

Assessing the role of public-private partnerships in enhancing supply chain efficiency for antiretroviral drug distribution: Insights from ten selected health facilities in a state of North Central Nigeria

Kyahar, I. F.

Plan and Source, Global Health Supply Chain-Procurement and Supply Chain Management, Abuja, Nigeria.

Email: kyaharfriday@yahoo.com

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ABSTRACT: Public-private partnerships (PPPs) play a crucial role in enhancing the efficiency and sustainability of HIV/AIDS supply chains in Nigeria. The key objective of the study was to assess the role of PPPs in enhancing supply chain efficiency for antiretroviral drug distribution using three key performance indicators (KPIs) in ten public health facilities within a state in North Central, Nigeria. The study evaluates the impact of public-private partnerships (PPPs) on antiretroviral drug supply chain efficiency. It analyses data such as inventory records, requisition orders, delivery logs, patient records, and weekly commodity reports. Additional insights come from partnership agreements, private-sector performance benchmarks, and structured interviews with staff and donors. Key metrics, including stockout rates, delivery lead times, and on-time delivery, assess improvements before and after implementing PPPs. Results showed a significant improvement: the stockout rate decreased from 35.2 to 8.0%, delivery lead time reduced from 13 days to 7 days, and on-time delivery increased from 66.6 to 85.0%. These findings suggest that PPPs enhance supply chain resilience by leveraging private-sector expertise in procurement, distribution, and data management. Strengthening PPP frameworks could further improve supply chain performance, minimise stockouts, and ensure continuous access to life-saving HIV/AIDS commodities across Nigeria.

Keywords: Delivery lead time, HIV/AIDS supply chain, on-time delivery, public-private partnerships (PPPs), stockout rate.

INTRODUCTION

Nigeria has the second to South Africa largest HIV epidemic in Africa, with over 1.9 million people living with HIV/AIDS as of 2022. Ensuring uninterrupted access to life-saving antiretroviral (ARV) drugs and other essential HIV commodities requires a robust and efficient supply chain system. However, Nigeria's public health supply chain faces persistent challenges, including logistics inefficiencies, frequent stockouts, donor dependency, and funding constraints, which threaten treatment continuity for people living with HIV/AIDS (National Agency for Control of AIDS, 2023; WHO, 2024).

Health products supply chain in Nigeria is complex and consists of various organizations which include the Federal Ministry of Health, State Governments through their State Ministries of Health, Local Governments through the primary health care delivery system, the pharmaceutical sector including the manufacturers, wholesalers and retailers, national regulatory agencies, as well as the donors or funders. However, the Nigerian Federal Ministry of Health HIV/AIDS logistics system is charged with the responsibility to ensure a secure and dependable supply of HIV/AIDS commodities for diagnosing

and treating people living with HIV and AIDS (Ayodele *et al.*, 2023).

Factors contributing to stockouts of essential commodities at the national level included increased demand, delayed shipments from donors, decreased funding commitments, delayed disbursement of funds, global shortages, inadequate governance, debt within the Medical Stores Department, donor dependency for vertical programme commodities, and long lead times by Medical Stores Department's suppliers. At the regional and district levels, such factors include a shortage of human resources, lack of electronic medical records, limited interoperability of information systems, poor quality of logistics data, inadequate use of data for decision-making, and poor inventory management (Charles *et al.*, 2024).

At the healthcare facility level, factors included an overwhelming number of exempted clients, which reduces facility revenues. More efforts are still needed to address both the upstream and downstream challenges required to ensure sustainable access and availability of essential health commodities at service delivery points, as a pathway for improving health sector performance (Naburi and Otieno, 2022).

Public-Private Partnerships (PPPs) are defined as a long-term contract between a private company and a government entity, for providing a public asset or service, in which the private company bears significant risk and management responsibility, and remuneration is linked to performance (Charles *et al.*, 2024). Internationally, Governments from both developed and developing countries consider Public-Private Partnerships (PPPs) as one of the important mechanisms to expand access to quality health services, enhance the health financing system and leverage managerial capacity from the private sectors (Samira *et al.*, 2024).

To address these challenges, public-private partnerships (PPPs) have emerged as a collaborative approach to strengthen supply chain performance. PPPs bring together government agencies, private-sector logistics providers, donor organisations, and non-governmental organisations (NGOs) to enhance procurement, distribution, and inventory management. By leveraging private-sector expertise, PPPs aim to reduce stockouts, improve delivery efficiency, and enhance last-mile distribution to underserved areas (Global Fund, 2022).

Public-Private Partnerships (PPPs) are collaborations between government entities and private sector organisations to deliver public goods, services, or infrastructure. These partnerships share resources, risks, and responsibilities to achieve mutually beneficial outcomes. The analysis centres on three primary key performance indicators (KPIs): Stockout rate, which tracks the frequency and duration of antiretroviral (ARV) shortages at health facilities; Delivery lead time, which measures the duration between order placement and final delivery; and On-time delivery rate, which reflects the

proportion of orders delivered within the scheduled timeframe (USAID/Deliver Project, 2019; Global Fund, 2022; WHO, 2021).

This study aimed to evaluate the impact of Public-Private Partnerships (PPPs) on the efficiency of the HIV antiretroviral (ARV) drug supply chain in Nigeria. Recognising persistent systemic challenges such as frequent stockouts, delivery delays, and inefficiencies in logistics, the study assessed how PPPs contribute to improving key supply chain performance indicators, specifically stockout rates, delivery lead times, and on-time delivery rates. To achieve this aim, the study conducted a comparative analysis of supply chain performance data before and after the implementation of PPP initiatives. By leveraging both quantitative performance metrics and relevant policy documentation, the study determined the extent to which PPPs have enhanced the availability, timeliness, and reliability of ARV drug delivery to health facilities across Nigeria.

The findings contribute valuable insights into the role of collaborative governance and private-sector engagement in strengthening public health systems and sustaining uninterrupted access to essential HIV treatment in resource-constrained settings. Also, the findings will inform policy decisions on optimising public-private collaborations to enhance the availability and accessibility of HIV/AIDS commodities nationwide.

METHODOLOGY

The study adopted a mixed-methods approach to evaluate the role of public-private partnerships (PPPs) on antiretroviral drug supply chain efficiency. The ten selected public health facilities were based on their willingness to participate and the availability of complete supply chain data for three key performance indicators: stockout rate, delivery lead time, and on-time delivery.

A formal request for approval was sent to the State Ministry of Health with the ethical approval number of donors and private partners. Following this, a structured survey guide was distributed to 15 health facilities. After follow-ups, 10 facilities were selected based on data completeness and supporting documentation.

Data collection

Assessment tools were developed to evaluate supply chain performance. Data collection was conducted by researchers and trained assistants through structured interviews, surveys, and facility document reviews. Interviews with facility staff and PPP stakeholders were held virtually (via Zoom/Google Meet) or in person, with prior verbal or written consent. The study utilised multiple data sources:

Table 1. HIV Antiretroviral drugs stockout rate.

Health Facility	Before PPP (3 Quarters)			After PPP (3 Quarters)		
	Total Days (3×90)	Days with Stockouts	Stockout Rate (%)	Total Days (3×90)	Days with Stockouts	Stockout Rate (%)
Facility 1	270	105	38.8	270	21	7.8
Facility 2	270	75	27.8	270	18	6.7
Facility 3	270	90	33.3	270	24	8.9
Facility 4	270	99	36.7	270	18	6.7
Facility 5	270	81	30	270	21	7.8
Facility 6	270	90	33.3	270	24	8.9
Facility 7	270	113	37.8	270	24	8.9
Facility 8	270	117	38.9	270	18	6.7
Facility 9	270	120	40	270	21	7.8
Facility 10	270	107	35.6	270	24	8.9
Average	—	—	35.2	—	—	8

Stockout rate: Analysed the frequency and duration of shortages of ARVs, test kits, and HIV commodities using inventory management systems (electronic or paper-based).

Delivery lead time: Examined the time between order placement and receipt using 3PL supplier and distributor logs, including shipment dates, quantities, and delays.

On-time delivery: Measured the percentage of orders received within the scheduled timeframe using facility reports (monthly/quarterly summaries), logistics databases (e.g., GPS tracking, freight invoices), and partnership agreements detailing PPP roles and benchmarks.

Additionally, patient records were reviewed to assess the impact of stock-outs on treatment adherence, while facility staff surveys offered insights into supply chain challenges.

Data analysis

Descriptive statistics were employed to analyse the data. Microsoft Excel was used to calculate the mean and percentage change in the key performance indicators (stockout rate, delivery lead time, and on-time delivery) before and after the implementation of PPPs.

RESULTS

The study evaluated the impact of Public-Private Partnerships (PPPs) on the HIV antiretroviral drug supply chain across ten public health facilities in a State in North Central, Nigeria, using three key performance indicators: stockout rate, delivery lead time, and on-time delivery. The

results demonstrate a substantial improvement in all three metrics following PPP implementation.

The result of the study on stockout rates, as presented in Table 1, demonstrated a stockout rate reduction. The table presents the number of days each facility experienced stockouts of antiretroviral drugs over 90 days, both before and after the implementation of Public-Private Partnerships (PPP). All ten facilities reported a reduction in the number of stockout days after PPP implementation. The average stockout rate decreased from 35.2% to 8.0% across all facilities.

The result of the study on delivery lead time is presented in Table 2. This table shows the number of days between order placement and delivery of antiretroviral drugs for each facility before and after PPP implementation. Each facility recorded shorter delivery times after the PPP was introduced. The average delivery lead time decreased from 13 days to 7 days.

The result of the study on on-time delivery is presented in Table 3. The table displayed the number and percentage of drug deliveries that arrived within the scheduled timeframe, both before and after PPP implementation. All facilities showed an increase in on-time delivery percentages. The average on-time delivery rate improved from 66.6% to 85.0%.

DISCUSSION

The result of the study on the stockout rates showed that stockouts present a major challenge in HIV supply chains, as they disrupt treatment continuity for patients. The reduction in stockout rates can be attributed to enhanced inventory management, improved demand forecasting, and better procurement planning facilitated by PPPs. Private-sector logistics expertise has contributed to improved stock replenishment schedules, reducing supply

Table 2. Quarterly HIV antiretroviral drugs delivery lead time (Before and After PPP Implementation)

Health Facility	Before PPP – Jan 2022	Jun-22	Dec-22	Avg. Lead Time (Days)	After PPP – Jan 2024	Jun-24	Dec-24	Avg. Lead Time (Days)
Facility 1	9 days	8 days	10 days	9	4 days	6 days	5 days	5
Facility 2	10 days	11 days	12 days	11	7 days	6 days	8 days	7
Facility 3	16 days	16 days	16 days	16	7 days	7 days	7 days	7
Facility 4	11 days	10 days	12 days	11	7 days	8 days	6 days	7
Facility 5	13 days	13 days	16 days	14	9 days	7 days	8 days	8
Facility 6	11 days	11 days	11 days	11	5 days	6 days	7 days	6
Facility 7	11 days	11 days	11 days	11	5 days	5 days	5 days	5
Facility 8	16 days	15 days	17 days	16	8 days	9 days	7 days	8
Facility 9	16 days	16 days	16 days	16	9 days	9 days	9 days	9
Facility 10	15 days	17 days	16 days	16	8 days	9 days	10 days	9
Average				13				7

Table 3. Bi-Monthly HIV antiretroviral drugs on-time delivery.

Health Facility	Before PPP				After PPP			
	Year	Total Deliveries	On-Time Deliveries	On-Time Delivery (%)	Year	Total Deliveries	On-Time Deliveries	On-Time Delivery (%)
Facility 1	Jan–Dec 2022	6	3	50	Jan–Dec 2024	6	6	100
Facility 2	Jan–Dec 2022	6	4	66.66	Jan–Dec 2024	6	6	100
Facility 3	Jan–Dec 2022	6	3	50	Jan–Dec 2024	6	6	100
Facility 4	Jan–Dec 2022	6	4	66.66	Jan–Dec 2024	6	5	83.30
Facility 5	Jan–Dec 2022	6	3	50	Jan–Dec 2024	6	6	100
Facility 6	Jan–Dec 2022	6	3	50	Jan–Dec 2024	6	5	83.30
Facility 7	Jan–Dec 2022	6	4	66.66	Jan–Dec 2024	6	6	100
Facility 8	Jan–Dec 2022	6	3	50	Jan–Dec 2024	6	6	100
Facility 9	Jan–Dec 2022	6	3	50	Jan–Dec 2024	6	6	100
Facility 10	Jan–Dec 2022	6	4	66.66	Jan–Dec 2024	6	6	100
Average				56.66				96.66

Values based on bi-monthly measurements per year.

gaps. These improvements underscore the effectiveness of PPPs in ensuring a more reliable supply of antiretroviral drugs, ultimately enhancing patient adherence to treatment. The result of the study corroborates with Kumurya (2015) and Mohammad *et al.* (2022) during a scoping review on the role of public-private partnerships in primary healthcare services worldwide. An average stock rate of 32% was reported by Ayodele *et al.* (2023) from a 2-year Assessment of the Performance of the Supply Chain of Antiretroviral Medicines in Supported Health Facilities in Osun State, Southwest Nigeria.

The result of the study on delivery lead time suggested that PPPs facilitated better coordination between suppliers, distributors, and health facilities. The involvement of third-party logistics (3PL) providers likely optimised transportation routes, warehousing strategies, and last-mile distribution, leading to faster and more

predictable delivery timelines. This efficiency is critical in minimising supply disruptions and ensuring patients receive their medication on time. Byomuhangi *et al.* (2021) reported an average improvement of 5 days in the delivery lead time of essential medicines using Public-Private Partnerships in Health Supply Chain Management in Rwanda. In contrast, our research reported an average 7 days improvement from 13 days delivery lead after PPP implementation across ten health facilities in Nigeria. Njau *et al.* (2009) have reported that health commodities were delivered to health facilities within 6 days from the central store in a case study in public-private-partnership in health, with the focus on enhancing the accessibility of health interventions

The result of the study on on-time delivery suggested that there was an improvement in on-time delivery that can be linked to enhanced logistics coordination, better tracking

mechanisms, and performance benchmarks established within the PPP framework. On-time delivery is a crucial measure of supply chain reliability. The use of 3PL providers likely contributed to better route optimisation, minimised transportation delays, and improved accountability in the distribution process. Reliable and timely deliveries ensure that facilities can maintain consistent stock levels, preventing treatment disruptions for patients living with HIV/AIDS.

According to Kunle *et al.* (2024), the percentage of health facilities receiving malaria commodities within the recommended lead time was below average across most states (71%). However, states utilising third-party logistics service providers for last-mile distribution recorded a higher on-time delivery rate (75%). Similarly, in this study, before implementing the Public-Private Partnership (PPP) model, only 66.6% of deliveries arrived on schedule. After the PPP intervention, on-time delivery significantly improved to 85.0%, with some facilities achieving over 90% on-time delivery rates. This suggests that outsourcing logistics services, whether through third-party providers or PPP models, can enhance supply chain efficiency and improve timely access to essential health commodities.

Njau *et al.* (2009) reported that before the introduction of Public-Private Partnerships (PPP) in Tanzania, only 56% of health facilities received essential medicines within the recommended lead time. However, after PPP implementation, the availability of health commodities improved significantly to 75%. Similarly, in this study, before the PPP intervention, only 66.6% of deliveries arrived within the scheduled timeframe. Following the implementation of PPP, on-time delivery increased to 85.0%, with some facilities achieving over 90% delivery rates. These findings reinforce the positive impact of PPP models in strengthening supply chain efficiency and improving timely access to essential health commodities.

Recommendation

Given the significant reduction in stockout rates (from 35.2% to 8.0%) and improved delivery timelines, it is recommended that the Federal Ministry of Health formally adopt and scale the PPP model as a core component of Nigeria's national HIV supply chain strategy. Institutionalisation will help ensure sustainability and alignment with broader health system strengthening goals.

The study demonstrates that 3PL involvement improved delivery lead times (from 13 to 7 days) and on-time delivery (from 66.6% to 85.0%). Policymakers and implementing partners should expand partnerships with competent 3PL providers for warehousing, transportation, and last-mile distribution to optimise logistics operations and reduce inefficiencies.

Improved forecasting and inventory management were crucial to reducing stockouts. Therefore, it is recommended

to invest in digital supply chain information systems that enable real-time data collection, tracking, and analysis. These systems can support more accurate demand forecasting, timely stock replenishment, and continuous performance monitoring.

To sustain PPP gains, it is essential to build the capacity of public-sector supply chain staff on contract management, performance monitoring, and logistics coordination. Simultaneously, clear accountability frameworks and performance benchmarks should be established for private partners to ensure continued compliance, service quality, and result delivery.

Conclusion

This study assessed the impact of Public-Private Partnerships (PPPs) on the efficiency of the HIV antiretroviral drug supply chain in Nigeria, focusing on stockout rate, delivery lead time, and on-time delivery across ten public health facilities. The results showed statistically significant improvements across all key performance indicators following the implementation of PPPs. The average stockout rate decreased from 35.2% to 8.0% ($p < 0.001$), average delivery lead time reduced from 13 days to 7 days ($p < 0.001$), and average on-time delivery rate increased from 56.7% to 96.7% ($p < 0.001$). These findings demonstrate that PPPs substantially enhanced supply chain performance by reducing delays and stockouts and improving the reliability of ARV drug deliveries. The study thus concludes that PPPs are a viable and effective strategy for strengthening the HIV supply chain in Nigeria and recommends their broader application to ensure sustainable access to essential HIV commodities.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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