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Research Article

Centralized Faith-based Pharmaceutical Supply Chain Performance in Cameroon: A System-level Audit

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Abstract

Background: Centralized pharmaceutical procurement can strengthen medicine quality assurance and reduce exposure to substandard and falsified medicines in low- and middle-income countries. However, medicine availability depends on how well procurement, forecasting, warehousing, inventory management, information systems, and distribution function as an integrated system. This study assessed the system-level performance of a centralized, faith-based pharmaceutical supply chain in Cameroon to identify operational strengths, performance gaps, and governance-related risks that affect sustained access to quality-assured medicines. Methods: A cross-sectional pharmaceutical supply chain audit was conducted over a 1-year period using the Pharmaceutical Supply Chain Initiative tripartite audit framework. Performance was assessed across forecasting, procurement, supplier sourcing, warehousing, inventory management, use of logistics management information systems, and distribution, using adapted USAID-recommended indicators. Quantitative benchmarking was complemented by participatory root-cause analysis using the Ishikawa framework. Results: Procurement-level quality assurance was strong: all products underwent quality testing, and 94.6% met pharmacopoeial standards. Internal warehouse handling accuracy and electronic order processing through the logistics management information system also met benchmark targets. In contrast, major downstream gaps were identified. Forecasting discrepancies reached 49.5%; supplier on-time delivery was low; warehouse storage utilization exceeded recommended capacity; inventory accuracy remained below target; and order-filling performance was poor at 38%. These gaps were associated with high stockout rates of 49.7% and inconsistent medicine availability across service delivery points, indicating misalignment between governance functions and downstream operational performance. Conclusions: Centralized procurement strengthened upstream quality assurance but did not ensure reliable availability of medicines when downstream supply chain functions were weak. Persistent gaps in forecasting, supplier performance, warehousing, inventory management, and distribution were associated with reduced service readiness and greater reliance on emergency or decentralized procurement pathways, which may increase risks to medicine quality. Strengthening pharmaceutical supply chains requires integrated end-to-end performance management, supported by routine system-level audits, to align governance and operational functions and sustain access to quality-assured medicines.

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Keywords

Pharmaceutical Supply Chain, Faith-based Organization, Health System Performance, Medicine Availability, Supply Chain Audit, Inventory Management, Substandard and Falsified Medicines, Cameroon

1. Introduction

Effective pharmaceutical supply chain management (PSCM) is a core health system function that underpins service delivery, treatment continuity, and patient safety in low- and middle-income countries (LMICs), where persistent weaknesses in forecasting accuracy, inventory control, warehousing capacity, and distribution performance continue to cause medicine shortages and service disruptions [1-3, 25, 28]. These challenges are especially consequential for health systems that rely on centralized procurement and distribution to ensure the availability of essential medicines across geographically dispersed service delivery points [1, 4, 10, 27].

Beyond efficiency considerations, pharmaceutical supply chains play a critical role in safeguarding patient safety through regulatory oversight of medicine quality, storage conditions, and traceability; when downstream weaknesses lead facilities to obtain medicines outside routine regulated channels, exposure to substandard and falsified medicines may increase [5-8].

Although centralized pharmaceutical procurement systems are widely promoted to improve quality assurance and cost efficiency, evidence demonstrates that strong upstream procurement controls alone do not guarantee medicine availability when downstream supply chain functions remain poorly integrated and governed [1, 9-11]. Despite growing recognition of these challenges, limited evidence exists on pharmaceutical supply chains as integrated systems or on how governance-level functions align with downstream operations to shape performance, particularly within faith-based health networks [1, 10, 11, 23].

Evaluations of pharmaceutical supply chains in Uganda, Ethiopia, and other health systems have documented persistent stockouts despite centralized procurement, driven by infrastructure constraints, supplier performance failures, forecasting inaccuracies, weak data quality, and disjointed distribution systems [2, 3, 25]. Similarly, global supply chain studies emphasize that downstream integration, inventory visibility, and distribution reliability are critical determinants of sustained performance improvement [14-16, 26, 28].

While previous studies have assessed individual supply chain functions or facility-level availability, fewer have examined pharmaceutical supply chains as integrated systems or explicitly linked downstream operational performance gaps to governance-level decisions and patient safety risks. Evidence remains limited on how centralized procurement systems within faith-based health networks function end-to-end, and how misalignment across forecasting, supplier management, warehousing, inventory management, data visibility, workforce capacity, and distribution can undermine medicine availability despite strong procurement quality assurance [25-28].

To address this gap, the present study conducted a system-level pharmaceutical supply chain audit of a centralized, faith-based health system in Cameroon using a structured audit framework. The study aimed to evaluate end-to-end supply chain performance, identify operational strengths and performance gaps across key functions, and examine how downstream failures contribute to stockouts, service disruptions, and increased reliance on high-risk procurement pathways affecting patient safety. By adopting a system-level audit approach, this study seeks to inform governance and policy reforms required to sustain access to quality-assured medicines in faith-based and other resource-constrained health systems.

2. Methods

2.1. Study Design

This study was conducted as a system-level pharmaceutical supply chain audit to assess end-to-end performance within a centralized faith-based health system, consistent with systems-based approaches to supply chain performance assessment [1, 12]. A cross-sectional design was applied to routinely implemented supply chain processes over a one-year period. This design enabled assessment of interconnected upstream and downstream functions rather than isolated service delivery points.

2.2. Audit Framework

The audit was guided by the Pharmaceutical Supply Chain Initiative (PSCI) tripartite audit framework (Figure 1), which organizes system-level evaluations into three sequential phases: preparation, on-site assessment, and reporting [12]. The framework was used to assess governance arrangements, operational processes, and performance management practices across the pharmaceutical supply chain. Data sources included direct observation of operational practices, structured interviews with supply chain personnel, and review of routinely generated records, including procurement documents,

supplier delivery reports, warehouse logs, LMIS data, inventory records, and distribution reports [13, 14]. These sources supported triangulation of performance across forecasting, procurement, supplier sourcing, warehousing, inventory management, LMIS functionality, and distribution [13-16].

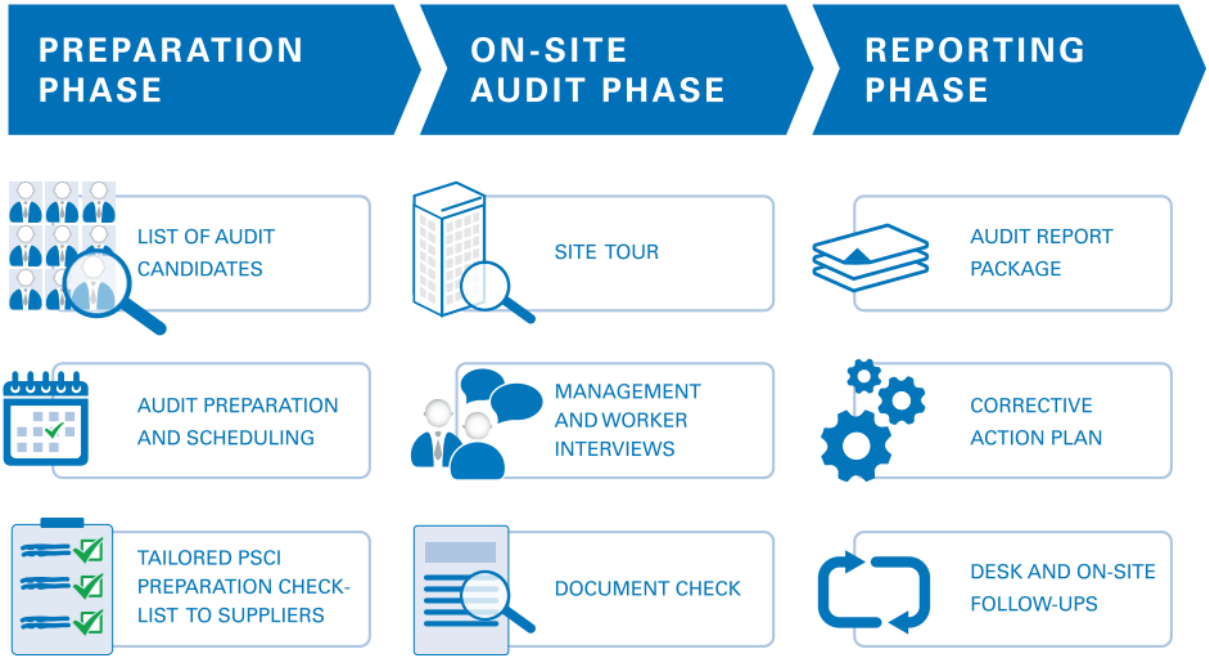

Figure 1. *Pharmaceutical Supply Chain Initiative (PSCI) audit framework: Schematic representation of the Pharmaceutical Supply Chain Initiative (PSCI) tripartite audit framework, illustrating the three sequential phases: preparation, on-site audit, and reporting, used to guide the system-level pharmaceutical supply chain audit [12].*

2.3. Performance Indicators and Benchmarking

Supply chain performance was evaluated using adapted public health supply chain indicators covering forecasting accuracy, supplier performance, warehousing, inventory management, distribution, and medicine availability. Indicators were selected to capture both upstream procurement quality-assurance processes and downstream operational performance affecting availability at service delivery points. Observed values were compared with predefined audit benchmark targets to identify deviations suggestive of system-level performance gaps [14-16].

Key indicators included forecasting accuracy, supplier order compliance, on-time delivery, warehouse storage capacity utilization, inventory accuracy, order processing time, order-filling rate, stockout rate, wastage and spoilage, shipment quantity accuracy, and transport capacity utilization [15, 16].

2.4. Data Analysis

Quantitative findings were interpreted at the system level by examining patterns of alignment and misalignment across forecasting, procurement, supplier performance, warehousing, inventory management, LMIS use, and distribution [1, 10, 11]. Rather than attributing outcomes to single-process failures, the analysis examined how cumulative performance gaps across interconnected functions affected medicine availability and service readiness.

2.5. Root-Cause Analysis

Participatory root-cause analysis was conducted using the Ishikawa fishbone framework to explore factors contributing to observed performance gaps across six domains: personnel, methods, equipment, materials, measurement systems, and the operational environment [17, 18]. This approach was used to contextualize quantitative findings and examine how governance-level decisions interacted with operational constraints to shape downstream supply chain performance.

2.6. Ethics Approval and Consent to Participate

This study was conducted as a system-level audit and quality-improvement assessment of a healthcare system's pharmaceutical supply chain. It did not involve human participants, patient data, clinical procedures, or biological materials. In accordance with institutional and national guidelines for quality-improvement audits, formal ethical review and informed consent were not required. Permission to conduct the audit was granted by the relevant institutional and health system authorities before data collection.

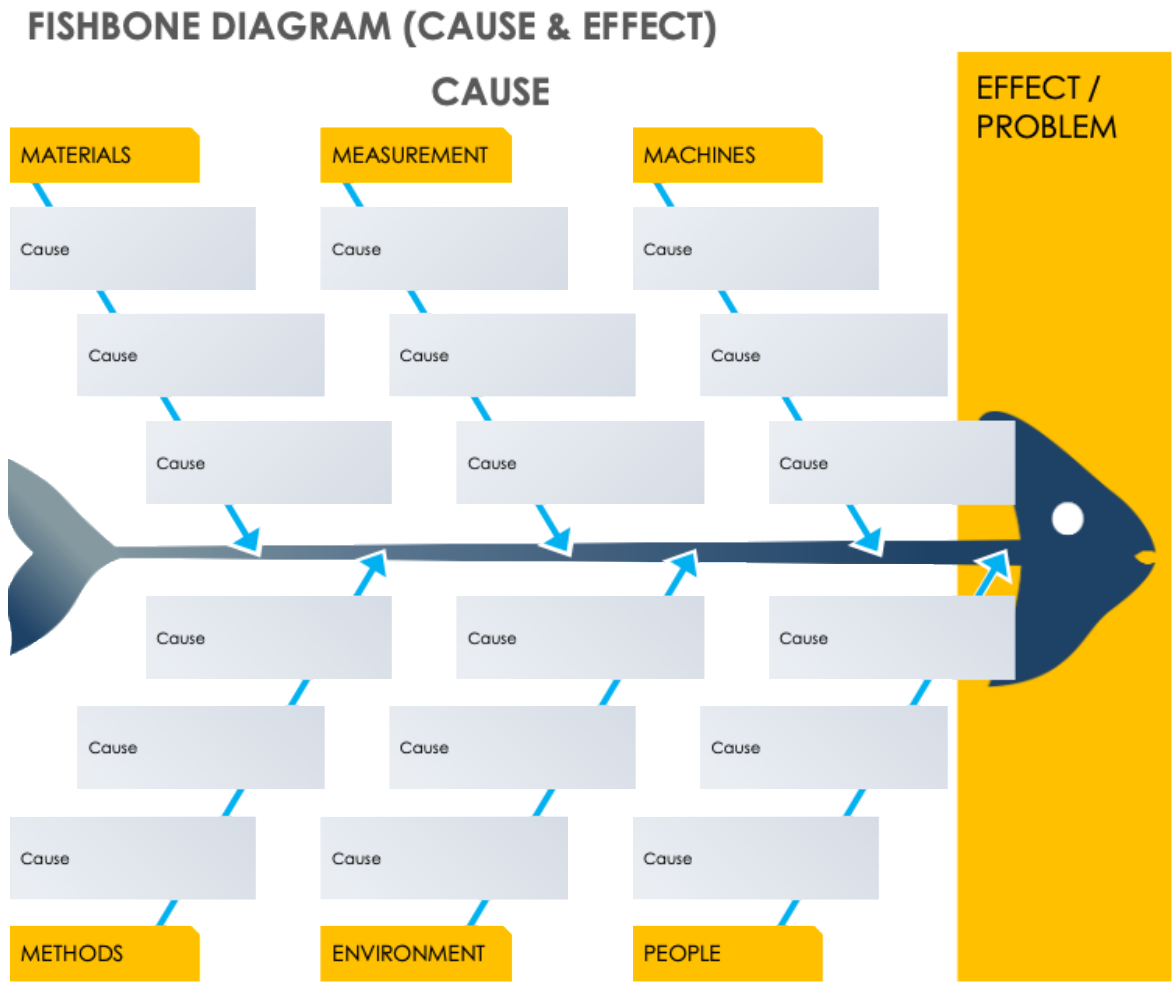

Figure 2. *Ishikawa (fishbone) framework for root-cause analysis: Conceptual framework illustrating the Ishikawa (fishbone) approach used to identify root causes of pharmaceutical supply chain performance gaps across six domains: personnel, methods, equipment, materials, measurement systems, and operational environment [18].*

2.7. Availability of Data and Materials

The data supporting the findings of this study were obtained from routine pharmaceutical supply chain records of a faith-based healthcare network and include sensitive operational and business information. In accordance with data governance policies and confidentiality agreements, these datasets are not publicly accessible. De-identified and aggregated data sufficient to support replication of the analyses may be provided by the corresponding author upon reasonable request and subject to approval by the relevant institutional authorities.

Using the audit framework, performance indicators, and benchmarking approach described above, the results section presents observed system-level performance across key functions of the pharmaceutical supply chain. Findings are reported descriptively across upstream and downstream domains, including forecasting, procurement, supplier performance, warehousing, inventory management, LMIS functionality, and distribution, to highlight areas of strength and performance gaps affecting medicine availability and service readiness.

3. Results

3.1. Overview of Supply Chain Performance

The audit evaluated the system-level performance of the centralized pharmaceutical supply chain across key functional areas using predefined audit indicators adapted from public health supply chain performance assessment approaches. Results are presented across upstream and downstream functions, including product selection and forecasting; procurement and supplier performance; warehousing and storage; inventory management and LMIS; and distribution, to highlight strengths and performance gaps affecting medicine availability and service readiness. Observed values were benchmarked

against predefined targets to identify strengths and performance gaps affecting medicine availability and service readiness (Figures 3-7).

3.2. Product Selection, Forecasting, and Procurement

Procurement-level quality assurance performed strongly. All procured products (100%) underwent quality testing, and 94.58% met United States Pharmacopeia (USP) and British Pharmacopeia (BP) standards. Procurement financial performance met targets, with an average profit margin of 20%, and productivity exceeded benchmarks, with a mean of 134.5 orders processed per procurement staff member annually (target: 50).

Performance gaps were observed in product selection and forecasting. Selection compliance for essential medicines was 91.72% (target: 100%), while compliance for medical supplies (59.44%) and laboratory supplies (50.71%) was substantially below target levels. Forecasting discrepancies were high, reaching 49.5% for medicines and 36.25% for consumables, exceeding the acceptable 10% threshold (Figure 3).

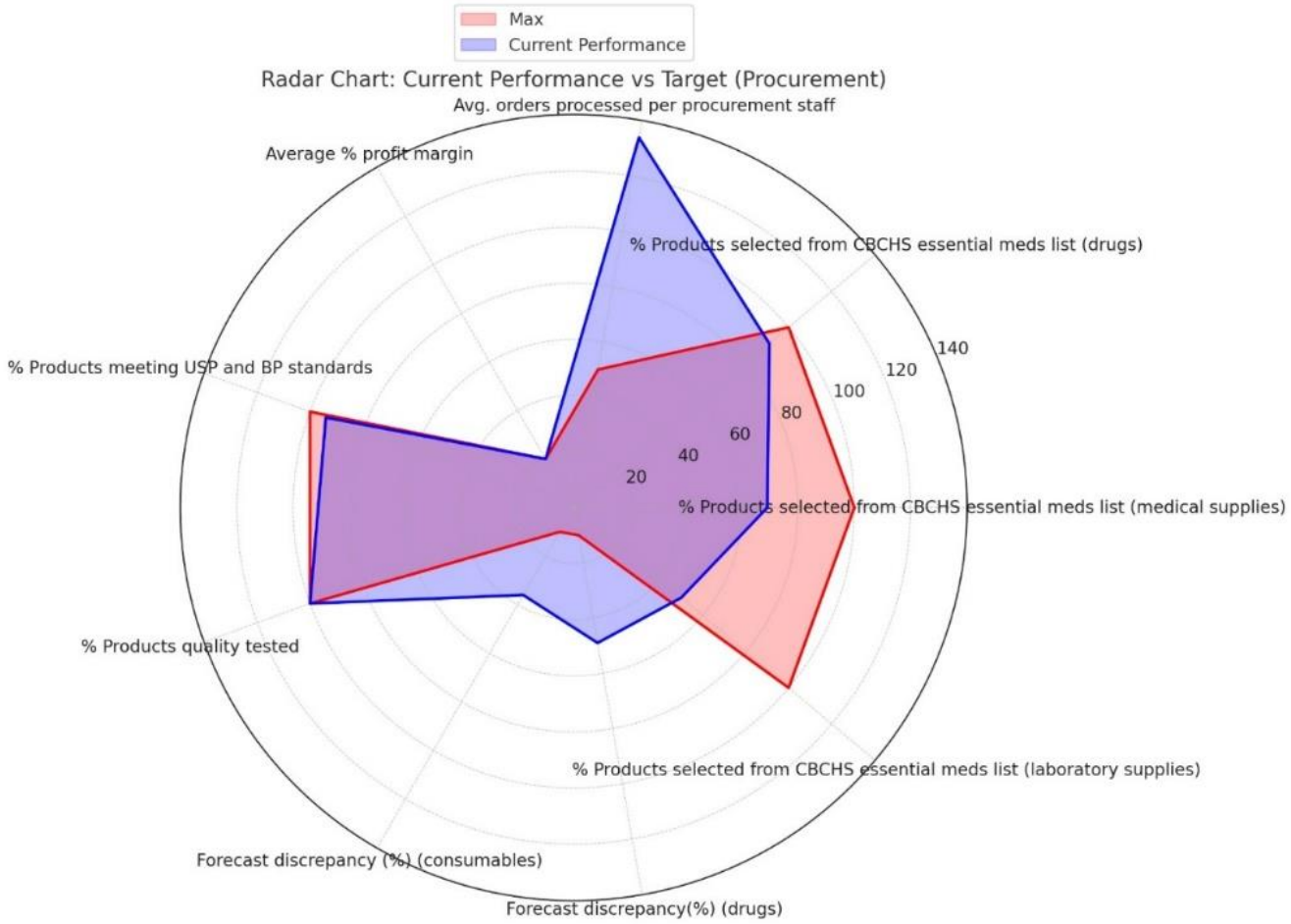

Figure 3. *Product selection, forecasting, and procurement performance compared with benchmark targets: Observed performance of key indicators related to product selection, forecasting accuracy, and procurement productivity compared with predefined audit benchmark targets.*

3.3. Supplier Performance and Pharmaceutical Sourcing

Supplier performance indicators fell below benchmark targets. Supplier order compliance was 65.4% against a 95% target, and on-time delivery performance was 12.6% against a 90% benchmark, indicating frequent delays and incomplete or inaccurate deliveries. Total supply costs accounted for 77.58% of the allocated budget and remained within acceptable financial limits (Figure 4).

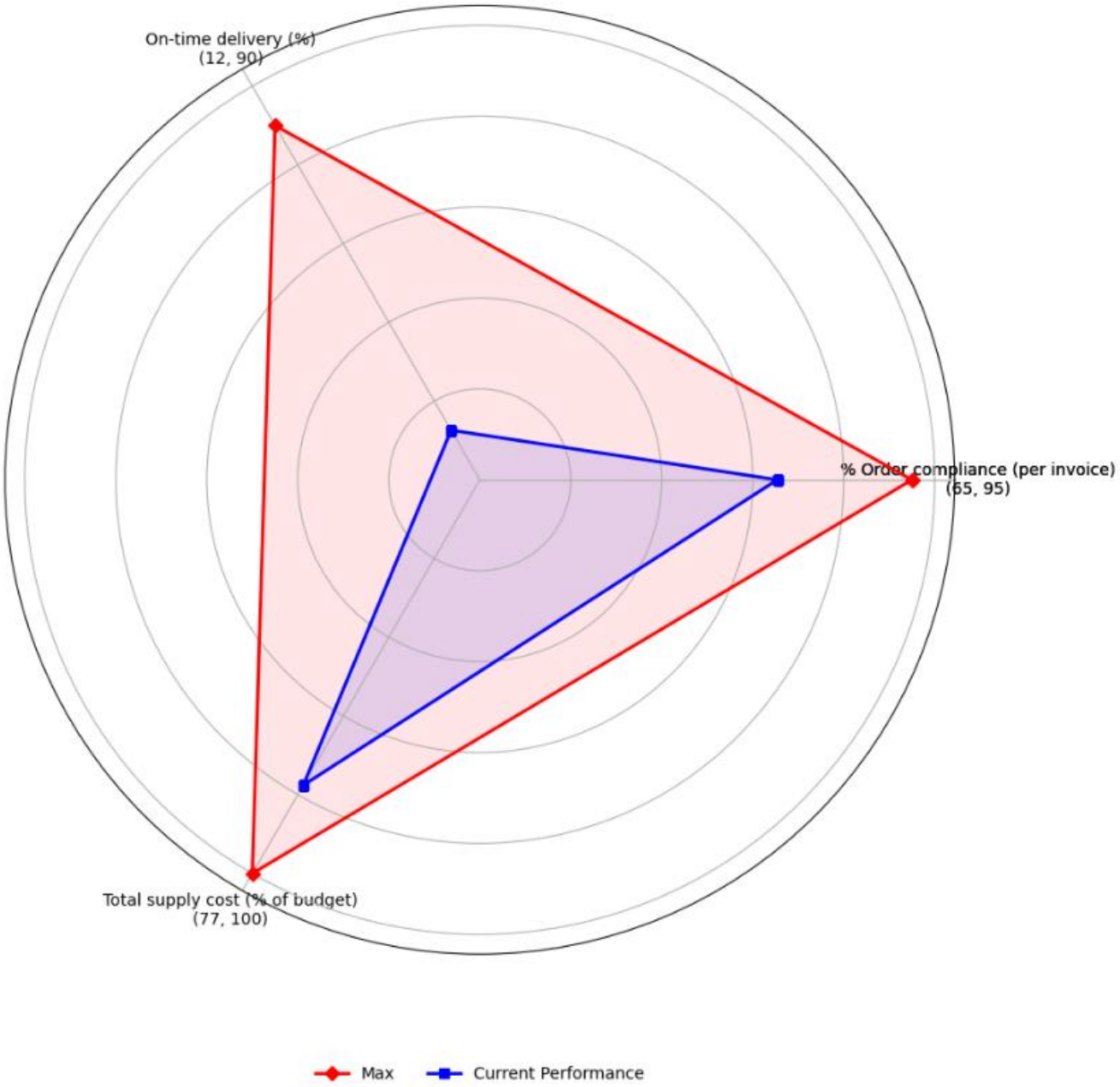

Figure 4. *Supplier sourcing and delivery performance compared with benchmark targets: Comparison of observed supplier order compliance and on-time delivery performance against predefined audit benchmark targets.*

3.4. Warehousing and Storage

Internal warehouse handling processes showed high accuracy. Put-away accuracy was 100%, picking accuracy was 98.69%, and no damaged products were recorded at reception (0.00%). However, capacity and accuracy constraints were evident. Inventory accuracy was 85.7% (target: 95%), and the average warehouse order processing time was 4 days compared with a 2-day benchmark. Storage space utilization reached 206.19%, substantially exceeding the recommended 85% threshold, indicating severe congestion (Figure 5).

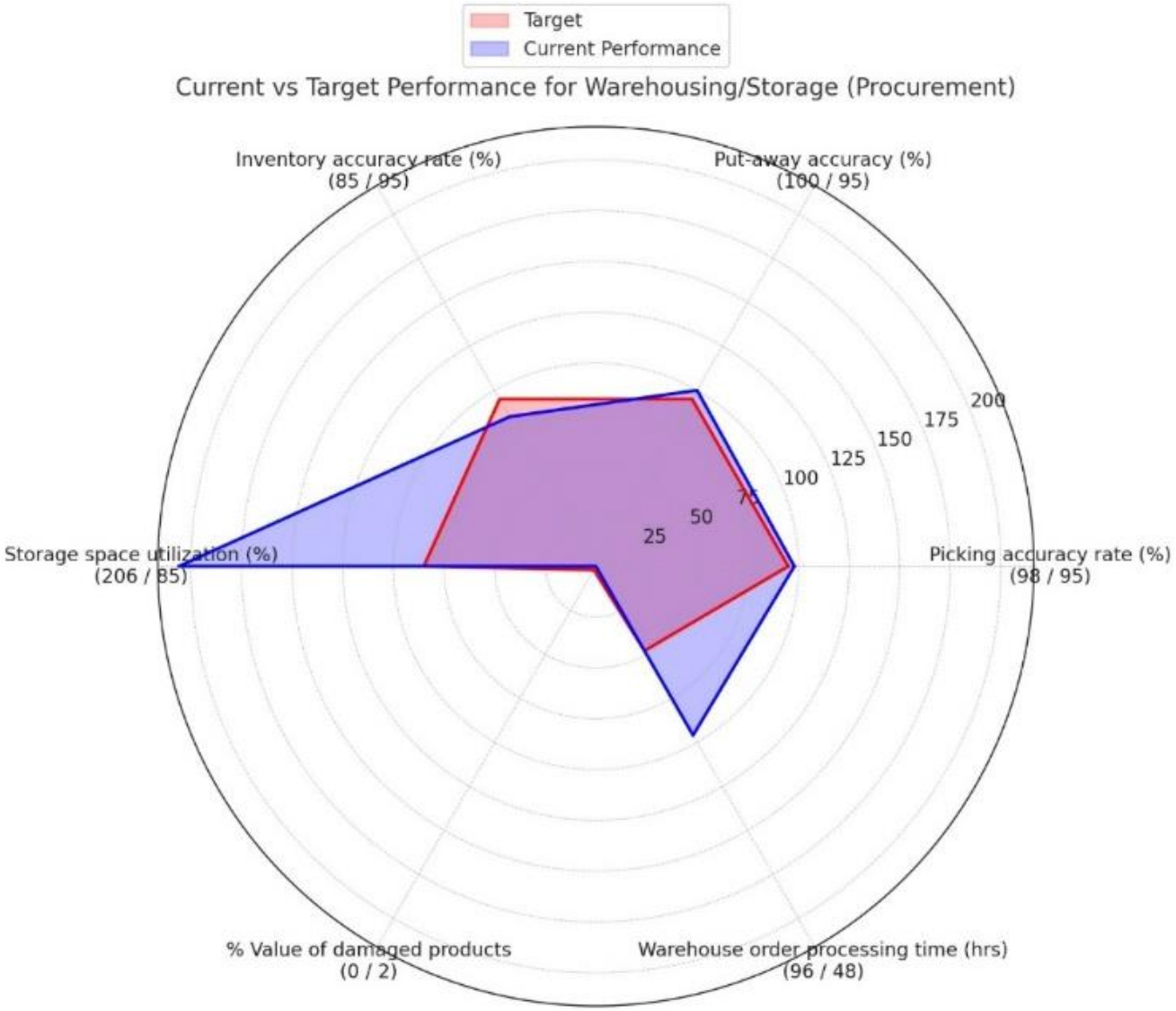

Figure 5. *Warehousing and storage performance compared with benchmark targets: Observed performance of warehousing and storage indicators, including inventory accuracy, order processing time, and storage space utilization, compared with recommended benchmark targets.*

3.5. Inventory Management, LMIS, and Customer Response

Most products (95.84%) were delivered with adequate remaining shelf life. Order entry time averaged 34 hours, and overall order turnaround time averaged 48 hours, both within target limits. All orders (100%) were processed electronically through the logistics management information system.

Despite these operational strengths, availability and fulfillment performance were poor. The stockout rate reached 49.7% (target: 5%), and the order-filling rate was 38% compared with a 95% benchmark. Inventory discrepancies included 11.17% overstocked items and 7.22% understocked or unaccounted items. Stock wastage due to expiry or damage was 2.06% (target: 2%), and spoilage was 0.15% (benchmark: 0.1%) (Figure 6).

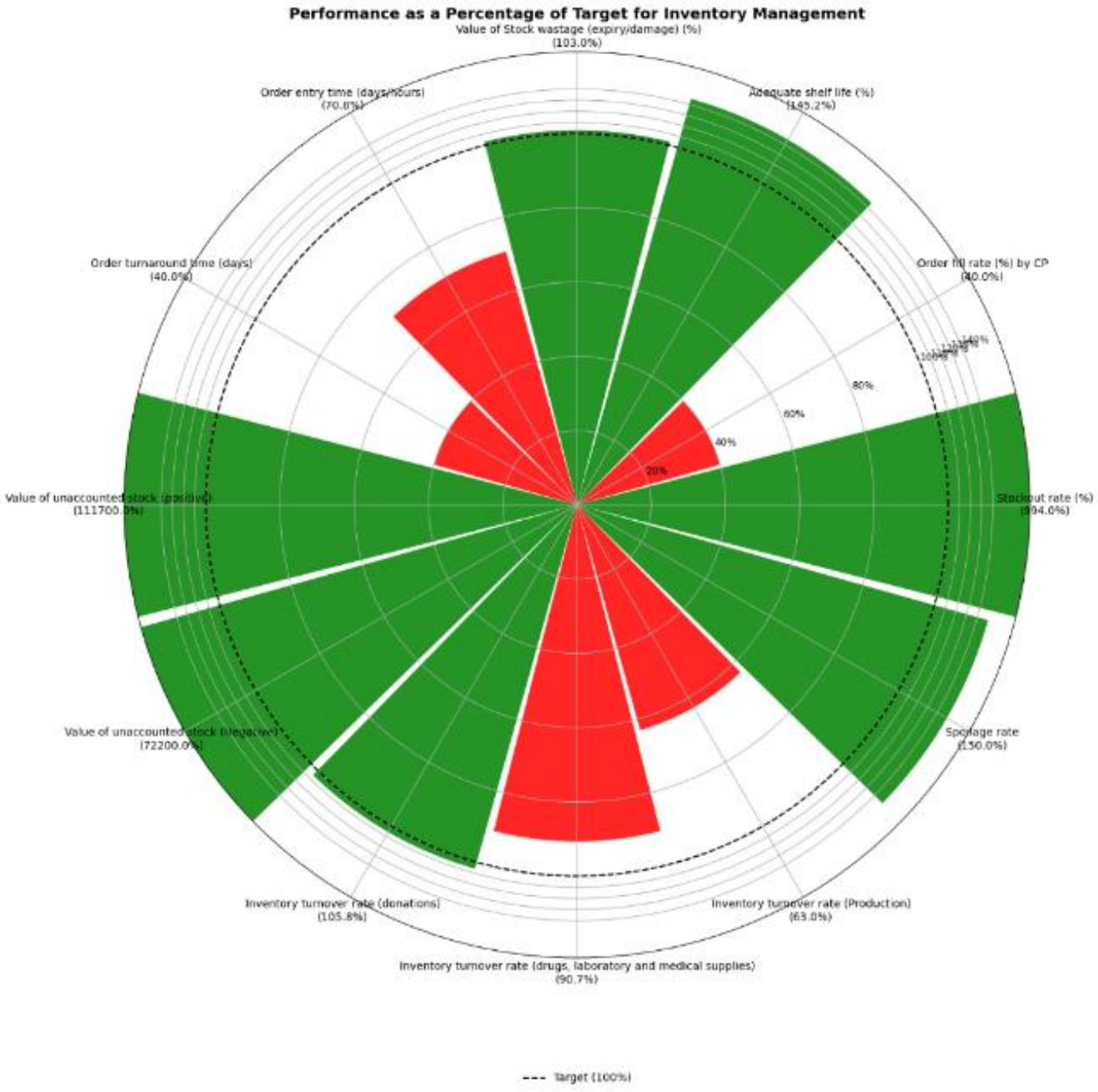

Figure 6. *Inventory management and order fulfillment performance: Performance of inventory management and order-fulfillment indicators, including stockout rate, order-filling rate, wastage, and spoilage, compared with benchmark targets.*

3.6. Distribution and Transport

All shipments (100%) arrived in good condition. However, shipment quantity accuracy was 11.76% compared with a 95% target, indicating frequent discrepancies between dispatched and received quantities. Vehicle turnaround time was 67% (benchmark: 50%), and vehicle capacity utilization was 80% compared with a 95% target (Figure 7).

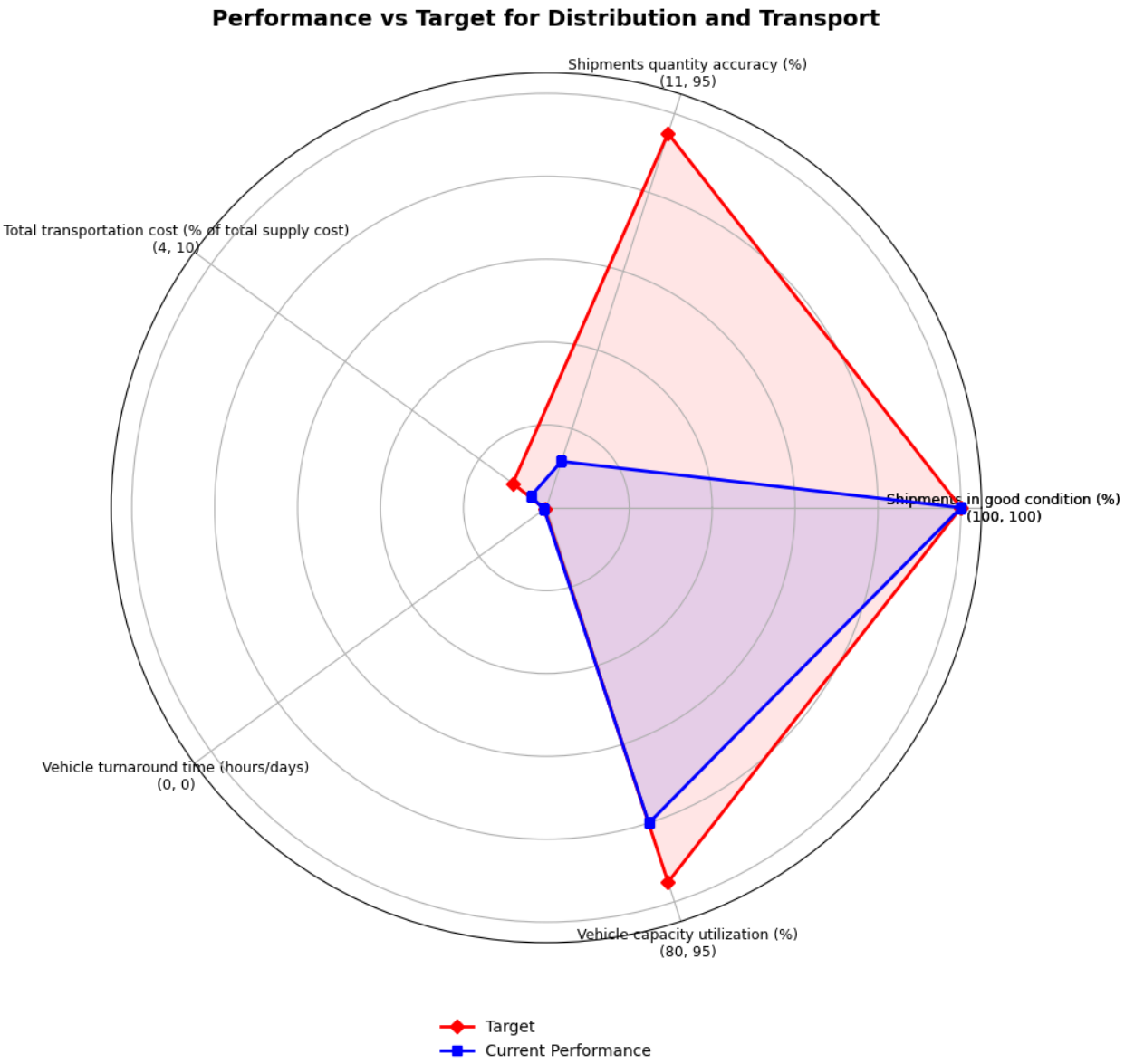

Figure 7. *Distribution and transport performance compared with benchmark targets: Observed performance of distribution and transport indicators, including shipment quantity accuracy, vehicle turnaround time, and vehicle capacity utilization, compared with recommended targets.*

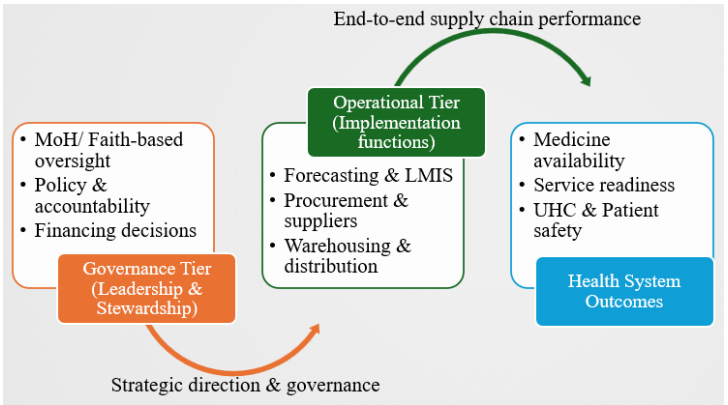

Figure 8. *Two-tier governance and operational mapping of the pharmaceutical supply chain performance: Conceptual mapping of governance and operational functions within the centralized pharmaceutical supply chain.*

As illustrated in Figure 8, governance-level functions related to stewardship, accountability, leadership, and resource allocation shape downstream operational performance across forecasting, procurement, warehousing, inventory management, and distribution, influencing medicine availability and patient safety.

This conceptual figure illustrates the relationship between governance-level functions (stewardship, accountability, leadership, and resource allocation) and downstream operational domains, including forecasting, procurement, warehousing, inventory management, and distribution. The mapping reflects system-level relationships observed during the audit and highlights areas of alignment and misalignment between governance and operations. The figure is illustrative and does not imply direct causal effects.

As illustrated in Figure 9, downstream supply chain failures lead to stockouts and increased reliance on emergency and decentralized procurement pathways, weakening quality assurance and increasing the risk of substandard and falsified medicines.

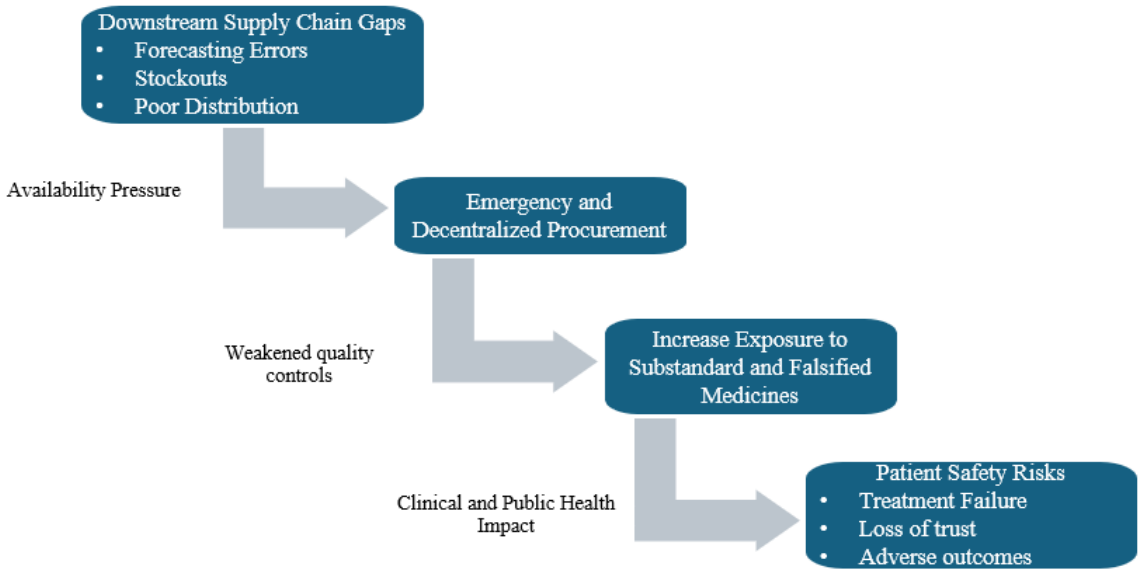

Figure 9. *Conceptual pathway linking downstream pharmaceutical supply chain failures with increased patient safety risk.*

This conceptual pathway illustrates how downstream supply chain performance gaps, such as forecasting inaccuracies, supplier delivery delays, warehousing constraints, inventory shortages, and distribution inefficiencies, are associated with greater reliance on emergency and decentralized procurement. These pathways may weaken routine quality-assurance controls and increase exposure to substandard and falsified medicines. The framework reflects relationships identified during the audit and does not represent measured causal effects.

Policy-relevant relationships are synthesized in Figure 10, which illustrates how governance-level interventions translate into coordinated operational actions to improve medicine availability and reduce reliance on emergency procurement.

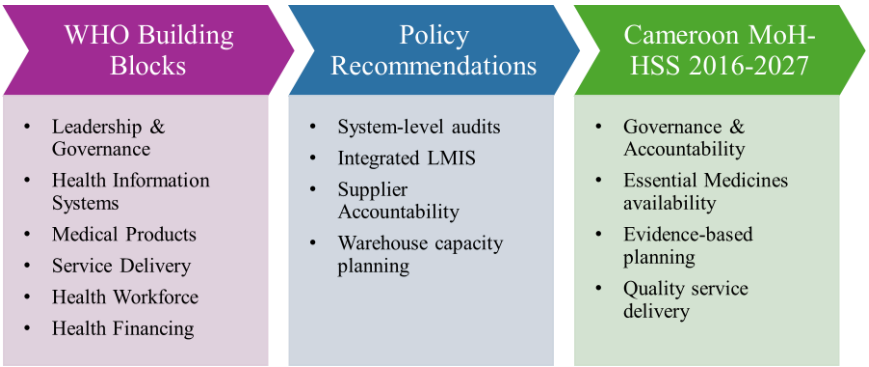

Figure 10. *Illustrative governance-to-operations alignment framework for strengthening pharmaceutical supply chain performance.*

This illustrative framework synthesizes audit findings to show how governance-level actions, including strengthened stewardship, accountability mechanisms, and resource allocation, may support coordinated operational improvements across forecasting, procurement, warehousing, inventory management, and distribution. The framework is intended to inform policy and performance management discussions and does not represent a tested intervention model.

3.7. Summary of Performance Gaps

Viewed across the supply chain, the results reveal significant variation in performance between upstream and downstream functions rather than consistent end-to-end results. While procurement-level quality assurance, internal warehouse handling accuracy, and electronic order processing met or exceeded benchmark targets, notable gaps were found in forecasting accuracy, supplier delivery reliability, storage capacity utilization, inventory availability, and distribution performance. The following discussion examines how this variation in end-to-end performance manifests at the system level and considers how alignment or misalignment across governance and operational areas relates to medicine availability and patient safety, as summarized in Figures 8 and 9.

4. Discussion

The findings reveal a clear disconnect between strong upstream pharmaceutical procurement and persistent downstream operational weaknesses, reinforcing evidence that centralized procurement alone is insufficient to ensure medicine availability without effective downstream integration [1, 9-11]. While procurement-level quality assurance, internal warehouse handling accuracy, and electronic order processing met or exceeded recommended benchmarks, substantial gaps were identified in forecasting accuracy, supplier performance, inventory availability, warehousing capacity, and distribution reliability.

4.1. Upstream Strengths and Limits of Centralized Procurement

Strong procurement-level quality assurance observed in this study confirms the value of centralized procurement systems in preventing the entry of substandard and falsified medicines [6-8]. Universal quality testing and high pharmacopeial compliance demonstrate effective upstream regulatory controls aligned with international best practices. However, as in other LMIC settings, these upstream safeguards did not prevent stockouts despite weak downstream supply chain performance [1, 2, 11]. This underscores that procurement quality assurance is only effective in protecting patients when embedded within a reliably functioning end-to-end supply chain.

4.2. Forecasting, Supplier Performance, and System Responsiveness

High forecasting discrepancies and weak supplier performance observed in this audit are consistent with prior studies linking inaccurate demand estimation, poor supplier accountability, procurement delays, weak data quality, and disjointed distribution to stockouts and service disruptions in LMIC supply chains [1-3, 9, 25]. Although electronic LMIS use was widespread, its corrective potential was limited where stock data were not systematically translated into consumption-based forecasting, supplier follow-up, and routine feedback for operational decision-making. This interpretation is consistent with evidence that electronic LMIS can improve stock visibility and ordering, but that benefits depend on data quality, infrastructure, training, management support, accountability, transparency, and regular use [15-17, 26].

4.3. Warehousing Capacity, Inventory Visibility, and Distribution Constraints

Severe warehouse congestion, inventory inaccuracies, and distribution inefficiencies reflect structural bottlenecks that can amplify disruption across supply chain tiers [18, 20, 21, 28]. In this audit, weak distribution and inventory performance appeared to reduce the practical benefits of strong procurement quality assurance by limiting reliable product availability at downstream service points. This pattern is consistent with supply chain integration, inventory-control, forecasting, and disruption propagation theory [10, 11, 20, 21, 28].

4.4. Governance-Operations Misalignment

As illustrated in Figure 8, pharmaceutical supply chain performance reflects interactions between governance-level functions such as stewardship, accountability, leadership, workforce capacity, data visibility, and resource allocation and downstream operational execution rather than isolated technical failures. Governance elements, including stewardship, accountability mechanisms, leadership, capacity development, and resource allocation, were observed to shape performance across forecasting, procurement, warehousing, inventory management, and distribution [10, 11, 22-24, 26]. While procurement-level quality assurance and selected warehouse handling processes performed well, misalignment between governance priorities and downstream operational capacity was evident in persistent forecasting inaccuracies, storage congestion, and weak supplier performance [10, 11, 24-26]. This mapping highlights how uneven performance across governance and operational levels can coexist within a centralized system.

4.5. Implications for Patient Safety and Substandard and Falsified Medicines Risk

Downstream supply chain failures were associated with increased reliance on emergency and decentralized procurement pathways, which may create vulnerabilities when purchases occur outside routine, regulated, or quality-assured channels [6-8, 19]. Figure 9 conceptualizes the pathways through which downstream supply chain performance gaps were associated with increased patient safety risks. High forecasting discrepancies, delayed supplier deliveries, warehouse congestion, inventory shortages, and distribution inefficiencies were linked to frequent stockouts and low order-filling rates [20, 21]. These operational disruptions increased reliance on emergency and decentralized procurement pathways, which may weaken routine quality-assurance controls when not governed by approved supplier lists, documentation standards, and retrospective review. Although this study did not directly measure medicine quality outcomes, the identified pathways are consistent with evidence that informal or weakly regulated medicine channels can increase exposure to substandard and falsified medicines.

In this context, risks to medicine quality arise less from observed failures in procurement testing than from systemic disruptions that may push facilities toward procurement outside routine regulated supply channels [6-8, 14].

4.6. System-Level Synthesis

Figure 10 presents an illustrative governance-to-operations alignment framework that synthesizes the audit findings and highlights potential pathways to strengthen performance in the pharmaceutical supply chain. The framework suggests that improved governance-level actions, such as strengthened stewardship, clearer accountability, and more responsive resource allocation, may support coordinated operational improvements across forecasting, procurement, warehousing, inventory management, and distribution. This framework is intended to inform policy and performance management discussions by translating system-level audit findings into actionable alignment principles, rather than proposing a tested intervention model.

Taken together, Figures 8 and 9 illustrate how governance-operations misalignment and downstream supply chain failures generate risks to medicine availability and patient safety, while Figure 10 illustrates the governance-operations pathway through which coordinated interventions can strengthen end-to-end pharmaceutical supply chain performance.

5. Conclusion

This system-level audit demonstrates that strong centralized procurement and quality-assurance mechanisms are necessary but insufficient to ensure the reliable availability of medicines when governance-level functions are misaligned with downstream operational capacity [1, 10, 11, 22, 23]. High forecasting discrepancies, poor supplier delivery performance, severe warehouse congestion, inventory inaccuracies, and distribution inefficiencies contributed to low order-filling rates and high stockout levels across the system [25-28].

As shown in Figure 10, pharmaceutical supply chain performance in this centralized faith-based health system was shaped by interactions between governance-level functions and downstream operational capacity [10, 11, 22, 23, 26], rather than by isolated functional weaknesses. Governance-level decisions related to stewardship, accountability, leadership, workforce capacity, data visibility, and resource allocation were observed to influence operational performance across forecasting, procurement, warehousing, inventory management, and distribution. Where governance priorities were misaligned with operational realities, downstream performance gaps persisted despite strong upstream procurement controls [11, 18, 25, 26, 28].

Persistent downstream disruptions may increase reliance on emergency procurement pathways that, if not governed by minimum quality-assurance safeguards, can heighten patient safety risks [6-8]. Strengthening pharmaceutical supply chains, therefore, requires an integrated, end-to-end performance management approach that aligns governance functions with operational execution, supported by routine system-level audits and capacity development [11, 19, 25, 26]. Reliable data visibility and inventory-control improvements are also needed to identify misalignment and guide corrective action [20, 21, 28].

5.1. Policy and Strategic Implications

Figure 10 presents an illustrative governance-to-operations alignment framework that translates the audit findings into policy-relevant insights. Strengthening pharmaceutical supply chains requires governance-driven alignment among stewardship, accountability, workforce capacity, data visibility, and operational execution across forecasting, supplier management, warehousing, inventory visibility, and distribution [10, 11, 22, 23, 26]. Recent evidence also supports the importance of demand planning, capacity development, medicine availability, and inventory-control improvements in resource-constrained health supply chains [25, 27, 28].

From a policy perspective, the findings suggest that safeguarding patients from substandard and falsified medicines requires governance mechanisms that extend beyond centralized procurement and quality testing to actively manage downstream supply chain performance as an integrated system. Institutionalizing routine system-level pharmaceutical supply chain audits offers a practical policy mechanism to identify misalignment, guide corrective action, and sustain access to quality-assured medicines [1, 12, 19].

Rather than proposing a specific intervention, the govern-

ance-to-operations alignment framework in Figure 10 is intended to inform policy and performance management discussions by illustrating how governance-level actions can support sustained improvements in the availability of medicines and service readiness. Applying such an alignment approach may help reduce reliance on emergency procurement, strengthen supply chain resilience, and support continued access to quality-assured medicines in low- and middle-income country settings.

5.2. Study Limitations

This study has several limitations that should be considered when interpreting the findings. Firstly, the assessment was conducted as a system-level pharmaceutical supply chain audit and relied primarily on routinely generated operational data, logistics management information system (LMIS) records, warehouse documentation, and staff-reported practices. While appropriate for evaluating supply chain performance and governance processes, these data sources may not fully capture informal procurement activities, undocumented emergency purchases, or medicine flows occurring outside formal reporting channels.

Secondly, the audit did not include laboratory-based post-market surveillance or chemical analysis of medicines at service delivery points. As a result, the study could not directly measure the prevalence of substandard and falsified medicines; instead, it identified structural and operational vulnerabilities, such as stockouts, emergency procurement, and distribution failures, that are known to increase exposure to these risks.

Thirdly, the one-year assessment period may not fully reflect seasonal demand variation, episodic supply disruptions, or public health emergencies, which can influence forecasting accuracy and availability. Repeated or longitudinal audits would be better suited to examining trends over time and the persistence of downstream performance gaps.

Finally, although participatory root-cause analysis strengthened contextual interpretation, the absence of external regulatory or pharmacovigilance datasets limited triangulation with national surveillance systems. Future studies integrating system-level audits with regulatory inspection data and post-market surveillance would provide a more comprehensive assessment of medicine quality risks.

6. Recommendations

Based on the system-level performance gaps identified in this audit, health systems should adopt an integrated, governance-driven approach to strengthening the pharmaceutical supply chain rather than relying solely on centralized procurement and quality testing. The following recommendations are proposed to improve the availability of medicines, reduce reliance on emergency procurement, strengthen capacity and data visibility, and sustain access to quality-assured medicines [25-28].

Recommendation I: Institutionalize governance-led, system-level performance management. Routine end-to-end pharmaceutical supply chain audits should be embedded within health system governance structures and linked to senior leadership review, time-bound corrective action plans, and clear accountability for implementation. A concise set of priority indicators should be monitored regularly across forecasting, procurement, supplier performance, warehousing, inventory management, LMIS functionality, distribution, medicine availability, and patient safety risk. This would help ensure that resource allocation and corrective actions are directed toward the performance gaps most likely to disrupt access to quality-assured medicines.

Recommendation II: Strengthen demand planning, supplier accountability, and procurement responsiveness as one integrated function. Forecasting should be anchored in facility-level consumption data, stock status, morbidity patterns, and service delivery trends, with routine forecast review meetings involving procurement, warehouse, LMIS, and facility representatives. At the same time, supplier contracts and framework agreements should include measurable service-level expectations for order completeness, delivery timelines, documentation quality, and corrective action after repeated underperformance. Integrating demand planning with supplier performance management would reduce forecast errors, improve procurement responsiveness, and support earlier identification of delivery risks.

Recommendation III: Improve warehousing, inventory visibility, and distribution reliability to protect medicine availability. Storage capacity should be reviewed against current and projected inventory volumes, with attention to space optimization, stock rotation, bin-location management, and segregation of slow-moving, expired, or damaged products. LMIS data should be used as an active performance-management tool through dashboards that track stockout rates, order-filling rates, inventory accuracy, supplier lead times, expiry risk, shipment quantity accuracy, and distribution discrepancies. Standardizing dispatch verification, receipt reconciliation, and transport planning to align with order volumes and facility needs would further reduce discrepancies and improve delivery reliability.

Recommendation IV: Safeguard patient safety by regulating emergency and decentralized procurement pathways. Because stockouts can push facilities toward procurement routes that bypass routine quality-assurance controls, emergency and decentralized procurement should be governed by minimum quality-assurance requirements, approved supplier lists, documentation standards, and retrospective review procedures. These safeguards would reduce exposure to substandard and falsified medicines while allowing limited emergency procurement to function as a controlled risk-management mechanism rather than an unmanaged workaround.

Abbreviations

AICT	Advances in Information and Communication Technology
BIHS	Baptist Institute of Health Sciences
BP	British Pharmacopeia
CBC	Cameroon Baptist Convention
DC	District of Columbia
IFIP	International Federation for Information Processing
LMICs	Low- and Middle-income Countries
LMIS	Logistics Management Information System
MDS-3	Managing Access to Medicines and Health Technologies, Third Edition
MSH	Management Sciences for Health
ORCID	Open Researcher and Contributor ID
PSCI	Pharmaceutical Supply Chain Initiative
PSCM	Pharmaceutical Supply Chain Management
USAID	United States Agency for International Development
USP	United States Pharmacopeia
WHO	World Health Organization

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Conflicts of Interest

The authors declare no conflicts of interest.

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