Optimizing Pharmaceutical Supply Chains And Health Services In Long-Term Nand Maternity Care: A Socio-Nursing Perspective Of Logistical Challenges And Solutions In Saudi Arabia

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Abstract

The pharmaceutical supply chain represents a critical component of healthcare delivery systems worldwide, yet significant challenges persist in specialized care settings such as long-term care facilities and maternity hospitals. This review examines the current state of pharmaceutical supply chain management in Saudi Arabia, with particular emphasis on logistical challenges affecting long-term care and maternity care settings. Through systematic analysis of recent literature and empirical evidence, this study identifies key operational barriers including medication shortages, inventory management deficiencies, cold chain disruptions, inadequate demand forecasting mechanisms, and infrastructure limitations. The Saudi healthcare system faces unique challenges stemming from high dependency on pharmaceutical imports, centralized procurement complexities, and the requirements of Vision 2030 healthcare transformation initiatives. This review synthesizes evidence on supply chain optimization strategies including technological innovations, improved forecasting models, enhanced cold chain management protocols, and resilience-building measures. Findings indicate that integrated approaches combining advanced information systems, collaborative stakeholder engagement, and adaptive inventory management significantly improve pharmaceutical availability and reduce operational costs. The study contributes to healthcare supply chain literature by providing a comprehensive analysis specific to Saudi Arabian long-term and maternity care contexts, offering evidence-based recommendations for policymakers and healthcare administrators seeking to enhance pharmaceutical logistics performance in specialized care environments.

Keywords: pharmaceutical supply chain, long-term care, maternity care, medication management, healthcare logistics, Saudi Arabia

1. INTRODUCTION

The shortage in continuous pharmaceutical supply chain represents one of the major problem areas in the Kingdom of Saudi Arabia healthcare system
. Healthcare delivery in specialized settings such as long-term care facilities and maternity hospitals demands consistent pharmaceutical availability to ensure patient safety and optimal clinical outcomes. A high level of service for medical supplies and effective inventory policies are essential objectives for all health care industries, as medicine shortages and improper use of pharmaceuticals can not only lead to financial losses but also have a significant impact on patients.

The Saudi Arabian healthcare sector operates within a rapidly transforming environment shaped by Vision 2030 initiatives, which aim to localize pharmaceutical manufacturing and enhance healthcare system resilience. Local production of pharmaceuticals plays a vital role in maintaining resilience of national healthcare systems, especially when it comes to facilitating access to needed medicines and decreasing exposure to imports and international supply chains
. However, the Kingdom currently imports over 70 percent of its pharmaceutical products, creating vulnerabilities in the supply chain that particularly affect specialized care environments requiring constant medication availability.

Long-term care facilities and maternity hospitals represent critical healthcare segments with distinct pharmaceutical supply challenges. Long-term care pharmacies play a crucial role in providing pharmaceutical services to residents of long-term care facilities such as nursing homes, assisted living communities, and skilled nursing facilities, where residents often have complex health conditions and require ongoing medical management
. Similarly, maternity care settings demand specialized pharmaceutical management to ensure the availability of temperature-sensitive medications, emergency obstetric supplies, and neonatal care products.

Pharmaceutical supply chain performance is a significant challenge confronting healthcare sectors to meet patient demand successfully and overcome drug shortage
. The complexity of pharmaceutical supply chains in Saudi Arabia is compounded by multiple factors including centralized procurement systems, regulatory requirements, infrastructure limitations in remote regions, and the need for cold chain management for temperature-sensitive products.

This review addresses a critical gap in the literature by examining pharmaceutical supply chain challenges specific to long-term and maternity care settings in Saudi Arabia. While general healthcare supply chain research exists, limited attention has been directed toward the unique operational requirements and constraints of these specialized care environments within the Saudi context. The research objectives are threefold: first, to identify and analyze the primary logistical challenges affecting pharmaceutical supply chains in Saudi Arabian long-term and maternity care facilities; second, to synthesize evidence on effective optimization strategies and technological solutions; and third, to provide evidence-based recommendations for enhancing pharmaceutical supply chain performance in these critical healthcare segments.

2. LITERATURE REVIEW

2.1 Pharmaceutical Supply Chain Structure in Saudi Arabia

The pharmaceutical procurement process in Saudi Arabia is regulated by the Saudi Food and Drug Authority, wherein the logistic departments in each hospital are required to follow the same system, with the National Unified Procurement Company playing a key role from the private sector in the procurement process
. The Saudi pharmaceutical supply chain operates through a multi-tier system involving manufacturers, distributors, group purchasing organizations, and healthcare facilities. Several Ministries including Commerce, Industry and Mineral Resources, Investment, and Finance, as well as the Public Investment Fund, are collaborating with private sectors to develop an attractive pharmaceutical sector, aiming to boost the local manufacturing of drugs and their active pharmaceutical ingredients to enhance the current market share to 40% under the Kingdom's long-term development plan.

The centralization of pharmaceutical procurement through NUPCO represents a significant structural characteristic of the Saudi system. Traditional procurement of pharmaceuticals for public health institutions is fraught with shortcomings that resulted in disruptions in essential medicines supply chain, with these disruptions potentially exacerbated in recent years with the requirement of all public health sectors to request their needs of prescription drugs and medical supplies through a single procurement body

2.2 Challenges in Pharmaceutical Supply Chains

2.2.1 Drug Shortages and Their Impact

Drug product shortages threaten health care quality and public health by creating barriers to optimal care, with the frequency of drug shortages rising dramatically since 2005 and now influencing broad areas of health care practice
. In the Saudi context, root causes for medication shortage include low profit margins for some necessary medications, poor management of the medication supply chain, a lack of government drug shortage detection, and weak local businesses that cannot compete with imported pharmaceutical products.

The consequences of drug shortages extend beyond mere inconvenience. An estimated $216 million dollars in extra labor costs are absorbed by healthcare institutions due to more expensive alternatives
, while 64% of healthcare practitioners believe that shortages posed a risk of adverse patient outcomes, with respondents reporting more than 1,000 adverse events and near-misses attributable to drug shortages.

Shortage issues can lead to various medication errors such as confusion between routes of administration, dilution errors, protocol deviations, and microbial contamination
. The impact on specialized care settings is particularly pronounced. Drug shortages cause 1% to 5% error rates in hospitals and create unsafe conditions for patients and staff 60% of the time, with many respondents reporting a 300% to 500% markup on medications on the shortage list.

2.2.2 Inventory Management Challenges

Pharmaceutical components characterize a large amount of hospital's operating expenses, with inventory costs in the healthcare sector substantial and estimated between 10% and 18% of total revenues. Effective inventory management in healthcare settings is complicated by multiple factors. Hospitals are operationally different from other businesses because it is

extremely difficult to make a forecast about patients and their consumption of drugs, with hospital pharmacy mainly holding a large amount of safety stock to cope with uncertainty demand, resulting in a high operational cost and drug expiry problems.

Inventory management has become crucial for healthcare organizations to accomplish the task of carrying vast quantities of a variety of drugs for emergency needs

In specialized care environments, inventory challenges are magnified. Due to prescription or patient residency changes, many medications go unused, and with traditional blister cards, the patient's remaining medications must be destroyed to ensure regulatory compliance, with approximately $2 billion dollars lost annually in the U.S. health care system due to disposing of unused oral solid medications in long-term care facilities

2.2.3 Cold Chain Management Requirements

Temperature-sensitive pharmaceuticals are products of perishable nature requiring controlled environments, including ergometrine, oxytocin, insulin, vaccines, and diagnostic reagents, with potency becoming less or even lost when exposed to temperature outside the recommended range, needing to be maintained between 2°C and 8°C temperature throughout the supply chain.

Cold chain management within pharmaceutical operations refers to the comprehensive system of temperature-controlled processes, infrastructure, and logistics that maintain the integrity, safety, and efficacy of temperature-sensitive pharmaceutical products throughout the entire drug development and commercialization lifecycle, encompassing storage, handling, packaging, transportation, and monitoring of products requiring specific temperature ranges from controlled room temperature to refrigerated conditions to cryogenic storage.

The maternal and child health supply chain particularly depends on effective cold chain management. The Nepali government worked to improve management and storage of key maternal health commodities, including oxytocin, which must be kept cold to maintain its efficacy, as this key medicine is the recommended drug for treating hemorrhage during and after childbirth, a leading cause of maternal death.

Managing cold chain logistics comes with several challenges including temperature fluctuations where even small temperature variations can affect the efficacy of pharmaceutical products, making it crucial to ensure consistent temperature control throughout the entire supply chain.

2.2.4 Demand Forecasting Complexities

Drug demand is often subject to uncertainty, making accurate forecasting more challenging, and waste and stock-outs are likely to decrease if drug demand forecasts are more accurate

. Drug demand is hard to predict, as the underlying patterns are often highly volatile, suffering from irregular or sporadic demand, with additional challenging patterns including those with changepoints where demand patterns show sudden shifts in their mean or variance

Demand forecasting impacts pharmaceutical supply chain performance, and the study found a significant positive relationship between demand forecasting and pharmaceutical supply chain performance

The challenges in forecasting are particularly acute in developing healthcare systems. Healthcare supply systems face challenges such as inaccurate drug forecasting and procurement delays compounded by data quality issues and communication gaps, with human, financial, infrastructure, and technological challenges, along with inadequate demand planning and weak information systems

2.3 Long-Term Care Pharmaceutical Supply Challenges

Medication management for older adults, particularly in long-term care facilities, presents several challenges, with medication errors widespread, impacting 16 to 27% of residents, often due to complexities such as polypharmacy, which increases the risk of adverse drug events including incorrect dosages and harmful interactions, particularly during transitions of care. Medication delivery in long-term care settings isn't just about getting prescriptions from point A to point B—it's also about ensuring efficiency, compliance, and patient safety

. The logistical complexity of long-term care pharmacy operations is substantial. Long-term care pharmacies serve residents of nursing homes, assisted-living communities, and extended-care communities, operating differently than traditional pharmacies as "closed-door" facilities, with procedures going above and beyond retail pharmacy processes, with core services including prescription processing, dispensing and delivery, medication management, and return, reuse, and disposal of medications.

2.4 Supply Chain Resilience and Disruption Management

Medical product shortages can represent a significant threat across the landscape of public health and health care delivery by undermining the ability to provide timely and high-quality care to patients. The COVID-19 pandemic dramatically exposed vulnerabilities in global healthcare supply chains. The COVID-19 pandemic has shown how fragile our healthcare supply chain is with product delays, drug shortages, and labor shortages being exacerbated in recent years.

With the COVID-19 pandemic revealing the vulnerability of global healthcare supply chains, the debate on how to increase supply chain resilience gained new momentum, with supply chain resilience defined as a supply chain's capacity to return to its original or a better state after absorbing a supply chain disruption, which are unplanned and unanticipated events that disturb the normal flow of goods.

Artificial intelligence, blockchain, big data analytics, and simulation are the most important technologies employed in supply chain management in healthcare, with published research concentrated mainly on generating resilience plans, and most research emphasizing the vulnerability of healthcare supply chains and the necessity of establishing better resilience methods.

2.5 Optimization Strategies and Technological Solutions

Successful implementation of systems has reduced hospital inventory rate to approximately 20% and decreased the average annual inventory error rate from 0.425‰ to 0.025‰, significantly boosting drug supply chain efficiency by 42.4%, minimizing errors in drug application, allocation, and distribution while increasing adverse reaction reports, with drug management across multiple hospital districts standardized, leading to improved access to medicines and enhanced patient satisfaction.

Mathematical models incorporating empirical data for evaluating pharmacy-hospital systems under demand uncertainty enable the determination of optimal policies that can reduce current hospital supply and administration costs by 16%, while also identifying an acceptable expiration date that minimizes the overall wastage of drugs.

Investigation of the role of inventory level control and demand forecasting on pharmaceutical supply chain performance found a significant positive relationship between inventory level control and pharmaceutical supply chain performance, with the relationship between demand forecasting and pharmaceutical supply chain performance also positive and significant

3. METHODS

This review employed a systematic approach to identify, evaluate, and synthesize peer-reviewed literature on pharmaceutical supply chain management in long-term care and maternity care settings, with specific attention to the Saudi Arabian healthcare context.

3.1 Search Strategy

A comprehensive literature search was conducted using multiple electronic databases including PubMed/MEDLINE, Scopus, Web of Science, and ScienceDirect. The search strategy incorporated combinations of keywords related to pharmaceutical supply chains, healthcare logistics, long-term care facilities, maternity hospitals, inventory management, drug shortages, cold chain management, demand forecasting, and Saudi Arabia. Search terms were adapted for each database using appropriate Boolean operators and medical subject headings. The initial search was conducted in November-December 2024, with supplementary searches completed in early 2025 to capture the most recent publications. The search was limited to articles published in English between 2010 and 2025 to ensure relevance to contemporary supply chain challenges while maintaining a reasonable temporal scope.

3.2 Eligibility Criteria

Studies were included if they met the following criteria: (1) peer-reviewed journal articles, systematic reviews, or reports from established organizations (WHO, World Bank, government health agencies); (2) focus on pharmaceutical supply chain management, healthcare logistics, or medication management; (3) relevance to long-term care facilities, maternity care settings, or similar specialized healthcare environments; (4) discussion of challenges, interventions, or optimization strategies applicable to pharmaceutical supply chains; and (5) verifiable bibliographic information including DOI or PubMed identification numbers.

Exclusion criteria included: (1) non-English language publications; (2) opinion pieces or commentaries without empirical data; (3) conference abstracts without full-text availability; (4) studies focused exclusively on retail pharmacy operations without relevance to institutional care settings; and (5) publications from predatory or non-peer-reviewed sources.

3.3 Data Extraction and Analysis

Following the initial search, titles and abstracts were screened for relevance to the research objectives. Full-text articles meeting preliminary inclusion criteria were retrieved and assessed for quality and relevance. Data extraction focused on: (1) study characteristics (author, year, country, study design); (2) supply chain challenges identified (categories, severity, impact); (3) interventions or optimization strategies described; (4) outcomes and effectiveness measures; and (5) recommendations for practice or policy.

The extracted information was synthesized thematically, organizing findings into major categories including supply chain structure, challenges (drug shortages, inventory management, cold chain, forecasting), sector-specific issues (long-term care, maternity care), resilience strategies, and optimization solutions. Evidence quality was assessed based on study design, sample size, methodology rigor, and consistency of findings across multiple sources.

3.4 Quality Assessment

Study quality was evaluated using established criteria appropriate to each study design. Empirical studies were assessed for methodological rigor, sample adequacy, data collection methods, and analytical approaches. Systematic reviews and meta-analyses were evaluated

using PRISMA guidelines. Reports from established organizations were assessed for authoritativeness, transparency of methodology, and evidence sources.

3.5 Synthesis Approach

Due to the heterogeneity of study designs, settings, and outcome measures, a narrative synthesis approach was employed. Findings were organized thematically to address each research objective, with attention to consistencies and contradictions across studies. Where quantitative data were available, descriptive statistics and effect sizes were reported. The synthesis emphasized identifying patterns of evidence relevant to the Saudi Arabian context while acknowledging limitations in direct applicability from international studies.

4. RESULTS

4.1 Pharmaceutical Supply Chain Infrastructure in Saudi Arabia

The Saudi Arabian pharmaceutical supply chain operates through a centralized procurement system primarily managed by the National Unified Procurement Company (NUPCO), established in 2009 under the Public Investment Fund. Analysis of the system reveals both strengths and persistent challenges affecting medication availability in specialized care settings. The Kingdom's pharmaceutical market, valued at approximately SAR 30-50 billion, exhibits a 5-6% annual growth rate driven by population expansion, increasing chronic disease burden, and healthcare system modernization. However, dependence on pharmaceutical imports exceeds 70%, creating vulnerability to global supply chain disruptions. Local manufacturing currently meets only 36% of domestic pharmaceutical needs through approximately 40 registered facilities.

Regulatory oversight is distributed among multiple entities. The Saudi Food and Drug Authority (SFDA) establishes quality standards and licensing requirements, while the Ministry of Health manages hospital operations and clinical protocols. This multi-agency structure creates coordination complexities that can delay procurement decisions and product distribution.

4.2 Major Supply Chain Challenges

4.2.1 Medication Shortages

Evidence indicates widespread medication shortages affecting Saudi healthcare facilities. Survey data from supply chain professionals reveal predominantly negative perceptions of centralized procurement efficacy in preventing shortages. Multiple causative factors contribute to this persistent problem:

Insufficient inventory buffers at facility level result from just-in-time delivery models that lack resilience against disruption. Manufacturing interruptions, whether due to quality issues, capacity constraints, or raw material scarcity, frequently trigger shortages of essential medications. Low profit margins on generic pharmaceuticals disincentivize production, particularly for older essential medicines.

The impact of shortages extends across multiple dimensions. Healthcare facilities report increased acquisition costs, with some medications experiencing price markups of 300-500% during shortage periods. Personnel time diverted to shortage management represents substantial hidden costs. Patient safety is compromised through increased medication errors, use of unfamiliar alternatives, and treatment delays.

Long-term care and maternity settings face particular vulnerability. Essential medications for chronic disease management in elderly populations and critical obstetric medications face

periodic unavailability. The specialized nature of these medications often limits therapeutic alternatives, increasing clinical risk.

4.2.2 Inventory Management Deficiencies

Inventory control emerged as a fundamental challenge across Saudi healthcare facilities. Key problems identified include inadequate demand forecasting mechanisms, lack of integrated information systems, insufficient automation, and poor coordination between procurement and clinical departments.

Hospital pharmacies commonly maintain safety stock levels that consume 10-18% of operating budgets, yet stock-outs persist due to forecasting inaccuracies and distribution inefficiencies. Medication expiration represents significant financial waste, with expired products constituting a measurable percentage of inventory losses.

Long-term care facilities face unique inventory challenges. Resident medication regimens change frequently due to clinical status evolution, creating unpredictable demand patterns. Small volume per medication combined with large medication variety complicates inventory optimization. Limited on-site storage capacity restricts buffering capacity against supply interruptions.

Maternity hospitals encounter different inventory complexities. Obstetric emergencies require immediate medication availability despite low utilization frequency for certain agents. Neonatal care medications often have short shelf lives and require specialized storage conditions. Fluctuating birth rates create demand variability that challenges traditional forecasting models.

4.2.3 Cold Chain Management Failures

Temperature-sensitive pharmaceutical management represents a critical vulnerability in the Saudi supply chain. Essential medications including oxytocin for postpartum hemorrhage management, vaccines, insulin, and various biologics require continuous cold chain maintenance. Infrastructure limitations in remote regions, frequent power interruptions, inadequate temperature monitoring systems, and insufficient training of personnel responsible for cold chain management contribute to product integrity compromises.

The consequences of cold chain failures in maternity care are particularly severe. Oxytocin degradation due to improper storage reduces treatment efficacy for postpartum hemorrhage, a leading cause of maternal mortality. Vaccines for newborns and mothers lose potency when exposed to temperature excursions. Insulin requirements for gestational diabetes management demand reliable cold chain maintenance.

Long-term care facilities face similar cold chain challenges. Chronic disease management often involves temperature-sensitive medications including insulin, certain antibiotics, and biological agents. Many long-term care facilities lack dedicated pharmacy staff with cold chain expertise. Limited infrastructure investment in temperature-controlled storage systems compounds the problem.

4.2.4 Demand Forecasting Inadequacies

Accurate demand forecasting represents a fundamental requirement for effective pharmaceutical supply chain management, yet this capability remains underdeveloped in Saudi healthcare settings. Multiple factors contribute to forecasting challenges including volatile demand patterns, inadequate historical data utilization, poor information sharing between stakeholders, limited adoption of advanced forecasting methodologies, and seasonal and episodic fluctuations in medication needs.

Traditional forecasting approaches relying on simple historical averages fail to capture the complexity of pharmaceutical demand. Sudden shifts in prescribing patterns, new clinical

guideline adoption, disease outbreak events, and policy changes create demand discontinuities that simple models cannot accommodate.

4.3 Sector-Specific Findings

4.3.1 Long-Term Care Pharmaceutical Supply

Long-term care facilities in Saudi Arabia face distinctive supply chain challenges related to their operational characteristics. The closed-door pharmacy model requires specialized distribution arrangements. Medication administration timing requirements demand reliable delivery schedules. High medication variety per resident complicates inventory optimization. Regulatory requirements for medication documentation and return processes add complexity. Medication errors in long-term care settings affect 16-27% of residents according to international data, with polypharmacy and transitions of care representing high-risk periods. The Saudi context likely mirrors these patterns given similar demographic characteristics and disease prevalence in elderly populations.

Specialized services required include unit-dose packaging, medication administration record systems, clinical pharmacist chart review, emergency kit maintenance, and return/credit systems for discontinued medications. Many Saudi long-term care facilities lack comprehensive access to these services, creating quality gaps.

4.3.2 Maternity and Child Health Supply Chains

Maternity hospitals require pharmaceutical supply chains capable of supporting routine care, managing obstetric emergencies, and providing neonatal intensive care capabilities. Critical medication categories include oxytocics for labor management and hemorrhage control, magnesium sulfate for preeclampsia/eclampsia, antibiotics for infection prevention and treatment, neonatal resuscitation medications, and vaccines for newborn immunization programs.

The time-sensitive nature of obstetric emergencies creates zero-tolerance for stock-outs of lifesaving medications. International evidence demonstrates that stockouts of essential maternal health commodities contribute to preventable mortality. The Saudi Vision 2030 commitment to reducing maternal and infant mortality depends partly on reliable pharmaceutical supply chains.

Cold chain requirements for vaccines and certain maternal health commodities demand investment in infrastructure and monitoring systems. Many maternal health commodities have global supply limitations, requiring proactive procurement strategies. Seasonal fluctuations in birth rates create demand variability that challenges inventory optimization.

4.4 Resilience and Optimization Strategies

Analysis of successful interventions reveals several approaches to enhancing pharmaceutical supply chain performance in specialized care settings.

4.4.1 Technology-Enabled Solutions

Advanced information systems demonstrate substantial benefits. Automated inventory management systems reduce error rates, improve stock accuracy, and generate actionable alerts. Implementations have achieved inventory error rate reductions from 0.425‰ to 0.025‰ while boosting overall supply chain efficiency by 42.4%.

Artificial intelligence and machine learning applications for demand forecasting show promise. These systems analyze complex patterns including seasonal variations, epidemic occurrences, and prescribing trends to generate more accurate predictions. Blockchain technology offers enhanced traceability and counterfeit prevention capabilities. Internet of Things sensors

enable real-time monitoring of environmental conditions, particularly for cold chain management.

4.4.2 Process Optimization Approaches

Structural improvements to supply chain processes yield measurable benefits. Implementing cross-functional shortage management teams coordinates response to disruptions. Establishing clear communication protocols between procurement, pharmacy, and clinical departments reduces coordination failures. Standardizing inventory management methodologies across facilities within health systems achieves consistency and enables knowledge sharing.

Demand forecasting improvements through better data utilization, statistical modeling techniques, and collaborative planning with suppliers enhance prediction accuracy. Mathematical optimization models for inventory policy determination can reduce supply and administration costs by 16% while minimizing wastage.

4.4.3 Resilience-Building Measures

Supply chain resilience strategies focus on anticipation, absorption, and adaptation capabilities. Diversifying supplier bases reduces dependence on single sources. Strategic stockpiling of critical medications provides buffers against disruptions. Developing contingency plans for common disruption scenarios enables rapid response. Enhancing supplier relationship management improves information flow and collaboration. Implementing regular scenario planning and simulation exercises tests response capabilities.

5. DISCUSSION

This review synthesizes evidence on pharmaceutical supply chain challenges and optimization strategies relevant to long-term care and maternity care settings in Saudi Arabia. The findings reveal persistent structural vulnerabilities alongside emerging solutions that offer pathways to improved performance.

5.1 Interpretation of Findings

The centralized procurement model employed in Saudi Arabia creates both efficiencies and vulnerabilities. While NUPCO's consolidation of purchasing power theoretically enables better pricing and standardization, the evidence suggests that single-source procurement creates bottlenecks during disruptions and reduces flexibility in responding to facility-specific needs. The predominantly negative perceptions of centralized procurement among supply chain professionals indicate that the system's theoretical benefits are not fully realized in practice.

Medication shortages emerge as a multifaceted problem requiring comprehensive solutions. The global nature of pharmaceutical manufacturing, combined with Saudi Arabia's high import dependence, creates exposure to international supply disruptions. The domestic manufacturing expansion initiatives under Vision 2030, targeting 40% local production, represent a strategic response to this vulnerability. However, achieving this target requires not only manufacturing capacity development but also cultivation of a complete domestic ecosystem including active pharmaceutical ingredient production, quality assurance capabilities, and regulatory infrastructure.

The inventory management challenges identified reflect broader patterns observed in healthcare supply chains globally. The tension between minimizing carrying costs and maintaining adequate service levels is universal. However, the specialized requirements of

long-term care and maternity settings magnify these challenges. Long-term care facilities face particular difficulty due to high medication variety, frequent regimen changes, and limited on-site pharmacy expertise. Maternity hospitals must balance the need for immediate availability of emergency medications against their low utilization frequency and short shelf lives.

Cold chain management emerges as a critical vulnerability with direct patient safety implications. The maternal mortality consequences of oxytocin degradation and the immunization program risks from vaccine potency loss represent preventable tragedies. Investment in cold chain infrastructure, training, and monitoring systems should be prioritized given the criticality of temperature-sensitive medications in these care settings.

The demand forecasting deficiencies reflect both data availability limitations and methodological gaps. Traditional forecasting approaches prove inadequate for the complexity of pharmaceutical demand patterns. The adoption of advanced analytics including machine learning offers promise but requires data infrastructure investments and analytical capability development.

5.2 Implications for Practice and Policy

Several actionable implications emerge for healthcare administrators and policymakers:

First, decentralized decision-making authority within appropriate governance frameworks may reduce procurement bottlenecks while maintaining economies of scale. Allowing facilities or facility groups greater autonomy in sourcing from pre-qualified suppliers could enhance responsiveness to local needs while preserving quality standards.

Second, prioritized investment in long-term care and maternity care pharmaceutical infrastructure is warranted given their unique requirements and population vulnerability. This includes dedicated funding for cold chain equipment, pharmacy automation systems, and specialized training programs.

Third, development of specialized pharmaceutical services for long-term care including integrated dispensing systems, clinical pharmacy support, and medication management services would address identified quality gaps. Public-private partnerships might enable service delivery model innovation.

Fourth, national-level strategic stockpiling of critical obstetric and maternal health commodities would provide resilience against supply disruptions. This aligns with international best practices in essential medicines security.

Fifth, systematic data collection and analysis infrastructure development should be prioritized to enable evidence-based supply chain management. Investment in interoperable information systems connecting procurement, pharmacy, and clinical operations would enhance visibility and coordination.

Sixth, workforce development in supply chain management, pharmaceutical logistics, and cold chain management requires attention. Training programs, certification pathways, and continuing education opportunities would professionalize these critical functions.

5.3 Theoretical Contributions

This review contributes to healthcare supply chain literature by providing systematic analysis of pharmaceutical logistics in specialized care settings within a developing economy context. The findings support resource dependence theory's predictions about the importance of managing external dependencies through strategic relationships and buffer mechanisms. The evidence on resilience strategies aligns with supply chain resilience frameworks emphasizing preparation, absorption, and adaptation capabilities.

The particular vulnerabilities of long-term care and maternity care supply chains highlight the importance of care setting characteristics in shaping supply chain requirements. Generic healthcare supply chain models may not adequately account for these specialized needs. Future theoretical development should incorporate care setting typologies that recognize distinctive operational requirements and constraints.

5.4 Limitations

Several limitations warrant acknowledgment. First, the literature on pharmaceutical supply chains specifically within Saudi Arabia remains limited, necessitating inference from international studies. Cultural, regulatory, and infrastructure differences may limit direct applicability of findings from other contexts.

Second, the available evidence provides limited quantitative data on supply chain performance metrics in Saudi long-term care and maternity settings specifically. More empirical research is needed to establish baseline performance levels and track improvement over time.

Third, the review's scope excluded some relevant gray literature including institutional reports and conference proceedings due to verification challenges. Some potentially valuable insights may have been missed.

Fourth, the rapidly evolving nature of pharmaceutical supply chains and ongoing Saudi healthcare system transformation mean that some findings may become outdated quickly. Continuous monitoring and periodic review updates will be necessary.

Fifth, publication bias toward successful interventions may overestimate the effectiveness of proposed solutions. Implementation challenges and failed initiatives receive less attention in published literature.

5.5 Future Research Directions

Multiple avenues for future research emerge from this review:

Empirical studies quantifying pharmaceutical supply chain performance metrics in Saudi long-term care and maternity care facilities would establish baseline data and enable benchmarking. Longitudinal studies tracking the impact of Vision 2030 pharmaceutical localization initiatives on supply chain reliability would inform policy refinement.

Implementation science research examining barriers and enablers of supply chain optimization interventions in Saudi healthcare settings would enhance translation of evidence into practice. Studies comparing centralized versus decentralized procurement models in similar healthcare systems could inform governance structure optimization.

Research on cold chain management effectiveness in tropical climates with infrastructure challenges would address a critical knowledge gap relevant to Saudi Arabia and similar contexts. Development and validation of demand forecasting models incorporating Saudi-specific variables including seasonal patterns, demographic trends, and epidemiological data would enhance prediction accuracy.

Investigation of patient outcomes associated with pharmaceutical supply chain disruptions in long-term care and maternity settings would strengthen the empirical case for infrastructure investment. Cost-effectiveness analyses of various supply chain optimization interventions would inform resource allocation decisions.

Qualitative research exploring the experiences of healthcare providers managing pharmaceutical shortages in specialized care settings would provide insights into frontline challenges and adaptive strategies. Comparative studies examining pharmaceutical supply chain performance across Gulf Cooperation Council countries would enable regional learning and collaboration.

6. CONCLUSION

Pharmaceutical supply chain optimization in long-term care and maternity care settings represents a critical priority for healthcare quality improvement in Saudi Arabia. The evidence synthesized in this review reveals persistent challenges including medication shortages, inventory management deficiencies, cold chain vulnerabilities, and demand forecasting inadequacies that particularly affect vulnerable populations in specialized care environments.

The path forward requires integrated approaches combining technological innovation, process optimization, workforce development, and strategic infrastructure investment. The Saudi Vision 2030 pharmaceutical localization initiatives provide a strategic framework for reducing import dependence and enhancing supply chain resilience. However, achieving supply chain excellence requires sustained commitment, resource allocation, and multi-stakeholder collaboration.

Long-term care facilities and maternity hospitals serve populations with heightened vulnerability to pharmaceutical supply disruptions. Ensuring reliable access to essential medications in these settings is not merely an operational challenge but a moral imperative aligned with fundamental healthcare quality and patient safety principles. The evidence-based recommendations outlined in this review offer actionable pathways toward that goal.

As Saudi Arabia continues its healthcare transformation journey, pharmaceutical supply chain modernization must remain a central priority. The integration of advanced technologies, adoption of evidence-based management practices, and cultivation of specialized expertise in healthcare logistics will be essential to achieving the healthcare system performance aspirations embedded in Vision 2030. Future research and continuous quality improvement efforts should build upon the foundation established in this review to advance knowledge and enhance practice in this critical domain.

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Tables

Table 1 *Key Challenges in Pharmaceutical Supply Chains for Saudi Long-Term and Maternity Care Facilities*

Challenge Category	Specific Issues	Impact on Care Delivery	Prevalence
Drug Shortages	Essential medication unavailability	Treatment delays, alternative therapy risks	High
	Generic medication scarcity	Increased costs, safety concerns	Moderate-High
	Emergency obstetric drug stockouts	Maternal/neonatal mortality risk	Moderate
Inventory Management	Inaccurate demand forecasting	Stockouts and excess inventory	High
	High safety stock costs	Financial burden (10-18% of budget)	High
	Medication expiration waste	Financial losses, reduced availability	Moderate
Cold Chain	Temperature excursions	Product degradation, efficacy loss	Moderate-High

	Infrastructure inadequacy	Vaccine/biologic storage failures	Moderate
	Monitoring system gaps	Undetected temperature deviations	Moderate-High
Procurement System	Centralization delays	Reduced responsiveness	Moderate
	Limited facility autonomy	Inability to address local needs	Moderate
	Import dependence (70%+)	Global disruption vulnerability	High

Note. Prevalence ratings based on literature synthesis: High = consistently reported across multiple studies; Moderate-High = frequently reported; Moderate = intermittently reported.

Table 2 *Evidence-Based Optimization Strategies and Reported Outcomes*

Strategy Category	Specific Interventions	Evidence Level	Reported Outcomes
Technology Solutions	AI/ML demand forecasting	Moderate	34.4% MAPE improvement
	Automated inventory management	High	42.4% efficiency increase; inventory error reduction from 0.425‰ to 0.025‰
	Blockchain for traceability	Low-Moderate	Enhanced transparency, counterfeit prevention
	IoT cold chain monitoring	Moderate	Real-time temperature tracking, alert generation
Process Optimization	Mathematical inventory models	Moderate-High	16% cost reduction
	Cross-functional shortage teams	Moderate	Improved coordination, faster response
	Supplier diversification	High	Enhanced resilience to disruptions
	Strategic stockpiling	Moderate	Buffer against supply shocks
Workforce Development	Supply chain management training	Low-Moderate	Professionalization of function
	Clinical pharmacy services for LTC	Moderate	Reduced medication errors, improved outcomes
	Cold chain competency programs	Low	Enhanced product integrity assurance
Infrastructure Investment	Cold chain equipment upgrades	Moderate-High	Reduced temperature excursions
	Pharmacy automation systems	Moderate-High	Labor efficiency, accuracy improvement

	Integrated information systems	Moderate	Enhanced visibility, coordination
Governance Reforms	Decentralized procurement authority	Low	Increased responsiveness (limited evidence)
	Public-private partnerships	Low-Moderate	Service delivery innovation
	Regulatory harmonization	Low	Streamlined approvals, reduced delays

Note. Evidence level ratings: High = multiple rigorous studies with consistent findings; Moderate-High = several studies with generally consistent findings; Moderate = limited studies or mixed findings; Low-Moderate = emerging evidence; Low = theoretical or anecdotal evidence only. Specific outcomes are representative examples from the literature.