ASSESSING DISRUPTIONS IN PHARMACEUTICAL SUPPLY CHAINS: A QUALITATIVE STUDY OF RESILIENCE AND RISKS IN THE SOUTH AFRICAN CONTEXT

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ABSTRACT

This study evaluates the disruptions in South African pharmaceutical supply chains, focusing on resilience mechanisms and risk factors essential for maintaining continuity and efficiency amidst various disruptions. It leverages a comprehensive literature review and qualitative insights from interviews with 25 local experts, employing a phenomenological approach to explore the strategic experiences and adaptations to supply chain challenges. Findings highlight the significance of diversified sourcing, strategic adaptability, and local production enhancement in ensuring supply chain robustness and pharmaceutical availability. The research underscores the importance of robust risk management, strategic foresight, and local capability investment, offering practical insights for stakeholders to enhance supply chain resilience. Contributing valuable perspectives to supply chain management discourse, it enriches the understanding of resilience and risk mitigation in the pharmaceutical sector, providing a basis for informed strategic planning and policymaking to safeguard against future disruptions.

Keywords: Pharmaceutical Supply Chains, Resilience, Risk Management, Supply Chain Disruptions, Strategic Adaptability, Diversified Sourcing.

1. INTRODUCTION

The pharmaceutical supply chain in South Africa is crucial for ensuring the availability of essential medications to the population. Recent events, like the COVID-19 pandemic, have highlighted the vulnerability of this supply chain to disruptions (Omoruyi, Dakora & Oluwagbemi, 2022). Events like pandemics, natural catastrophes, or other situations can have a major impact on the availability of medicines, leading to potential harm to public health (Wang & Jie, 2019). Resilience and effective risk management strategies are essential for maintaining the integrity of the pharmaceutical supply chain in South Africa (Wang & Jie, 2019).

Resilience and risk management are essential for maintaining the uninterrupted flow of pharmaceuticals in the supply chain, particularly during unexpected events (Wang & Jie, 2019). Research has demonstrated that interruptions in the supply chain can create substantial difficulties for suppliers and customers, highlighting the importance of taking proactive steps to reduce risks and strengthen resilience (Nel, Goede & Niemann, 2018). Organisations within the pharmaceutical supply chain must be able to efficiently respond to disruptions in order to survive and succeed (Nel et al., 2018).

This study aims to investigate disruptions in the pharmaceutical supply chain in South Africa, analyse their impact, and assess the role of resilience and risk management approaches in tackling these difficulties. This study intends to provide useful insights into the specific dynamics of the pharmaceutical supply chain in South Africa and contribute to the creation of policies to strengthen its resilience (Omoruyi et al., 2022).

1.1 *Overview of the pharmaceutical supply chain in South Africa*

The pharmaceutical supply chain in South Africa is crucial for providing necessary pharmaceuticals to the populace. This supply chain encompasses multiple stages, such as pharmaceutical production, distribution

to wholesalers, retailers, and finally to healthcare facilities and patients (Hertig, Baney & Weber, 2019). It includes primary and secondary wholesale distributors, packaging, and dispensers such as hospitals and community pharmacies working together to guarantee the prompt delivery of medications to end consumers (Hertig et al., 2019).

Figure 1 below depicts a flowchart representing the pharmaceutical supply chain in South Africa. The flowchart offers a detailed summary of the process by which pharmaceutical items are distributed from production to end-users in South Africa. The system consists of primary, secondary, and tertiary stages, reflecting the logistical complexity in the country. Reverse logistics involves managing the return flow of commodities, particularly for expired or defective products. The "Additional Steps" section recognises that the pharmaceutical supply chain is interconnected with other important elements like international commerce and government action, which are essential for a comprehensive comprehension of the pharmaceutical supply chain in the country.

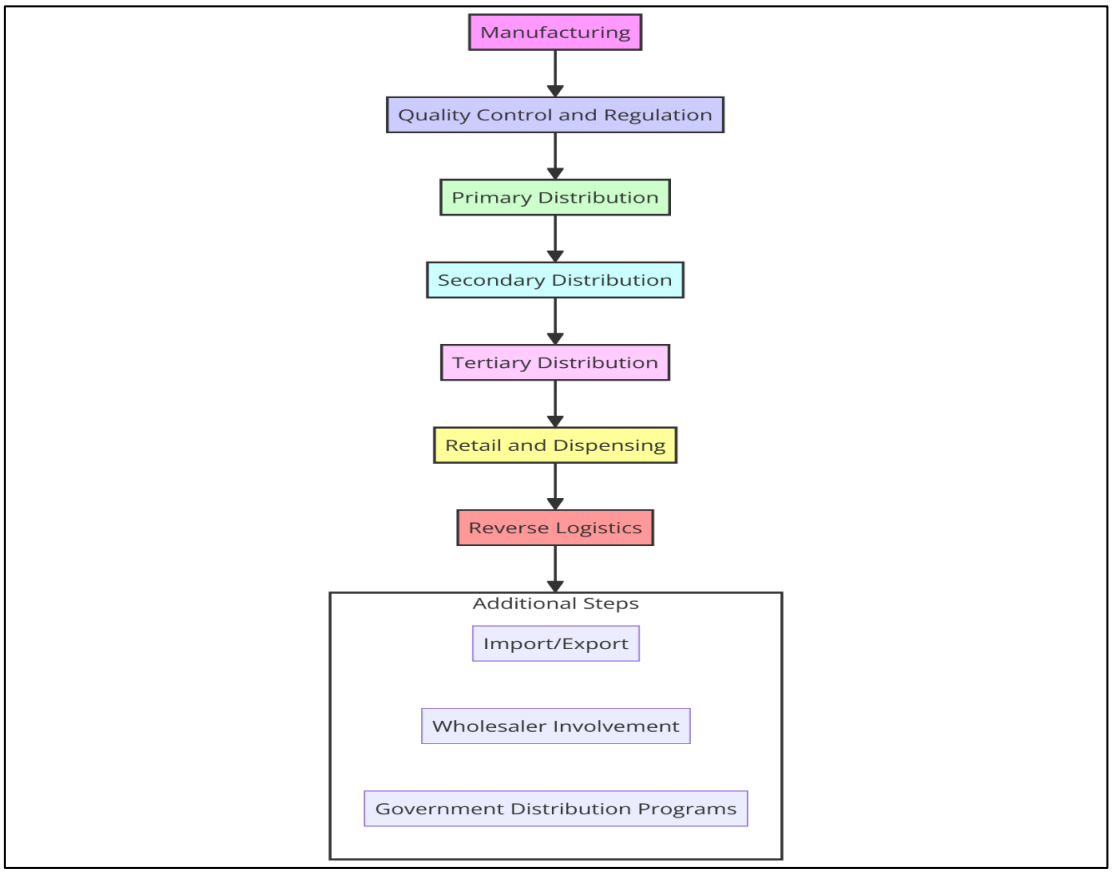

FIGURE 1
PHARMACEUTICAL SUPPLY CHAIN IN SOUTH AFRICA

Source: Own Compilation

The pharmaceutical supply chain in South Africa has been greatly affected by recent issues, including the COVID-19 epidemic. The pandemic has resulted in shortages of medical devices, essential pharmaceuticals, and pharmaceutical items because of disruptions such as border closures, transit limitations, and international commerce disruptions (Okafor, Olalaye, Asobara & Umeodinka, 2021). The recent interruptions have highlighted the supply chain's susceptibility to external shocks and the significance of resilience in preserving its integrity (Okafor et al., 2021).

Resilience and risk management are essential for maintaining the pharmaceutical supply chain's continuity in South Africa. Research has shown that interruptions in the supply chain can lead to significant outcomes, emphasising the need for proactive actions to reduce risks and strengthen resilience. Organisations within the pharmaceutical supply chain must have the ability to successfully adapt to disturbances in order to survive and thrive.

1.2 *Impact of disruptions on the supply chain*

Disruptions in the pharmaceutical supply chain in South Africa have been notably severe recently, with the COVID-19 epidemic exacerbating issues within the system. The pandemic has shown weaknesses in the supply chain, demonstrating the lack of flexibility and the extensive impact of interruptions on a worldwide level (Okafor et al., 2021).

The pandemic disruptions have produced a cascading impact on the pharmaceutical supply chain, affecting multiple points and relationships. Border closures, transportation limitations, and disruptions in international trade have led to scarcities of crucial medicines, medical gadgets, and pharmaceutical products (Tirivangani, Alpo, Kibuule, Gaeseb & Adenuga, 2021). The disruptions have shown the importance of strong risk management strategies and resilience mechanisms to address issues in the supply chain (Nel et al., 2018).

The pharmaceutical supply chain in South Africa, along with many others worldwide, has encountered exceptional hurdles as a result of the epidemic. The disruptions have impacted both the availability of medicines and the operational capacity of the entire supply chain network. The pharmaceutical supply chain in the country has been challenged by delays in delivery, damaged stock, theft, high gasoline expenses, and expired stock, testing its resilience (Turan & Öztürkoğlu, 2022).

Recognising the problems, there is an increasing acknowledgement of the need for proactive steps to improve the resilience of the pharmaceutical supply chain. Proposed strategies to mitigate vulnerabilities caused by disruptions include utilising technology such as blockchain for supply chain management, adopting multi-echelon inventory management practices, and engaging in green supply chain management activities (Malan, Labuschagne, Brechtelsbauer, Goff & Schellack, 2018; Al-Zaidi, Al-Zuhairi & Salih, 2019; Omoruyi et al., 2022). Stakeholders in the pharmaceutical supply chain in South Africa should enhance their potential to overcome future obstacles and maintain a steady supply of important pharmaceuticals by comprehending disruptions' effects and employing robust risk management and resilience measures.

1.3 *Importance of resilience and risk management*

Resilience and risk management are essential for protecting the integrity of the pharmaceutical supply chain in South Africa. Resilience refers to the supply chain's capacity to endure and bounce back from disturbances, while risk management concentrates on recognising, evaluating, and reducing possible threats that may affect the supply chain (Wang & Jie, 2019).

In the pharmaceutical sector, timely access to medications is crucial for public health, and any interruptions can lead to serious outcomes. Implementing efficient risk management solutions is crucial for pre-emptively managing potential disruptions, such as those triggered by the COVID-19 pandemic, natural disasters, or geopolitical events (Wang & Jie, 2019). Pharmaceutical supply chains can enhance their ability to predict and address difficulties by adopting strong risk management strategies, which helps maintain the uninterrupted delivery of vital pharmaceuticals to patients (Wang & Jie, 2019).

Resilience is essential for companies to preserve supply chain integrity by allowing them to adjust to unexpected situations and swiftly recover from interruptions. An enduring pharmaceutical supply chain can lessen the effects of interruptions on product availability, decrease lead times, and improve overall operational efficiency (Wang & Jie, 2019). Organisations can enhance their ability to handle uncertainties and external changes in the supply chain by incorporating resilience, ensuring the uninterrupted flow of pharmaceutical supplies.

Furthermore, including technology such as blockchain and Internet of Things (IoT) sensors can improve supply chain visibility, traceability, and transparency, leading to enhanced risk management techniques (Singh, Dwivedi & Srivastava, 2020). The technologies mentioned allow for the continuous monitoring of pharmaceutical items in real-time to guarantee their genuineness, excellence, and adherence to regulations across the supply chain (Singh et al., 2020). Pharmaceutical firms in South Africa can improve their risk management capabilities and raise the resilience of their supply chains by utilising these advances.

1.4 *Objectives of the study and its significance*

The study aims to evaluate interruptions in the pharmaceutical supply chain in South Africa, which are important for the pharmaceutical business. The main goal is to thoroughly assess the effects of disruptions on the supply chain, with a specific focus on current issues like the COVID-19 pandemic, natural catastrophes, and other unexpected events (Remko, 2020; Umar, 2023). The study aims to identify vulnerabilities and weaknesses in the supply chain that are revealed during disruptions through a qualitative approach. This will enhance the understanding of resilience and risk management practices needed to effectively tackle these challenges (Remko, 2020; Umar, 2023).

The study intends to evaluate the sources of resilience in the pharmaceutical supply chain in South Africa and explore how these sources might be used to improve the integrity and operational efficiency of the supply chain. The study aims to examine how businesses may proactively reduce risks and develop adaptive capacity to navigate disruptions successfully by analysing the relationship between risk management techniques and resilience capabilities (Naz, Kumar, Majumdar & Agrawal, 2021; Mu, Asselt, Wagenberg & Fels-Klerx, 2023).

This study is important in the South African pharmaceutical setting because it has the ability to provide valuable insights for making strategic decisions and formulating policies within the industry. The study aims to empower stakeholders in South Africa's pharmaceutical supply chain by addressing specific challenges and proposing customised resilience and risk management solutions. This will help ensure the continuous availability of essential medications to the population (Um & Han, 2020; Liu, Lu, Shi, Hu & Li, 2023). The study's results can be used as a basis for future research projects and practical actions to improve the resilience and sustainability of the pharmaceutical supply chain in South Africa (Shweta, Kumar & Chandra, 2022; Al-Ayed & Al-Tit, 2023).

2. **THEORETICAL FRAMEWORK**

2.1 Supply chain disruptions

Supply chain disruptions, especially in the pharmaceutical industry, have received considerable attention because of their potential effects on public health and the accessibility of vital pharmaceuticals. The COVID-19 pandemic has emphasised the weaknesses in pharmaceutical supply chains, emphasising the crucial requirement for resilience and efficient risk management measures (Okafor et al., 2021; Tirivangani et al., 2021).

Research has highlighted the significance of improving pharmaceutical supply chain resilience to successfully manage interruptions. Researchers have studied resilience analytics and modelling methods to measure and improve the resilience of supply chains, particularly during pandemics such as COVID-19 (Golan, Jernegan & Linkov, 2020; Golan, Trump, Cegan & Linkov, 2021). Utilising resilience analytics, like as stress tests and digital twins, can help measure efficiency-resilience trade-offs and enhance system performance after a disturbance (Golan et al., 2021).

Research has investigated the elements that affect the robustness of pharmaceutical supply chains. Power-based behaviours, supply chain integration, and end-to-end traceability using technologies such as blockchain are crucial for enhancing resilience in the pharmaceutical industry (Sim, Zhang & Chang, 2022;

Yaroson, Breen, Hou & Sowter, 2023). Utilising technology like blockchain can increase traceability, eliminate data silos, and promote supply chain resilience (Sim et al., 2022).

Moreover, the literature has highlighted the significance of collaborative regulation, supply chain diversification, and digital transformation in enhancing pharmaceutical supply chain resilience (Bastani, Dehghan, Kashfi, Dorosti, Mohammadpour, Mehralian & Ravangard, 2021; Yin & Ran, 2022). Collaborative efforts among stakeholders, diversification strategies, and digital tools can contribute to building a more resilient pharmaceutical supply chain capable of withstanding disruptions.

The pharmaceutical and healthcare industry involves numerous markets, products, processes, and intermediaries, leading to a fragmented supply chain that is impacted by changes in various areas (Ward & Hargaden, 2019). Drug Shortages: Drug shortages can be caused by a variety of factors, such as lack or shortage of raw materials, manufacturing difficulties, regulatory and political actions, just-in-time inventory systems, market shifts, and unexpected increases in demand (Takawira & Pooe, 2024). Quality defects represent a top disturbance factor for pharmaceutical firms, especially in Western and Eastern Europe, highlighting the critical nature of pharmaceutical products (Takawira & Mutambara, 2023).

Disruptions in the pharmaceutical supply chain can lead to drug shortages, making it difficult or impossible to meet the therapeutic needs of patients or populations (Takawira & Pooe, 2024). The vulnerabilities of pharmaceutical supply chains during the COVID-19 pandemic were identified, emphasising the need for resilience to ensure a sustained supply of high-quality pharmaceutical products and services during crises (Yaroson, Breen, Hou & Sowter, 2019; Stark & Zweig, 2024).

An assessment of supply chain resilience in the pharmaceutical sector revealed the need for improvement in supply chain capabilities, particularly in flexibility in sourcing, order fulfilment, visibility, and collaboration (Ponomarov & Holcomb, 2009). Dimensions of supply chain agility, such as alertness, accessibility, connectivity, and visibility, were found to be capable of reducing the impact of drug shortages in the pharmaceutical supply chain (Christopher & Peck, 2004). Building resilience in pharmaceutical supply chains involves the adoption of comprehensive demand management strategies, the use of data analytics, and the need for local production to develop local skills and enterprises (Liu et al., 2023).

The COVID-19 pandemic has highlighted the need for strategies such as research and development, marketing strategies, collaborative supply chain disruption management, and local production to overcome disruptions in the South African pharmaceutical supply chain (Yaroson et al., 2019). The importance of local research and development initiatives, integration of digital technologies, effective communication, local manufacturing, and strong relationships with suppliers and customers were highlighted as key strategies for mitigating disruptions in the South African pharmaceutical supply chain (Yaroson et al., 2019).

Figure 1 below illustrates a conceptual map that elucidates the multifaceted nature of supply chain disruptions within the pharmaceutical industry. This visual representation employs a series of interconnected nodes, each corresponding to a significant aspect within the context of supply chain management. At the core of this map lies the node labelled “Supply Chain Disruptions,” depicted with a blue dot, symbolising the central theme of the discourse.

Radiating from this central node are three principal components, each distinguished by a unique colour. The first of these, “Mitigation Strategies,” is indicated by a red dot and is further linked to concepts of “Resilience” and “Supply Chain Coordination.” This suggests that the development of robust and adaptive strategies is crucial for maintaining the integrity of the supply chain amidst various challenges.

The second component, “Impact,” marked by a green dot, is associated with the outcomes of disruptions, specifically “Customer Satisfaction” and “Medicines Shortages.” This connection underlines the direct consequences that supply chain interruptions can have on both the consumer experience and the availability of critical pharmaceutical products.

The third and final component, "Causes," is symbolised with a purple dot, drawing attention to the underlying factors that precipitate disruptions. Notably, this element is tied to "Demand Planning and Management" and the broader context of a "Pandemic," highlighting the complexities and external variables that can influence the supply chain.

Moreover, the map extends to include additional pertinent concepts such as "Supply-Chain-Modelling" and "Inventory Management," which are essential to the mitigation strategies and are indicative of the practical approaches employed to counteract the disruptions.

Upon analysis of Figure 1, it becomes apparent that a confluence of strategic responses, measurable impacts, and root causes influences the pharmaceutical industry's supply chain disruptions. Mitigation strategies are underscored as a vital response to disruptions, with a clear emphasis on the necessity for resilience and effective coordination. The repercussions of these disruptions manifest in the form of diminished customer satisfaction and the occurrence of medicine shortages, signifying major concerns that the industry must address. Additionally, the causes of such disruptions are interconnected with broader issues, including the challenges posed by pandemics and the intricacies of demand planning and management.

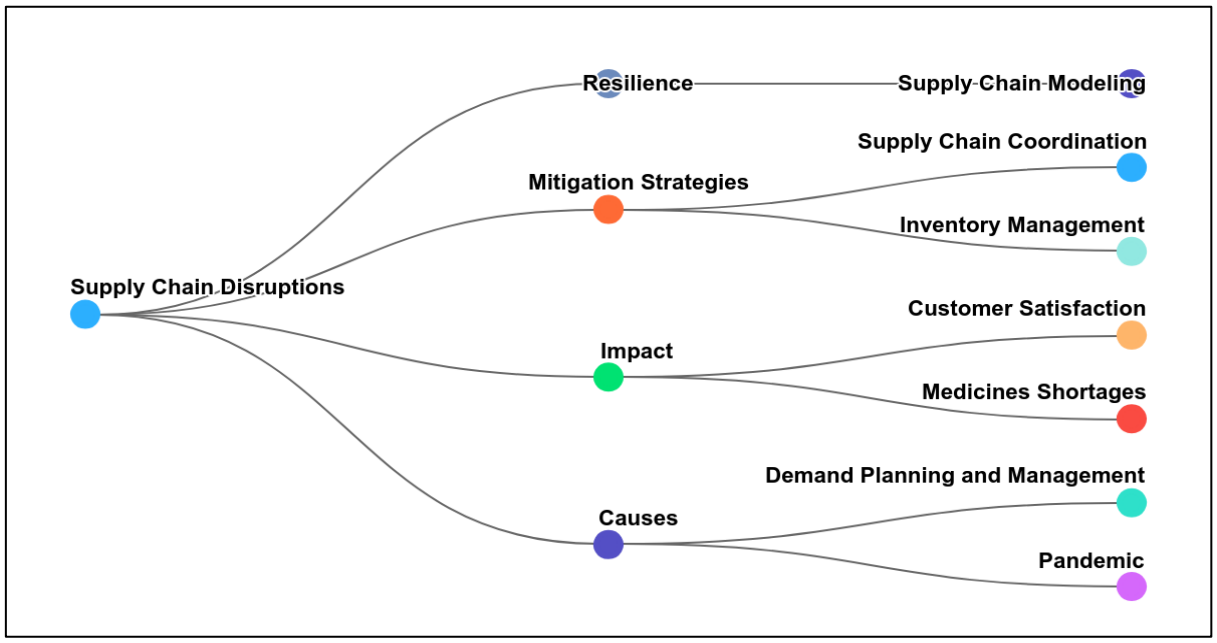

FIGURE 1
CONCEPTUAL MAP OF SUPPLY CHAIN DISRUPTIONS

Source: Own compilation

2.2 *Resilience and risk management theories*

Resilience and risk management theories are crucial in enhancing the robustness of supply chains, especially in the pharmaceutical sector. The literature provides valuable insights into the theoretical foundations and practical implications of these concepts, highlighting their effectiveness in mitigating disruptions and fostering adaptive capacities within supply chains. Studies Um and Han (2020); and Pu, Qiao and Feng (2023) emphasise the importance of integrating dynamic capabilities, relational perspectives, and mitigating strategies to enhance supply chain resilience. These theories stress the significance of developing a risk management culture, promoting collaboration, and leveraging capabilities to improve the adaptive capacity of supply chains in the face of uncertainties and disruptions.

Ali, Gölgeci and Arslan (2021) and Ganguly and Kumar (2019) highlight the relationship between knowledge management methods, risk management culture, and resilience in enhancing supply chain

performance. Organisations may improve their comprehension of how knowledge management, risk management culture, and resilience impact supply chain resilience in complex contexts such as the pharmaceutical sector by combining these principles. The literature examines how strategic leadership, business continuity planning, and supply chain resilience can improve organisational performance (Habani & Kamaruddin, 2021). Strategic leadership and resilience-building methods are crucial for managing interruptions and maintaining operational continuity in supply chains, particularly during unexpected occurrences like the COVID-19 pandemic.

Supply chain resilience has gained attention due to various crisis events causing disruptions (Schätter, Haas & Morelli, 2023). Resilience in supply chains involves the ability to bounce back from disruptions and maintain functionality (Anderluh & Herburger, 2022). Resilient supply chains are characterised by capabilities such as flexibility, robustness, velocity, visibility, and collaboration (Geske & Novoszel, 2022). A systematic literature review proposes a new definition of resilience in supply chain management, integrating different aspects found in the literature (Zavala-Alcívar, Verdecho & Alfaro-Saiz, 2023). A framework of overall supply network resilience (SNRES) provides insights for evaluating resilience at different levels of a supply network (Yao & Fabbe-Costes, 2018).

Pharmaceutical supply chains face disruptions leading to medicine shortages, necessitating an assessment of resilience and vulnerabilities (Ward & Hargaden, 2019). The downstream section of pharmaceutical supply chains requires improvement in supply chain capabilities, particularly in flexibility in sourcing, order fulfilment, visibility, and collaboration (Ward & Hargaden, 2019). Agility within the pharmaceutical supply chain, including dimensions such as alertness, accessibility, connectivity, and visibility, can reduce the impact of dynamic disruptions like drug shortages (Yaroson et al., 2019). The importance of resilience in pharmaceutical supply chains is highlighted by incidents such as drug recalls and revenue losses due to supply chain disturbances (Huq, Pawar & Rogers, 2015).

Medicine shortages are a prevalent issue, necessitating an assessment of the resilience of pharmaceutical supply chains in the South African context (Ward & Hargaden, 2019). Challenges in assessing disruptions in pharmaceutical supply chains in the South African context include the need for improvement in supply chain capabilities, particularly in flexibility and visibility (Ward & Hargaden, 2019). The impact of disturbance factors differs substantially across different supply chain configurations, highlighting the need for a tailored approach to resilience in the South African pharmaceutical supply chain (Huq et al., 2015).

Resilience in pharmaceutical supply chains is crucial due to the critical nature of pharmaceutical products and the impact of disturbances on the supply network (Huq et al., 2015). Resilience in the pharmaceutical supply chain is linked to the ability to tackle disruptions efficiently, particularly in the face of unpredictable events (Antomarioni, Bevilacqua, Ciarapica & Marcucci, 2019). The resilience approach is a key component in the fashion industry supply chain, where it has been instrumental in distinguishing successful firms from unprofitable ones (Antomarioni et al., 2019). The literature provides insights into the key resilience theories applicable to supply chains, the application of risk management theories to pharmaceutical supply chains, the challenges of assessing disruptions in pharmaceutical supply chains in the South African context, and the key factors contributing to resilience in pharmaceutical supply chains. However, it is important to note that while the literature provides valuable information, they do not directly address all aspects of the study, particularly in the context of the South African pharmaceutical supply chain.

2.3 *Relevance of these theories to the South African pharmaceutical industry*

The concepts of resilience and risk management are crucial for the South African pharmaceutical business, particularly when evaluating interruptions and improving supply chain integrity. Implementing these theories can greatly influence the industry's capacity to properly address difficulties and guarantee the continuing availability of important drugs to the population.

The South African pharmaceutical industry can improve supply chain resilience by establishing organisational antecedents and promoting a risk management culture, as suggested by Remko (2020); and Nikookar and Yanadori (2021) studies on dynamic capabilities theory and relational perspectives. Pharmaceutical firms in South Africa can enhance their ability to endure disruptions by incorporating these theories into their operations, which will help them develop adaptive capacities to address unforeseen occurrences and hazards.

The study by Gupta and Kayande (2023) highlights the significance of comprehending vulnerabilities in pharmaceutical supply chains and creating adaptive models to improve resilience capacities. The South African pharmaceutical sector may enhance the resilience of their supply chains and ensure continued drug flow during crises like the COVID-19 pandemic by implementing these ideas to detect and address weaknesses proactively.

The theories of supply chain integration and resilience, as examined in research by Golan et al. (2020); and Zhuo, Ji and Yin (2020), offer useful insights on improving the supply chain resilience of the South African pharmaceutical business. Pharmaceutical firms can enhance their supply chain operations, increase agility, and create effective risk mitigation methods by utilising these theories.

Applying resilience and risk management theories in the South African pharmaceutical business is crucial for developing adaptive capacities, improving supply chain resilience, and maintaining operational continuity. Pharmaceutical firms in South Africa can enhance their strategic planning and operations by integrating these theories. This will help them manage disruptions, enhance supply chain performance, and efficiently provide necessary pharmaceuticals to fulfil the healthcare demands of the population.

2.4 *The historical-hermeneutic approach and interpretivism*

The historical-hermeneutic perspective and interpretivism are crucial in comprehending the intricacies of supply chain dynamics, especially within the South African pharmaceutical business. The methods provide valuable perspectives on the historical development, cultural impacts, and interpretive structures that influence supply chain operations and decision-making processes.

The historical-hermeneutic method examines the historical background of supply chains, analysing the development of practices, technologies, and connections in the sector. This approach delves into past trends, disruptions, and innovations to gain a comprehensive picture of the evolution of the South African pharmaceutical supply chain and how historical events impact its contemporary dynamics.

Interpretivism emphasises subjective interpretations, meanings, and social conceptions that form the basis of supply chain interactions. This approach highlights the significance of context, culture, and human agency in influencing supply chain habits and results. Interpretivism can provide insight into the cultural variables, stakeholder interactions, and decision-making processes that affect supply chain dynamics in the South African pharmaceutical business.

By utilising the historical-hermeneutic approach and interpretivism, researchers can reveal the fundamental narratives, values, and beliefs influencing supply chain behaviours in the South African pharmaceutical business. By examining past patterns, societal impacts, and personal viewpoints, these methods provide a comprehensive view of supply chain operations, allowing stakeholders to make well-informed choices, predict obstacles, and promote adaptability when faced with disturbances.

Thus, there is a lack of direct literature on the historical-hermeneutic approach or interpretivism in the existing corpus of knowledge. The literature provides useful insights into supply chain dynamics and resilience in the pharmaceutical business, but it does not specifically discuss the historical-hermeneutic approach and interpretivism in understanding supply chain dynamics. The research aimed to thoroughly assess the effects of interruptions on the supply chain, with a specific focus on recent issues like the COVID-19 pandemic, natural catastrophes, and other unexpected events (Remko, 2020; Umar, 2023). The study aims to identify vulnerabilities and weaknesses in the supply chain that are exposed during disruptions through a qualitative

research approach. This will enhance understanding of the resilience and risk management practices needed to effectively address these challenges (Remko, 2020; Umar, 2023).

3. METHODOLOGY

The qualitative research design employed in our study on "Assessing Disruptions in Pharmaceutical Supply Chains: A Qualitative Review of Resilience and Risks in the South African Context" encompasses various methodological approaches to gain a comprehensive understanding of supply chain dynamics. The study followed a historical-hermeneutic approach, subjective knowledge, interpretivism, and phenomenological methodologies to explore the experiences and perceptions of 25 pharmaceutical supply chain experts in South Africa (Creswell & Creswell, 2023). The research design involved in-depth interviews with purposively sampled experts to provide their insights, experiences, and subjective interpretations of disruptions and resilience strategies within the pharmaceutical supply chain. The study employed a qualitative exploratory approach; hence, the study aimed to uncover in-depth perspectives and underlying meanings for this study, as there are ongoing concerns affecting the influence of supply chain operations in South Africa (Saunders, Lewis & Thornhill, 2023). Thematic analysis using Atlas-ti software was utilised to identify recurring patterns, themes, and insights from the interview data. This analytical approach allowed for a systematic exploration of the qualitative data, enabling the researchers to extract meaningful insights and develop a comprehensive understanding of the resilience and risk management practices within the South African pharmaceutical supply chain (Braun & Clarke, 2022). By integrating these qualitative research methodologies, the study provided an in-depth analysis of disruptions, resilience, and risks in the South African pharmaceutical supply chain. The utilisation of interpretive approaches and qualitative data analysis techniques enabled the study to uncover valuable insights that can inform strategic decision-making, promote supply chain resilience, and contribute to the advancement of knowledge in the field of pharmaceutical supply chain management.

4. FINDINGS

The provided table 1 below contains qualitative data on various individuals involved in the pharmaceutical supply chain in South Africa. The variables captured include an ID code for each individual (P01 to P25), Gender (Male/Female), Position held within their respective organisation, Years of experience in their role, the Category of player/actor in the pharmaceutical industry they represent (such as Drug manufacturer, Drug distributor/wholesaler, Independent retail pharmacy, etc.), and the Province where they are based (KwaZulu-Natal, Gauteng, Western Cape).

From the data, the positions range from high-level executive roles like Owner/Chief Executive Officer (CEO) to more specialised roles such as Supply Chain Planner or Demand Manager. Years of experience vary widely from as few as six years to as many as 30 years. The categories of players/actors in the pharmaceutical supply chain are also diverse, including manufacturers, suppliers, distributors, and importers. Lastly, the data shows a concentration of individuals based in the provinces of Gauteng and KwaZulu-Natal, with a few from the Western Cape.

An analysis of the dataset reveals several insights into the pharmaceutical supply chain in South Africa. Positions held by these individuals suggest a mixture of strategic management and operational roles, indicating a comprehensive representation of the supply chain hierarchy in the sample. The years of experience among the individuals suggest that there are both seasoned professionals with extensive industry knowledge and relatively newer professionals who might bring fresh perspectives or innovative approaches to the industry. The range of experience could indicate a robust potential for mentorship and knowledge transfer within the sector.

The player/actor category showcases a supply chain with various stakeholders, from drug manufacturers to retail pharmacies. This diversity suggests a complex network with multiple touchpoints, which can be both a strength in terms of specialisation and a potential risk in the face of disruptions. Geographically, there is a notable concentration of individuals in KwaZulu-Natal and Gauteng, two provinces known for their economic

activity and industrial hubs. This could reflect the centralisation of the pharmaceutical industry in these regions, which may have implications for supply chain resilience and risks, particularly if other regions are underserved or if there is over-reliance on certain areas.

Table 1. Qualitative data on various individuals involved in the pharmaceutical supply chain in South Africa

ID	Gender	Position	Years of experience	Player/actor/ category	Province
P01	Male	Owner/Chief Executive Officer (CEO)	30	Drug manufacturer	KwaZulu-Natal
P02	Male	Chief Executive Officer (CEO)	19	Drug distributor / wholesaler	Gauteng
P03	Male	Chief Executive Officer (CEO)	20	Independent retail pharmacy	Western Cape
P04	Male	Chief Operating Officer (COO)	28	Drug distributor / wholesaler	KwaZulu-Natal
P05	Male	Procurement and Planning Manager	6	Pharmaceutical supplier	Gauteng
P06	Female	Regional Sales Manager	15	Primary pharmaceutical importer	Kwazulu-Natal
P07	Female	Sales Manager	25	Drug manufacturer	Gauteng
P08	Female	Professional Sales Representative	24	Primary pharmaceutical importer	KwaZulu-Natal
P09	Female	Sales Manager	19	Drug manufacturer	KwaZulu-Natal
P10	Female	Sales Representative	20	Pharmaceutical supplier	KwaZulu-Natal
P11	Female	Sales Representative	25	Drug manufacturer	KwaZulu-Natal
P12	Female	Sales Representative	30	Drug manufacturer	KwaZulu-Natal
P13	Female	Sales Representative	12	Primary pharmaceutical importer	KwaZulu-Natal
P14	Male	Business Analyst	10	Pharmaceutical supplier	Gauteng
P15	Female	Sales Representative	23	Drug distributor / wholesaler	KwaZulu-Natal

P16	Male	Supply Chain Team Lead	12	Drug manufacturer	Gauteng
P17	Male	Supply Chain Professional	21	Pharmaceutical supplier	Gauteng
P18	Female	Senior Supply and Demand Planner	7	Drug manufacturer	Gauteng
P19	Male	Responsible Pharmacist	10	Retail Pharmacy	Gauteng
P20	Female	Supply Chain Specialist	9	Drug manufacturer	Gauteng
P21	Male	Demand Planner	6	Drug manufacturer	Gauteng
P22	Female	Demand planning lead	16	Drug manufacturer	Gauteng
P23	Male	Supply Chain Planner	7	Drug distributor / wholesaler	Gauteng
P24	Male	Supply Chain professional	24	Drug manufacturer	Western Cape
P25	Female	Demand Manager	14	Drug manufacturer	Gauteng

Source: Own compilation

An analysis of the gender distribution shows a nearly equal representation of males and females within the sample of pharmaceutical supply chain professionals, with females having a slight majority. This suggests a balanced gender composition, which could contribute to diverse perspectives and approaches within the industry.

Upon examining the geographical distribution, it is apparent that there is a higher representation of females in KwaZulu-Natal compared to Gauteng, with eight females positioned in the former and only five in the latter. This indicates that KwaZulu-Natal not only has a higher number of females in the dataset but also that females represent a significant portion of the sample from that province.

This geographical distribution could have implications for regional dynamics within the pharmaceutical supply chain. KwaZulu-Natal's higher female representation might reflect regional industry practices, socio-economic factors, or educational opportunities that favour or result in higher female participation in the sector. Conversely, Gauteng, which is known as South Africa's economic powerhouse, has fewer females represented in this sample, which could suggest different industry dynamics or barriers to entry for females in this region.

The data does not provide the total number of professionals in these provinces or the sizes of their companies, which limits the ability to draw broader conclusions about the entire industry's gender and geographical distribution. However, within this sample, there is a notable trend of female participation that could be indicative of the industry's inclusiveness and diversity in these regions.

4.1 *Thematic presentation of the interview data*

The thematic presentation of the interview data from the pharmaceutical supply chain experts reveals a nuanced understanding of pharmaceutical supply chain resilience and risks, particularly in the context of the COVID-19 pandemic's impact on South African supply chains. The interviews illuminate a landscape marked by the necessity for strategic adaptability, where companies had to rapidly adjust their operational strategies in response to the unfolding crisis. Participants voiced the criticality of diversified sourcing, reflecting on the pandemic's exposure of vulnerabilities associated with over-reliance on single-source suppliers and the consequent shifts towards more resilient procurement strategies.

A recurrent theme was the call for enhanced local production capabilities. This pivot is seen as a strategic countermeasure to the fragilities of global supply chains, underscored by the pandemic's disruption of international logistics. The narratives also disclosed the inconsistent impact across the sector, with some companies experiencing minimal disruptions while others faced significant challenges in maintaining supply chain continuity. This variance highlights the complex interplay of external and internal factors that influence supply chain resilience.

Furthermore, the participants' accounts shed light on the dynamic responses to demand fluctuations, illustrating how some entities adeptly managed these shifts, whereas others struggled. The integration of these firsthand experiences provides a rich, empirically grounded insight into the operational realities faced by the pharmaceutical sector during an unprecedented global health crisis, underscoring the imperative for strategic foresight, flexibility, and robust risk management practices to navigate future uncertainties.

Table 2. Summary of the findings

Theme	Description	Participant Quote
Strategic Adaptability	Necessity of adjusting strategies rapidly in response to market changes.	"the rapid changes in the market required us to swiftly adapt our strategies to maintain supply chain continuity" (P03, P23, and P13).
Diversified Sourcing	It is important to reduce dependency on single sources by diversifying suppliers.	"We realised the risk of single sourcing when our usual supplies were disrupted; diversification became our top priority" (P07, 25 and 017).
Enhanced Local Production	Shifting towards local manufacturing to mitigate global supply chain disruptions.	"Increasing our local manufacturing capacity has been a strategic shift to lessen our dependency on international suppliers" (P09, P13 and P19).
Inconsistent Impact	Variability in how different sectors of the supply chain were affected.	"While some parts of our supply chain were barely touched, others were completely overwhelmed by the demand spikes" (P01, P02 and P12).
Varied Responses to Demand Fluctuations	Differences in companies' abilities to adapt to sudden demand changes.	"Our ability to quickly scale up production in response to fluctuating demands played a crucial role in our resilience strategy" (P06, P20 and P16).

The summarized findings from the dataset, as encapsulated in Table 2 above, provide a thematic overview of the strategic undertakings by professionals in the South African pharmaceutical supply chain to manage and mitigate disruptions. The themes, which include Strategic Adaptability, Diversified Sourcing, Enhanced Local Production, Inconsistent Impact, and Varied Responses to Demand Fluctuations, are reflective of the nuanced and multifaceted strategies employed by the industry to navigate the complex landscape of supply chain management.

Strategic Adaptability emerges as a recurrent theme, emphasising the necessity for organisations to rapidly adjust their strategies in response to the dynamic market conditions. This theme is underpinned by participants' recognition that swift adaptation is crucial for maintaining supply chain continuity, as articulated by quotes from participants P03, P23, and P13.

Similarly, the theme of Diversified Sourcing underscores the importance of reducing dependency on single sources by expanding the supplier base, as substantiated by the experiences of participants P07, P25, and

P17. This strategy is seen as a proactive approach to ameliorate risks associated with single sourcing, which became particularly evident when usual supplies were disrupted.

Enhanced Local Production is identified as another strategic pivot, where increasing local manufacturing capacity is viewed as a means to lessen dependency on international suppliers. This shift, as highlighted by participants P09, P13, and P19, is indicative of a broader trend towards strengthening local supply chains as a buffer against global disruptions.

The theme of Inconsistent Impact captures the variability in how different sectors of the supply chain were affected by disruptions. The participant quotes from P01, P02, and P12 reveal that while some sectors remained relatively unscathed, others were disproportionately challenged by surges in demand.

Lastly, varied responses to demand fluctuations highlight the differential capabilities of companies to adapt to sudden changes in demand. The ability to scale up production swiftly, as noted by participants P06, P20, and P16, played a pivotal role in the resilience strategies of certain organisations.

Collectively, these themes elucidate the complex and adaptive strategies that are essential for the resilience of pharmaceutical supply chains in the face of disruptions. The qualitative insights from the participants underscore the diversity of experiences and strategic responses within the industry, reflecting the need for tailored approaches to supply chain management that are responsive to the unique challenges posed by the South African context.

FIGURE 2
WORD-CLOUD F

Source: Own compilation

Figure 2 above presents a word cloud that visually summarises key concepts and terms associated with the findings from the analysis of disruptions in the South African pharmaceutical supply chain. The word cloud emphasizes the most prominent themes identified by the participants in the study.

Central to the word cloud is the term "supply," which underscores the focus on supply chain dynamics. Surrounding it, the word "disruptions" looms large, indicating the primary concern of the study, which is the interruptions and irregularities faced within the supply chain. The prominence of the word "strategic" suggests that the approach to mitigating these disruptions is thoughtful and methodical, emphasising the importance of planning and long-term thinking.

The term "pharmaceutical" directly ties the discussion to the specific industry under examination, while "chain" further reinforces the interconnected nature of the supply process. "Resilience" appears as a critical concept, highlighting the capacity of the industry to withstand and recover from the challenges it faces.

Other significant words such as "pandemic" and "COVID" reflect the contemporary context in which these supply chains operate, likely referencing the global health crisis that has precipitated many disruptions and necessitated a re-evaluation of existing systems and practices.

Terms like "challenges," "planning," and "insights" suggest a focus on identifying difficulties, preparing strategic responses, and gaining understanding from the disruptions experienced. The presence of "strategic" adjacent to "planning" points to the deliberate and considered efforts made to ensure supply chain continuity and effectiveness.

Smaller yet still noticeable terms such as "stock," "shortages," and "risks" speak to the operational issues encountered, while "local" hints at the strategies employed to mitigate global dependencies, aligning with the theme of Enhanced Local Production identified in the findings.

Overall, Figure 2 encapsulates the multifaceted and complex nature of managing pharmaceutical supply chains in the face of unprecedented disruptions, with a clear emphasis on strategic planning, resilience, and the need for adaptability in both local and global contexts.

The findings on resilience, risk identification, and mitigation strategies in the South African pharmaceutical supply chain, informed by the key themes from the findings, illustrate a sector deeply impacted by the COVID-19 pandemic. The themes underscore a heightened focus on strategic adaptability, where firms have learned to swiftly recalibrate their operations in response to sudden supply chain disruptions. Diversified sourcing emerges as a critical risk mitigation strategy, highlighting the importance of reducing reliance on singular supply sources to enhance supply chain resilience. The shift towards enhanced local production is identified as a strategic move to mitigate risks associated with global supply chain vulnerabilities. The inconsistency in the impact of disruptions and the varied responses to demand fluctuations underscore the complex, multifaceted nature of supply chain risks, necessitating a comprehensive approach to resilience-building that incorporates robust planning, flexible operational capabilities, and strategic foresight. This nuanced understanding is crucial for formulating effective strategies to fortify the pharmaceutical supply chain against future disruptions.

The findings from the analysed documents reveal that the South African pharmaceutical supply chain faced significant disruption impacts due to the COVID-19 pandemic, leading stakeholders to employ adaptive strategies. For example, disruptions in international logistics prompted companies to reassess and enhance their local manufacturing capacities, aiming to reduce dependence on overseas suppliers. Additionally, the fluctuating demand for medical supplies led to the adoption of flexible inventory management and strategic stockpiling to ensure continuous supply. These adaptive strategies reflect a broader trend towards increasing resilience and agility within the supply chain, enabling stakeholders to better anticipate and respond to future disruptions while maintaining operational continuity.

5. DISCUSSION

The identified themes resonate with existing literature on supply chain resilience and risks, particularly in the context of the pharmaceutical industry. Scholars have emphasised the importance of strategic adaptability, diversified sourcing, and enhanced local production as pivotal elements in fostering supply chain resilience (Remko, 2020; Ivanov & Dolgui, 2021). The South African pharmaceutical supply chain's response to COVID-19-induced disruptions showcases a practical application of these theoretical frameworks. For instance, the shift towards local manufacturing and diversified sourcing those mirrors strategies advocated by Negri, Cagno, Colicchia and Sarkis (2021), who highlight the need for building resilience through increased supply chain flexibility and multi-sourcing strategies.

Moreover, the nuanced impacts of disruptions and the corresponding adaptive strategies align with the literature that calls for dynamic capabilities in supply chain management (Chowdhury, Paul, Kaisar & Moktadir, 2021b; Raj, Mukherjee, de Sousa Jabbour & Srivastava, 2022). The ability of firms to quickly adjust their operational and strategic plans in response to sudden market changes is a testament to the theoretical construct of supply chain agility as a critical component of resilience (Hosseini, Ivanov & Dolgui, 2019). This real-world embodiment of theoretical insights underlines the critical importance of agility and flexibility in managing supply chain risks, particularly in industries as crucial and sensitive as pharmaceuticals, where disruptions can have far-reaching implications.

The findings from the qualitative study of South African pharmaceutical supply chains offer significant implications for understanding their resilience. The emphasis on strategic adaptability and diversified sourcing resonates with existing literature, suggesting that flexibility and supplier variety are crucial in buffering against disruptions (Ivanov, 2021). These strategies are indicative of a resilient supply chain capable of maintaining continuity despite unexpected challenges, aligning with the call for robust risk management practices in pharmaceutical logistics (Ivanov, Dolgui, Das & Sokolov, 2019).

Moreover, the shift towards enhanced local production highlights a strategic response to mitigate global supply chain vulnerabilities, an approach supported by studies emphasising the importance of localized manufacturing in enhancing supply chain resilience (Hosseini et al., 2019). This strategy not only addresses immediate supply chain risks but also contributes to long-term sustainability and self-reliance, echoing the broader discourse on building resilience in the face of global uncertainties (Chowdhury, Liza, Tanvir, Ra & Mohajon, 2021a). These findings underscore the critical need for adaptive strategies that are responsive to both current and future supply chain challenges, reinforcing the importance of strategic foresight and flexibility in the pharmaceutical sector's risk management practices.

The unexpected findings or anomalies in the data, when compared to the broader theoretical framework of supply chain resilience, present intriguing insights. Typically, literature on supply chain resilience emphasizes the importance of redundancy, flexibility, and collaboration to mitigate risks and adapt to disruptions (Chowdhury et al., 2021a). However, the data revealed instances where companies experienced varying degrees of disruption impact, suggesting that resilience strategies might not be uniformly effective across all segments of the pharmaceutical supply chain. This discrepancy could be due to the unique challenges faced by the pharmaceutical industry, such as stringent regulatory requirements and the critical need for product availability (Ivanov & Dolgui, 2021).

Linking the study's findings to the broader theoretical framework, it appears that while the general principles of supply chain resilience hold, the specific context of the pharmaceutical industry in South Africa introduces unique challenges and necessitates tailored strategies. The anomalies, such as the varied impact of disruptions and the differing adaptive capacities of companies, highlight the importance of contextual factors in shaping supply chain resilience. This suggests that the theoretical models of resilience may need to be adapted or expanded to more accurately reflect the realities faced by the pharmaceutical supply chains, especially in contexts that are influenced by complex socio-economic and logistical factors (Linnenluecke, 2017; Pettit, Croxton & Fiksel, 2019).

The critical analysis of the findings through a historical-hermeneutic lens and subjective knowledge offers a profound understanding of supply chain resilience and risks, particularly within the pharmaceutical sector. Historical-hermeneutic insights allow us to interpret the accumulated experiences and lessons learned from past disruptions, thereby enriching our strategic foresight and decision-making processes (Savin-Baden & Major, 2023). This approach underscores the significance of contextual understanding in shaping adaptive strategies and resilience-building measures. Subjective knowledge, derived from the personal experiences and perceptions of supply chain stakeholders, provides depth and nuance to the objective data, offering a comprehensive view of the vulnerabilities and strengths within the supply chain (Chen, Xie & Liu, 2021). Integrating these insights can lead to a more holistic and informed framework, enhancing the capacity to anticipate, respond to, and recover from disruptions, thus reinforcing the overall resilience of the supply chain. This synthesis of historical and subjective perspectives contributes significantly to the strategic development of robust, resilient supply chain systems that are well-equipped to navigate the complexities of contemporary and future challenges (Nadkarni & Prügl, 2021).

The table 3 below highlights a comparative analysis of resilience strategies and supply chain challenges within the pharmaceutical industry, contrasting the South African context with the global landscape. The aspects under consideration are Strategic Adaptability, Diversified Sourcing, and Enhanced Local Production.

In the South African context, Strategic Adaptability is deemed essential due to the unique local challenges such as infrastructure deficiencies and economic volatility. The need for agility in strategy is key to navigating the fluctuating market conditions and ensuring continuity in supply chain operations.

Globally, Strategic Adaptability is also crucial but for different reasons. It is particularly vital for addressing broader global disruptions, which can include geopolitical tensions, trade barriers, and other international crises that affect the movement of pharmaceutical goods across borders. This adaptability allows organisations to navigate a rapidly changing global landscape.

When it comes to Diversified Sourcing, in South Africa, the focus is on diminishing the overreliance on specific international suppliers. This is a strategic move aimed at creating a more robust supply chain that is less vulnerable to international disruptions, which could be a result of political instability, logistical issues, or natural disasters affecting key suppliers.

In the global context, Diversified Sourcing is similarly directed at mitigating risks. However, the emphasis is on addressing the vulnerabilities that arise from having concentrated manufacturing hubs, which are often in a few select regions or countries. The strategy also considers the potential impact of geopolitical tensions that could disrupt trade routes and supply networks.

Enhanced Local Production within South Africa is aimed at bolstering the country's manufacturing capabilities to counteract international supply chain disruptions. This strategic shift is indicative of a move towards greater self-reliance and is motivated by the necessity to mitigate the risks associated with international sourcing, thereby ensuring a more stable supply of pharmaceutical products.

On the global stage, Enhanced Local Production is a strategy being adopted to reduce dependency on global supply chains and to improve self-sufficiency. This approach is not only a response to the vulnerabilities exposed by the COVID-19 pandemic but also a long-term strategy to build resilience against a variety of international supply chain risks.

In summary, the table 3 illustrates that while the strategies of Strategic Adaptability, Diversified Sourcing, and Enhanced Local Production are consistent across both the South African and global contexts, the motivations and specific challenges that drive these strategies can vary significantly. The South African pharmaceutical supply chain is influenced by local market dynamics and infrastructural issues, while the global supply chain must contend with international trade complexities and geopolitical risks.

Table 3. Comparison of the South African context with global pharmaceutical supply chain challenges and resilience strategies

Aspect	South African Context	Global Context
Strategic Adaptability	Essential due to local challenges like infrastructure and economic volatility.	Crucial for dealing with global disruptions, such as geopolitical tensions and trade barriers.
Diversified Sourcing	Aimed at reducing reliance on specific international suppliers.	Focus on mitigating risks from concentrated manufacturing hubs and geopolitical tensions.
Enhanced Local Production	Increasing local manufacturing to mitigate international supply chain disruptions.	Strategies to reduce dependency on global supply chains and improve self-sufficiency.

The comparison between the South African pharmaceutical supply chain and global challenges reveals unique and common aspects of resilience and risk management. Globally, pharmaceutical supply chains face issues like geopolitical tensions, trade disruptions, and reliance on concentrated manufacturing hubs, which can lead to significant vulnerabilities (Ivanov, 2020). In contrast, South Africa's specific challenges are heightened by its emerging economy status, where issues such as local infrastructure constraints, regulatory environments, and economic volatility play a more pronounced role (Faggioni, Rossi & Sestino, 2023). However, both contexts share the need for strategic adaptability, diversified sourcing, and enhanced local production as key resilience strategies. These strategies are crucial for mitigating risks associated with global dependencies and for ensuring a steady supply of pharmaceuticals, irrespective of global or local disruptions. The comparison underscores both unique local considerations and universal strategies integral to enhancing supply chain resilience in the pharmaceutical sector.

6. IMPLICATIONS

The practical implications for industry stakeholders in enhancing supply chain resilience and risk management, as derived from the findings, emphasise the necessity of adopting a multifaceted approach. Stakeholders should prioritize establishing robust frameworks that incorporate strategic adaptability, diversified sourcing, and enhanced local production capabilities. The insights highlight the importance of proactive risk assessments and the integration of advanced analytics for predictive insights, enabling stakeholders to anticipate disruptions and implement pre-emptive measures. Strengthening partnerships, investing in technology to enhance visibility across the supply chain, and fostering a culture of continuous improvement are pivotal. These strategies collectively contribute to building a resilient supply chain, capable of withstanding and quickly recovering from future disruptions, thereby ensuring sustained supply chain continuity and security.

The policy implications drawn from the findings suggest a strategic blueprint for enhancing the robustness of the pharmaceutical supply chain against disruptions. Policymakers should consider formulating regulations that encourage pharmaceutical companies to adopt diversified sourcing and enhance local manufacturing capacities. Such policies could include incentives for local production, guidelines for maintaining strategic stockpiles, and support for public-private partnerships to bolster supply chain infrastructure. Additionally, fostering a regulatory environment that supports innovation and technology adoption can significantly contribute to building a more resilient supply chain, enabling the pharmaceutical industry to respond more effectively to future disruptions.

Future research should delve deeper into the dynamic interplay between evolving global health challenges and pharmaceutical supply chains, focusing on longitudinal studies to track changes over time and the effectiveness of implemented resilience strategies. Investigating the role of technological advancements, such as AI and blockchain, in enhancing supply chain transparency and efficiency warrants further exploration. Additionally, comparative studies across different geographical regions could provide valuable insights into global best practices and the contextual factors influencing supply chain resilience, offering a comprehensive roadmap for navigating future health crises.

7.CONCLUSION

The study unveiled critical insights into the pharmaceutical supply chain's vulnerabilities and resilience strategies in South Africa, spotlighting the imperative for robust risk management practices in the face of disruptions like the COVID-19 pandemic and other unforeseen events. The key findings emphasise the necessity of strategic adaptability, diversified sourcing, and enhanced local production, underscoring their broader significance in fortifying the supply chain against global health crises. These insights not only contribute to the theoretical framework of supply chain management but also offer practical guidelines for industry stakeholders to navigate future challenges effectively. Reflecting on the study's contributions, it bridges the gap between theory and practice, providing a comprehensive overview of the real-world challenges and strategic responses within the South African pharmaceutical supply chain. It lays the groundwork for future research, advocating for continuous exploration into innovative resilience-building measures and strategic planning. The findings underscore the importance of a proactive, informed approach to supply chain management, ensuring that the pharmaceutical sector can maintain stability and continuity in the face of evolving global health challenges, ultimately safeguarding public health and the industry's economic stability.

7.1 Data availability statement

The data supporting this study's findings are available on request from the corresponding author, B. However, the data are not publicly available due to restrictions, such as the fact that they contain information that could compromise the privacy of research participants.

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