# BINDURA UNIVERSITY OF SCIENCE EDUCATION


## FACULTY OF COMMERCE

## DEPARTMENT OF ECONOMICS

**The Impact of Digital Transformation on Public Sector Supply Chain Resilience During Emergencies and Crises: A Case of Zimbabwe's Public Hospitals During COVID-19**

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## APPROVAL FORM

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

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

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# DEDICATION

I **Sherphard Tizirai,** 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.

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# Abstract

This study investigates the impact of digital transformation on the resilience of public hospital supply chains in Zimbabwe during emergencies and crises. A quantitative approach was selected, and 384 public healthcare institutions in Zimbabwe were provided with the same questionnaire. The sample was chosen by stratified random sampling to make sure that all provinces and hospital levels were included. The instrument was developed using a thorough and rigorous method to ensure its validity and reliability. A pilot study was done to check the questions' clarity and how well they match the construct, which resulted in changes that enhanced the questionnaire's accuracy. The tool's content validity was confirmed by expert reviews from digital health professionals and logistics specialists. To check reliability, Cronbach's alpha was used, and all constructs were above 0.7, which means they are internally consistent. The study used descriptive statistics and multiple linear regression to analyses the data. Results from Objective 1 indicate that public hospitals in Zimbabwe are at a moderate point in their digital transformation. The findings for Objective 2 suggest that hospital supply chain resilience is moderate. Even though institutions have basic plans for emergencies, they are not very flexible and coordination between departments is weak, which makes it harder for them to recover from disruptions and maintain their work. Objective 3 multiple regression analysis demonstrated a statistically significant and positive relationship between digital transformation and supply chain resilience. In conclusion, the research shows that digital transformation supports supply chain resilience. The study recommends creating a national digital health strategy, invest in digital tools, train staff in using them, and move logistics decisions to local levels. Collaboration and interoperability among public health departments are necessary for achieving both scalability and sustainability. Based on policy implications, the Ministry of Health should give priority to digital transformation and include digital indicators in their national health monitoring systems. This means public hospitals should form lasting relationships with digital companies and start using flexible and real-time logistics systems. Limitations of the study include the cross-sectional nature of data, which limits causal inference, and reliance on self-reported data, which may introduce response bias. The study's results cannot be applied to private hospitals and rural clinics. Future studies should use designs that last over time or combine different methods, examine private healthcare institutions, and analyze other factors that help healthcare systems become resilient, such as the quality of governance, leadership, and culture.

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# CHAPTER 1

# INTRODUCTION

## 1.1 Introduction

Public sector supply chains need to demonstrate resilience during emergencies because it maintains essential service delivery particularly for healthcare. Supply chain resilience receives essential support from digital transformation which allows for enhanced efficiency alongside improved transparency and better responsiveness. Public hospitals in Zimbabwe face critical supply chain disruption problems because of economic instability and policy challenges and the global COVID-19 pandemic thus requiring immediate technological integration. Research has not established how extensively digital tools such as data analytics, blockchain and automation have been implemented and what effects they have on supply chain resilience. This research examines the effects digital transformation has on public hospital supply chain responsiveness and adaptability in emergency situations throughout Zimbabwe. The study seeks to reveal both opportunities and obstacles which will help government leaders improve healthcare supply chain resilience by implementing digital innovations.

## 1.2 Background of the Study

In recent decades, the frequency and severity of natural disruptions such as pandemics, floods, earthquakes, wildfires and cyclones have significantly increased, severely impacting global supply chains. Global records from 2022 in EM-DAT indicate that 387 natural disasters took lives of more than 30,700 victims and affected 185 million people and resulted in economic losses exceeding $223.8 billion (CRED, 2023). Traditional supply chain systems faced major vulnerabilities when these disruptions occurred which resulted in extensive delays together with shortages and increased costs. The 2019 Cyclone Idai disaster in Southern Africa caused the death of 1,300 people and displaced 2.6 million residents while damaging the entire local supply infrastructure (ReliefWeb, 2019). The COVID-19 pandemic revealed existing supply chain weaknesses that caused complete logistics shutdowns and extended procurement delays and disrupted worldwide trade operations (OECD, 2021). The stronger need for better supply chain frameworks which respond and adapt persists because of escalating shocks from climate change and globalization.

This research investigates digital transformation as a strategic solution to enhance supply chain resilience during such emergencies.

Emergencies and crises place immense pressure on public health supply chains, often resulting in delayed access to essential medicines, equipment and healthcare services. Advanced economies revealed essential failures within their health logistics systems when facing the COVID-19 pandemic on a global scale. At crucial times India together with Italy and Brazil experienced extensive oxygen shortages along with ventilator and PPE and vaccine deficits which exposed the weaknesses in their supply chain networks (WHO, 2020). The response to the 2010 Haiti earthquake and 2014 Ebola outbreak in West Africa faced delays because of ineffective supply chain distribution and unclear inventory tracking and insufficient coordination systems (UNICEF, 2015; MSF, 2016). The World Health Organization (2021) documented these disruptions as causes of preventable deaths that worsened public health results. The public health supply chain faces ongoing difficulties due to subpar procurement systems and inadequate infrastructure together with separated logistics processes. The worldwide patterns demonstrate a critical requirement for innovative system changes within public health supply chain management systems that handle crises.

Humanitarian organizations and international development actors have increasingly turned to digital tools to strengthen supply chain resilience in crisis-prone regions. Different UN agencies including WFP and UNICEF use drone logistics with blockchain traceability and digital tracking to monitor their supply operations (WFP 2021, UNICEF 2020). These technical solutions help deliver supplies faster while matching supply with needs better and show what is happening in challenging humanitarian situations. The Global Humanitarian Response Plan used digital health logistics platforms to help emergency medical supply distribution and procurement coordination across worldwide organizations during COVID-19 (UNOCHA, 2020). Mobile logistics management tools Supply and Logistics have been set up in remote areas to simplify vaccine and drug transportation according to GAVI (2021). These innovations show promise but need further development to work consistently across all healthcare settings especially in poor regions (Peters et al., 2022). Humanitarian actors who take part in digital innovation show us the ways health supply chains can transform throughout the public sector.

Africa remains particularly vulnerable to health supply chain disruptions due to recurring epidemics, conflict, climate shocks and weak infrastructure. During the 2014-2016 Ebola outbreak in West Africa inventory management problems and medical resource distribution failures made response efforts too late and caused unnecessary deaths (UNDP, 2016). The COVID-19 pandemic blocked vaccine and PPE deliveries throughout Africa which shows that the region needs better systems to prepare for emergencies (Africa CDC, 2021). African countries continue to use basic hand-written systems that do not let users see what happened to products or track medical supplies effectively (PATH, 2020). The African Union shows that more than half of African health supply chains rely on basic digital systems. While the Africa Medical Supplies Platform and Gavi-supported ELMIS programs have been established they have faced limited acceptance across the region (Gavi, 2022). Insufficient technical skills and budget shortages alongside weak policies slow down development in this area. African countries should build digital networks and partner across regions to make their public health supply systems more resistant and faster to respond during emergencies.

The public health supply chain in Zimbabwe suffers from chronic operational problems and poor maintenance which makes it vulnerable to supply chain disruptions during crises. During the COVID-19 pandemic the Ministry of Health and Child Care (MoHCC) found major weaknesses in how they prepared for emergencies plus how they bought and managed medical supplies (MoHCC, 2021). The public health system continues to face ongoing problems with drug shortages and empty supplies at rural clinics plus ineffective decision-making tools (Chikowore & Mlambo, 2022). In 2021 the Ministry of Health and Child Care found that only 30% of public health facilities across the nation used digital supply chain management tools (MoHCC, 2021). The lack of clear teamwork between departments and missing digital platforms make it harder to handle emergencies (Bvumburai & Mandizvidza, 2022). E-health and electronic procurement system pilot projects run in urban areas face difficulties expanding across the entire country. This situation calls for a systematic investigation into how digital transformation can enhance supply chain resilience in Zimbabwean public hospitals.

### 1.3 Problem Statement

Public hospital supply chains face major challenges from continuous crises which include economic downturns combined with disease outbreaks and global supply chain breakdowns. The

public healthcare sector of Zimbabwe shows restricted and scattered implementation of digital transformation solutions despite their known advantages for supply chain enhancement. Public hospitals maintain their inventory management systems on paper while using manual methods which produces delayed medical supply deliveries and critical shortages along with suboptimal procurement operations. COVID-19 exposed critical weaknesses which demonstrated the necessity to implement digital solutions including automated inventory tracking with real-time data analytics and integrated procurement systems. Digital adoption has faced resistance along with funding constraints and insufficient infrastructure which act as barriers to change. This research investigates how far digital transformation helps public hospitals in Zimbabwe build supply chain resilience through identification of crucial challenges and opportunities to guide policy decisions and strategic measures.

### 1.4 Research Objectives

**Main Objective:**

To assess the impact of digital transformation on the resilience of public sector supply chains in Zimbabwe's public hospitals during emergencies and crises.

**Sub-Objectives:**

i. To examine the current state of digital transformation in Zimbabwe's public hospital supply chains.
ii. To assess the level of resilience in Zimbabwe's public hospital supply chains during emergencies and crises.
iii. To evaluate the impact of digital transformation initiatives in Zimbabwe on the resilience of public hospital supply chains during emergencies and crises.

### 1.5 Research Questions

**Main Research Question:**

How does digital transformation impact the resilience of public sector supply chains in Zimbabwe's public hospitals during emergencies and crises?

**Sub-Questions:**

i. What is the current state of digital transformation in Zimbabwe's public hospital supply chains?
ii. What is the current level of resilience in Zimbabwe's public hospital supply chains during emergencies?
iii. What is the impact of digital transformation initiatives on the resilience of public hospital supply chains during emergencies and crises.

### 1.6 Significance of the Study

The research adds essential knowledge about digital transformation's ability to strengthen supply chain resilience for Zimbabwe's public hospitals throughout emergencies and crises. The research gives important guidance to government agencies and policymakers about how digital technologies enhance supply chain efficiency and visibility and responsiveness in healthcare. The study reveals essential barriers and possibilities which will support policymakers to develop digital adoption policies for public healthcare institutions.

Hospital administrators together with supply chain managers gain practical value from this research because it presents solutions to reduce disruptions and shorten procurement times and improve inventory management. Healthcare institutions should understand how digital tools like real-time tracking, automation and data analytics benefit supply chain performance to make better implementation choices.

The research adds value to academic knowledge about digital transformation efforts in healthcare systems operating with limited resources. The research findings about public sector digitalization and supply chain resilience in low-income economies will serve as a basis for future studies because Zimbabwe lacks extensive research on this topic. The study provides relevant insights to international development organizations and donors by offering evidence-based recommendations to support digital transformation initiatives in Zimbabwe's healthcare sector.

### 1.7 Assumptions of the Study

The research depends on various fundamental assumptions about how digital transformation affects public sector supply chain resilience within Zimbabwe's public hospitals. The study begins with the premise that digital transformation offers supply chains improved emergency response capabilities through real-time data access and automated inventory control systems. The research

bases its findings on the assumption that Zimbabwe's public hospitals currently maintain low digital adoption rates because their traditional manual systems prevent efficient crisis management. The main obstacles to digital transformation in public healthcare supply chains stem from financial limitations and insufficient technical know-how and weak digital infrastructure. The research assumes that healthcare administrators together with policymakers understand digitalization's value yet encounter various obstacles in executing its implementation. The research assumptions state that the study's outcomes will deliver practical recommendations which can help Zimbabwe's public healthcare sector to develop strategic policies.

### 1.8 Delimitations of the Study

This research examines the impact of digital transformation on public sector supply chain resilience within Zimbabwe's public hospitals throughout emergencies and crises. The research examines public healthcare institutions exclusively and omits private hospitals together with other healthcare facilities from the study. Public hospitals deal with distinctive supply chain difficulties because of government regulations along with funding limitations.

The research analyses three digital technologies: automated inventory systems and real-time data analytics and e-procurement solutions. The analysis omits non-digital supply chain techniques in order to study digital transformation's influence on resilience enhancement.

The research boundaries are set to Zimbabwe's public hospitals instead of expanding to a wider international or regional scope. The study provides detailed knowledge of local conditions that enables researchers to generate recommendations which directly benefit national policy initiatives.

The research investigates supply chain resilience effects from digital transformation projects that hospitals started ten years ago. The research excludes older initiatives dating before the stated time period to focus on initiatives relevant to present healthcare supply chain challenges.

The research dedicates its attention to studying hospital internal policies and systems instead of disruptions affecting supply chains at a global level. Zimbabwe's public hospitals concentrate their primary efforts on internal digital transformation while maintaining awareness of external influences.

## 1.9 Definition of Terms

The following key terms are defined to ensure clarity and consistency throughout the study:

Digital Transformation: In the context of healthcare, digital transformation refers to the integration of digital technologies such as automated inventory systems, e-procurement platforms and real-time data tracking into hospital operations to improve efficiency, visibility and responsiveness (Henri, 2021).

Supply Chain Resilience: The capability of a hospital to predict, absorb, adapt and rebound to supply chain disturbances like stockout, pandemics or logistical delays is what is meant by supply chain resilience with the aim of sustaining essential services (Pettit, Fiksel & Croxton, 2010).

Automated Inventory Systems: It is a computer program that helps to monitor the number of items in the inventory, automates stock replenishment procedures and minimize human elements involved in stock management (Yadav & Desai, 2020).

E-Procurement: An online form of procurement, in which goods and services are obtained through electronic systems, which improve transparency, minimize paperwork and accelerate the supply process (Neupane, Soar & Vaidya, 2014).

Real-Time Data Tracking: This implies monitoring the location and condition of supplies in real time by the use of technology such as RFID, GPS, or IoT devices, being able to make faster decisions and remove uncertainty related to logistics (Fernandez-Carames & Fraga-Lamas, 2018).

Hospital Supply Chain: An integrated system of individuals, procedures, technologies, as well as resources dealing with the procurement of medical supplies and equipment in a hospital context (medical supplies) and equipment (Alverson et al., 2017).

## 1.10 Acronyms

| Acronym | Full Meaning |
|---|---|
| ICT | Information and Communication Technology |
| SCM | Supply Chain Management |
| MoHCC | Ministry of Health and Child Care |
| RFID | Radio Frequency Identification |

| | |
|---|---|
| IoT | Internet of Things |

## 1.11 Chapter Summary

This chapter has introduced the study by providing background, problem statement, research objectives and research questions. It emphasized the importance of studying the role of digital transformation in the supply chain of public hospitals in Zimbabwe, particularly due to the persistence of logistical and infrastructural issues in the case of emergencies. The chapter also addressed the significance of the study, which included the contributions that the study was expected to make to policy, practice, and future research. The assumptions on which the study was based were mentioned, and delimitations were made to explain the scope and boundaries of the study. Also, the main terms of the study were defined, and the list of acronyms was given to facilitate clarity and consistency in the dissertation.

Chapter Two: Literature Review expounded on both the Supply Chain Resilience Theory and the TOE framework. Research was conducted in different areas to analyse the digital initiatives in healthcare logistics and define the most significant challenges and advantages. The chapter went on to talk about the effect of digital maturity on the responsiveness of the supply chain and cited gaps in the current research that needs to be filled.

Chapter Three: Research Methodology presented the methodology of the study. It outlined the manner in which a positivist research paradigm and quantitative design was employed to guide the collection of empirical data. The chapter described research design, target population, sample size, and sampling methods that would be used to determine the respondents. It also described the data collection activities like the design and administration of the research instrument. The data analysis procedures were discussed, and the way in which the results were going to be interpreted was indicated. The reliability and validity were factored in to make the results precise and stable. Lastly, ethical concerns such as informed consent, confidentiality and pilot testing were considered to enhance the credibility and integrity of the study.

Chapter Four: Data Presentation and Analysis presented and analysed the data with the help of both descriptive and inferential statistics in order to summarize the responses of health professionals. The results were organized into the questionnaire sections: starting with

organizational characteristics, then digital transformation indicators, and lastly supply chain resilience. The results were tabulated and interpreted to fit the objectives of the study.

Chapter Five: Summary, Conclusions and Recommendations drew together the main findings of the research and connected them to the initial research questions and available literature. It evaluated the role of digital transformation in improving supply chain resilience and elaborated on the implications of its findings to the healthcare policy and infrastructure as well as the operations of the hospitals in Zimbabwe. The chapter ended with the conclusion and recommendations, limitations of the study, and future scope of the research based on which the healthcare logistics can be enhanced with the help of emerging technologies.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

This chapter provides a thorough overview of the literature related to digital transformation and resilience in supply chains in Zimbabwe's public hospitals. First, it discusses the theories that support the study, including Supply Chain Resilience Theory, the Technology Acceptance Model and the Dynamic Capabilities Theory. The chapter next presents the main ideas that explain the relationship between digital transformation and resilience. A thorough review of studies is then performed, focusing on the study's goals: looking at the current status of digital transformation, assessing resilience levels and evaluating the effects of digital tools on resilience during crises. The chapter studies global, regional and local studies to highlight important themes, show typical approaches and point out major knowledge gaps. This chapter's literature review serves as a base for the study's research design and emphasizes the importance of examining Zimbabwe's health issues in their context.

## 2.2 Theoretical Framework

The next section describes the key theories that validate the key concepts of the study. It examines how healthcare supply chains can manage disruptions through new technologies and acquisition of strategic skills. Supply Chain Resilience Theory and Dynamic Capabilities Theory provide the basis of the study of how digital transformation enhances the resilience of public hospitals.

### 2.2.1 Supply Chain Resilience Theory

According to the Supply Chain Resilience (SCR) Theory, supply chains are expected to be capable of managing surprises, responding to them and recovering even though they remain operational and adaptable. Initially, the theory was suggested by Ponomarov and Holcomb and in the course of time the theory has grown to include resilience in the context of robustness, flexibility and responsiveness in supply chain networks. SCR that Khan et al. (2020) define relies on proactive and reactive measures that maintain the supply chain in motion in case of an emergency. Birkie et al. (2021) further stated that digital tools and real-time analytics could enhance the capacity of a company to respond to changes and make sound decisions. Yahaya and Barasa (2022) included

risk anticipation and technology application as valuable factors contributing to healthcare systems. Achora and Kamanyire (2020) are convinced that resilience in health systems plays a crucial role in maintaining essential services in the case of pandemics, particularly when medical logistics are threatened.

SCR Theory is useful because it stresses preparedness at the systems level and the need for flexibility which matters a lot in healthcare. Thakkar and Joshi (2023) highlight that the theory helps in conducting empirical studies by using measurable concepts such as how quickly a system recovers and how redundant it is. Also, this theory promotes working with several actors and investing in infrastructure that allows for quick responses which is important when resources are scarce (Dube & Marange, 2021). Some critics such as Banda and Chigudu (2022), say that the theory does not always consider issues like weak institutions and poor digital infrastructure in low-income countries. Mlambo et al. (2023) also point out that SCR Theory overlooks the role of behaviour and politics in decision-making for procurement and logistics in the public sector. In spite of its drawbacks, the theory helps explain vulnerabilities and resilience as something that keeps improving rather than remaining fixed.

This study uses the SCR Theory due to the fact that it is relevant to the supply chains of the public hospitals in Zimbabwe that frequently face health emergencies, economic issues and logistical challenges. The theory will inform the study in the analysis of how hospitals manage, react and recover to supply chain disruptions through the application of technology. According to Tshuma and Hove (2021), the SCR framework can help identify the areas of weakness in the public health logistics and plan the way to develop resilience. Similarly, Mukurunge and Ndlovu (2022) examine the issue of disaster response in rural healthcare facilities, showing that the preparedness of a facility may influence the duration that a facility can sustain care. Mazikana and Mupfiga (2023) state in their research that policymakers can compare the performance of various hospitals by applying flexibility, responsiveness and risk management. Chivasa and Mangena (2024) state that the use of SCR Theory in the digital transformation initiatives may provide practical recommendations aimed at enhancing the responsiveness of health services provided within the Zimbabwean public sector.

### 2.2.3 Dynamic Capabilities Theory

The Dynamic Capabilities Theory (DCT) which postulates that the ability of an organization to adapt and integrate various skills both internally and externally is critical in sustaining competitive advantage in dynamic markets was developed by Teece, Pisano and Shuen in 1997. Under this theory, organizations ought to be keen on opportunities and threats and utilize them and transform their processes in order to remain in line with the changes occurring. These capabilities are required in the face of emergencies by the public health supply chains to manage disruptions and maintain the flow of logistics. Mutize and Gumede (2021) claim that hospitals must be adaptable and capable of predicting shortages, utilizing their resources efficiently and rearranging their procurement strategies in a short period of time. Recently, Barreto (2020) and Teece (2021) have noted that the application of digital technologies and learning in organizations contributes to their better adaptation to changes. This transformation indicates the growing significance of the model in the process of digital transformation of the public sector, particularly in the event of an unanticipated health crisis such as a pandemic.

DCT is especially strong because it stresses the importance of being flexible and always improving, making it fit for the health sector. Many industries, including logistics and public administration, have applied this theory to show how institutions manage to perform well despite uncertainty (Marufu & Ndlovu, 2022). The focus on learning and new ideas in education supports digital transformation which requires systems to be updated using user input and changing situations. Some critics believe that the theory covers too many areas and is difficult to apply, especially in areas with few resources (Mushayi & Mhaka, 2023). Also, because capabilities are abstract, their use in research can be unclear or inconsistent unless they are clearly defined (Zhou & Bhebhe, 2021). In countries such as Zimbabwe, the theory's focus on updating organizations may be held back by problems such as strict bureaucracy, lack of money and political meddling which slow down changes in government bodies.

In spite of these issues, DCT can be used here to outline how public hospitals in Zimbabwe can use digital technology to improve their supply chain management. During emergencies like disease outbreaks or disasters, hospitals should be prepared to handle their usual duties and respond quickly to secure important supplies. Mudarikwa and Chikowore (2022) indicate that hospitals with flexible supply processes and leaders who responded well coped better with the scarcity of

supplies during the COVID-19 pandemic. Likewise, Mhandu and Tafirenyika (2023) discovered that companies that used digital tools and flexible supplier relationships became more resilient during logistical challenges. Through the dynamic capabilities lens, the study evaluates how hospitals notice changes, adopt new technologies and redesign their supply systems to deal with disruptions. Therefore, the theory supports the evaluation of how digital transformation helps or hinders the strength of a supply chain.

## 2.3 Digital Transformation and Its Role in Supply Chains

### 2.3.1 Conceptualising Digital Transformation

Digital transformation (DT) is the basic change in the way organisations use digital technologies to innovate processes, improve performance, and create value to stakeholders. It is not limited to the simple digitalisation of the analogue processes but also a cultural and strategic transformation of organisations. Vial (2019) defines digital transformation as a set of co-ordinated changes in products, processes and organisational structures, supported by integration of digital technologies. Researchers distinguish between digitisation, i.e., the conversion of analogy information into digital, and digitalisation, i.e., optimisation of processes with the assistance of digital tools (Henriette et al., 2016). The final outcome of the two is digital transformation, which involves a systemic shift, which enables novel business models, higher customer involvement, and efficiency. It has been applied in various fields, including healthcare, finance, and logistics, and education, and it is often linked to cloud computing, big data analytics, the Internet of Things (IoT), and artificial intelligence (AI) (Verhoef et al., 2021).

Among the key characteristics of digital transformation is that it is multi-dimensional and encompasses technological, organisational and environmental dimensions. Technology-Organisation-Environment (TOE) framework is an effective instrument to examine the forces and barriers of digital transformation, particularly in the case of such industry as public healthcare, where institutional inertia and policy framework are significant aspects (Baker, 2012). One of the key factors that determine adoption is availability of infrastructure and IT skills that constitute technological readiness. Organisational factors, such as the commitment of the leadership, the ability of the staff, and culture, also determine the success of transformation efforts (Sebastian et al., 2017). External factors which influence the rate and extent of change include the regulatory environments, competitive pressures and societal expectations. These complex factors confirm the

idea that DT is not just a technological initiative but a multi-faceted strategic change that is affected by the evolving internal and external environment (Susanti et al., 2023).

Digital transformation also involves a shift in mentality and organisational learning, particularly in those industries where decisions are typically made in a hierarchical way and in paper form. It introduces new roles, processes and expectations that shatter the normalcy. Bharadwaj et al. (2013) are of the opinion that organisations undergoing digital transformation must come up with dynamic capabilities to sense and respond to technological opportunities in the right time. This includes the encouragement of innovation, learning agility, and scaling digital initiatives. Digital transformation in the field of healthcare and other mission-critical sectors is closely linked to the service delivery, accountability, and data-driven decision-making (Ismail et al., 2017). However, change programs are normally faced with resistance due to perceived threats to job positions, lack of data security and institutional resistance to change. As such, digital transformation is not a technological issue but a strategic, stakeholder, and long-term organisational change commitment (Schallmo et al., 2017).

### 2.3.2 Digital Technologies Driving Transformation

The digital transformation is largely influenced by the application of advanced technologies that change the manner in which organisations operate, communicate and deliver services. The core enablers are the Internet of Things (IoT), cloud computing, big data analytics, blockchain, and artificial intelligence (AI) to automate, integrate, and make data-driven decisions (Iansiti and Lakhani, 2020). To illustrate, IoT devices allow monitoring of assets and the environment in real-time, which enhances efficiency in different sectors. Cloud computing facilitates access to computing resources in an on-demand manner, scales up or down and reduces the infrastructure cost and allows remote access to systems and data (Almeida et al., 2020). Big data analytics, in its turn, allows organisations to extract valuable insights out of large amounts of data, to make predictive and prescriptive decisions. Most of the industries that are transforming, including logistics, healthcare, retail and manufacturing, have the digital backbone of the technologies that are central to the increasing organisational agility, transparency and responsiveness in the volatile environments (Ghosh et al., 2021).

Artificial intelligence is important in transforming business operations by means of intelligent automation and cognitive abilities. The machine learning algorithms are able to find patterns in the past data to predict trends, anomalies, and enhance the accuracy of planning in the supply chain and service delivery (Davenport and Ronanki, 2018). In healthcare logistics, such as in the case of AI, stock levels can be optimised, demand can be forecasted, and clinical decisions can be assisted. On the same note, blockchain provides decentralised, tamper-proof record-keeping that increases transparency, traceability, and trust in multi-stakeholder supply chains (Saberi et al., 2019). Digital twins are virtual representations of physical systems that are becoming common in manufacturing and logistics to model and optimise performance in the real world (Fuller et al., 2020). The combination of these technologies, which is also known as the Industry 4.0, results in the creation of a digital ecosystem that is interconnected and in which operational, tactical, and strategic decisions are constantly supported by real-time data and intelligent systems (Lee et al., 2014).

Nevertheless, although digital technologies have transformative potential, their use is not evenly distributed across sectors and regions. The differences in digital maturity, the presence of infrastructure, regulatory preparedness, and human capital introduce inequality in the implementation of technologies and their locations (Nambisan et al., 2019). In most developing environments, obstacles like exorbitant prices, poor connectivity, and technical skills are impediments to the implementation of technologies like AI and IoT. Digital adoption is also threatened by organisational resistance to change and cybersecurity issues (Wang et al., 2021). In addition, the inability of legacy systems to integrate with new platforms may slow down or make the change process complex. Therefore, although technology is the driver of digital transformation, the key to its successful results lies in the alignment of technological potentials with strategic objectives, the preparedness of stakeholders, and the realities of the situation (Li et al., 2018). The digital divide and the equitable access to enabling technologies are one of the priorities in the global transformation initiatives.

### 2.3.3 Sectoral Applications of Digital Transformation

Digital transformation has penetrated different industries where each of them has adopted the use of digital technologies as a way of creating value, efficiency, and responsiveness. The use of digital technologies such as mobile banking, blockchain, and robo-advisors has transformed how financial organizations engage with their customers, the efficiency of their operations, and security (Gomber

et al., 2018). Retail and e-commerce industries have applied big data analytics, AI, and augmented reality to personalise shopping, simplify inventory and logistics operations (Huang and Rust, 2021). Industry 4.0 technologies such as cyber-physical systems and digital twins have transformed the production process to smart factories, which are dynamic to changes in supply and demand (Kagermann et al., 2013). These examples of applications demonstrate that the digital transformation cannot be seen as the universal solution but the sector-specific process that depends on the peculiarities of challenges, regulatory frameworks, and competition. The plasticity of digital technologies in different spheres emphasizes their multifunctionality and the possibility of modification and enhancement of performance and resilience in unpredictable conditions (Warner and Wagner, 2019).

The other industry that has undergone a lot of change is the logistics and transportation industry which has been incorporated with the use of GPS tracking, route optimisation algorithms and real-time fleet management systems. Such technologies reduce delays, improve the accuracy of delivery, and fuel consumption, and this enables logistics providers to respond more effectively to disruptions (Rai et al., 2019). Likewise, digital technologies, including learning management systems (LMS), virtual classrooms, and AI-powered tutoring services, have resulted in the revolution in content delivery, interaction with learners, and access to education in the education sector (Bond et al., 2021). Agricultural sector has not been left behind and smart farming technologies like IoT-based irrigation system, drone surveillance, and AI-based crop diagnostics have found their way to the agricultural sector to enhance productivity and sustainability (Wolfert et al., 2017). Digital transformation in such industries does not only improve the outcomes of the operations but also results in more social goals, including inclusivity, sustainability, and innovation. These sectoral experiences are very helpful to the best practices and contextual challenges that can be applied to the public health systems.

The healthcare sector is usually behind in digital maturity because of the sensitivity of the data, the complexity of regulatory requirements, and the lack of coherent infrastructure despite the promising developments in the sector (Fahy and Williams, 2021). However, revolutionary projects are popping up in the world. Decision support systems, electronic health records (EHRs), and telemedicine platforms have enhanced the coordination of care and access to data in patients (Mesko et al., 2017). Digital supply chains such as eLMIS, predictive analysis, and barcode

scanning are some of the tools that hospitals and health ministries in different countries are using to streamline inventories and monitor medical supplies (Yadav, 2015). The sector specific applications indicate that although the technology potential is high across the board, the level of sectoral preparedness, policy frameworks, and commitment by leadership define the speed and success of digital transformation. A comparative sectoral perspective also identifies important enablers, including interoperability, digital skills, and strategic vision, that can guide transformation work in complex, resource-constrained sectors, such as public healthcare (Agarwal et al., 2020).

### 2.3.4 Digital Transformation in Healthcare Supply Chains

The medical chains of supply are an inalienable component of the functioning of the medical systems and ensure the efficient and prompt supply of drugs, equipment, and other necessary supplies. Digitalization in this field involves the use of electronic logistics management systems (eLMIS), inventory tracking technologies, and cloud-based platforms, which increase visibility, coordination, and accuracy (USAID, 2018). The tools facilitate in-time monitoring of stock balances, prevent stockouts and enhance accountability of the supply flows. According to De Vries and Huijsman (2011), the traditional healthcare supply chain was disintegrated and reactive and it was more likely to be characterised by manual operations and lack of data integration. Data-based decisions and predictive planning is possible with the implementation of digital systems, which is required in routine work and response to emergencies. In addition, automated replenishment systems and mobile data collection contribute to efficiency in the supply chain by reducing delays and human error, and, as a result, to the delivery of better services and the use of resources (Nguyen et al., 2020).

One of the major impacts of digital transformation in that supply chain is improved traceability and transparency in the healthcare supply chains. The barcode scanning, RFID tagging, and blockchain are some of the most popular technologies that have been used in the past years to track medical commodities between the manufacturer and the point-of-use and reduce losses, pilferage, and risks of counterfeits (Kumar et al., 2021). Regulatory compliance and better demand forecasting are also possible with the technologies. In addition, the supply trends, warehouse management, and the improvement of the last-mile delivery effectiveness are analyzed with the help of AI-powered systems (Reddy and Sharma, 2022). Large hospital networks can provide the

procurement officers and facility managers access to real-time information that can be used to make informed decisions about restocking and distribution by means of centralised dashboards. Such level of digital visibility is particularly critical during the health crisis like pandemic when supply chains are heavily strained and must be able to react in real-time to the increased demand. That is why this trifecta of automation, analytics, and digital integration has become a pillar in the management of healthcare logistics (Sharma et al., 2023).

The future of healthcare supply chains is promising but there exist several barriers to full digital maturity. Disjointed information system, poor infrastructure as well as low digital literacy of medical staff remain a barrier particularly in low and middle-income economies (WHO, 2021). In addition, digital systems, such as software licenses, data storage, and update, might be costly to underfunded health institutions (Agarwal et al., 2020). Resistance to change, problems with data security and lack of policy frameworks also complicate the process of digital integration. However, capacity-building programmes, donor-funded projects and public-private partnerships are emerging as the main channels of digital advancement. These efforts are driving innovation and encouraging adoption of scalable digital models of logistics, which can support not only the daily provision of care, but also long-term sustainability of the system. Digital transformation will become more important in the health supply chain management, and a sustainable investment, interoperability, and development of human capital will be the key to successful fulfilment of its potential (Leung et al., 2022).

## 2.4 Supply Chain Resilience

### 2.4.1 Defining Supply Chain Resilience

The ability of a supply chain to foresee, adjust and recover to disruptive events and maintain uninterrupted operations and adapt to the new normal is referred to as supply chain resilience (SCR). SCR has evolved with the recent proposal by Ponomarov and Holcomb (2009) and now incorporates not just robustness and risk mitigation but also flexibility, agility and adaptability in dynamic environments. According to Wieland and Durach (2013), resilience involves both proactive and reactive abilities, including the ability to foresee the disruptions, react fast, and recover following the events. It is especially topical in the context of the modern global networks that are more interdependent, and the shocks, such as pandemics, natural disasters, or geopolitical instability, could create a ripple effect. Resilience has now been viewed as a strategic supply chain

management need, particularly in sectors that handle basic goods and services such as healthcare, food, and energy (Tukamuhabwa et al., 2015). This dynamism in definition has brought up resilience as a measurable construct, multi-dimensional in the logistics and operations literatures.

Supply chain resilience has four dimensions, namely robustness, agility, redundancy, and visibility. The term robustness implies the capacity of supply chain systems to withstand shocks without a meaningful adjustment to the performance, and the term agility reflects the speed and flexibility of adapting operations to the shocks (Ivanov and Dolgui, 2020). Redundancy, e.g. buffer stocks or backup suppliers, offers alternatives in the event of failures, and visibility gives real time information of stock, suppliers and demand fluctuations. To ascertain the profile of a supply chain in terms of resilience a model was postulated by Pettit et al. (2010) to align these capabilities to the vulnerability factors. The model is common in the empirical studies and it has been applied in the environment of healthcare, manufacturing and humanitarian logistics. It also states that there should be a balance between efficiency and resilience-building activities as lean supply chains, despite being cost-efficient, lack the redundancy and flexibility that is required in a crisis (Sheffi and Rice, 2005). These are the dimensions of the theoretical framework of the analysis of resilience in various supply chain structures.

More recently, resilience has been not only described as a reactive capability, but also as a dynamic capability, which is a result of learning, adaptation and innovation. Birkie et al. (2021) are convinced that supply chains ought to set up learning-based cultures that can recognise weak signals and re-arrange resources in the face of uncertainty. Such shift in thinking transforms resilience into an ongoing strategic capability that is incorporated in supply chain design and governance. It involves the development of information-sharing systems, cross-training of employees, and the development of modular supply systems that can prioritize under pressure in the field of healthcare logistics (Kumar and Kumar, 2020). Unlike the definitions of risk management, which are static, resilience is concerned with the organisational agility, resource orchestration and continuous improvement. The greater interest in this perspective has led researchers to think about how digital transformation can be integrated with resilience, where digital technologies would maximize anticipation, coordination and recovery capacities in the ecosystem of supply chains (Alicke et al., 2021). This evolving consciousness is the context against which the study of resilience in the vital service sectors such as healthcare takes place.

### 2.4.2 Drivers and Enablers of Resilience

Resilience in the supply chain is not an accident; it is developed as a result of design decisions and organisational abilities that allow systems to withstand, absorb and recover disruptions. Organisational leadership and strategic vision is one of the critical drivers since it forms the basis of developing resilient systems (Pettit et al., 2010). Leadership commitment is there to make resilience part of the goals, investment choices, and cultural approach of the supply chain. Also, the supply chain cooperation with the upstream and downstream partners increases information flow and coordination of operations in the crisis (Scholten and Schilder, 2015). Flexibility and responsiveness also come with cross-functional integration in organisations. Leadership is an important aspect in proactive planning, scenario development, and risk awareness training. An organized leadership framework does not only enable quick response to crisis but also supports endless learning and resilience culture along the supply chain (Ambulkar et al., 2015). These are the qualities that make resilient firms stand out of the rest that are still vulnerable.

Information sharing and digital infrastructure is another key enabler of resilience that enhances supply chain visibility and situational awareness. Fast and efficient decision-making in the case of disruptions is impossible without visibility, which means the possibility to track operations, inventory, demand, and supplier performance in real-time (Brandon-Jones et al., 2014). Enterprise resource planning (ERP) systems, cloud platforms, and IoT sensors are technologies that offer organisations the means of detecting threats early and efficiently coordinate responses to them. Besides, supply chains can be more proactive and adaptive, as predictive analytics and AI can identify disruptions and propose mitigation measures (Dubey et al., 2021). Ivanov et al. (2019) reveal that digital technologies can contribute to resilience in two ways, both improving reactive recovery and proactive risk detection. They are particularly crucial in the case of the public health system where access to medical supplies can be a life or death situation. As a result, digital capacity and interoperability of systems are becoming an essential part of resilient supply chains as an investment.

Resilience is also dependent on human capital and learning orientation. In chaotic conditions, experienced individuals who can analyze information, restructure operations, and manage crisis response activities are essential (Mandal, 2017). Staff cross-training guarantees the operations in case of staff shortage and decentralised decision-making enables faster changes at the local levels

(Tang, 2006). In addition, resilient organisations promote organisational learning culture in which past disruptions are examined to guide future preparedness. Mentzer et al. (2001) point out that past shocks can be used to learn and improve constantly and be innovative. Resilience is therefore not only formed by systems and structures but also by individuals who work and run them. Building team strength, facilitating psychological safety, and establishing knowledge retention by documenting and training are some of the tactics that will increase workforce resilience. In combination, leadership, information infrastructure, and human capabilities form a triumvirate of enablers that define the capacity of a supply chain to survive and thrive on disruption.

### 2.4.3 Resilience in Healthcare and Critical Supply Chains

Supply chains in healthcare are especially fragile because they are complex, urgent, and rely heavily on stable logistics and the availability of the necessary medical supplies. In contrast to commercial supply chains, healthcare systems are required to be operational even in the case of an emergency like a pandemic, natural disaster, and conflict, when demand suddenly increases and access to resources is limited (Kumar et al., 2020). Resilience in supply chains in the healthcare industry is thus paramount in providing continuity of care and protection of the health of the population. Ivanov and Dolgui (2020) state that healthcare systems need redundancy and agility-stockpiles and diversified supplier networks as well as rapid response capacity. The COVID-19 pandemic has revealed serious vulnerabilities in health logistics all over the world, such as lack of personal protective equipment (PPE), test kits, and ventilators, which highlights the necessity of more robust resilience measures (Paul and Chowdhury, 2020). Such interferences brought the significance of strategic risk planning, localised sourcing, and visibility of the healthcare supply chain to enhance preparedness and recovery.

The resilience requirements of critical infrastructure sectors are similar because they all play vital roles in society, including healthcare, food, water, and energy. In such industries, disruptions in the supply chain may cause systemic failures in the community, economy and national security (Sheffi, 2005). In the case of healthcare, the strength of the procurement and distribution systems guarantees the availability of life-saving drugs, vaccines, and medical equipment in time (Yadav and Smith, 2021). Pre-positioning of supplies, supplier diversification and flexible warehousing systems are some of the resilience practices that have been promoted by the humanitarian logistics field (Balcik and Beamon, 2008). Such methods enhance fast response and decrease the reliance

on unstable transport channels. Moreover, the synergetic partnerships with foreign organisations, non-governmental organisations and the players in the private sector have been successful in strengthening resilience during major emergencies. These partnerships enable shared procurement, infrastructure, and data sharing, which contribute to the responsiveness of critical supply systems when under pressure (Mosadeghrad, 2020).

The evolution of resilience in healthcare supply chains is also associated with the participation of digital technologies, decentralisation of logistics decision-making, and institutional shifts. Agile planning and response is being supported by the increased use of real-time inventory systems, GIS-enabled distribution tracking, and predictive analytics tools (Munjal et al., 2021). In addition, decentralised logistics system where health facilities and regional depots can operate without the central command system enhances responsiveness and reduces excessive reliance on centralised command systems. The systems of governance and policies ought to be modified as well to promote resilience, such as through flexible procurement regulations, emergency logistics processes, and multi-level coordination systems (Tang and Veelenturf, 2019). It is also necessary to possess capacity-building exercises that increase data literacy, cross-functional communications, and scenario planning. The above practices can be helpful in the transformation of the healthcare supply chains into adaptive and anticipatory networks that can withstand repetitive and complex disruptions. In that respect, resilience in logistics in healthcare is turning into a strategic capability, instead of an operational need (Pettit et al., 2019).

### 2.4.4 Building Resilient Healthcare Supply Chains

Despite the fact that a larger number of people are now aware of the need to have resilience in healthcare supply chains, a couple of barriers still hinder the process. The lack of coherent infrastructure and data silos that limit the visibility and responsiveness of supply chains is one of the problems (WHO, 2021). The majority of healthcare systems operate on a fragmented legacy system with limited interoperability, and the inventory levels or demand within the facilities are difficult to monitor. Moreover, the absence of infrastructure, such as unreliable power, poor roads, and inadequate warehouses, compromises the efficiency of logistics operations, especially in rural areas or underserved areas (Yadav, 2015). These loopholes undermine the shock-absorbing ability of the system or re-allocation of resources in the event of emergency. There is also the issue of inability to share information between hospitals, suppliers and ministries due to the lack of

integrated information systems, which leads to redundancy, shortages of supply and ineffective procurement. Another problem is the lack of centralised supply chain governance that results in unequal protocols and separated responsibility (Mosadeghrad, 2020).

The other major threat is financial constraint and lack of investment in digital and human capital. The building of resilience can be costly regarding the initial investments in technologies, staff training, infrastructure, and policy modification, which are constrained in the environment of the public healthcare system (Agarwal et al., 2020). It is not easy to purchase high end inventory systems or logistics staff training programmes due to budgetary constraints that can be utilized to concentrate on short term service delivery as opposed to long term capacity building. In addition, donor funds tend to be project-oriented, and they may not align with national priorities and long-term system strengthening. Without a stable source of finance, healthcare supply chains will not develop backup networks of suppliers, emergency reserves, or decentralised logistics strategies (Paul and Chowdhury, 2020). The inability to invest in digital literacy and supply chain skills limits the utilization of technologies even in the cases when they are present. The comparative insufficiency of resilience planning and operational needs provides a rationale to the significance of sustainable financing and institutional commitment to long-term readiness (Munjal et al., 2021).

The institutional resistance to change and regulatory rigidity are the key barriers to resilience-building efforts, in addition to resource limitations. Healthcare supply chains tend to be a low-risk appetite, a stiff bureaucracy, and innovation is either cynically regarded or bureaucratically bogged down (Pettit et al., 2019). The existing standard procurement procedures may not be flexible enough to meet the emergency or when there is need to fast track alternative suppliers during emergencies. The lack of desire by the health workers to adopt new systems or workflows, especially in the environment that does not involve technical support or frequent changes in policies, may also motivate the resistance (Scholten and Schilder, 2015). Moreover, their policy frameworks are weak and the accountability structures are not clear hence causing delay in implementation and coordination during emergencies. Legal and regulatory barriers such as complex importation procedures or sub-national autonomy are also barriers to agile decision-making (Tang and Veelenturf, 2019). The answer to these challenges must be technical as well as organisational, which requires the transformation of the organisation, inclusive governance models and leadership, capable of creating systemic change.

## 2.5 The Role of Digital Transformation in Enabling Supply Chain Resilience

### 2.5.1 Intersection of Digital Transformation and Resilience

The study of the relationship between digital transformation and supply chain resilience is increasingly popular in the academic and policy environment due to the fact that the two phenomena are associated with the need to be flexible and responsive in the complex environment. The enablers of the technology foundation and organisations that facilitates resilient behaviours in the supply chains are founded on digital transformation which is rooted on the Technology-Organisation-Environment (TOE) model (Baker, 2012). The TOE theory states that the digital adoption is influenced by both internal capabilities and external pressures that also lead to the development of resilience (Oliveira and Martins, 2011). On the other hand, Supply Chain Resilience (SCR) Theory targets on how systems foresee, absorb and recover disturbances through powerful and flexible strategies (Ponomarov and Holcomb, 2009). These theories are similar in the aspects of agility, visibility, and collaboration. The blending of these frameworks enables a conceptual model that digital transformation is a resilience enabler and multiplier enhancing adaptive capacities through the utilization of technology-based solutions (Dubey et al., 2021).

Organisations that have managed to combine digital transformation and resilience strategies can build a competitive edge in turbulent environments in the dynamic capabilities approach. Teece et al. (2016) define dynamic capabilities as the ability of the organisation to integrate, create and re-integrate internal and external competencies in order to adapt to the rapidly changing environments. Digital technologies such as predictive analytics, cloud computing, and IoT increase these capabilities and enable the creation of early warning systems, real-time monitoring, and the redistribution of resources (Ghosh et al., 2021). It is a view that resilience is not a reactive ability but an active strategic ability through the use of digital tools. Digital transformation thus can be important in the operationalisation of resilience, shifting the organisations with a fixed defence-based structure to anticipatory and data-driven organisations (Brusset and Teller, 2017). Such a conceptual mix can be applied to improve the interpretation of how the digital investments can be translated into resilience performance within the critical areas of supply chain particularly in high stakes sectors like healthcare where the stakes of disruption are high stakes.

A number of researchers have suggested integrative models which depict this convergence. As an example, Dubey et al. (2020) proposed a model that connects the big data analytics capability with

supply chain resilience mediated by organisational flexibility and learning orientation. On the same note, Pettit et al. (2019) believe that digital transformation increases supply chain resilience through the creation of better visibility, collaboration, and risk mitigation, especially when integrated into strategic supply chain design. These models signify the change in the literature where digital transformation and resilience were considered as independent fields to the new understanding that they are interrelated and complementary to each other. The combined lens provides a more comprehensive perspective of the supply chain systems that have to work in the environment of chronic uncertainty and systemic risk. In this way, the theoretical discussion of this intersection still guides the empirical research and policy frameworks aimed at empowering logistics networks by means of the coordinated digital and resilience efforts (Ivanov and Dolgui, 2020).

### 2.5.2 Linking Digital Tools to Resilience Outcomes

The studies in different sectors are increasingly showing that digital tools play a vital role in enhancing supply chain resiliency. Big data analytics (BDA) is linked with improved demand planning, real-time inventory management, and disruption response, particularly in humanitarian and health supply chains (Dubey et al., 2020). BDA assists organisations to find patterns, detect risks earlier and make decisions with more speed and precision using the large volumes of data collected and analysed. On the same note, the Internet of Things (IoT) devices have facilitated improved asset tracking and monitoring the quality of the pharmaceuticals in the logistics chain to make sure that essential products such as vaccines are not ruined because of the inability to maintain the temperature in an appropriate range (Queiroz et al., 2020). The visibility is also a significant component of resilience, which is enhanced by the tools as they ensure transparency at different nodes of the supply chain. Real-time dashboards and analytics based on IoT can assist the decision-makers to adjust their procurement, distribution and warehousing dynamically, in accordance with changes in the supply-demand scenario (Chong et al., 2017).

Application of cloud-based platforms and mobile supply chain applications have also been found useful in the enhancement of coordination and accessibility in the distributed healthcare networks. Remote facilities in low- and middle-income countries have also been enabled to report on the stock in real-time, which has contributed to preventing stockouts and improving the sustainability of service delivery by adopting cloud-hosted logistics management information systems (LMIS)

(USAID, 2018). The platforms are interoperable and can be integrated with the national health information systems, which is a necessity in the case of coordinated emergency response. Moreover, pharmaceutical supply chains are also an empirical application of the blockchain technology where it is used to promote traceability and prevent the entry of counterfeit drugs into the market (Saberi et al., 2019). The digital solutions are not only operational resilience, but also institutional trust, data integrity and international standards compliance. It is stated that the effectiveness of such tools is increased when they are applied in combination with training programmes and strategic alignment of IT and supply chain functions (Moktadir et al., 2021).

In spite of the encouraging results, empirical studies also indicate contextual obstacles that influence the extent to which digital tools can be used to improve resilience. It has been observed that the digital maturity, organisational culture, and leadership commitment have a significant impact on the results of technology investments (Pettit et al., 2019). To illustrate, Munjal et al. (2021) discovered that in the absence of defined governance frameworks and internal technical capabilities, digital systems in healthcare logistics tend to become underutilised or unnecessary. Equally, digital tool performance in resilience-building endeavors can be hampered by the lack of infrastructure in terms of poor internet connectivity, device shortage, and data safety issues (Wamba et al., 2020). Also, certain digital interventions can potentially add complexity or reliance on third-party vendors, exposing them to cybersecurity risks. The above limitations reiterate the need to use digital transformation initiatives in a favourable institutional context that encompasses regulatory advice, capacity development, and performance monitoring. To conclude, though empirical evidence can confirm the resilience-enabling nature of digital tools, the full potential of the latter can only be realized in a favourable operational and strategic environment.

### 2.5.3 Strategic Digital Interventions for Resilient Health Systems

Digital interventions are increasingly being appreciated as highly significant facilitators of the resilience of healthcare supply chains. One of the most successful interventions is the Electronic Logistics Management Information Systems (eLMIS) and it provides real-time data on stock, expiration, and consumption trends at health facilities (USAID, 2018). eLMIS eliminates stockouts and overstocking by enabling data-driven forecasting and automatizing the process of replenishment, particularly of essential medicine and vaccines. The last-mile delivery is also enhanced by Geographic Information Systems (GIS) and mobile health (mHealth) applications,

which assist in optimising the routes and checking the delivery in real-time (Kumar et al., 2020). Such tools ensure that there is continuity of supply especially in the remote areas in the case of an emergency. These systems must be combined with the national health strategies and they must be interoperable with other health information systems so that they can be implemented strategically. When introduced into the institutional workflows, such technologies can improve decision-making and accountability throughout the healthcare delivery chain, as well as the logistics performance (Leung et al., 2022).

Artificial Intelligence (AI) and predictive analytics are becoming an innovative tool of health system resilience. These technologies help in carrying out early warning systems which will detect bottlenecks in the supply chain or disease outbreak and action can be taken even before it occurs (Wamba et al., 2020). To give an example, historical consumption data, seasonal trends and epidemiological patterns can be analysed using machine learning algorithms to predict future stock needs at facility level (Moktadir et al., 2021). During the COVID-19 pandemic, the AI-powered dashboards assisted the health ministries in some countries to allocate limited resources such as PPE and oxygen based on the current demand and utilisation rates in real-time (Choudhury et al., 2021). The application of AI to risk stratification and demand-supply simulation modelling is also present, and health systems may simulate different scenarios of response prior to a crisis. However, data quality, technical infrastructure, and governance frameworks are required to facilitate responsible AI application, and thus the implementation can be successful. Training and change management programs should then come in to help in adoption of such tools.

Together with data and intelligence platforms, blockchain technology and digital twin systems are emerging as the trendy strategic interventions to increase transparency and scenario planning in healthcare logistics. Medical supplies can be traced using blockchain and this can be helpful in auditing, reporting to donors, and compliance with regulations since the records are tamper-proof (Saberi et al., 2019). Its decentralised nature allows the cooperation of multiple actors and ensures the data integrity. Meanwhile, the virtual replicas of supply chains, digital twins, allow decision-makers to test disruptions and interventions and design resource allocation within a controlled virtual setting (Fuller et al., 2020). These interventions raise the degree of preparedness and reduce the risks of trial-and-error during the real crises. They are costly to install and technically demanding making their application limited to low-resource environments despite their potential.

Health systems need enabling policy environments, cross-sector partnerships and long-term investment strategies to not only focus on innovations but also sustainability to scale such interventions (Ghosh et al., 2021). It is a sustainable and resilient process in case of a strategic correlation between digital tools and the goals of public health.

### 2.6 Conceptual Framework

A conceptual framework uses a well-defined structure to display the relationships among important study variables. The theoretical direction of the research comes from this framework because it explains how the various elements related to the research problem are connected (Saunders et al., 2019). Here, the study outlines the connection between digital transformation (as independent variable) and supply chain resilience (as dependent variable) in Zimbabwe's public hospitals.

#### Independent Variable: Digital Transformation

Technology adoption in public sector supply chains helps to improve how things are done, how they are monitored and how quickly they can respond. This study focuses on the following important elements of digital transformation:

- **Automated Inventory Management** – Use of digital systems to track and manage medical supplies in real time.
- **Real-time Data Analytics** – Application of big data and predictive analytics to optimize procurement and distribution decisions.
- **E-Procurement Systems** – Digital platforms that streamline procurement processes and supplier management.

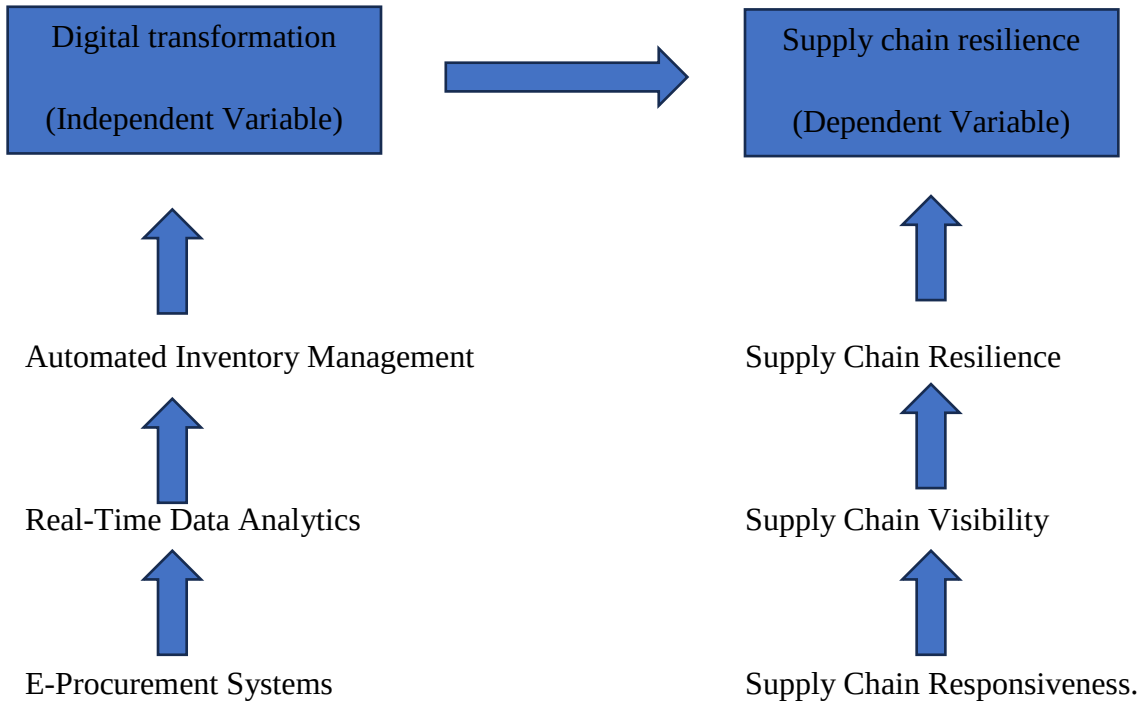
#### Dependent Variable: Supply Chain Resilience

Supply chain resilience refers to the ability of public hospitals to withstand, adapt to and recover from supply chain disruptions during emergencies and crises. Key aspects of resilience in this study include:

- **Supply Chain Efficiency** – The ability to optimize resource use and reduce wastage.

- **Supply Chain Visibility** – Real-time tracking of inventory and supply chain processes.
- **Supply Chain Responsiveness** – The ability to quickly adapt to supply disruptions and ensure continuous service delivery.

**Figure 2.1:** Conceptual Framework




This framework posits that an effective digital transformation strategy positively influences supply chain resilience by improving efficiency, visibility and responsiveness.

### 2.7 Empirical Review

This section looks at empirical research on how digital transformation is used in supply chains and how it affects their ability to stay resilient in healthcare systems. It analyses actual evidence to explain how digital tools are used, the difficulties in implementing them and what outcomes they produce in various workplaces.

#### 2.7.1 Digital Transformation

**Modgil et al. (2022)**Modgil et al. (2022) investigated to examine what drives digital transformation in healthcare supply chains and how it influences operations in public health. The

research was based on quantitative approach through conducting a survey of supply chain professionals working in healthcare institutions in India. Structural Equation Modelling (SEM) was used to analyse the data of 215 valid responses. This research applied the TOE theory and dynamic capabilities theory in order to investigate the effects of digital adoption on agility and responsiveness. Among some of the significant digital technologies considered were electronic logistics management systems (eLMIS), cloud computing, big data analytics, and mobile tracking systems. It was discovered that top management support, appropriate IT systems and training are essential in order to have digital transformation in healthcare logistics.

The findings indicated that digital transformation significantly enhances the flexibility of the supply chain, response, and outcomes in public hospitals. The digital tools helped to track the inventory more easily, reduced the possibility of stockouts, and enabled the quicker response to the logistical issues. The study found that digital maturity enhances performance in the supply chain especially in a period of higher demand like when a disease outbreak occurs. Moreover, Modgil et al. (2022) observed that cooperation in the procurement, warehousing, and distribution departments was easier in hospitals with digital solutions. It was established that the appropriate organizational structure and digital tools in accordance with the strategy were key factors to successful implementation. The study says that digital transformation is not only about technology but also management and it takes a long time before everyone in the healthcare supply chain remains committed and cooperates to have long-term benefits.

**Wamba et al. (2020)**

Modgil et al. (2022) conducted a research to examine how digital technology can impact the performance of healthcare supply chains and public health operations. The study examined the impact of big data analytics (BDA) on the performance of the supply chains in the public hospitals. The study group used the quantitative method, where a specific group of questions was sent to healthcare logistics and IT experts in 30 European and Sub-Saharan African hospitals. The data was analyzed in PLS-SEM to observe the relationship between big data analytics capability, IT infrastructure flexibility, and supply chain agility. The research was based on the Resource-Based View (RBV) and Dynamic Capability Theory to understand how digital competencies can assist a company to enhance its business activities. It was noted that BDA assists healthcare organizations to track their stock in real-time, forecast demand, and exchange information among various groups.

The analysis of data showed that big data analytics enhanced flexibility and responsiveness of supply chains in the public hospital. Hospitals with already established BDA practices were in a position to respond faster to the changes in supplies and forecast shortages more accurately compared to their counterparts. The flexibility of IT infrastructure was identified to contribute to the effectiveness of big data tools. According to Wamba et al. (2020), hospitals which employed BDA experienced better maintenance of services, reduced stockout, and coordination with their suppliers in times of crisis. The authors concluded that the skills of BDA, skilled workers, and flexible IT systems are required to make healthcare supply chains sustainable.

**Reddy and Reinartz (2022)**

Reddy and Reinartz (2022) examined the role of digital infrastructure in the COVID-19 pandemic in India in relation to vaccine distribution. They employed a qualitative case study method in order to investigate the design, implementation, and results of CoWIN system, the primary digital solution to manage COVID-19 vaccines in India. Semi-structured interviews with health ministry officials, IT developers and hospital administrators were conducted, as well as documents and system data. The aim of the research was to observe the impact of digital architecture, data integration, and real-time monitoring on the efficiency and transparency of the vaccine distribution. The authors demonstrated the role of digital coordination in enabling the collaboration of government, hospital, and logistics providers with the help of systems theory.

It was established that CoWIN made things more transparent, less vaccines went to waste, and the delivery of vaccines at the public health centers was improved. The system allowed to trace the doses when they were being transferred to the local vaccination centers after being stored in national warehouses to distribute them to the areas where they were needed most quickly. As Reddy and Reinartz (2022) noted, the fact that CoWIN can collaborate with state health systems and operate automated reporting tools enhanced the decision-making process and reduced the number of manual errors. It was acknowledged that not all people have digital skills and access, yet the digital environment was perceived to increase the trust in the government and the population. It was discovered that well established digital infrastructure and adequate directions to all stakeholders, the public health supply chains are capable of managing high-pressure and high-volume scenarios.

**Sivarajah et al. (2021)**

A research by Sivarajah et al. (2021) was conducted to determine the preparedness of the public healthcare institutions towards digital transformation, primarily in supply chain processes. The information was gathered through surveys and interviews, where the former included 182 medical workers and the latter a smaller sample of hospital managers and IT officers. In order to evaluate these factors, the authors used a Digital Readiness Assessment Framework that examined the technological infrastructure, leadership support, organisational culture, and digital skills. The study applied the TOE framework and sought to determine the influence of internal and external factors on the capacity of a public hospital supply chain to implement digital solutions.

As the findings suggest, the level of digital transformation readiness differed significantly across institutions, primarily because institutions lacked the digital skills and change management capabilities of their employees. Sivarajah et al. (2021) found that digital tools were present in most hospitals, but their application was ineffective due to the lack of connected systems, the inability to connect and the absence of training. The individuals who participated in the study reported that effective change required good leadership, teamwork, and training of skills. Instead, the failure to adopt change, the old way of buying and the little money invested in an organization affected many organizations. The authors discovered that digital transformation in the logistics of public health can only be successful when all three elements, structural, cultural, and technological, are enhanced. Governments and health institutions can use their findings when planning digital solutions to long-term management of supply chains.

### 2.7.2 Resilience

**Ivanov and Dolgui (2020)**

Ivanov and Dolgui (2020) conducted a simulation study to determine how robust supply chains in healthcare can assist to control the impact of significant disruptions, particularly those related to the COVID-19 pandemic. The model applied system dynamics to demonstrate the spread of interruptions in the supply chain by considering the demand and supply issues. The team investigated the way to make the European public healthcare systems more resilient through backup suppliers, flexible lead times and maintaining a buffer of emergency stock. This was to determine the most effective structures in hospital logistics when it comes to responding and

recovery of disruptions. They merged both the concepts of control theory and network optimization to determine how the system would perform under different crises.

Healthcare supply chains incorporating flexibility, redundancy and multiple sources of supply were found to recover faster and offer a superior level of service when disruption occurred in the simulation. Ivanov and Dolgui (2020) explain that excessively lean JIT models are incredibly vulnerable in the event of a systemic shock, particularly when the global supplier networks are disrupted simultaneously. It was explained that resilient structures became more effective when real-time data and analytics were used online. It was also identified that the delay in initiating the emergency procurement was the cause that made the situation of disruption much worse. The authors have discovered that the most appropriate strategy in times of emergence is to possess both physical and digital resilience in the supply chains of the public hospitals. Their research reveals that health logistics systems must be re-conceptualized as flexible and robust upon the pandemic.

**Tukamuhabwa et al. (2015)**

Tukamuhabwa et al. (2015) conducted an empirical research to determine the dominant capabilities of defining the supply chain resilience (SCR) within the public sector organizations, and focused on the healthcare supply environment in the Sub-Saharan Africa. The study team gave itself the option of a quantitative survey and conducted research among 143 experts in the supply chain who work in the area of public health and regulatory agencies of Uganda. The exploratory and the confirmatory factor analysis were applied to ensure that resilience has four core dimensions, as follows: readiness, response, recovery, and growth. On the basis of Resource-Based View (RBV) and contingency theory, the purpose of the study was to determine the way internal capabilities interact with external challenges on supply chains to influence the resiliency of the healthcare logistics of the public.

Based on the study, the four dimensions of resilience (readiness, response, recovery, and growth) are valid and statistically related and can be used to make the supply chains of the nation more resilient, especially those of the public hospitals. According to Tukamuhabwa et al. (2015), preparation and anticipation of risks caused the largest impact on resilience. It was indicated that rapid responses such as emergency buying and other flexible terms with supplier was highly significant during the times of disruption. Most of the institutions lacked the effective recovery

and growth skills; this implies that they were not having clear long-term strategy. The team discovered that resilience was to be developed through adherence to operational and institutional plans and that healthcare systems in the community had to enrol in training, develop plans to cope with any eventualities and also employ alternative suppliers to ease the increasing uncertainty.

**Golan et al. (2020)**

Golan et al. (2020) analyzed the ability of healthcare supply chains to deal with the impacts of the COVID-19 pandemic surrounds the enhancement of resiliency as demonstrated by public hospitals on its part. In the given research, scientists combined numbers methods and interviews to analyse the performance of supply chains and obtain the opinions of managers at hospitals and local public health organizations in North America and Europe. It was done with the goal of verifying the level of preparedness of the institutions in the context of managing the information, sourcing in case of the crisis, so as to maintain the supply chain status quo. Resilience was determined by the researchers based on the inventory turnover, stockout rate, lead time variability, and service level consistency.

It was discovered that the healthcare systems based on the idea of decentralization, the presence of several suppliers, and digital systems were far more effective to withstand the supply chain shock. Golan et al. (2020) report that the most affected when the pandemic began were the companies with a little safety inventory where the distribution of resources was imported across the world. The users of digital dashboards and predictive analytics could redistribute resources without any difficulties and anticipate resource shortages and this prevented delays in patient care. The research states that enhancing the resilience of the supply chains in the case of public hospitals involves restructuring the supply chain as well as technology to support rapid decision-making. The researchers have highlighted that resilience ought to be regarded as a key performance indicator of supply chains along with cost-efficiency and speed.

**Khan et al. (2020)**

Khan et al. (2020) considered the influence on the resilience of supply chains in the health sector in regions where the crisis and conflict are a frequent issue. To conduct the study, a qualitative multiple case study design was applied with the considerations that involve the examination of issues in three developing countries whose political environments are subjected to instabilities and

are faced with health emergencies on an ongoing basis. We also collected data through an interview with healthcare administrators, logistics coordinators, and procurement officers and through the documents concerning the health system performance. This framework employed by the study considered resilience and analysed the impact of culture, governance and stakeholder relationships on the capacity of health supply chain to absorb and absorb shocks.

The findings indicated that institutional agility, good collaboration between various agencies, and independence in governance were the key driving forces in the existence of a potent health supply chain. Khan et al. (2020) mention that the facilities, which took local decisions, had an opportunity to react more quickly and alter their purchasing and supplying principles to the actual situation. Instead, those systems with concentrated power and a great role played by politics, in the aftermaths of emergencies took a long period to manage an emergency due to red tape. It was also mentioned that resilient systems engaged community members and they employed informal means to obtain provisions in case of blockage of usual channels. Even though not all the case sites had online tools available, they significantly enhanced the level of coordination and transparency where they were utilized. It was observed that resilience of health systems is only possible through shifting policies, promoting decentralized leadership and applying solutions that fit the fact of weak health systems.

### 2.7.3 Digital Transformation on Supply Chain Resilience

**Pereira et al. (2021)**

One of the studies led by Pereira et al. (2021) aims at examining the positive role of digital systems in logistics in relation to the coping capability of a supply chain faced with emergencies, particularly those that lead to pandemics. The data was collected through survey that was sent to supply chain professionals and logistics managers working within Brazilian and Portuguese public hospitals. Researchers employed SEM to investigate the pivotal connection among digital tool utilization, high exposure to the supply chain, and resilience. The Dynamic Capabilities View (DCV) proved to assist the research since it shows how organizations enhance their capabilities through technology usage. They were the elements of logistics management information systems (LMIS), mobile tracking, and electronic procurement systems.

It was observed in findings that they used digital tools to enable the companies to lower their lead times, have a better view of their stock and better situated against any sudden rise in demand. Pereira et al. (2021) found out that hospitals using real-time dashboards and integrated supply chain systems managed emergency cases and resources allocation more effectively. Moreover, the communication between central stores and the decentralized facilities happened more easily due to the digital systems and this allowed preventing the stock imbalances and the delays. The scholars also discovered that the more digital advanced the hospitals were, the more they could be maintained in times of crisis. As the authors discovered, digital transformation can be useful not only when it comes to efficiency but also to flexibility, meaning that it is essential in terms of the resilience of the supply chain of the public hospitals in times of emergency.

**Queiroz et al. (2021)**

In their article Queiroz et al. (2021) examined how blockchain technology may enhance resilience, transparency, and flexibility of health care supply chains in uncertain situations. The study involved the analysis of the survey of 160 managers of supply chains, as well as interviews with blockchain specialists in various healthcare organizations in North America and Europe. In order to measure the impact of blockchain, the researchers turned to the Technology Organizational Environment or TOE framework. The case study was directed towards the manner in which the necessary medical supplies and vaccines are truly distributed at the instance of an emergency case as in case of public hospitals.

It was also discovered that blockchain technology increased data accuracy, decreased counterfeiting risk and the ability to track the supply chain of medical supplies in real-time. As shown in research by Queiroz et al. (2021), supply chain partners grew to appreciate each other more due to the impossibility of altering records of their interactions and the ability to observe these records. Respondents who participated in the survey explained that by verifying its suppliers and tracking items throughout the process, it was less complicated to cope with rush orders and the problem of fraud could be avoided. As the study has highlighted, it is quite difficult to cope with technical problems and rules, though, during the crisis, the decentralized nature of blockchain could assist. Their research revealed that under the support of effective institutional frameworks and regulations, blockchain and other advanced technologies can make institutional supply chains within the sphere of healthcare more open and reliable.

**PATH (2019)**

In 2019, PATH conducted operational research; the study suggested that implementation of electronic Logistics Management Information Systems (eLMIS) has been used to improve health supply chains in Tanzania, Zambia, and Kenya. In assessing the impact, the research adopted a quasi-experimental research while comparisons of indicators measuring supply chain levels were conducted before and after introduction of eLMIS in the public health facilities. The information was collected out of national health logistic databases, warehouse reports, and interviews with stakeholders within the 24-month implementation phase. The critique focused on the way to improve inventory, correctness of information, visualize the supply chain, and preparedness to emergence.

Major improvement was seen in the enhancing of adequate stock, correct data and quicker decisions after utilizing eLMIS. According to PATH (2019), the number of stockouts of the necessary medicines has dropped by more than 30%, and the time spent on making orders was decreased by 20-40% in various districts. Due to the system, health managers always had an opportunity to track and forecast what would happen in real time, thus they could act in case of any sudden growth of a demand or a distribution problem. The data in the system got more reliable, which allowed all the members in the supply chain to be more transparent and responsible. The study revealed that eLMIS enabled the maintenance of the essential services in the context of disruption or crisis in the public health systems.

**WHO (2021)**

A report by WHO (2021) provided a global overview of digital health systems and their contributions to keeping supply chains stable in the context of the COVID-19 pandemic. Information that was analyzed involved more than 25 countries that were chosen to constitute a variety of income levels and which was analyzed using a multi country case synthesis method. Documents have been reviewed, country reports utilized and experts on healthcare logistics and government officials interviewed to prepare the report. This was to know the impact of the well-developed digital systems on the capacity of countries to maintain the provision of the much-needed health services during the crisis.

The WHO (2021) report suggests that highly developed areas in terms of digital logistics, such as LMIS, electronic procurement, and dashboards, managed to retain medicine availability and follow through more with the heighted demand. Rwanda and Estonia have been commended using mobile and cloud-based solutions to (a) make decisions in a short time scale; (b) have transparency in their supply chains. In the meantime, the non-digitally-complete countries had to deal with the problem of scattered data, teamwork problems, and difficulties associated with stock management. It has been established that robust digital infrastructure under the direction of national policies and with the help of competent workforce is a crucial element of health supply chains being resilient. WHO claimed that the digital transformation ought to be perceived as the long-term investment not only with the goal of enhancing the efficiency but also to assist in crisis preparation to construct a stronger system.

### 2.5 Chapter Summary

This chapter has analysed literature on digital transformation and resilience in public healthcare systems, especially in Zimbabwe. The review pointed out three important theories Supply Chain Resilience Theory, the Technology Acceptance Model and Dynamic Capabilities Theory that show how digital systems can improve how healthcare logistics are prepared, flexible and continuous. The empirical review also studied the current use of technology, challenges in operations and the part technology plays in handling emergencies. Although digital tools are recognized, there are still major issues with using them, connecting them and coordinating hospitals in Zimbabwe. Because of these gaps, a digital transformation framework needs to be developed for each specific situation. The subsequent chapter describes the techniques and tools used to gather information and analyse it to reach the stated aims and answer the research questions.

# CHAPTER 3

# METHODOLOGY

## 3.1 Introduction

This chapter details the approach used to study the effects of digital transformation on the ability of public sector supply chains to handle emergencies and crises in Zimbabwe's public hospitals. It outlines the main ideas, research process, techniques and methods used to collect and analyze the data. The research is based on a positivist paradigm that aims to be objective and resort to measurements and measurements and applies a quantitative approach to obtain information about a particular group. A survey was conducted so as to ensure that no public hospital in Zimbabwe was left behind. It also discusses the population and sampling procedure, the questionnaire to be used in the data collection and the procedures of analysing the responses. It is discussed to ensure high quality of the data and protection of the rights of the participants based on effective approaches.

## 3.2 Philosophical Research Paradigm

Research philosophy is the set of beliefs that helps shape the process of learning in research. It sets out the researchers' beliefs about reality, knowledge and the methods they use to collect it (Saunders et al., 2019). Many researchers use different philosophies such as positivism, interpretivism, critical realism and pragmatism to examine and understand reality. As an example, interpretivism centre's on people's personal experiences and is useful for studying human behaviour in qualitative situations (Creswell & Poth, 2018). Unlike other approaches positivism comes from the natural sciences and depends mainly on facts that can be observed and measured often applying experiments or surveys. Selecting a research philosophy is essential since it ensures all research steps are combined and connected, from choosing objectives and designing tools to understanding the results.

This research uses a positivist philosophy, this means that the study focuses on using data to draw conclusions through objective methods. Positivism believes that reality exists apart from human perception and can be measured by visible signs (Bryman, 2016). Through positivism, the researcher was able to statistically determine the link between digital transformation and supply

chain resilience using the collected data from the questionnaire. Using this method, can easily generalize, ensure reliability and replicate results which is important when managing the supply chain of public hospitals in Zimbabwe. While interpretivism is concerned with what individuals think, positivism helps find patterns that can be used in various places, so it is ideal for policy research in healthcare.

Positivism was chosen for its ability to produce measurable results and apply to a wide range of situations. Since the focus of this study was on how digital systems affect hospital supply chain stability, a philosophy that supports analysing data with numbers is needed. Positivism supports the use of correlation and regression to see how strong and in what direction different variables are related (Saunders et al., 2019). In addition, focusing on numbers rather than individual interpretations helps eliminate biases and makes the findings more trustworthy (Creswell, 2014). Since there isn't much data on healthcare digitalization in Zimbabwe, positivism helps guide decisions, implement digital solutions and improve readiness in health supply chains.

### 3.3 Research Methodology

Research methodology describes the main approach used to plan, carry out and examine research to answer the research questions and meet the objectives. It involves the study's basic beliefs, the ways data is collected and how the information is analysed (Creswell & Creswell, 2018). Usually, the data and inquiry determine whether a study should be quantitative, qualitative or use mixed methods. With qualitative methods, researchers investigate complicated, subjective topics by interviewing people, studying cases and observing, but quantitative methods mainly use data, measurements and statistics (Saunders et al., 2019). Combining different strategies allows researchers to see the problem from various sides. The researcher should choose a methodology that suits the kind of data being used and the purpose of the study. In the case of public health systems, qualitative research can look into how policies are carried out, while quantitative research is more effective for studying how the system works and its relationships.

For this study, a quantitative research methodology is used because the aim is to assess the impact of digital transformation on the resilience of public hospital supply chains during emergencies through statistics. A quantitative approach involves using a standardized questionnaire to gather data and helps you use statistics such as descriptive analysis, correlation and regression (Bryman,

2016). Using this approach is justified by the need for objectivity, repeatability and results that can be used for many people. The research used a quantitative strategy to measure digital tool adoption and supply chain responsiveness to evaluate if there is a link between them.

### 3.4 Research Strategy

A research strategy describes the way a study will be done to meet its objectives and answer its questions. It requires choosing the right approach for collecting and studying data depending on the research paradigm and methodology (Saunders et al., 2019). Experiments, case studies, ethnography and surveys are typical strategies and each is matched to a particular type of research. Surveys are useful in positivist research because they make it possible to gather a lot of standardized data that can be studied using statistics. Using surveys in healthcare systems research helps to analyse trends, actions and the success of systems among various groups of people or healthcare organizations. Creswell and Creswell (2018) state that surveys are useful for identifying general trends and links between variables, so they are suitable for measuring digital supply chain system adoption and performance in Zimbabwe's public hospitals.

In this study, the survey approach was used to collect data from supply chain managers, procurement officers and administrative personnel in public hospitals. The questionnaire filled out by participants measured how digitized their supply chains are and how they believe the supply chain will respond to future crises. Likert-scale questions in the survey made it possible to get consistent responses and compare hospitals of different sizes and locations using statistics (Bryman, 2016). Surveys are both fast and affordable and this was well suited for carrying out this study as it covered the entire country. Saunders et al. (2019) explain that using a survey strategy, researchers can collect data from a large group which is needed to make findings relevant for policy decisions. Moreover, the survey allows for identifying certain digital habits and challenges, giving a wide but detailed picture of digital progress in the public health supply chain area.

### 3.5 Population and Sample Size

#### 3.5.1 Population

A population in research refers to the entire number of individuals with identical characteristics and is capable of being sampled to conduct a study (Creswell & Creswell, 2018). In this study, the target population consists of supply chain employees, procurement officers, hospital

administrators and logistical staff at the Zimbabwean public hospitals. Since they deal with the procurement and distribution of medical supplies as well as their management, these people will be able to provide useful information about the digital transformation and the robustness of the supply chain. The population was determined by using the list of the public hospitals in the Ministry of Health and Child Care list provided by the government. The researchers decided to involve people who take part in the work of supply chains since it would ensure correct information about the digital systems and readiness to emergencies in various units of the public healthcare.

### 3.5.2 Sample Size

A sample size refers to the number of people selected in a bigger population to participate in a survey. The sample represents the entire population and is able to provide reliable outcomes. In order to determine the appropriate sample size, this paper adopts Cochran formula (1977). The formula is effective in large population where the population size is unknown or probability sampling is undertaken.

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

Where:

- n= the required sample size
- Z= the Z-value corresponding to the confidence level (for 95% confidence level, Z=1.96Z)
- p = estimated proportion of the population (for unknown population, used p=0.5)
- E= margin of error (for 5% margin of error, E=0.05)

Based on Cochran's formula, the required sample size is approximately 384

## 3.6 Sampling Techniques

Sampling techniques refer to the general use of a subset of individuals, phenomena, or events within a bigger population to represent the whole population in a study (Etikan & Bala, 2017). In order to have participants from a wide range of public hospitals in Zimbabwe the study made used stratified random sampling. In stratified sampling, the population is divided into similar subgroups

and random respondents are chosen from each group to match the overall population (Taherdoost, 2016). It helps minimize bias in the sample and increases the accuracy of estimating population characteristics mainly when different subgroups have different levels of digital tool use or crisis management skills. By including each category of hospital in proportion, stratification helps the findings be more widely applicable. Acharya et al. (2013) argue that stratified sampling is effective in healthcare research because operational features differ from institution to institution and region to region.

### 3.7 Data Collection Method

The data was collected mainly using a structured questionnaire. Many quantitative researchers use structured questionnaires because they can efficiently collect the same type of information from a large group (Creswell & Creswell, 2018). The survey was created to determine the current state of digital transformation in Zimbabwe's public hospital supply chains and check major signs of strength during emergencies and crises. Participants answered questions that were easy to count and could be used in statistical analysis. The frameworks used to develop the items were Kane et al. (2015) for digital maturity and Ponomarov & Holcomb (2009) for supply chain resilience. Because the tool was standardized, it allowed for similar data collection at all types of hospitals.

One advantage of using structured questionnaires is that they make it possible to repeat, remain objective and compare results. Since everyone answers the same questions in the same way, it is simpler to find patterns, run statistical analyses and make general conclusions (Bryman, 2016). Moreover, because they are both cheap and fast to use, structured questionnaires are ideal for large-scale projects like this one. They help reduce interviewer bias because little interpretation is needed when collecting data. Using a self-administered process made it easier for people to respond honestly and confidentially, mainly when handling challenges and evaluating digital and emergency preparedness within the organization.

Still, there are some drawbacks to using structured questionnaires. They limit the study of personal feelings and may cause people to misunderstand the fixed answers which could affect the quality of the collected data (Kelley et al., 2003). To solve this, the questionnaire went through a pilot study and was adjusted to make sure it was clear, reliable and relevant to the study. To ensure the items were consistent, Cronbach's alpha was calculated and experts were consulted during the

development phase to confirm the content. The quality control steps reduced the drawbacks of the questionnaires and improved the reliability of the study's data, resulting in meaningful results that followed the study's quantitative plan.

### 3.8 Data Analysis

The data gathered from the structured questionnaires was analyzed with descriptive and inferential statistics using IBM SPSS. Means, standard deviations and frequencies were used to describe the characteristics of public hospitals and check how well they adopted digital tools and handled crises in their supply chains. Two composite variables were formed to stand for Digital Transformation (independent variable) and Supply Chain Resilience (dependent variable), both based on several items from the questionnaire. The analysis used multiple linear regression to test the impact of digital transformation on supply chain resilience while considering the characteristics of the hospitals. Control variables included type of hospital, average monthly patient load, presence of an emergency logistics plan and number of full-time supply chain staff. The regression model used is represented as:

$$\text{Supply Chain Resilience} = \beta 0 + \beta 1(\text{Digital Transformation}) + \beta 2(\text{Hospital Type}) + \beta 3(\text{Patient Load}) + \beta 4(\text{Logistics Plan}) + \beta 5(\text{Staff Size}) + \varepsilon$$

The model was selected to help understand the impact of digital transformation after considering the variations between institutions. SPSS allowed for accurate calculations, model fitting and diagnostic checks, so the results were reliable and useful for healthcare policy and planning.

### 3.9 Reliability and validity

Data collection and analysis processes were implemented to ensure reliability and validity of the study results. First, a draft form of the questionnaire was given to a sample selected in the target population to determine its transparency and usefulness regarding the research theme. This pre-testing period enabled the elimination of the items that were ambiguous or biased and, in turn, made the instrument consistent with the objectives of the study and more reliable in measurement (Saunders et al., 2019). The responses given by pilot respondents helped make some minor adjustments, which made the instrument more usable and sufficient to measure digital transformation and supply chain resilience in the specified context (Creswell & Creswell, 2018).

After pilot testing, Cronbach alpha was used to measure internal consistency since it is a popular measurement of reliability used in social science research. Researchers usually do not regard a scale as reliable when alpha is less than 0.7 (Tavakol & Dennick, 2011). Therefore, the digital infrastructure, system responsiveness, and logistical agility items were put through this process. The high alpha values confirmed the validity of the items included in each construct referring to a common construct hence reliability was established. In addition, the survey tool was reviewed in content and theoretically by professionals with an expertise in digital health systems and hospital supply chain management. Their comments made sure that the indicators matched up with the modern theory and practice in the field of healthcare logistics (Bryman, 2016).

Verification and cleaning activities were systematic and increased the quality of data. The answers were subjected to checks whether they contain missing information, unusual values and errors, thus reducing the possible measurement bias. Since the questionnaire followed the protocol that was already established in healthcare and logistics research, the results can be applied to a similar situation (Sekaran & Bougie, 2019). Also, triangulation was used in the sense that the results of various demographic subgroups were analyzed thereby minimizing chances that results could have been due to measurement artefacts. These stringent practices together made the data reliable and generated results that depict the effect of digital transformation and resilience on the supply chains in the Zimbabwean public hospitals.

### 3.10 Research Ethics

The study was carried out in an ethically acceptable way that did not undermine the autonomy, privacy or well-being of the subjects. Each of the respondents gave an informed consent before the data was collected and all information with regard to the purpose of the study and the fact that participating was voluntary and that they could withdraw at any time without incurring any repercussions was fully disclosed. The informed consent process complied with the principle of respect autonomy and respect persons, whereby none of the participants was coerced into participating in the study. No one was forced to sign and there was enough time to go through the information before signing it. The ethical principles specified in the Belmont Report were closely adhered to, and dignity was preserved during the process of data-collection.

The study was conducted in manner that ensured privacy and confidentiality of the participants. The questionnaire was based on the retrieval of only de-identifiable answers whereas all data was made anonymous at once. All the obtained information was stored in digital files that had additional protection in the form of passwords and could be accessed by the investigators exclusively. These actions met the requirements of data-minimisation and security expressed by Saunders et al. (2019). Extensive measures were taken to avoid bias in the data analysis and reporting, and the research procedures were transparent, and no important data was omitted and/or altered. The given study was also checked and approved by the corresponding institutional review boards, which serves as the evidence of its adherence to the set standards and moral principles of the modern social studies.

All the possible attempts were made to make sure that the evaluation of the systems within the institution did not influence the participants either psychologically or professionally. The questions were posed in a neutral manner and the respondents were free to ignore any question that would make them feel uneasy. The results were always reported truthfully regardless of whether they conformed to what was predicted or not. Since the researchers were honest and responsible, their work remained credible and could be applied in the future decisions. The ethical approach employed in the study ensured that the study was legitimate and contributed to establishing a respectful, secure, and professional environment, as Bryman (2016) and Resnik (2020) recommend.

### 3.11 Chapter Summary

The chapter has outlined the methodology that was used to analyse how digital transformation affects the resilience of public hospital supply chains in Zimbabwe during emergency and crisis situations. It emphasized the use positivist approach, quantitative methods and conducting a survey to ensure the findings could be used everywhere and measured accurately. The population of the study was given. The study employed stratified random sampling and the sample size was determined to be 384. It also outlined how a survey was used to gather data, how the data was analysed and the actions taken to guarantee its validity and reliability. The process of ensuring reliability and validity were presented. The chapter also highlighted how ethical issues were addressed. Chapter 4: Data Presentation, Analysis and Discussion follows next.

# CHAPTER 4

# DATA PRESENTATION, ANALYSIS AND DISCUSSION

## 4.1 Introduction

This chapter details and investigates the findings from the questionnaires completed by staff at public hospitals in Zimbabwe. The survey collected 384 responses which was the same as the sample size we calculated. Data is analysed through descriptive statistics, cross-tabulations, correlation and regression analysis to address the research questions and accomplish the study aims. The discussion reviews the findings and compares them with the literature presented in Chapter 2.

## 4.2 Response Rate

The table below presents the questionnaire distribution and response rate:

**Table 4.1: Response Rate**

| Description | Frequency | Percentage (%) |
|---|---|---|
| Questionnaires Distributed | 400 | 100.0 |
| Questionnaires Returned | 384 | 96.0 |
| Questionnaires Not Returned | 16 | 4.0 |

The high response rate of 96% indicates excellent participation, ensuring data reliability and representativeness.

## 4.2 Organizational Characteristics

This section presents a descriptive analysis of the questionnaire responses collected from supply chain

personnel across Zimbabwe's public hospitals. It summarizes the frequency distributions and percentages for each survey item, offering insights into hospital characteristics, digital transformation practices and supply chain resilience levels.

| Variable | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| Type of hospital | 384 | 1 | 3 | 2.1927 | 0.89346 |
| Average monthly patient load | 384 | 1 | 4 | 2.6250 | 0.92259 |
| Presence and status of emergency logistics plan | 384 | 1 | 3 | 1.7135 | 0.79570 |
| Number of full-time supply chain staff | 384 | 1 | 4 | 2.0026 | 0.98950 |
| Valid N (listwise) | 384 | | | | |

**Table 4.1: Descriptive Statistics of Organizational Characteristics**

### 4.2.1 Type of Hospital

The data in Table 4.1 show that public referral hospitals were the most common among all hospital and they had a mean value of 2.19 and a standard deviation of 0.89. This showed that there were more tertiary-level health institutions among respondents. This pattern demonstrates that referral hospitals are often key in handling complex and emergency needs because they have a wider range of duties and larger catchment areas this is supported by Chatterjee & Srinivasan, (2021). For this reason, their supply chain systems tend to be even more complicated and prone to interruptions than those in rural or general hospitals. This view is supported through a study by Yahaya and Barasa (2022) which points out that central hospitals have to handle more logistics and must use advanced systems for managing their stock and risks. The fact that referral hospitals play a major role in the study highlights how digital transformation and resilience work in Zimbabwe's public health supply chain.

### 4.2.2 Average Monthly Patient Load

Table 4.1 reveals that the average number of patients attending hospitals was 2.63 (SD = 0.92), so most hospitals served between 1,000 and 10,000 patients per month. Having many patients in hospitals at once puts high demand on their supply chains for fast delivery of medicines, PPE and other resources. Increased patient numbers can result in stockouts, so hospitals must rely on accurate forecasting, mainly during emergencies (Acheampong et al., 2022). Large hospitals need advanced digital tools to handle the frequent replenishment of supplies and to monitor their use in real time. Asiedu and Akuffo (2021) state that facilities with a high volume of patients are more

likely to gain from data integration that can shorten the time needed for procurement. It is important to adjust digital tools based on hospital demand to ensure operations keep going and bottlenecks in critical care are minimized.

### 4.2.3 Presence and Status of Emergency Logistics Plan

The research showed that the average score was 1.71 (SD = 0.80) which means that some hospitals had emergency plans, but most were either not current or not being followed. Such a finding is worrying due to the major role proactive planning plays in ensuring the supply chain can handle crises. When logistics systems are outdated, hospitals might not handle sudden changes in supplies well, mainly in pandemics and disaster situations (Zhou et al., 2021). A lack of proper contingency planning makes it difficult for the organization to operate and serve its customers well. According to Birkie et al. (2020), it is very important to have clear guidelines for stockpiling, sourcing and communication with stakeholders in emergency situations. This outcome highlights that Zimbabwe's public hospitals need to regularly review and update their emergency logistics plans to manage risks and improve how they respond.

### 4.2.4 Number of Full-Time Supply Chain Management Staff

Table 4.1 reveals that the average number of dedicated supply chain employees was 2.00 (SD = 0.99), so most facilities had 3–5 such staff members. Because of this, it may not be possible for the staff to deal with complex buying, managing inventory and emergency logistics in places where demand is high. Wogayehu and Belay (2022) state that a lack of staff in supply chain departments can result in data entry problems, delays in ordering and difficulty working with vendors. Furthermore, having trained people is important because not knowing how to use the tools can prevent them from being used (Mutegi et al., 2020). This suggests that organizations should focus on developing their workforce, so they have enough staff and people who can work with digital supply chain systems. Increasing the skills and numbers of staff is essential for improving daily operations and emergency response in Zimbabwean hospitals.

### 4.3 Objective 1: To examine the current state of digital transformation in Zimbabwe's public hospital supply chains

**Table 4.2: Descriptive Statistics on Digital Transformation of Hospital Supply Chains**

| Variable | N | Mean | Std. Deviation |
|---|---|---|---|
| Adoption of automated inventory systems | 384 | 2.6042 | 1.28846 |
| Adoption of e-procurement systems | 384 | 2.5938 | 1.24601 |
| Adoption of real-time data tracking tools | 384 | 2.5755 | 1.24306 |
| Use of digital tools in daily operations | 384 | 3.0312 | 1.26782 |
| Integration of digital systems | 384 | 3.0182 | 1.23152 |
| Use of real-time data for decision-making | 384 | 2.9427 | 1.26691 |
| Overall supply chain digitalization | 384 | 2.9948 | 1.28456 |

**Presentation**

Table 4.2 shows the results of descriptive statistics for digital transformation in Zimbabwe's public hospital supply chains, using seven main variables. 384 participants took part in the survey and provided the data. Automated inventory systems were adopted with a mean score of 2.60, while e-procurement systems and real-time tracking tools had mean scores of 2.59 and 2.58. The average score for using digital tools daily was the highest (M = 3.03), followed by scores for digital integration between departments (M = 3.02) and overall digitalization (M = 2.99). The use of real-time data for making decisions was rated at 2.94. The average value for all items is close to the middle of the scale, and the standard deviations range from 1.23 to 1.29, suggesting that the responses are not identical. These findings show that digital technology is present in public hospitals, but its use is still not the same or as effective in all institutions.

**Analysis**

The findings suggest that Zimbabwe's public hospitals are moving towards digital transformation. While many hospitals have begun to use automated inventory systems and e-procurement platforms, they have not yet fully integrated digital technologies into their operations. Even though these tools are crucial for supply chain visibility, they are not widely used, which points to a need for greater adoption. While more people use digital tools every day and systems are used in

departments, this engagement is not yet at the level of a full transformation. The average score for using real-time data in decision-making shows that analytics is not heavily used. The overall digitalization means of 2.99 suggests that the health supply chain is moving towards digitalization, although it is not even in every area. Higher standard deviation indicates that adoption rates differ among hospital types, departments, or geographic areas.

**Discussion**

According to the findings, digital transformation in Zimbabwe's public hospital supply chains is ongoing, though it is still at a moderate level, much like what was reported by Modgil et al. (2022) in their study of public health systems. The reason for the low use of automated inventory and real-time tracking tools is similar to what Sivarajah et al. (2021) identified, such as poor infrastructure, lack of proper training, and different systems. Even though integration among departments is getting better, it is still not as good as it should be, as the WHO (2021) pointed out, since partial digital adoption can make things less efficient during emergencies. Reddy and Reinartz (2022) also found that systems such as CoWIN rely on digital maturity, such as real-time analytics and one central platform to improve their ability to handle challenges. According to the findings, policy changes, building digital infrastructure, and training are important to address the gap in implementation. If the country has a unified digital health strategy, it will be easier for different systems to work together, stay consistent, and improve the supply chain's performance in emergencies.

## 4.4 Objective 2: To assess the level of resilience in Zimbabwe's public hospital supply chains during emergencies and crises

**Table 4.3: Descriptive Statistics on Hospital Supply Chain Resilience**

| Variable | N | Mean | Std. Deviation |
|---|---|---|---|
| Preparedness for supply disruptions | 384 | 2.9922 | 1.25473 |
| Response speed to emergencies | 384 | 2.9844 | 1.29258 |
| Flexibility during emergencies | 384 | 2.9870 | 1.25677 |
| Effectiveness of risk alert systems | 384 | 2.9401 | 1.21309 |
| Resilience during crises | 384 | 2.9115 | 1.23376 |
| Recovery after disruptions | 384 | 2.9609 | 1.24369 |

| | | | |
|---|---|---|---|
| Frequency of risk assessments | 384 | 3.0234 | 1.25454 |
| Supplier partnerships effectiveness | 384 | 2.9609 | 1.22465 |
| Overall resilience rating | 384 | 2.9635 | 1.23851 |

**Presentation**

Table 4.3 highlights the main statistics related to resilience in Zimbabwe's public hospital supply chains. Some of the variables are preparedness, fast response, flexibility, risk alert systems, recovery abilities, and risk assessment processes. The scores for preparedness for supply disruptions (M = 2.99), response speed (M = 2.98), and flexibility (M = 2.99) were close to the middle, so the company has moderate capacity. The average score for resilience during crises was 2.91, but the effectiveness of risk alert systems was a little higher at 2.94. Responding to disruptions (M = 2.96) and forming relationships with suppliers (M = 2.96) were seen as moderately strong. The greatest score was for the frequency of risk assessments at 3.02, and the total resilience rating was 2.96. The standard deviations were between 1.21 and 1.29, which means that resilience is experienced differently in different institutions. The findings indicate that while Zimbabwe's public hospital supply chains are not fully prepared, they are able to adapt in some areas.

**Analysis**

The scores suggest that Zimbabwe's public hospitals can cope with emergency-related supply chain difficulties, but not very well. Even though hospitals have some emergency plans, their ability to act quickly and effectively is not always the same, suggesting that the plans are not always well-executed. In addition, it is difficult to adapt logistics during emergencies because there are few flexible tools and authority is not shared. Because risk alert systems are not widely used in hospitals, it takes longer to notice and handle possible supply issues. Even though recovery methods are used, they are not always organized, and risk assessments are not always turned into actual plans. The low score for supplier collaboration points out that there is not much external coordination, which could hinder the country's access to emergency supplies. The study shows that while some systems are active, they are not fully integrated, consistent, or supported by institutions.

**Discussion**

The results are in line with previous studies and research that prove resilience in public health supply chains depends on several factors. Khan et al. (2020) state that a truly resilient system can handle shocks, recover fast, and gain lessons from the disruptions. It is shown by the moderate scores that while Zimbabwean hospitals are starting to use resilience practices, they are not yet applied in a regular and organized way. In a similar way, Tukamuhabwa et al. (2015) pointed out that hospitals need to be prepared and flexible to maintain a strong supply chain, an area where the hospitals in this study scored less than 3.0. As Pereira et al. (2021) mention, depending on manual methods still makes it hard to detect and deal with risks, so it is important to invest in digital alert systems. In addition, not having strong supplier relationships is similar to the findings by Queiroz et al. (2021), who said that trust between partners is important for a quick response during emergencies. As a result, resilience can be improved by making operational changes and also by strengthening digital infrastructure, allowing more decisions to be made locally, and working with suppliers for a long period.

### 4.3 Inferential Analysis

To examine the effect of digital transformation on hospital supply chain resilience, a multiple linear regression analysis was conducted using Digital Transformation as the independent variable and Supply Chain Resilience as the dependent variable. Organisational characteristics Type of Hospital, Average Monthly Patient Load, Presence of Emergency Logistics Plan, and Number of Fulltime SCM Staff were included as control variables. Table 4.12 presents the model summary results.

**Table 4.12: Model Summary**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| **1** | 0.108 | 0.012 | 0.000 | 0.399 |

The R Square value of 0.012 indicates that approximately 1.2% of the variance in hospital supply chain resilience can be explained by the combined effect of digital transformation and selected institutional characteristics (hospital type, patient load, staff size, and emergency plan presence). Although this is a small effect, it suggests that these variables have a limited role in predicting resilience. Other unmeasured factors may be more influential.

**Table 4.13: ANOVA**

| Model | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| **Regression** | 0.500 | 5 | 0.100 | 0.628 | 0.678 |
| **Residual** | 60.173 | 378 | 0.159 | | |
| **Total** | 60.673 | 383 | | | |

The ANOVA results confirm that the overall model is not statistically significant (F = 0.628, p = 0.678), indicating that the predictors do not jointly account for a meaningful variation in supply chain resilience at the 5% significance level.

**Table 4.14: Coefficients of the Regression Model**

| Predictor Variable | B | Std. Error | Beta | t | Sig. |
|---|---|---|---|---|---|
| **(Constant)** | 2.603 | 0.077 | — | 33.893 | .000 |
| Digital Transformation | 0.148 | 0.034 | 0.210 | 4.305 | .000 |
| Type of Hospital | 0.002 | 0.019 | 0.006 | 0.090 | .929 |
| Average Monthly Patient Load | 0.010 | 0.018 | 0.033 | 0.547 | .585 |
| Presence of Emergency Logistics Plan | -0.002 | 0.021 | -0.006 | -0.090 | .928 |
| Number of Fulltime SCM Staff | -0.002 | 0.017 | -0.006 | -0.103 | .918 |

Table 4.14 presents the regression results showing how digital transformation and organisational factors relate to supply chain resilience in public hospitals. The findings indicated that digital transformation had a significant and positive effect on resilience, with a coefficient (B) of 0.148 and a standardised beta (β) of 0.210. This means that for every one-point increase in the level of digital transformation, the supply chain resilience score also increased by 0.148 units, assuming all other variables remained constant. This suggests that hospitals with stronger digital systems and practices are better positioned to withstand and manage supply chain disruptions.

In contrast, the control variables included in the model type of hospital, average monthly patient load, presence of an emergency logistics plan, and number of full-time supply chain staff did not show any statistically significant relationship with resilience. Their p-values were all above the 0.05 threshold, and their beta values were very small, indicating a limited or negligible effect. For example, type of hospital (β = 0.006), patient load (β = 0.033), emergency plan presence (β = -0.006), and supply chain staffing levels (β = -0.006) had no meaningful predictive value. These results highlight that, within the scope of this study, organisational characteristics alone are not

strong predictors of resilience. Rather, it is the extent of digital transformation that plays the most important role in strengthening hospital supply chains.

### 4.5 Chapter Summary

This chapter showed and analysed the statistics from the study, using the same organization as the research questionnaire. The analysis showed that public hospitals in Zimbabwe have moderate use of digital technologies, mainly seen in inventory systems, buying online and tracking tools. Limitations such as poor infrastructure, shortages of skilled workers and little help from the government are still holding back digital transformation. Supply chain resilience factors such as being prepared, flexible and having risk alert systems were rated as only moderately strong which means the institutions are not fully ready to handle disruptions. Results from inferential analysis suggest that digital transformation and supply chain resilience are only weakly related and are not statistically significant. Despite the benefits of digital tools, their lack of integration and inconsistent use limit their effects. Ensuring that agencies can work together, partner with others and have well-trained staff is still very important for becoming more resilient. The results highlight that it is crucial for the nation to work together to unify digital activities and improve the healthcare supply chain’s strength and adaptability.

# CHAPTER 5

# SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

## 5.1 Introduction

The chapter wraps up the study by summarising the main findings, drawing final conclusions and giving relevant recommendations. The study was carried out to find out how digital transformation affects the resilience of supply chains in public hospitals in Zimbabwe. The study also examined how hospital structure and the use of digital tools play a role in their preparedness, response and recovery from disruptions in the supply chain. The chapter uses the data analysis from Chapter 4, where both descriptive and inferential methods were applied to find significant patterns and relationships. The chapter also outlines what the research adds to the field, presents useful recommendations and highlights the study's limitations. The recommendations aim to support public health institutions, policymakers and future researchers in strengthening digital and logistical systems for healthcare in Zimbabwe and other similar places.

## 5.2 Summary of Key Findings

The research found that the majority of public hospitals in Zimbabwe have made moderate progress in digital transformation, but the use of automated inventory, e-procurement and tracking technology is still at an early stage. Even though digital tools are part of daily supply chain work, integration among departments is not always done. Important hurdles like high costs, not enough skilled people, poor infrastructure and limited government help kept digitalisation from progressing. Even with these problems, hospitals started using real-time data from their supply chain to make decisions, showing a move toward using data more in their supply chain activities.

Factors related to an organization were not found to make a big difference in how resilient the supply chain was. The type of hospital, average number of patients each month and the number of supply chain management staff did not vary much in deciding how well the hospital could handle disruptions. Most hospitals did not have detailed and updated emergency logistics plans which may lower their preparedness and ability to handle sudden shortages. Having outdated logistics strategies in place underlines the difficulty of the institution to respond quickly to unexpected challenges.

Hospitals generally felt they were moderately prepared, flexible and able to recover when faced with disruptions in the supply chain. Even so, hospitals rarely performed regular risk assessments and few used technologies to identify risks in the supply chain. Also, many hospitals faced disruptions at least once every three months which indicated problems in managing inventory, buying supplies and coordinating with suppliers. It often took a long time for companies to recover which showed that better preparation was necessary in logistics management. This highlights that supply chain planning and continuity systems should be improved.

According to the regression analysis, digital transformation had a very small, yet not significant, impact on supply chain resilience. This means that although digitalisation helps with responsiveness and adaptability, its influence is not very significant because implementation is not advanced. Having control variables such as hospital type and logistics staffing did not change the results much, suggesting that digital transformation must be supported by other changes to ensure resilience. Examples are training the workforce, updating institutions and making policy-based investments in digital health to ensure a stable supply chain.

### 5.3 Conclusions

This study set out to examine how digital transformation influences the resilience of Zimbabwe's public hospital supply chains during emergencies and crises. Drawing from both descriptive and inferential analyses, as well as literature and empirical studies, the findings reveal important insights that are best concluded in alignment with the study's three objectives.

**Objective 1: To examine the current state of digital transformation in Zimbabwe's public hospital supply chains**

According to the study, Zimbabwe's public hospitals are in the beginning to middle stages of adopting digital technologies. Most companies have only moderately adopted main technologies such as automated inventory, e-procurement, real-time tracking, and system integration. It appears that these results are not the same for every institution. Because of high costs, poor digital infrastructure, not enough digital literacy, and little help from the government, growth has been slow. However, some companies are starting to use digital tools for managing their stock and making decisions. The evidence indicates that digital transformation is taking place, but it is not fully organised and still fragmented. Upgrading digital infrastructure, setting up national standards

for system integration, and investing more in digital literacy programmes are important for increasing the use of digital tools in public health institutions.

**Objective 2: To assess the level of resilience in Zimbabwe's public hospital supply chains during emergencies and crises**

The supply chains of public hospitals in Zimbabwe were found to be moderately resilient, with some capacity to prepare, respond, and adjust, but there is still much room to improve. It was shown that hospitals are ready to handle changes, but they do not have systems to detect risks instantly and continue to rely on old manual actions. Risk assessments are not done regularly, and preparing for recovery is still not done in a planned way. Besides, when suppliers are not closely connected and procurement is centralized, it becomes difficult to quickly respond to health crises. The results agree with studies that point out that strong health supply chains should be prepared, use decentralized logistics, have flexible ways to buy supplies, and rely on data for risk management. Even though some resilience structures are present in Zimbabwe's hospitals, they are not fully implemented due to inertia, rules, and not enough money for supply chain development.

**Objective 3: To evaluate the impact of digital transformation initiatives on the resilience of Zimbabwe's public hospital supply chains during emergencies and crises**

There was a significant positive connection between digital transformation and supply chain resilience found in the inferential analysis ($\beta = 0.210$, $p < .001$). The model's overall ability to explain the data was low ($R^2 = 0.012$), which means digital tools play a limited role in resilience compared to other factors. The type of hospital, the number of patients, and having emergency logistics plans did not have a major impact on resilience. The result suggests that it is systemic digital investment that leads to better resilience, not the characteristics of individual institutions. It is proven once again that digitisation should be combined with organisational changes, skills development, and policies. With real-time analytics, combined dashboards, and interconnected systems, you can buy products more quickly, notice disruptions earlier, and see your inventory better. As a result, digital transformation greatly helps, but is not the only factor in making a country resilient, so other improvements are also needed.

## 5.4 Recommendations

For digital transformation to be successful in Zimbabwe's public hospital supply chains, the government must put in place solid national plans and provide the necessary financial support. The Ministry of Health and Child Care should put together a digital health system that highlights the importance of integration, interoperability and standardization among all hospitals. Financial resources should be used to put in place important technologies like automated inventory, e-procurement and real-time tracking. To ensure hospitals improve and follow national standards, they should be checked through performance audits that meet digital benchmarks.

Hospital administrators should focus on joining digital platforms for logistics, procurement and pharmacy units. These systems should be able to work well in both city and country hospitals, especially when resources like good internet and trained staff are scarce. Setting up digital taskforces inside the company can help guide digital transformation, solve problems and watch over progress. Digital systems should be introduced locally and users should get hands-on training to encourage them to use the systems and reduce their reluctance.

In technology, hospitals must focus on buying systems that are both affordable, scalable and easy to use on low-bandwidth networks. Working together with local experts, NGOs and international health partners may result in solutions that fit the local needs. Mobile-based procurement tools, instant supply dashboards and risk alerts can increase both visibility and responsiveness. In addition, hospitals must use strong data security methods, regularly examine their systems and maintain their digital infrastructure to ensure the system keeps working smoothly.

Capability development is the final key factor in achieving the maximum positive impact of digital transformation on supply chain stability. Training for supply chain staff such as procurement officers, pharmacists and store managers, should stress the use of technology, forecasting techniques and data-driven strategies. Digital logistics modules should be included in the training programs at public health education institutions. Forming peer groups or teams among hospital supply chain professionals will support closer cooperation, new ideas and sharing of digital best practices. Using these strategies, the public healthcare supply system in Zimbabwe will become more resilient and use digital tools effectively.

## 5.5 Limitations of the Study

Even though this study adds valuable information about digital transformation and supply chain resilience in Zimbabwe's public hospitals, it has certain limitations. At the beginning, researchers gathered data by asking participants to fill out questionnaires and this approach could result in biased or overstated answers about digital tools and their effectiveness. In addition, this study only looked at public sector hospitals instead of private ones, so the findings may not apply to the entire health sector.

The research collected information at a particular moment in time, not looking at how things changed or developed over time. Therefore, it is difficult to determine whether digital transformation leads to better resilience outcomes. Even though attempts were made to confirm the constructs, some of the composite indices showed weak internal consistency, indicating that better measurement tools and qualitative studies could be helpful in the future.

## 5.6 Recommendations for Future Studies

The study has revealed significant connections between digital transformation and resilience of the Zimbabwean public hospitals. However, multiple gaps and drawbacks indicate that there is more to be studied in the academic field. Nevertheless, there are a number of gaps and limitations that can be used as the basis of further academic research. The following suggestions are given to inform the future research:

### Expand beyond quantitative approaches

Future research could be more informative by involving interview or focus groups with medical workers, supply chain managers, or policymakers. They would enable them to know more about the way individuals perceive and respond to digital change and resilience within their organisations. A mixed-methods approach would assist us in gaining more insight into the social and technical problems and opportunities that hospitals encounter in the process of implementing digital tools.

**Broaden the scope to include multiple healthcare tiers and geographic diversity**
Though this study predominantly focused on the case of public hospitals, future research ought to also incorporate primary health care facilities, rural clinics, and even the private hospitals. The

degree to which these entities are resilient may be influenced by the level of digital advancement, resources, and organisation preparedness. The results would be more helpful to all people and would be used to design better policies using a larger sample.

**Explore long-term impact and system-wide effects**

Longitudinal research on digital transformation over the years would be valuable in understanding the long-term impact of digital adoption on resilience, especially across various crisis cycles, including pandemics or natural disasters. The researchers of the future should also examine the impact of digital supply chain changes on the health system in general, including patient outcomes, equity, and costs.

**Investigate policy, regulatory, and governance enablers**

Further studies are required to learn more about the role of national policies, digital governance regulations, and leadership in determining digital transformation in healthcare outcomes. An examination of how governments fund, enforce and collaborate with private firms can provide an end-to-end view of what is required to achieve digital resilience.

**Assess emerging technologies and innovative models**

Hospital supply chains can be improved by future research on how blockchain, artificial intelligence, IoT, and digital twins may increase visibility, traceability, and responsiveness. Researching on such innovations in the developing world in collaboration would assist in coming up with solutions that can be implemented in resource poor locations.

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# APPENDICES

**Questionnaire**

**The Impact of Digital Transformation on Public Sector Supply Chain Resilience in Zimbabwe's Public Hospitals**

**Section A: Demographics and Organizational Characteristics**

| Question 1: What type of hospital do you work in? | Code |
|---|---|
| ☐ **Public General Hospital** | 1 |
| ☐ **Public Referral Hospital** | 2 |
| ☐ **Rural District Hospital** | 3 |

**Question 2: What is the average monthly patient load in your hospital?**

| Response Option | Code |
|---|---|
| ☐ Less than 1,000 patients | 1 |
| ☐ 1,000–5,000 patients | 2 |
| ☐ 5,001–10,000 patients | 3 |
| ☐ More than 10,000 patients | 4 |

**Question 3: Does your hospital have a dedicated emergency response and logistics plan?**

| Response Option | Code |
|---|---|
| ☐ Yes – regularly updated and implemented | 1 |
| ☐ Yes – but outdated or not regularly followed | 2 |
| ☐ No formal emergency logistics plan | 3 |

**Question 4: How many full-time staff are responsible for supply chain management functions?**

| Response Option | Code |
|---|---|
| ☐ 1–2 personnel | 1 |
| ☐ 3–5 personnel | 2 |
| ☐ 6–10 personnel | 3 |
| ☐ More than 10 personnel | 4 |

# Section B: Digital Transformation of Hospital Supply Chains

***(Measurement Scale: 1 = Not at all, 5 = To a very great extent)***

**Q5. To what extent has your hospital adopted the following digital supply chain technologies?**

| Technology | Not at all (1) | Small extent (2) | Moderate extent (3) | Great extent (4) | Very great extent (5) |
|---|---|---|---|---|---|
| **Automated Inventory Systems** | ☐ | ☐ | ☐ | ☐ | ☐ |
| **E-Procurement Systems** | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Real-Time Data Tracking Tools** | ☐ | ☐ | ☐ | ☐ | ☐ |

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**Q6. To what extent are digital tools used in day-to-day supply chain operations?**

| Response Option | Code |
|---|---|
| ☐ **Not at all** | 1 |
| ☐ **To a small extent** | 2 |
| ☐ **To a moderate extent** | 3 |
| ☐ **To a great extent** | 4 |
| ☐ **To a very great extent** | 5 |

**Q7. To what extent are digital systems integrated across different hospital departments (e.g., pharmacy, procurement, IT)?**

| Response Option | Code |
|---|---|
| ☐ **Not at all** | 1 |
| ☐ **To a small extent** | 2 |
| ☐ **To a moderate extent** | 3 |
| ☐ **To a great extent** | 4 |
| ☐ **To a very great extent** | 5 |

**Q8. To what extent do the following challenges affect the implementation of digital supply chain tools in your hospital?**

| Challenge | Not at all (1) | Small extent (2) | Moderate extent (3) | Great extent (4) | Very great extent (5) |
|---|---|---|---|---|---|
| **High cost of implementation** | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Lack of skilled personnel** | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Poor internet/digital infrastructure** | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Staff resistance to change** | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Inadequate government support** | ☐ | ☐ | ☐ | ☐ | ☐ |

**Q9. To what extent does your hospital use real-time supply chain data to make decisions?**

| Response Option | Code |
|---|---|
| ☐ **Not at all** | 1 |
| ☐ **To a small extent** | 2 |
| ☐ **To a moderate extent** | 3 |
| ☐ **To a great extent** | 4 |
| ☐ **To a very great extent** | 5 |

**Q10. To what extent is your hospital's supply chain digitalized overall?**

| Response Option | Code |
|---|---|
| ☐ **Not at all** | 1 |
| ☐ **To a small extent** | 2 |
| ☐ **To a moderate extent** | 3 |
| ☐ **To a great extent** | 4 |
| ☐ **To a very great extent** | 5 |

# Section C: Resilience of Hospital Supply Chains

***(Measurement Scale: 1 = Very low, 5 = Very high)***

**Q11. How would you rate your hospital's preparedness for supply chain disruptions (e.g., stockouts, pandemics)?**

| Response Option | Code |
|---|---|
| ☐ **Very low** | 1 |
| ☐ **Low** | 2 |
| ☐ **Moderate** | 3 |
| ☐ **High** | 4 |
| ☐ **Very high** | 5 |

**Q12. How quickly can your hospital respond to unexpected shortages or emergencies?**

| Response Option | Code |
|---|---|
| ☐ **Very low** | 1 |
| ☐ **Low** | 2 |
| ☐ **Moderate** | 3 |
| ☐ **High** | 4 |
| ☐ **Very high** | 5 |

**Q13. How flexible is your hospital in adapting its supply chain during emergencies?**

| Response Option | Code |
|---|---|
| ☐ **Very low** | 1 |
| ☐ **Low** | 2 |
| ☐ **Moderate** | 3 |
| ☐ **High** | 4 |
| ☐ **Very high** | 5 |

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**Q14. How effective are your hospital's systems in alerting management about supply chain risks?**

| Response Option | Code |
|---|---|
| ☐ **Very low** | 1 |
| ☐ **Low** | 2 |
| ☐ **Moderate** | 3 |
| ☐ **High** | 4 |
| ☐ **Very high** | 5 |

**Q15. How frequently does your hospital experience major supply chain disruptions?**
***(Reverse scale — higher = fewer disruptions)***

| Response Option | Code |
|---|---|
| ☐ **Very frequently (monthly)** | 1 |
| ☐ **Frequently (quarterly)** | 2 |
| ☐ **Occasionally (once/twice a year)** | 3 |
| ☐ **Rarely** | 4 |
| ☐ **Very rarely (almost never)** | 5 |

**Q16. How resilient is your hospital's supply chain in maintaining services during crises?**

| Response Option | Code |
|---|---|
| ☐ **Very low** | 1 |
| ☐ **Low** | 2 |
| ☐ **Moderate** | 3 |
| ☐ **High** | 4 |
| ☐ **Very high** | 5 |

**Q17. How well does your hospital recover its supply chain performance after disruptions?**

| Response Option | Code |
|---|---|
| ☐ **Very low** | 1 |
| ☐ **Low** | 2 |
| ☐ **Moderate** | 3 |
| ☐ **High** | 4 |
| ☐ **Very high** | 5 |

**Q18. How regularly does your hospital conduct risk assessments for supply chain disruptions?**

| Response Option | Code |
|---|---|
| ☐ **Very rarely** | 1 |
| ☐ **Rarely** | 2 |
| ☐ **Sometimes** | 3 |
| ☐ **Often** | 4 |
| ☐ **Very regularly** | 5 |

**Q19. How effective are supplier partnerships in ensuring reliable supply during emergencies?**

| Response Option | Code |
|---|---|
| ☐ **Very ineffective** | 1 |
| ☐ **Ineffective** | 2 |
| ☐ **Moderately effective** | 3 |
| ☐ **Effective** | 4 |
| ☐ **Very effective** | 5 |

**Q20. Overall, how would you rate the resilience of your hospital's supply chain system?**

| Response Option | Code |
|---|---|
| ☐ **Very low** | 1 |
| ☐ **Low** | 2 |
| ☐ **Moderate** | 3 |
| ☐ **High** | 4 |
| ☐ **Very high** | 5 |