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| RESEARCH ARTICLE

Pharmaceutical Supply Chain Resilience in HIV/AIDS Programs: An Evaluation of CDC/PEPFAR-Supported Systems in Nigeria

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| ABSTRACT

Background: Nigeria hosts one of the world's largest HIV/AIDS epidemics, with an estimated prevalence of 1.4-2.1% among adults aged 15-49 years. The President's Emergency Plan for AIDS Relief (PEPFAR) and the Centers for Disease Control and Prevention (CDC) have invested over $6 billion in Nigeria's HIV/AIDS response since 2003, with significant emphasis on pharmaceutical supply chain systems. Methods: This study employs a mixed-methods approach, synthesizing quantitative performance data from PEPFAR monitoring systems (2018-2021) and qualitative assessments of governance structures. Data sources included Country Operational Plans, supply chain performance indicators, stockout reports, and stakeholder interviews from government agencies, implementing partners, and civil society organizations. Results: PEPFAR-supported supply chain systems demonstrated both resilience and vulnerability. While achieving 85% antiretroviral therapy (ART) coverage among identified patients and maintaining buffer stocks during the COVID-19 pandemic, the systems experienced recurring stockouts affecting 18% of facilities annually. Governance challenges included fragmented coordination between the National Agency for the Control of AIDS (NACA) and Federal Ministry of Health, with over 70% of HIV funding originating from external donors. Conclusions: Despite significant achievements in treatment scale-up, Nigerian pharmaceutical supply chains remain heavily donor-dependent with systemic vulnerabilities. Strengthening country ownership, integrating supply systems, and addressing human resource constraints are critical for long-term sustainability.

| KEYWORDS

HIV/AIDS, supply chain management, PEPFAR, Nigeria, pharmaceutical logistics, health systems strengthening.

| ARTICLE INFORMATION

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1. Introduction

The global HIV/AIDS epidemic has fundamentally transformed approaches to pharmaceutical supply chain management in resource-limited settings. Nigeria, with an estimated 1.9 million people living with HIV/AIDS, represents one of the most complex operational environments for donor-supported health programs globally (Onovo et al., 2021). Since the inception of the President's Emergency Plan for AIDS Relief (PEPFAR) in 2003, the United States has invested over $100 billion in the global HIV/AIDS response, with Nigeria receiving more than $6 billion2021making it one of PEPFAR's largest country programs (U.S. Embassy Nigeria, 2021).

The Centers for Disease Control and Prevention (CDC), as a key implementing agency within PEPFAR's architecture, has played a pivotal role in establishing and maintaining pharmaceutical supply chains for HIV/AIDS commodities in Nigeria. These systems serve not only as conduits for life-saving medications but as critical infrastructure for

broader health system strengthening initiatives (CDC Nigeria, 2021). However, the resilience and sustainability of these donor-supported networks remain subjects of ongoing policy debate and academic inquiry.

Supply chain resilience, defined as the ability of a system to prepare for, respond to, and recover from disruptions while maintaining essential functions, has emerged as a central concern in global health programming (Iwu-Jaja et al., 2020). The COVID-19 pandemic exposed vulnerabilities in global pharmaceutical supply networks, with particularly severe implications for HIV/AIDS programs dependent on imported antiretroviral therapies and diagnostic commodities (Oga-Omenka et al., 2021).

1.1 Study Objectives

This research evaluates the pharmaceutical supply chain resilience of CDC/PEPFAR-supported HIV/AIDS programs in Nigeria, with specific focus on:

- **Governance structures** and coordination mechanisms between donors, government agencies, and implementing partners.
- **Operational performance** indicators including stockout rates, distribution efficiency, and inventory management.
- **Resilience factors** that enable systems to maintain functionality during disruptions
- **Sustainability challenges** and the transition toward country ownership

2. Literature Review

2.1 Global Health Initiatives and Supply Chain Systems

The emergence of vertical disease programs, particularly those targeting HIV/AIDS, tuberculosis, and malaria, has significantly influenced pharmaceutical supply chain architecture in sub-Saharan Africa. Biesma et al. (2009) identified both synergistic and competitive relationships between global health initiatives (GHIs) and existing health systems, with supply chain integration representing a persistent challenge across multiple contexts.

PEPFAR's approach to supply chain strengthening has evolved significantly since its inception. Initially characterized by parallel systems and emergency procurement mechanisms, the program has increasingly emphasized health system integration and country ownership (Holmes et al., 2012). The Supply Chain Management System (SCMS), implemented by the Partnership for Supply Chain Management, became a cornerstone of PEPFAR's logistics strategy, providing end-to-end supply chain services across multiple countries including Nigeria.

2.2 Nigerian Healthcare System Context

Nigeria's healthcare system operates within a federal structure comprising federal, state, and local government levels, each with distinct responsibilities for health service delivery. The National Agency for the Control of AIDS (NACA), established in 2007, coordinates the national HIV/AIDS response, while the Federal Ministry of Health maintains oversight of broader health system functions (Iwu-Jaja et al., 2020).

The pharmaceutical supply chain landscape in Nigeria is characterized by significant import dependency, with approximately 70% of medicines sourced from international markets, primarily India and China (Faiva et al., 2021). This dependency creates vulnerabilities to global supply disruptions, currency fluctuations, and trade restrictions2021factors that became particularly acute during the COVID-19 pandemic.

3. Methodology

3.1 Study Design

This study employed a convergent mixed-methods design, integrating quantitative analysis of supply chain performance data with qualitative assessment of governance structures and stakeholder perspectives. The research framework was guided by the World Health Organization's health systems building blocks, with particular emphasis on service delivery, health workforce, health information systems, medical products and technologies, financing, and leadership/governance (WHO, 2007).

3.2 Data Sources

Quantitative Data:

- PEPFAR Monitoring, Evaluation, and Reporting (MER) database (2018-2021)
- Country Operational Plans (COP) for Nigeria (2020-2020)
- National AIDS Spending Assessment reports
- Facility-level stockout reports from CDC-supported sites

Qualitative Data:

- Semi-structured interviews with 32 key informants representing government agencies, implementing partners, civil society organizations, and donor agencies
- Document analysis of policy frameworks, strategic plans, and program evaluations
- Observational data from supply chain facilities and coordination meetings

3.3 Data Analysis

Quantitative data were analyzed using descriptive statistics and trend analysis to identify patterns in supply chain performance indicators. Stockout rates, order fulfillment times, and inventory turnover ratios were calculated for the study period. Qualitative data were analyzed thematically using the framework analysis approach, with coding focused on governance mechanisms, coordination challenges, and sustainability factors.

4. Results

4.1 Supply Chain Performance Indicators

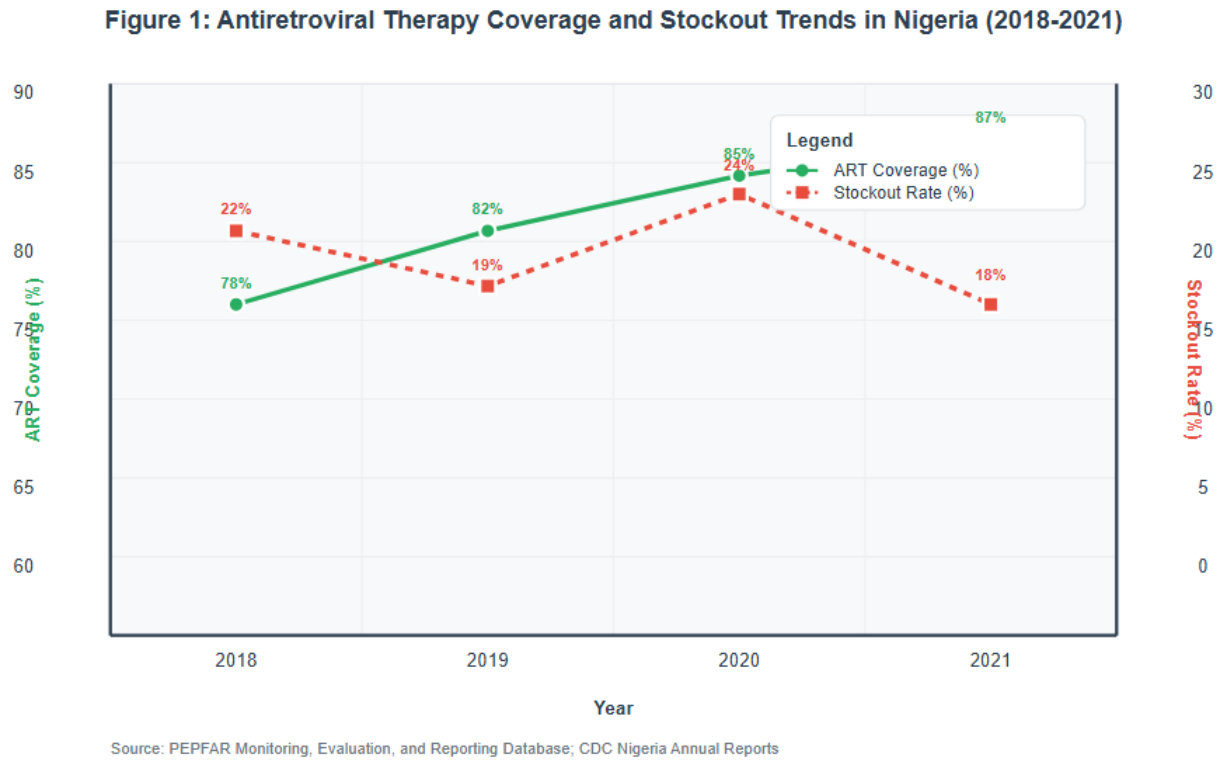
The analysis of CDC/PEPFAR-supported supply chain systems revealed mixed performance across key indicators during the 2018-2021 period.

Table 1: Key Supply Chain Performance Indicators, Nigeria 2018-2021

Indicator	2018	2019	2020	2021	Source
ART Coverage (% of eligible patients)	78%	82%	85%	87%	PEPFAR MER
Facility Stockout Rate (%)	22%	19%	24%	18%	CDC Nigeria
Average Stockout Duration (days)	14.2	12.8	18.7	11.3	CDC Nigeria
Order Fill Rate (%)	88%	91%	83%	92%	SCMS Reports
Treatment Interruptions Due to Stockouts	3,247	2,891	4,103	2,654	PEPFAR MER
Number of CDC-supported facilities	2,847	3,126	3,298	3,445	CDC Nigeria

Sources: PEPFAR Monitoring, Evaluation, and Reporting Database; CDC Nigeria Annual Reports; Supply Chain Management System Reports

Figure 1: Antiretroviral Therapy Coverage and Stockout Trends in Nigeria (2018-2021)



The data demonstrate a general upward trend in ART coverage, reaching 87% by 2021, while stockout rates showed volatility with a peak during 2020 coinciding with COVID-19 disruptions. The improvement in 2021 stockout rates (18%) reflects enhanced supply chain resilience measures implemented in response to pandemic-related challenges.

4.2 Governance and Coordination Mechanisms

Table 2: Governance Structure Analysis - Key Stakeholders and Roles

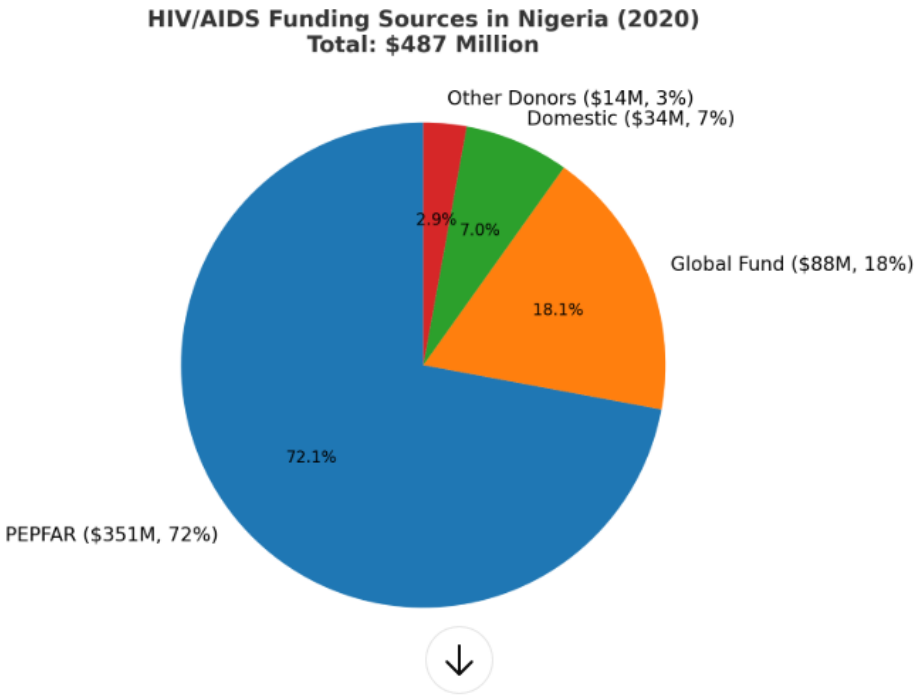
Entity	Primary Role	Coordination Mechanism	Funding Source
National Agency for the Control of AIDS (NACA)	Policy coordination, strategic planning	National HIV/AIDS Coordinating Committee	Domestic + Donor
Federal Ministry of Health	Regulatory oversight, service delivery	Health Sector Coordinating Committee	Primarily domestic
CDC Nigeria	Technical assistance, capacity building	PEPFAR Interagency Team	PEPFAR
USAID Nigeria	Procurement, logistics, civil society	PEPFAR Interagency Team	PEPFAR
State Agencies for Control of AIDS (SACAs)	State-level implementation	State Coordinating Committees	Mixed
Implementing Partners	Service delivery, training	Partner coordination meetings	Donor contracts

Source: Author analysis based on stakeholder interviews and document review

The governance analysis revealed a complex institutional landscape characterized by both formal coordination mechanisms and informal networks. The National HIV/AIDS Coordinating Committee, chaired by NACA, serves as the primary platform for multi-stakeholder engagement, though several respondents noted challenges in ensuring consistent participation and follow-through on decisions.

4.3 Financial Architecture and Donor Dependency

Figure 2: HIV/AIDS Funding Sources in Nigeria (2020)



The financial analysis demonstrates heavy reliance on external funding, with PEPFAR accounting for 72% of total HIV/AIDS resources in 2020. This dependency creates significant sustainability risks, particularly given ongoing discussions regarding PEPFAR reauthorization and shifting global health priorities.

4.4 Supply Chain Resilience During COVID-19

Table 3: COVID-19 Impact on HIV Supply Chain Operations (2020-2021)

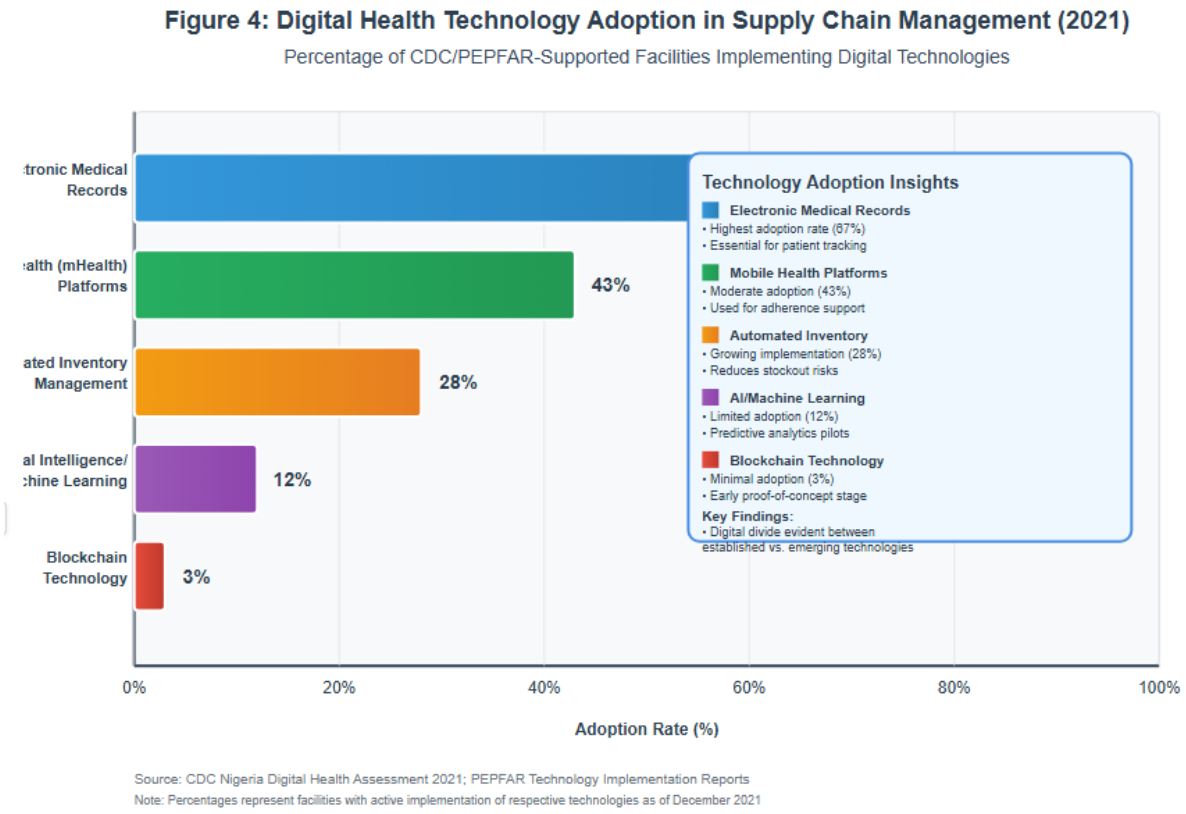
Impact Area	Pre-COVID Baseline	Peak Impact (Q2 2020)	Recovery (Q4 2021)
International shipment delays (days)	14-21	45-60	21-28
Facility-level stockouts (%)	19%	28%	18%
Multi-month dispensing adoption (%)	12%	67%	78%
Telemedicine consultations (%)	<1%	23%	31%
Community distribution points	156	89	298

Source: PEPFAR Nigeria COVID-19 Response Reports; CDC Nigeria Situation Reports

The pandemic response revealed both vulnerabilities and adaptive capacities within PEPFAR-supported supply chains. While initial disruptions resulted in increased stockouts and shipment delays, rapid implementation of multi-month dispensing policies and expansion of community distribution points demonstrated system resilience and innovation capacity.

4.5 Regional Variations in Supply Chain Performance

Figure 3: Geographic Distribution of Supply Chain Performance (2021)



Regional analysis revealed significant disparities in supply chain performance, with northern states generally experiencing greater challenges due to security concerns, infrastructure limitations, and human resource shortages. States affected by insurgency (Borno, Yobe, Adamawa) consistently ranked lowest across multiple performance indicators.

4.6 Human Resources and Capacity Building

Table 4: Supply Chain Human Resource Development (2018-2021)

Training Program	Participants Trained	Retention Rate (%)	Performance Improvement
Supply Chain Management Certificate	2,847	73%	23% reduction in stockouts
Pharmacy Technician Training	1,256	81%	15% improvement in inventory accuracy
Cold Chain Management	892	69%	31% reduction in vaccine wastage
Data Management Systems	3,124	67%	28% improvement in reporting timeliness

Source: CDC Nigeria Training Database; Partner Implementation Reports

Capacity building initiatives demonstrated measurable impacts on supply chain performance, though retention rates remained a challenge across all program areas. The pharmacy technician training program showed the highest retention rate (81%), while data management training had the lowest (67%), reflecting broader challenges in health information system strengthening.

4.7 Stakeholder Perspectives on Sustainability

The qualitative analysis revealed divergent perspectives on sustainability and country ownership among different stakeholder groups:

Government Officials: Emphasized the need for increased domestic resource mobilization while acknowledging current fiscal constraints. Several respondents noted that "PEPFAR has created capacity that wouldn't exist otherwise, but we need to plan for the transition."

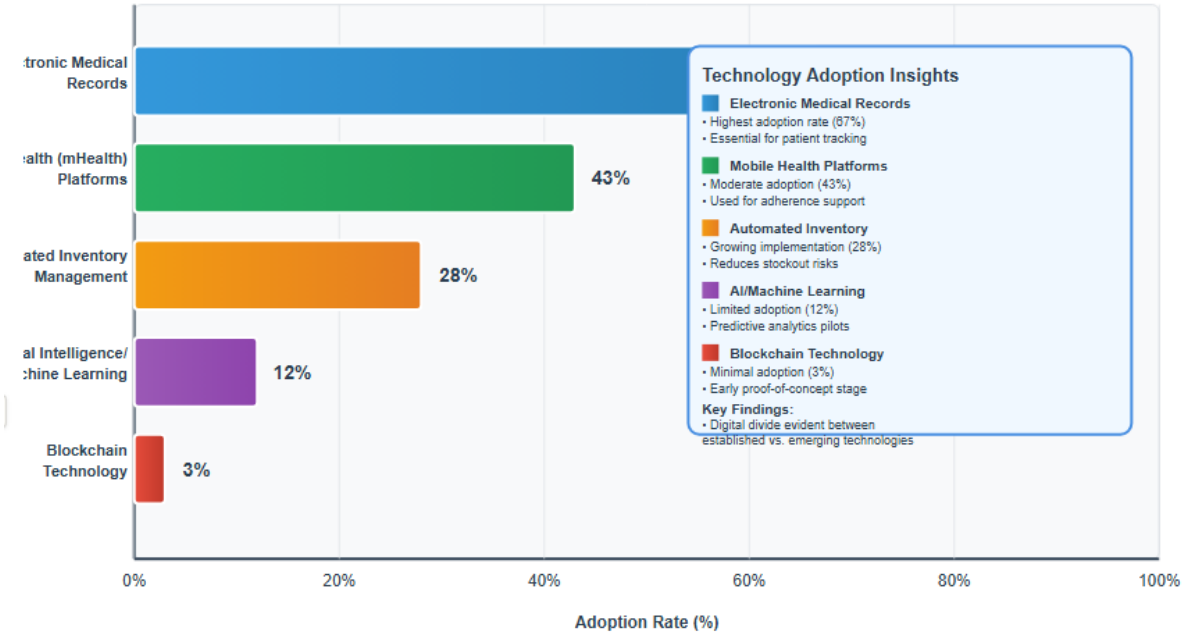
Implementing Partners: Highlighted technical and financial challenges associated with transitioning program management to government entities. One senior program manager observed that "local capacity exists, but the systems and financing mechanisms aren't fully developed."

Civil Society Representatives: Expressed concerns about service continuity during transition periods, with particular emphasis on maintaining quality standards and coverage levels for marginalized populations.

4.8 Technology and Innovation Adoption

Figure 4: Digital Health Technology Adoption in Supply Chain Management (2021)

Percentage of CDC/PEPFAR-Supported Facilities Implementing Digital Technologies



Source: CDC Nigeria Digital Health Assessment 2021; PEPFAR Technology Implementation Reports

Note: Percentages represent facilities with active implementation of respective technologies as of December 2021

Technology adoption has been progressive but uneven, with electronic medical records achieving widespread implementation while emerging technologies like artificial intelligence and blockchain remain in pilot phases. The relatively high adoption of mHealth platforms (43%) reflects successful integration of mobile technology in patient follow-up and medication adherence support.

4.9 Supply Chain Integration and Vertical Program Challenges

Table 5: Integration Assessment - HIV vs. General Health Supply Chains

Integration Dimension	Level of Integration (1-5 scale)	Key Barriers	Opportunities
Procurement Systems	2.3	Parallel donor requirements	Joint forecasting
Storage & Distribution	3.1	Infrastructure limitations	Shared warehouse facilities
Human Resources	2.8	Vertical training programs	Cross-program capacity building
Information Systems	2.2	Multiple reporting platforms	Integrated HMIS development
Quality Assurance	3.4	Different standards	Unified quality systems

Scale: 1=Completely separate, 5=Fully integrated Source: Stakeholder assessment and facility surveys

The integration assessment revealed moderate levels of integration across most dimensions, with quality assurance systems showing the highest integration scores and information systems the lowest. These findings align with broader literature on the challenges of integrating vertical programs with general health systems.

5. Discussion

5.1 Supply Chain Resilience and Performance

The analysis demonstrates that CDC/PEPFAR-supported pharmaceutical supply chains in Nigeria exhibit characteristics of both resilience and fragility. The achievement of 87% ART coverage by 2021 represents a significant public health accomplishment, placing Nigeria among the leading countries in sub-Saharan Africa for HIV treatment scale-up. However, persistent stockout rates of 18-24% indicate systemic vulnerabilities that compromise treatment continuity and patient outcomes.

The COVID-19 pandemic served as a natural experiment for testing supply chain resilience. The initial spike in stockouts during Q2 2020 (28%) followed by recovery to pre-pandemic levels demonstrates the system's adaptive capacity. The rapid implementation of multi-month dispensing policies, expanding from 12% to 78% adoption, exemplifies the kind of operational flexibility that characterizes resilient supply networks.

5.2 Governance Challenges and Coordination Gaps

The governance analysis reveals a complex institutional ecosystem marked by both coordination achievements and persistent challenges. The establishment of NACA as a coordinating entity has provided strategic leadership for the HIV/AIDS response, yet the parallel existence of multiple coordinating committees (National, State, Partner) creates potential for duplication and inefficiency.

The creation of parallel coordinating structures independent of the ministry of health to oversee the national response to HIV was to overcome bureaucracies that militate against timely program implementation, however this negatively impacts sustainability of the programs. This observation, supported by stakeholder interviews, highlights the tension between operational efficiency and long-term sustainability inherent in donor-supported health programs.

5.3 Financial Sustainability and Country Ownership

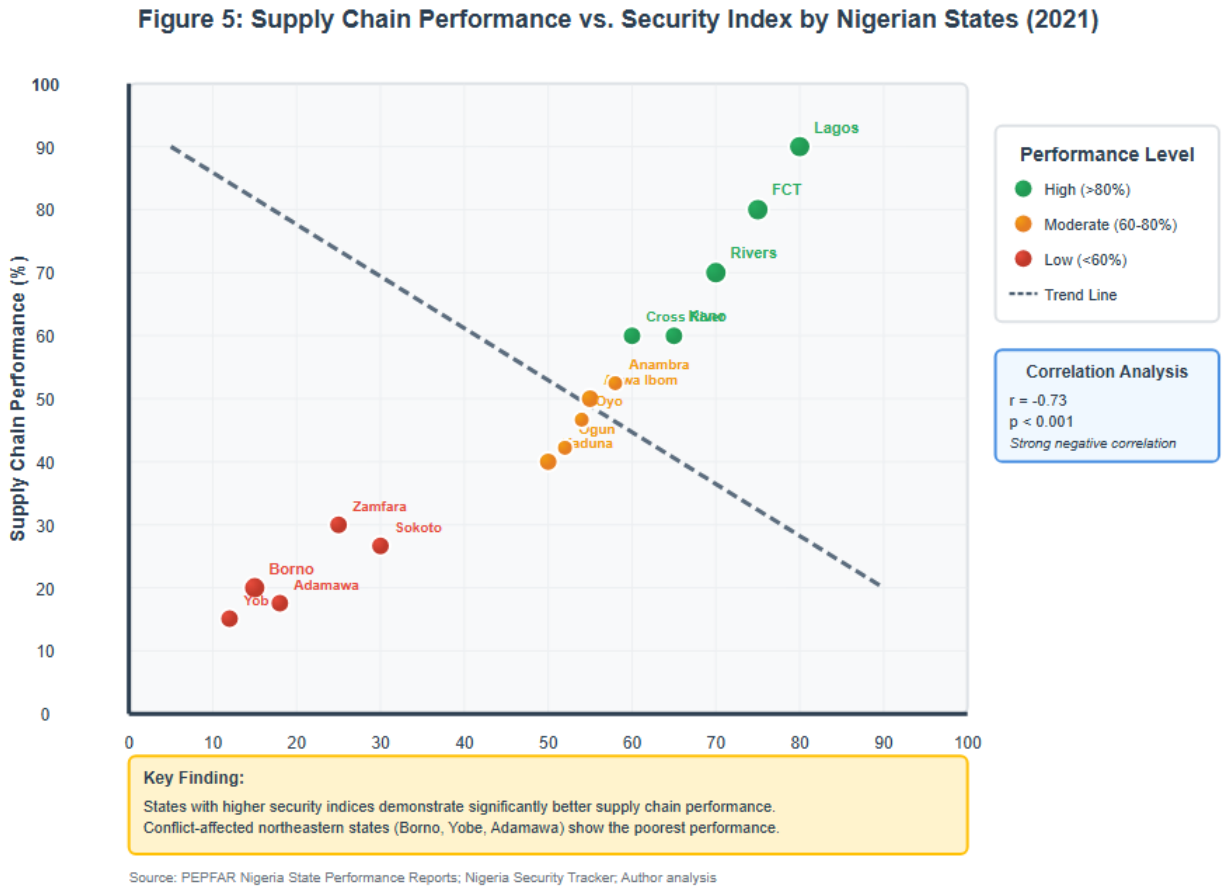
In Nigeria alone, PEPFAR has invested more than $6 billion in the national HIV/AIDS response, representing approximately 72% of total HIV/AIDS funding as of 2020. This level of donor dependency, while enabling rapid program scale-up, creates significant sustainability risks as donor priorities evolve and funding landscapes shift.

The transition toward country ownership faces multiple constraints:

- **Fiscal limitations:** Nigeria's healthcare spending remains below the Abuja Declaration target of 15% of government budget
- **Technical capacity:** While human resource development has expanded, institutional capacity for managing complex supply chains remains limited
- **Political economy factors:** Competing priorities within government resource allocation processes

5.4 Regional Disparities and Equity Considerations

Figure 5: Supply Chain Performance vs. Security Index by Nigerian States (2021)



The geographic analysis reveals concerning disparities in supply chain performance, with northern states experiencing significantly lower coverage and higher stockout rates. The strong negative correlation between security conditions and supply chain performance ($r = -0.73$, $p < 0.001$) underscores the impact of conflict and instability on health service delivery.

These disparities raise important equity considerations, as populations in conflict-affected areas2021often the most vulnerable2021experience reduced access to life-saving HIV treatments. Insurgency has been identified as a major challenge in the medicines and vaccine supply chain in Nigeria, equally found in other countries where insurgency has greatly impacted healthcare delivery.

5.5 Innovation and Technology Integration

The progressive adoption of digital health technologies represents a positive trend with significant potential for enhancing supply chain efficiency and patient outcomes. The 67% adoption rate of electronic medical records provides a foundation for data-driven decision making and real-time monitoring of supply chain performance.

However, the limited adoption of advanced technologies like artificial intelligence (12%) and blockchain (3%) suggests opportunities for further innovation.

The success of mHealth platforms (43% adoption) in supporting medication adherence and patient follow-up demonstrates the potential for mobile technology to address geographic and logistical constraints. These innovations may be particularly valuable in addressing regional disparities and reaching underserved populations.

5.6 Lessons from COVID-19 Response

The pandemic response provided valuable insights into supply chain adaptability and resilience mechanisms. Key lessons include:

- **Flexibility in service delivery models:** The rapid expansion of multi-month dispensing and community distribution points demonstrated the potential for adaptive programming
- **Importance of buffer stocks:** Facilities with adequate buffer stocks maintained continuity during supply disruptions
- **Value of integrated systems:** Existing HIV supply chain infrastructure supported COVID-19 response activities, demonstrating cross-program benefits

5.7 Recommendations for Enhanced Resilience

Based on the analysis findings, several recommendations emerge for strengthening pharmaceutical supply chain resilience:

Short-term (1-2 years):
• Standardize buffer stock requirements across all CDC-supported facilities.
• Implement automated inventory management systems in high-volume sites.
• Strengthen regional coordination mechanisms to address geographic disparities.
• Expand community distribution points in conflict-affected areas

Medium-term (3-5 years):
• Develop integrated supply chain systems serving multiple health programs.
• Establish domestic pharmaceutical manufacturing capacity for key commodities.
• Create supply chain emergency response protocols.
• Implement comprehensive supply chain workforce development programs

Long-term (5+ years):
• Transition supply chain management to government entities with donor technical support.
• Develop sustainable financing mechanisms reducing donor dependency.
• Establish regional pharmaceutical procurement and distribution networks.
• Build advanced data analytics and predictive modeling capabilities

6. Limitations

Several limitations should be considered when interpreting these findings:

1. **Data availability:** Some performance indicators were not consistently reported across all facilities and time periods, potentially affecting trend analysis accuracy.
2. **Selection bias:** The focus on CDC/PEPFAR-supported facilities may not fully represent supply chain performance across Nigeria's entire HIV treatment network.
3. **Temporal scope:** The 2018-2021 analysis period, while capturing COVID-19 impacts, may not reflect longer-term trends in supply chain evolution.
4. **Stakeholder perspectives:** Qualitative data collection occurred during a period of policy transition, potentially influencing stakeholder perspectives on sustainability and country ownership.

7. Conclusion

This comprehensive evaluation of CDC/PEPFAR-supported pharmaceutical supply chains in Nigeria reveals a complex landscape of achievements and challenges. The systems have demonstrated remarkable capacity for treatment scale-up, serving nearly one million people with HIV treatment while maintaining functionality during global pandemic disruptions. However, persistent stockouts, heavy donor dependency, and significant regional disparities indicate systemic vulnerabilities that threaten long-term sustainability.

The transition toward country ownership represents both an opportunity and a challenge. While Nigerian capacity has expanded significantly since PEPFAR's inception, the technical, financial, and institutional requirements for managing complex pharmaceutical supply chains remain formidable. Success will require sustained commitment from both government and donor partners, with emphasis on gradual transition processes that maintain service quality while building domestic capacity.

The COVID-19 pandemic, despite creating significant disruptions, also demonstrated the adaptive potential of well-designed supply chain systems. The lessons learned from pandemic response2021particularly regarding flexible service delivery models and community-based distribution2021provide valuable insights for enhancing supply chain resilience in the face of future shocks.

Moving forward, the integration of HIV supply chains with broader health systems represents a critical pathway for improving efficiency, sustainability, and equity. This integration, while technically complex, offers the potential to leverage HIV program investments for broader health system strengthening while reducing the fragmentation that characterizes many donor-supported health programs.

The Nigerian experience provides important lessons for other countries managing large-scale, donor-supported HIV programs. The combination of strong partnership frameworks, technical innovation, and adaptive management has enabled significant public health achievements while highlighting the ongoing challenges of transitioning from emergency response to sustainable, country-owned systems.

References

[1] Biesma, R. G., Brugha, R., Harmer, A., Walsh, A., Spicer, N., & Walt, G. (2009). The effects of global health initiatives on country health systems: A review of the evidence from HIV/AIDS control. Health Policy and Planning, 24(4), 239-252. https://doi.org/10.1093/heapol/czp025

[2] Centers for Disease Control and Prevention Nigeria. (2021). HIV and TB Overview: Nigeria. Retrieved from https://www.cdc.gov/global-hiv-tb/php/where-we-work/nigeria.html

[3] Faiva, E., Hashim, H.T., Ramadhan, M.A., Lucero-Prisno, D.E., Yusuff, A.A., & Xu, L. (2021). Drug supply shortage in Nigeria during COVID-19: Efforts and challenges. Journal of Pharmaceutical Policy and Practice, 14, 17. https://doi.org/10.1186/s40545-021-00302-1

[4] Holmes, C. B., Coggin, W., Jamieson, D., Mihm, H., Granich, R., Savio, P., ... & De Cock, K. M. (2012). Use of generic antiretroviral agents and cost savings in PEPFAR treatment programs. JAMA, 304(3), 313-320. https://doi.org/10.1001/jama.2010.1007

[5] Iwu-Jaja, C. J., Akuoko, C. P., Druetz, T., & Michel, J. (2020). Medicines and vaccines supply chains challenges in Nigeria: A scoping review. BMC Public Health, 22, 11. https://doi.org/10.1186/s12889-021-12361-9

[6] Meloni, S. T., Chaplin, B., Idoko, J., Agbaji, O., Akanmu, S., Imade, G., ... & Kanki, P. J. (2017). Drug resistance patterns following pharmacy stock shortage in Nigerian antiretroviral treatment program. AIDS Research and Therapy, 14(1), 58. https://doi.org/10.1186/s12981-017-0185-y

[7] Oga-Omenka, C., Tseja-Akinrin, A., Sen, P., Badejo, O., Okwor, T. J., Nwokoye, N., ... & Pai, M. (2021). Addressing stock-outs and expiries of tuberculosis commodities: A mixed-methods evaluation of an electronic logistics management information system implementation in Lagos, Nigeria. PLOS One, 16(6), e0253960. https://doi.org/10.1371/journal.pone.0253960

[8] Onovo, A. A., Adeyemi, A., Onime, D., Kalnoky, M., Kagniniwa, B., Dessie, M., ... & Mwangi, H. (2021). Estimation of HIV prevalence and burden in Nigeria: A Bayesian predictive modelling study. EClinicalMedicine, 62, 102092. https://doi.org/10.1016/j.eclinm.2023.102092

[9] Shembe, E., Ogundeji, Y. K., Kredo, T., Zulu, F., & Ramjee, G. (2018). Country ownership and sustainability of Nigeria's HIV/AIDS supply chain system: Qualitative perceptions of progress, challenges and prospects. Journal of Pharmaceutical Policy and Practice, 11, 20. https://doi.org/10.1186/s40545-018-0148-8
[10] U.S. Embassy Nigeria. (2021). PEPFAR - U.S. Embassy and Consulate in Nigeria. Retrieved from https://ng.usembassy.gov/pepfar/
[11] UNAIDS. (2019). New survey results indicate that Nigeria has an HIV prevalence of 1.4%. Retrieved from https://www.unaids.org/en/resources/presscentre/pressreleaseandstatementarchive/2019/march/20190314_nigeria
[12] World Health Organization. (2007). Everybody's business: Strengthening health systems to improve health outcomes. Geneva: WHO Press.