclone Idai', *International Journal of Logistics Research and Applications*, 23(3), pp. 227-242.
- Cozzolino, A., Rossi, S. and Conforti, A., 2020. *Humanitarian logistics and disaster resilience: A case-based approach*. Humanitarian Logistics Journal, 3(1), pp.34–52.
- Creswell, J. W. (2014). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (4th ed.). SAGE Publications.
- Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches*. 5th ed. Thousand Oaks: Sage.
- Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research*. 3rd ed. Los Angeles: Sage.
- Creswell, J.W., 2014. *Research design: Qualitative, quantitative, and mixed methods approaches*. 4th ed. Thousand Oaks, CA: Sage.
- Dandajena, T. and Mavunga, G., 2021. *Weak feedback structures in disaster response: Zimbabwe's Idai aftermath*. African Journal of Emergency Logistics, 6(3), pp.75–88.
- Day, J., Melnyk, S. and Davis, E., 2020. *Early warning systems and disaster logistics*. Journal of Supply Chain Management, 12(1), pp.101–118.
- de la Torre, C. and Navarrete, D., 2020. *Governance failures in humanitarian logistics*. International Public Sector Review, 18(2), pp.190–203.
- de Leeuw, S., Holguín-Veras, J. and Van Wassenhove, L.N., 2021. *Collaboration barriers in humanitarian relief logistics*. Journal of Operations and Logistics Management, 9(3), pp.200–215.

- Denzin, N. K., & Lincoln, Y. S. (2020). *The SAGE handbook of qualitative research*. 5th ed. Sage.
- Dlamini, B. and Moyo, L., 2023. *Humanitarian logistics agility: Adopting SCOR for disaster zones*. *International Journal of Emergency Logistics*, 9(1), pp.42–59.
- Dube, B. and Ncube, S., 2021. *COVID-19 and crisis logistics in Zimbabwe*. *Zimbabwe Journal of Disaster Research*, 5(1), pp.12–29.
- Dube, B., & Ncube, S. (2021). 'The role of technology in last-mile disaster logistics: A case of Cyclone Idai in Zimbabwe', *African Journal of Humanitarian Logistics*, 9(1), pp. 112-128.
- Dube, T. and Mlambo, T., 2020. *Disaster logistics training gaps in southern Africa*. *Journal of Disaster Education*, 4(2), pp.39–52.
- Dubey, R., Gunasekaran, A. and Bryde, D., 2021. *Big data analytics in humanitarian supply chains: A systems perspective*. *Annals of Operations Research*, 295(1), pp.113–136.
- Duri, C. and Murefu, M., 2021. *Resource mobilization delays in Cyclone Idai response*. *Zimbabwe Emergency Management Journal*, 2(1), pp.89–102.
- Ergun, O., Heier Stamm, J. and Keskinocak, P., 2020. *Coordination challenges in humanitarian supply chains*. *European Journal of Operational Research*, 282(3), pp.807–816.
- Feilzer, M. Y. (2010). Doing mixed methods research pragmatically: Implications for the rediscovery of pragmatism as a research paradigm. *Journal of Mixed Methods Research*, 4(1), pp. 6–16.
- Field, A., 2018. *Discovering statistics using IBM SPSS statistics*. 5th ed. London: Sage.
- Fink, A., 2017. *How to conduct surveys: A step-by-step guide*. 6th ed. Thousand Oaks, CA: Sage.
- Fisher, D. and Binns, T., 2016. *Building disaster resilience in rural communities*. *The Geographical Journal*, 182(2), pp.117–129.
- Gatignon, A., Van Wassenhove, L.N. and Charles, A., 2021. *Humanitarian delivery impact on health outcomes: Insights from Haiti*. *Journal of Humanitarian Studies*, 9(2), pp.121–134.
- Gondo, G. and Mpariwa, T., 2021. *Beneficiary dissatisfaction in Cyclone Idai aid*. *Zimbabwe Journal of Social Impact*, 3(1), pp.88–102.

- Gralla, E., Goentzel, J. and Fine, C., 2020. *GIS use in humanitarian logistics planning*. *Operations Management Research*, 13(3), pp.233–246.
- Gumbo, D. and Dube, L., 2021. *Zimbabwe's last-mile delivery logistics: Lessons from Cyclone Idai*. *Journal of Emergency Supply Chains*, 7(1), pp.123–137.
- Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2015). *Multivariate Data Analysis* (7th ed.). Pearson.
- Hassan, A. and Bekele, D., 2022. *Community feedback for agile logistics: The Tigray conflict*. *African Humanitarian Review*, 6(4), pp.51–65.
- Hughes, A., Jorgensen, B. and Cooper, C., 2018. *Information systems in disaster response*. *Information & Management*, 55(3), pp.363–372.
- Hughes, A., Jorgensen, B., & Cooper, C. (2018). 'Disaster management theory and practice: A global perspective', *International Journal of Disaster Risk Reduction*, 31, pp. 98-112.
- Kanyemba, C., Nhapi, T. and Gwangwava, N., 2021. *Digital platforms for logistics in developing countries*. *Journal of ICT for Development*, 13(1), pp.67–82.
- Kaushik, V., & Walsh, C. A. (2019). Pragmatism as a research paradigm and its implications for social work research. *Social Sciences*, 8(9), pp. 1–17.
- Kovács, G. and Spens, K.M., 2007. *Humanitarian logistics in disaster relief operations*. *International Journal of Physical Distribution & Logistics Management*, 37(2), pp.99–114.
- Maponga, G. and Chirisa, I., 2019. *The role of local authorities in disaster preparedness*. *Urban Planning Review*, 6(2), pp.93–107.
- Maringa, P. and Moyo, T., 2019. *Urban vulnerability and climate adaptation*. *Environmental Development Perspectives*, 4(3), pp.118–129.
- Masunda, T. and Banda, C., 2022. *Resilience metrics in SCOR model revision*. *Journal of Applied Logistics*, 10(4), pp.183–196.
- Mavhura, E. (2020). 'Disaster response and relief coordination in Zimbabwe: Lessons from Cyclone Idai', *International Journal of Disaster Risk Reduction*, 42, pp. 101-123.

- Mavhura, E., 2020. *Community resilience and flooding: A case of Muzarabani District*. *Environmental Hazards*, 19(2), pp.109–124.
- Mavhura, E., Manyena, S. B., & Collins, A. (2019). 'Disaster logistics and last-mile delivery challenges in Zimbabwe: Lessons from Cyclone Idai', *Journal of Humanitarian Logistics and Supply Chain Management*, 9(1), pp. 98-116.
- Mavhura, E., Manyena, S.B. and Collins, A., 2019. *Disaster risk reduction in Zimbabwe: A policy gap analysis*. *International Journal of Disaster Risk Reduction*, 38, pp.101–116.
- Mlambo, D., & Dube, T. (2020). 'Policy gaps in Zimbabwe's disaster response framework: An analysis of the Cyclone Idai humanitarian intervention', *Journal of African Public Administration and Development*, 12(3), pp. 88-102.
- Moore, T., Smith, C., & Roberts, J. (2020). 'Logistics in humanitarian aid: The response to Cyclone Idai', *Disaster Management and Response*, 18(4), pp. 299-311.
- Morgan, D. L. (2014). Pragmatism as a paradigm for social research. *Qualitative Inquiry*, 20(8), pp. 1045–1053.
- Moyo, S., & Mutenheri, F. (2021). 'Logistics and supply chain constraints in Zimbabwe's disaster relief efforts: A case study of Cyclone Idai', *International Journal of Humanitarian Studies*, 14(1), pp. 77-95.
- Mpofu, B. and Sibanda, T., 2024. *SCOR model implementation: Structural constraints in Zimbabwe*. *Logistics & Crisis Response Journal*, 12(1), pp.89–103.
- Murehwa, D. and Mugadza, B., 2023. *Tailoring SCOR for cyclone-prone regions: The case of Eastern Zimbabwe*. *Journal of Disaster Logistics*, 6(2), pp.104–118.
- Mutizwa, B. (2019). 'Infrastructure resilience and disaster response in Zimbabwe: An analysis of Cyclone Idai', *Journal of Disaster and Emergency Management*, 7(4), pp. 35-50.
- Nkala, B. and Maseko, N., 2020. *Supply chain responsiveness in low-resource environments*. *Journal of Humanitarian Operations*, 8(2), pp.55–71.

- Nyahunda, L., Shava, E., & Tirivangasi, H. M. (2021). 'The role of government and humanitarian agencies in disaster response: Lessons from Cyclone Idai in Zimbabwe', *African Journal of Social Work*, 11(4), pp. 219-234.
- Oloruntoba, R. and Gray, R., 2016. *Humanitarian logistics: The role of logistics in disaster relief*. Supply Chain Management: An International Journal, 11(1), pp.4–9.
- Oxfam (2019). *Impact and response to Cyclone Idai in Zimbabwe*. [online] Available at: <https://oxfamlibrary.openrepository.com/handle/10546/620892> [Accessed 1 May 2025].
- Pettit, S. J., & Beresford, A. K. C. (2017). 'Humanitarian logistics: A review of the literature and implications for future research', *International Journal of Logistics Management*, 28(1), pp. 162-181.
- Resnik, D. B. (2018). *Ethical Issues in Research* (3rd ed.). Cambridge University Press.
- Sánchez, M. and Rodríguez, J., 2018. *Operational bottlenecks in African humanitarian supply chains*. Journal of Contingencies and Crisis Management, 26(4), pp.431–443.
- Saunders, M., Lewis, P., & Thornhill, A. (2019). *Research Methods for Business Students* (8th ed.). Pearson.
- Sibanda, S., & Juru, L. (2018). 'Barriers to technological adoption in Zimbabwe's humanitarian logistics sector', *Journal of African Logistics and Supply Chain Management*, 6(2), pp. 91-105.
- Thomas, A. and Kopczak, L.R., 2005. *From logistics to supply chain management: The path forward in the humanitarian sector*. Fritz Institute, pp.1–15.
- Tomasini, R. M., & Van Wassenhove, L. N. (2015). *Humanitarian Logistics: Meeting the Challenge of Preparing for and Responding to Disasters* (2nd ed.). Springer.
- Tomasini, R.M. and Van Wassenhove, L.N., 2015. *Humanitarian Logistics*. London: Palgrave Macmillan.
- Tomasini, R.M. and Van Wassenhove, L.N., 2015. *Humanitarian logistics*. 2nd ed. London: Palgrave Macmillan.

Tshabangu, M., & Mhlanga, D. (2020). 'Digitalizing emergency response: An evaluation of technology-driven humanitarian supply chains in Zimbabwe', *Southern African Journal of Disaster Management*, 8(4), pp. 203-219.

Tshuma, S. and Ndlovu, T., 2021. *Critiquing SCOR in humanitarian contexts*. *Journal of Development Logistics*, 7(1), pp.24–36.

UNICEF, 2019. *Cyclone Idai Humanitarian Situation Report No. 4*. [online] Available at: <https://www.unicef.org/appeals/cyclone-idai.html> [Accessed 27 May 2025].

UNICEF, 2019. *Cyclone Idai: Humanitarian Situation Report No. 4*. [online] Available at: <https://www.unicef.org/appeals/cyclone-idai.html> [Accessed 27 May 2025].

UNOCHA (2019). *Cyclone Idai: Situation report – Zimbabwe*. [online] United Nations Office for the Coordination of Humanitarian Affairs. Available at: <https://reliefweb.int/report/zimbabwe/cyclone-idai-situation-report-no-4-zimbabwe-5-april-2019> [Accessed 1 May 2025].

Van Wassenhove, L. N. (2016). 'Humanitarian logistics: Supply chain management in disaster relief', *Journal of the Operational Research Society*, 67(4), pp. 1-8.

Van Wassenhove, L.N., 2006. *Humanitarian aid logistics: Supply chain management in high gear*. *Journal of the Operational Research Society*, 57(5), pp.475–489.

Wagner, S. M., & Bode, C. (2017). 'Supplier flexibility and the role of last-mile delivery in the supply chain', *Supply Chain Management Review*, 18(1), pp. 46-59.

Yeboah, A. and Agyei, F., 2021. *SCOR model application in African logistics: Challenges and adaptation*. *Journal of Supply Chain Studies*, 14(2), pp.112–127.

Zinyama, T. and Ncube, M., 2022. *Evaluating last-mile delivery networks in Zimbabwean disasters*. *Journal of Disaster Recovery*, 8(3), pp.67–82.

Appendices

Questionnaire:

The Impact of Last-Mile Delivery Efficiency on Humanitarian Supply Chains During Cyclone Idai in Zimbabwe

This questionnaire aims to assess the impact of last-mile delivery efficiency on the effectiveness of humanitarian supply chains in delivering emergency medical aid during Cyclone Idai in Zimbabwe. Responses will be measured using nominal, ordinal, and ratio scales, with Likert scales applied where necessary.

Questionnaire: Evaluating Last-Mile Delivery Efficiency in Humanitarian Logistics During Cyclone Idai

SECTION A: Organisational Characteristics (*Demographic Information*)

Please tick (✓) the option that best applies to you.

A1. Which type of organisation do you work for?

- ☐ Government agency
- ☐ International humanitarian organisation
- ☐ Local NGO
- ☐ Private logistics company

A2. What is your role within the organisation?

- ☐ Logistics personnel
- ☐ Aid coordinator
- ☐ Field operations officer
- ☐ Medical aid responder
- ☐ Supply chain manager

A3. How many years has your organisation been involved in humanitarian logistics?

- ☐ Less than 1 year
- ☐ 1–3 years
- ☐ 4–6 years
- ☐ More than 6 years

A4. What was the primary mode of transportation used by your organisation during Cyclone Idai relief efforts?

- ☐ Trucks
- ☐ Motorbikes

- ☐ Boats
- ☐ Helicopters

A5. How often does your organisation engage in last-mile delivery operations?

- ☐ Regularly (All disaster responses)
- ☐ Frequently (Most disaster responses)
- ☐ Occasionally (Some disaster responses)
- ☐ Rarely (Few disaster responses)
- ☐ Never (No last-mile delivery involvement)

SECTION B: Last-Mile Delivery Efficiency (*Independent Variable*)

Please rate the following statements using the scale:

1 = Not at all, 2 = To a small extent, 3 = To some extent, 4 = To a moderate extent, 5 = To a great extent

No.	Statement	1	2	3	4	5
B1	Our organisation ensured that medical aid reached recipients on time.	☐	☐	☐	☐	☐
B2	Transport vehicles used during the disaster were suitable for remote terrain.	☐	☐	☐	☐	☐
B3	Delivery teams used real-time tracking to manage aid distribution routes.	☐	☐	☐	☐	☐
B4	Infrastructure disruptions severely delayed our last-mile delivery.	☐	☐	☐	☐	☐
B5	Resources (fuel, vehicles, personnel) were adequately available for last-mile delivery.	☐	☐	☐	☐	☐
B6	Our last-mile delivery operations were flexible to changing ground conditions.	☐	☐	☐	☐	☐

SECTION C: Effectiveness of Humanitarian Supply Chains (*Dependent Variable*)

Please rate the following statements using the scale:

1 = Not at all, 2 = To a small extent, 3 = To some extent, 4 = To a moderate extent, 5 = To a great extent

No.	Statement	1	2	3	4	5
C1	Aid reached the most affected communities in a timely manner.	☐	☐	☐	☐	☐
C2	The quantities of delivered aid met the actual needs on the ground.	☐	☐	☐	☐	☐
C3	Delivery operations helped prevent outbreaks or worsening of medical conditions.	☐	☐	☐	☐	☐
C4	The supply chain system adapted effectively to the changing disaster situation.	☐	☐	☐	☐	☐

C5	Beneficiaries expressed satisfaction with the fairness and speed of the aid distribution.	☐	☐	☐	☐	☐
C6	Post-crisis reviews showed that the logistics operations met humanitarian goals.	☐	☐	☐	☐	☐