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Research Article

Distribution Patterns and Supply Chain Implications of Intravenous Fluids Across State Government Owned Hospitals in Plateau State, Nigeria: August 2025 – May 2026

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ABSTRACT

Background: Intravenous (IV) fluids are designated essential medicines by the World Health Organization and are clinically indispensable across all hospital specialties (WHO, 2019). Systematic evidence on IV fluid distribution patterns within Plateau State Government owned Hospitals has been absent, limiting evidence-based procurement and supply chain planning. Objectives: To characterise the distribution patterns, monthly trends, facility-level variation, and cost implications of IV fluid supply across seventeen secondary hospitals and one tertiary hospital in Plateau State, Nigeria, between August 2025 and May 2026. Methods: Retrospective cross-sectional analysis of commodity distribution records from the PS-DMCMA central warehouse, cross-referenced against facility requisition invoices. Descriptive statistics were applied across six product lines, eighteen facilities, and ten calendar months. Results: A total of 107,600 units of IV fluid (500 mL equivalents) were distributed. Normal Saline 0.9%

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dominated at 45,240 units (42.0%), followed by 5% Dextrose Saline (23,360 units; 21.7%) and Ringer's Lactate (16,840 units; 15.6%). Plateau State Specialist Hospital (PSSH) received 37.1% of all Normal Saline distributed. Zero distribution was recorded across all six product lines in November 2025, indicative of a critical supply disruption. Total estimated expenditure for the ten-month period was is NGN 57,501,000 (approximately USD 42,063.9)F Conclusions: Normal Saline dominance is consistent with global evidence on crystalloid utilisation in infectious disease-endemic settings.Pronounced seasonal demand peaks in October 2025 and May 2026, a complete supply disruption in November 2025, and near-total absence of 20% Mannitol supply across seven of ten months reveal critical gaps in forecasting, safety stock planning, and logistics management. Transition to consumption-data-driven quantification, seasonal demand adjustment, and expanded logistics management information system (LMIS) adoption are ugently required.

INTRODUCTION

1.1 Background and Rationale

Intravenous (IV) fluids are designated essential medicines by the World Health Organization (WHO) and are clinically indispensable across emergency resuscitation, perioperative care, paediatric rehydration, maternal health, and critical care management (WHO, 2019). Therapeutically, they serve to restore circulating volume, correct electrolyte imbalances, maintain hydration, and deliver intravenous medications (Lobo et al., 2013; Myburgh & Mythen, 2013). Evidence-based prescribing of IV fluids is important for patient safety, as both insufficient fluid replacement and excessive fluid administration can lead to serious clinical complications.

(Powell-Tuck et al., 2011; Raghunathan et al., 2014).

In Nigeria, IV fluids represent a major budgetary line item for public health facilities and state-level pharmaceutical supply agencies (FMoH, 2022). The country's pharmaceutical supply chain faces well-documented systemic challenges: inadequate quantification and demand forecasting, fragmented logistics information systems, poor inventory management, financial constraints, and logistical barriers to rural distribution (Olutuase et al., 2022; FMoH, 2023). These weaknesses have contributed to recurrent stock-outs of essential medicines, including IV fluids, across public health facilities a pattern exacerbated during the COVID-19 pandemic and persisting in its aftermath (WHO, 2016; Olutuase et al., 2022).

The Plateau State Drugs and Medical Commodities Management Agency (PS-DMCMA) is the central supply chain entity responsible for the procurement, warehousing, and distribution of essential medicines including all six IV fluid products in this study to state government owned hospitals across Plateau State, Nigeria. Despite this central role, no published study has systematically characterised IV fluid distribution patterns within this group of health facilities. Without such data, PS-DMCMA's procurement planning rests on order-quantity estimates rather than verified consumption evidence, increasing the risk of stock-outs, wastage through expiry, and inefficient resource allocation (Management Sciences for Health [MSH], 2012; FMoH, 2023).

This study addresses that gap by analysing PS-DMCMA distribution data across eighteen facilities seventeen secondary hospitals and one tertiary hospital over the ten-month period from August 2025 to May 2026.

1.2 Significance

The findings carry direct and immediate relevance for PS-DMCMA's procurement cycle, Public Hospitals' management decisions, and Plateau State's broader health system strengthening agenda. By quantifying actual distribution volumes, identifying demand concentration, documenting supply disruptions, and projecting expenditure, this study provides the evidence base required for demand-driven, consumption-based pharmaceutical planning in Plateau State.

2. Statement of the Problem

Despite the critical clinical role of IV fluids, several systemic challenges compromise their optimal management within Plateau State's public health system:

- Absence of consumption-based procurement data: PS-DMCMA's quantification has historically relied on facility requisition quantities rather than verified consumption records, a known driver of

forecast inaccuracy in LMIC pharmaceutical supply chains (MSH, 2012; Olutuase et al., 2022).

- Fragmented logistics management information systems: The absence of a harmonised, state-wide LMIS means distribution data are recorded manually and inconsistently across facilities, limiting their analytical utility for quantification and performance monitoring (Olutuase et al., 2022; FMoH, 2023).
- Shortage vulnerability: Nigeria's pharmaceutical supply chain has demonstrated recurrent fragility, with essential medicine stock-outs reported across public facilities (WHO, 2016; Olutuase et al., 2022). IV fluids high-volume, clinically critical, and logistically demanding are among the most shortage-prone commodity categories.
- Rising commodity costs: Exchange rate volatility and dependence on importation make efficient, evidence-based procurement planning an urgent economic necessity (FMoH, 2022; FMoH, 2023).

The absence of published, facility-level IV fluid distribution evidence for Plateau State means that PSDMCMA lacks the quantitative foundation for demand-driven procurement. This study directly addresses that evidence gap.

3. Research Objectives

3.1 General Objective

To assess the distribution patterns, monthly trends, facility-level variation, and supply chain implications of intravenous fluids across state managed hospitals in Plateau State, Nigeria, from August 2025 to May 2026.

3.2 Specific Objectives

- To quantify the total and product-specific distribution of IV fluids across study facilities during the study period.
- To identify the most and least distributed IV fluid products and analyse their clinical and supply chain significance.
- To describe monthly distribution trends and identify seasonal demand patterns and supply disruption events.
- To compare IV fluid distribution volumes across individual health facilities and facility levels.
- To estimate the cost implications of IV fluid distribution within the study period.
- To generate evidence-based recommendations for improving IV fluid forecasting, procurement, and inventory management in Plateau State.

4. Literature Review

4.1 Classification and Clinical Uses of Intravenous Fluids

Intravenous fluids are sterile solutions administered directly into the venous circulation for therapeutic purposes. They are classified into two broad categories: crystalloids and colloids. Crystalloids including Normal Saline 0.9%, Ringer's Lactate, and Dextrose solutions are the most widely administered class globally, valued for their safety profile, availability, and cost-effectiveness (Perel & Roberts, 2012; Lobo et al., 2013). Colloids, including human albumin and semi-synthetic alternatives, are used less frequently in resource-limited settings owing to their higher cost and uncertain net clinical benefit (Myburgh & Mythen, 2013; Perel & Roberts, 2012).

Crystalloids are further classified by tonicity. Isotonic solutions Normal Saline 0.9% and Ringer's Lactate are used for volume replacement and fluid resuscitation. Hypertonic solutions including 20% Mannitol and 5% Dextrose Saline carry specific indications: Mannitol is the standard pharmacological agent for managing raised intracranial pressure, while hypertonic Dextrose-Saline combinations are used for specific metabolic and nutritional indications. Each product carries distinct contraindications and risks that mandate prescriber competence and institutional oversight (Powell-Tuck et al., 2011; Krajewski et al., 2015).

4.2 Global Patterns of IV Fluid Utilisation

Normal Saline 0.9% is consistently the most administered IV fluid product globally, a pattern documented across hospital settings in high-income countries, middle-income countries, and LMICs (Raghunathan et al., 2014; Myburgh & Mythen, 2013). Ringer's Lactate is the most commonly recommended alternative, and its use has grown following evidence associating large-

volume Normal Saline administration with hyperchloraemic metabolic acidosis and kidney injury (Krajewski et al., 2015; Raghunathan et al., 2014).

Rational use of IV fluids defined by the WHO as patients receiving the right medicine, at the right dose, for the right duration, at the lowest cost (WHO Conference of Experts, 1987) is a recognised global challenge. Irrational prescribing patterns, including excessive fluid loading in perioperative settings and inappropriate product selection for resuscitation, have been extensively documented (Powell-Tuck et al., 2011; Raghunathan et al., 2014). In sub-Saharan Africa, where infectious diseases drive the greatest share of IV fluid demand, the FEAST trial demonstrated that aggressive fluid bolus therapy with Normal Saline in critically ill African children was associated with increased mortality compared to no bolus, fundamentally reshaping resuscitation guidelines in LMICs (Maitland et al., 2011).

4.3 Seasonal Disease Burden and IV Fluid Demand in Nigeria

In Nigeria, IV fluid consumption is driven predominantly by the infectious disease burden, which exhibits well characterised seasonal patterns. Malaria transmission peaks at the beginning of and during the rainy season, while typhoid fever prevalence rises progressively through the rainy season and peaks at its end, driven by contaminated water and food sources (Olowolafe et al., 2024). In Plateau State located in Nigeria's middle belt with a rainy season from approximately April to October the post-rainy season period (October–November) and the dry season transition (April–May) are therefore epidemiologically high-risk windows for IV fluid-requiring illnesses including malaria, typhoid fever, diarrhoeal disease, and dehydration-related presentations. These seasonal patterns have direct implications for pharmaceutical supply chain planning. Static procurement models based on average monthly consumption (AMC) systematically underestimate peak-season demand, generating stockouts precisely when clinical need is greatest (MSH, 2012; FMoH, 2023).

4.4 Pharmaceutical Supply Chain Challenges in Nigeria

Nigeria's public pharmaceutical supply chain faces multiple well-documented structural challenges. A systematic scoping review by Olutuase et al. (2022) identified the following as the principal drivers of supply chain failure across Nigerian public facilities: difficulty with medicines selection; procurement inefficiencies; poor distribution systems; inadequate inventory management; poor storage infrastructure; financial constraints; insecurity; transportation challenges; and inadequate human resources. These findings are corroborated by two successive Federal Ministry of Health (FMoH) strategic planning documents, which identify forecasting accuracy and LMIS coverage as the highest-priority areas for supply chain strengthening in Nigeria's public health facilities (FMoH, 2022; FMoH, 2023).

4.5 Consumption-Based Forecasting and LMIS

Consumption-based forecasting wherein historical consumption data drives future procurement projections is universally recognised as the most accurate quantification method for essential medicines in stable disease-burden environments (MSH, 2012; WHO, 2019). The MSH MDS-3 framework specifies that consumption data should be collected at facility level, validated against dispensing records, and aggregated at the state or national level to produce statistically robust procurement quantities. In the absence of such data, morbidity-based estimates derived from epidemiological data and treatment guidelines represent the best available alternative, though they are inherently less precise (MSH, 2012). The adoption of digital LMIS platforms, including DHIS2 and Nigeria OpenLMIS, has improved supply chain transparency and reporting accuracy in several Nigerian states; however, coverage in Plateau State government owned hospitals remains limited (Olutuase et al., 2022; FMoH, 2023).

METHODOLOGY

5.1 Study Design

A retrospective cross-sectional research design was employed. Commodity distribution data were extracted and analysed for all eighteen study facilities over the

ten-month period from August 2025 to May 2026. The retrospective approach enabled systematic analysis of existing institutional records without the resource demands and ethical complexity of prospective data collection.

5.2 Study Setting

The study was conducted within the PS-DMCMA operational network in Plateau State, north-central Nigeria. Plateau State covers approximately 30,913 km² across seventeen local government areas (LGAs) and is located within Nigeria's middle belt, characterised by a bimodal climate with a rainy season from approximately April to October. Eighteen state government owned hospitals were included in the study: one tertiary hospital (Plateau State Specialist Hospital, PSSH) and seventeen secondary hospitals distributed across the seventeen LGAs,

5.3 Data Sources and Extraction

Distribution data were extracted from three complementary institutional sources to ensure accuracy and completeness:

- PS-DMCMA central warehouse distribution records the primary data source, capturing all issues to Health facilities during the study period.
- Facility requisition forms submitted to PS-DMCMA used as secondary verification for quantities reported as distributed.
- PLASUPPLY, the PS-DMCMA digital inventory and logistics management platform outputs cross-referenced against warehouse records and facility invoices to identify and resolve discrepancies.

Data extraction covered six IV fluid product lines across eighteen facilities over ten calendar months (August 2025 to May 2026). All quantities are reported in 500 mL pack equivalents.

5.4 Study Variables

- Primary outcome variable: Quantity of IV fluid units distributed (500 mL equivalents) per product, per facility, per month.
- Explanatory variables: IV fluid product type; facility level (secondary or tertiary); facility location (LGA); month of distribution.

5.5 Data Analysis

Descriptive statistical analysis was applied. The analysis comprised: total and proportional distribution by product; monthly trend analysis across the study period; facility-level comparative analysis; cost estimation based on PS-DMCMA procurement unit prices; and identification of zero-distribution events. Data were organised and validated in Microsoft Excel 2021 and summarised in tabular and narrative formats.

5.6 Ethical Considerations

This study is based exclusively on routinely collected, anonymised institutional distribution and logistics data. No individual patient data, clinical records, or personally identifiable information were accessed. Ethical approval was not required under applicable national guidelines for secondary analysis of aggregated, de-identified administrative records.

RESULTS

6.1 Overall Distribution by Product

A total of 107,600 units of IV fluid (500 mL pack equivalents) were distributed across the eighteen study facilities between August 2025 and May 2026. Six product lines were captured. Table 1 presents the product-level breakdown in descending order of distribution volume.

Table 1: ***Total IV Fluid Distribution by Product, August 2025 – May 2026 (n = 107,600 units)***

IV Fluid Product	Units Distributed	% of Total
Normal Saline 0.9% (500 mL)	45,240	42.0%
5% Dextrose Saline (500 mL)	23,360	21.7%
Ringer's Lactate (500 mL)	16,840	15.6%
5% Dextrose Water (500 mL)	16,000	14.9%
4.3% Dextrose Water (500 mL)	5,360	5.0%

IV Fluid Product	Units Distributed	% of Total
20% Mannitol (500 mL)	800	0.7%
TOTAL	**107,600**	**100.0%**

Normal Saline 0.9% was the dominant product at 45,240 units (42.0% of all distribution). 5% Dextrose Saline ranked second at 23,360 units (21.7%), followed by Ringer's Lactate at 16,840 units (15.6%) and 5% Dextrose Water at 16,000 units (14.9%). 4.3% Dextrose Water accounted for 5,360 units (5.0%). 20% Mannitol recorded the lowest distribution at 800 units (0.7%) the only product representing less than 1% of total supply.

6.2 Monthly Distribution Trends

Table 2 presents the monthly breakdown of distribution across all six product lines for the study period. A monthly total column has been added to facilitate trend interpretation.

Note: November 2025 (red) recorded zero distribution across all six product lines simultaneously.

Table 2: ***Monthly IV Fluid Distribution by Product, August 2025 – May 2026 (units)***

Month	Normal Saline	5% Dextrose Saline	20% Mannitol	Ringer's Lactate	4.3% Dextrose Water	5% Dextrose Water	Monthly Total
Aug 2025	1,360	760	60	500	520	1,200	4,400
Sep 2025	7,700	1,800	500	140	560	10,000	20,700
Oct 2025	9,780	1,940	120	3,980	1,060	2,400	19,280
Nov 2025	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Dec 2025	5,500	6,600	120	4,040	180	2,400	18,840
Jan 2026	2,600	2,300	0	800	780	0	6,480
Feb 2026	4,300	2,100	0	2,500	80	0	8,980
Mar 2026	3,900	2,940	0	1,900	760	0	9,500
Apr 2026	2,100	480	0	380	100	0	3,060
May 2026	8,000	4,440	0	2,600	1,320	0	16,360
TOTAL	**45,240**	**23,360**	**800**	**16,840**	**5,360**	**16,000**	**107,600**

Three distinct patterns emerge from the monthly data. First, Normal Saline peaked in October 2025 (9,780 units), May 2026 (8,000 units), and September 2025 (7,700 units), with troughs in April 2026 (2,100 units) and January 2026 (2,600 units). Second, the overall monthly total was highest in September 2025 (20,700 units) and October 2025 (19,280 units), and lowest in April 2026 (3,060 units). Third, and most critically, November 2025 recorded zero distribution across all six product lines simultaneously. This finding is noteworthy, as the likelihood of six independent product lines simultaneously reporting zero clinical demand within the same calendar month is extremely low. This pattern is consistent with a central warehouse stockout, a distribution system disruption, or a complete data recording failure any of which constitutes a supply chain failure with direct clinical consequences. 20% Mannitol also recorded zero distribution from January to May 2026, representing five consecutive months without any reported movement, a pattern unlikely to be consistent with expected clinical demand.

6.3 Facility-Level Distribution

Table 3 presents the distribution of each product across all eighteen facilities for the full study period, with facility row totals included. PSSH is highlighted.

Note: PSSH (row 18, highlighted) is the sole tertiary-level facility. All figures are 500 mL unit equivalents.

Table 3: ***Facility-Level IV Fluid Distribution by Product, August 2025 – May 2026 (units)***

Facility	Category	Normal Saline	5% Dextrose Saline	20% Mannitol	Ringer's Lactate	4.3% Dextrose Water	5% Dextrose Water	Total
Comprehensive HC Dadin Kowa	*Secondary*	4,400	1,600	0	1,580	800	0	8,380
Cottage Hospital Bassa	*Secondary*	2,420	640	0	400	280	0	3,740
Cottage Hospital Bokkos	*Secondary*	1,560	1,400	80	300	500	1,600	5,440
Cottage Hospital Dyeirok	*Secondary*	420	140	20	300	20	400	1,300
Cottage Hospital Kwalla	*Secondary*	800	600	40	600	180	800	3,020
Cottage Hospital Siken	*Secondary*	100	360	0	160	40	0	660
Gen. Hospital Angware	*Secondary*	200	600	0	300	0	0	1,100
Gen. Hospital Barkin Ladi	*Secondary*	1,600	1,300	0	240	160	0	3,300
Gen. Hospital Dengi	*Secondary*	900	980	20	720	320	400	3,340
Gen. Hospital Langtang	*Secondary*	2,600	1,600	40	800	200	800	6,040
Gen. Hospital Mabudi	*Secondary*	1,000	700	0	800	360	0	2,860
Gen. Hospital Mangu	*Secondary*	2,600	1,800	100	780	420	2,000	7,700
Gen. Hospital Pankshin	*Secondary*	2,540	2,240	20	1,320	380	400	6,900
Gen. Hospital Riyom	*Secondary*	560	240	60	280	160	1,200	2,500
Gen. Hospital Shendam	*Secondary*	4,200	5,200	80	3,460	600	1,600	15,140
Gen. Hospital Tunkus	*Secondary*	1,500	1,700	20	500	300	400	4,420
Gen. Hospital Kwall	*Secondary*	1,040	260	20	500	360	400	2,580
Plateau State Specialist Hospital	*Tertiary*	**16,800**	**2,000**	**300**	**3,800**	**280**	**6,000**	**29,180**
TOTAL		**45,240**	**23,360**	**800**	**16,840**	**5,360**	**16,000**	**107,600**

PSSH dominated distribution with 29,180 units in total (27.1% of all IV fluids distributed across the network). Of this, 16,800 units were Normal Saline, representing 37.1% of all Normal Saline distributed. Among secondary facilities, General Hospital Shendam (15,140 units), Comprehensive Health Centre Dadin Kowa (8,380 units), and General Hospital Pankshin (6,900 units) recorded the highest total volumes. Cottage Hospital Siken (660 units) and General Hospital Angware (1,100 units) recorded the lowest. 20% Mannitol was received by only six of the eighteen facilities, with PSSH accounting for 300 of the 800 total units (37.5%), followed by Cottage Hospital Bokkos (80 units) and General Hospital Mangu (100 units).

6.4 Cost Implications

Based on the PS-DMCMA weighted average procurement unit price of NGN 538.40 per 500 mL IV fluid bag across the six product lines, the estimated total expenditure on IV fluids across all study facilities for the ten-month period is NGN 57,501,000 (approximately USD 42,063.9 at the prevailing parallel market exchange rate of NGN 1,367/USD). Normal Saline, at 42.0% of total volume, represents the single largest cost driver. Annualised, the total IV fluid expenditure projects to approximately NGN 69 million, underscoring the economic significance of evidence-based procurement planning for this commodity category.

DISCUSSION

7.1 Dominance of Normal Saline

Normal Saline 0.9% was the dominant IV fluid product, accounting for 42.0% of all units distributed. This is consistent with patterns documented in the global and sub-Saharan African literature. Myburgh &

Mythen (2013) describe Normal Saline as the most widely administered crystalloid globally, a pattern driven by its broad clinical indications, relative stability, and universal availability. In high-infectious-disease-burden settings such as Plateau State, isotonic volume resuscitation for malaria, typhoid fever, sepsis, and diarrhoeal illness explains a substantial proportion of Normal Saline demand consistent with the epidemiological evidence from Olowolafe et al. (2024) on the seasonal co-incidence of malaria and typhoid fever in Nigerian hospitals.

The concentration of Normal Saline at PSSH (16,800 units; 37.1% of total Normal Saline) reflects the tertiary hospital's referral function and higher per-patient IV fluid requirements associated with complex surgical, emergency, and critical care cases (Lobo et al., 2013). However, the stark volume differential between PSSH and peripheral secondary hospitals also warrants scrutiny. Demand suppression at secondary health facilities, resulting from persistent supply shortages and subsequent under-ordering of medicines, is a well-documented phenomenon in fragile pharmaceutical supply chains (MSH, 2012; Olutuase et al., 2022). If secondary facilities have learned to requisition conservatively in anticipation of partial supply, observed distribution data will systematically underestimate true clinical demand.

The predominance of Normal Saline over balanced crystalloids such as Ringer's Lactate, while partially justified by infectious disease resuscitation requirements, raises rational use concerns. Krajewski et al.'s (2015) meta-analysis demonstrated that high-chloride fluid regimens of which Normal Saline is the archetype are associated with hyperchloraemic metabolic acidosis and impaired postoperative renal function compared to balanced alternatives. Raghunathan et al. (2014) further demonstrated that Normal Saline selection over balanced crystalloids was associated with higher in-hospital mortality in critically ill adults with sepsis. In facilities without structured prescribing audit and clinical pharmacist oversight, product selection may reflect institutional habit or prescriber familiarity rather than evidence-based clinical decision-making.

7.2 The November 2025 Supply Disruption

The complete absence of IV fluid distribution across all six product lines in November 2025 is the most clinically significant finding of this study and demands explicit attention in this discussion. In a functional supply chain, it is statistically implausible for all six product lines to record zero demand in the same calendar month across a network of eighteen health facilities. The pattern is almost certainly attributable to a central warehouse stock-out, a logistics distribution failure, or a systematic data recording breakdown at the PS-DMCMA level all of which represent supply chain failures with direct, immediate, and potentially life-threatening consequences for patients requiring IV fluid therapy.

This finding is consistent with the documented fragility of Nigeria's public pharmaceutical supply chain. Olutuase et al. (2022) identified stock-outs as a pervasive consequence of inadequate inventory management and forecasting failures across Nigerian public health facilities. WHO (2016) similarly identifies insufficient safety stock and reactive rather than proactive replenishment as the principal structural drivers of essential medicine shortages in LMICs. The absence of a documented root cause analysis for this event within PS-DMCMA records is itself a governance concern and highlights the need for mandatory incident reporting and investigation protocols for supply disruption events.

7.3 Seasonal Demand Patterns and Supply Chain Implications

The monthly data reveal a seasonal demand pattern aligned with Plateau State's epidemiological calendar. Normal Saline peaks in October 2025 and May 2026 periods corresponding to the end of the rainy season (peak malaria and typhoid transmission) and the onset of the hot dry season (peak dehydration and heat-related illness), respectively. These observations are consistent with Olowolafe et al.'s (2024) Nigeria-based evidence that malaria prevalence peaks at the beginning of the rainy season while typhoid fever prevalence rises progressively through the rainy season and peaks at its end, with co-infection burden peaking in April to June.

Static AMC-based procurement fails to account for these predictable seasonal fluctuations. The MSH MDS-3 framework recommends applying seasonal adjustment factors calculated from at least two years of consumption data to AMC estimates for products with documented seasonal demand patterns (MSH, 2012). While this study provides only one year of data, the signal is sufficiently consistent with known epidemiological patterns to justify prospective seasonal adjustment of procurement for the September–October and April–May windows in future planning cycles (FMoH, 2023).

7.4 Supply Vulnerability of Low-Volume Critical Products

20% Mannitol recorded zero distribution in seven of the ten study months and was received by only six of eighteen facilities. This level of supply fragility for a product that serves as the primary pharmacological agent for raised intracranial pressure management including in trauma, cerebral malaria, and post-surgical neurology is clinically unacceptable. The near-exclusive concentration of Mannitol at PSSH (37.5% of total) and Cottage Hospital Bokkos (10%) suggests that secondary facilities in most LGAs currently have no reliable access to this critical product, this needs to be further investigated

4.3% Dextrose Water, which supports paediatric maintenance fluid therapy and is indicated in specific neonatal and maternal clinical scenarios, recorded zero distribution in three months. Although its overall volume is modest (5.0% of total), its absence in sporadic months represents a potential gap in paediatric care capacity at peripheral facilities.

7.5 Comparison with the Literature

The product distribution profile observed Normal Saline dominance followed by Dextrose Saline and Ringer's Lactate mirrors patterns reported across West African public health facility networks in the supply chain literature (Olutuase et al., 2022). The 21.7% share of 5% Dextrose Saline is higher than would be expected from evidence-based prescribing guidelines and may reflect its use as a general-purpose maintenance fluid or drug diluent in settings where prescribing protocols are not enforced a pattern consistent with findings from Nigerian pharmacy practice literature (Olutuase et al., 2022). The FEAST trial (Maitland et al., 2011) and subsequent reviews have specifically cautioned against Dextrose-containing solutions as primary resuscitation fluids in paediatric and sepsis contexts; their disproportionate use in this dataset suggests a rational use intervention gap that should be addressed through facility-level prescribing audits and prescriber education.

8. Recommendations

The following recommendations are derived directly from the study findings and are grounded in the peer-reviewed supply chain and clinical literature:

8.1 Transition to Consumption-Based Quantification

PS-DMCMA should transition from order-quantity-based to consumption-data-driven quantification for all IV fluid products. Monthly distribution summaries from all Health facilities should be systematically collated, validated against facility dispensing records, and incorporated into annual procurement quantification exercises. Seasonal adjustment factors should be calculated for the October and May demand peaks identified in this study and applied prospectively. A minimum safety stock buffer equivalent to at least two months of peak-season consumption should be established and maintained at the central warehouse at all times (MSH, 2012; FMoH, 2023).

8.2 Mandatory Supply Disruption Incident Reporting

The November 2025 zero-distribution event must be formally investigated, root-caused, and documented. PS-DMCMA and management of state government owned hospitals should jointly develop a supply disruption incident reporting protocol, requiring that any product-level stock-out of more than 72 hours triggers mandatory documentation of causes and corrective actions. Annual disruption data should be incorporated into the supply chain performance monitoring framework (WHO, 2016; FMoH, 2023).

8.3 Standardise and Expand LMIS Adoption

All state government owned hospitals should be equipped with and trained on a harmonised LMIS such as PLASUPPLY, DHIS2, or Nigeria OpenLMIS to enable real-time stock visibility, automated consumption reporting, and reorder trigger alerts. Manual stock card systems should be digitised and standardised across the network to enable state-level data aggregation (Olutuase et al., 2022; FMoH, 2023).

8.4 Establish Minimum Stock Thresholds and Differentiated Safety Stock Protocols

Facility-specific minimum and maximum stock levels should be established for each IV fluid product based on AMC data from this and subsequent annual distribution reports. Safety stock buffers should be differentiated by product criticality: higher buffers for low-volume, high-criticality products (20% Mannitol, 4.3% Dextrose Water) and seasonal uplift protocols for high-volume products during October and May demand peaks (MSH, 2012).

8.5 Implement Rational IV Fluid Use Programmes

The State Ministry of Health (SMoH) and the Pharmaceutical Society of Nigeria (PSN) Plateau State Branch should jointly develop and implement a rational IV fluid use programme across all study facilities. Core components should include: standard treatment guidelines for IV fluid therapy aligned with the GIFTASUP framework (Powell-Tuck et al., 2011) and adapted for the Nigerian clinical context; structured prescriber education sessions; periodic prescribing audit and feedback cycles; and prospective prescribing surveillance by clinical pharmacists. The programme should specifically address the potentially excessive use of 5% Dextrose Saline as a maintenance or resuscitation fluid in contexts where balanced crystalloids are clinically indicated (Raghunathan et al., 2014; Maitland et al., 2011).

8.6 Strategic Procurement Consolidation for Normal Saline

Given that Normal Saline accounts for 42.0% of total IV fluid volume and an estimated NGN 29.8 million of the ten-month expenditure, PS-DMCMA should engage NAFDAC-registered manufacturers in framework pricing negotiations for annual bulk procurement of Normal Saline. Framework agreements, tied to supply reliability performance indicators, offer the most direct pathway to both cost reduction and supply security for the single most critical product in the IV fluid portfolio.

8.7 Dedicated Supply Protocol for 20% Mannitol

Given the clinical importance of 20% Mannitol in the management of neurological emergencies, its near-total absence from distribution records across seven months and most secondary health facilities warrants targeted intervention. The available evidence suggests that the primary challenge may not be product unavailability but rather inadequate requisitioning and demand recognition at facility level. To address this gap, hospital managements should establish a dedicated monitoring framework for Mannitol utilization and requisition patterns. This should include: (i) maintaining a minimum stock level of 20 units per secondary facility and 100 units at PSSH; (ii) routine review of facilities reporting zero requisition for extended periods to determine whether this reflects true clinical demand or under-ordering; (iii) targeted training and supportive supervision for pharmacy and clinical staff on the appropriate forecasting and requisition of emergency medicines; and (iv) integration of Mannitol stock status and requisition performance indicators into hospital readiness assessment framework.

8.8 Institutionalise Annual IV Fluid Distribution Reporting

This study should serve as the template for an annual IV fluid distribution report, produced jointly by PS-DMCMA and management of these hospitals. Annual reporting will build the longitudinal consumption dataset required for reliable seasonal adjustment factors, trend analysis, and evidence-based forecast calibration over time (MSH, 2012).

CONCLUSION

This study provides the first systematic, quantitative analysis of IV fluid distribution patterns across the government owned hospitals in Plateau State, Nigeria, covering the ten-month period from August 2025 to May 2026. A total of 107,600 units were distributed

across eighteen facilities spanning six product lines. Normal Saline 0.9% dominated at 42.0% of all distribution, consistent with global evidence on crystalloid utilisation in infectious disease-endemic settings (Myburgh & Mythen, 2013; Maitland et al., 2011). Distribution was markedly concentrated at PSSH, which received 27.1% of all units distributed.

Three critical supply chain findings demand immediate action. First, November 2025 recorded zero distribution across all six product lines simultaneously a sentinel event almost certainly representing a central supply chain failure rather than a genuine reduction in clinical demand. Second, 20% Mannitol recorded zero distribution in seven of ten months and reached only six of eighteen facilities, sor which the evidence suggest a utilization gap for this irreplaceable neurological emergency medicine. Third, seasonal demand peaks in October 2025 and May 2026 are consistent with known infectious disease epidemiological patterns in Nigeria's middle belt (Olowolafe et al., 2024) and reveal that static AMC-based procurement systematically underestimates peak-month demand.

The estimated ten-month expenditure is NGN 57,501,000 (approximately NGN 69 million annualised) establishes the economic scale of this commodity category and underscores the financial case for evidence-based, consumption-data-driven procurement planning. Implementation of the eight recommendations presented in this paper grounded in the MSH MDS-3 framework, WHO essential medicines guidance, and the peer-reviewed supply chain and clinical literature would substantively reduce stock-out risk, improve rational use, and deliver measurable cost efficiencies in PS-DMCMA's IV fluid supply chain. Annual replication of this analysis is recommended to build the longitudinal data set required for reliable demand forecasting and performance monitoring.

REFERENCES

1. Federal Ministry of Health Nigeria. (2022). National Essential Medicines List (6th ed.). Department of Food and Drug Services, Abuja.
2. Federal Ministry of Health Nigeria. (2023). National Health Supply Chain Strategic Plan 2023–2027. Logistics Management Division, Abuja.
3. Krajewski, M. L., Raghunathan, K., Paluszkiewicz, S. M., Schermer, C. R., & Shaw, A. D. (2015). Meta-analysis of high- versus low-chloride content in perioperative and critical care fluid resuscitation. British Journal of Surgery, 102 (1), 24–36. https://doi.org/10.1002/bjs.9651
4. Lobo, D. N., Lewington, A. J. P., & Allison, S. P. (2013). Basic Concepts of Fluid and Electrolyte Therapy. Bibliomed Medizinische Verlagsgesellschaft, Melsungen.
5. Maitland, K., Kiguli, S., Opoka, R. O., Engoru, C., Olupot-Olupot, P., Akech, S. O., Nyeko, R., Mtove, G., Reyburn, H., Lang, T., Brent, B., Evans, J. A., Tibenderana, J. K., Crawley, J., Russell, E. C., Levin, M., Babiker, A. G., & Gibb, D. M. (2011). Mortality after fluid bolus in African children with severe infection. New England Journal of Medicine, 364 (26), 2483–2495. https://doi.org/10.1056/NEJMoa1101549
6. Management Sciences for Health. (2012). MDS-3: Managing Access to Medicines and Health Technologies. Management Sciences for Health, Medford, MA. Available at: https://msh.org/resources/mds-3-managing-access-to-medicines-and-health-technologies/
7. Myburgh, J. A., & Mythen, M. G. (2013). Resuscitation fluids. New England Journal of Medicine, 369 (13), 1243–1251. https://doi.org/10.1056/NEJMra1208627
8. Olowolafe, T. A., Agosile, O. F., Akinpelu, A. O., Aderinto, N., Wada, O. Z., & Olawade, D. B. (2024). Malaria and typhoid fever co-infection: a retrospective analysis of University Hospital records in Nigeria. Malaria Journal, 23 (1), 220. https://doi.org/10.1186/s12936-024-05052-4
9. Olutuase, V. O., Iwu-Jaja, C. J., Akuoko, C. P., Adewuyi, E. O., & Khanal, V. (2022). Medicines and vaccines supply chains challenges in Nigeria: a scoping review. BMC Public Health, 22 (1), 11. https://doi.org/10.1186/s12889-021-12361-9
10. Perel, P., & Roberts, I. (2012). Colloids versus crystalloids for fluid resuscitation in critically ill patients. Cochrane Database of Systematic Reviews, (6), CD000567.

https://doi.org/10.1002/14651858.CD000567.pub5

11. Powell-Tuck, J., Gosling, P., Lobo, D. N., Allison, S. P., Carlson, G. L., Gore, M., Lewington, A. J., Pearse, R. M., & Mythen, M. G. (2011). British consensus guidelines on intravenous fluid therapy for adult surgical patients (GIFTASUP). BAPEN. Available at: https://www.bapen.org.uk/pdfs/bapen_pubs/giftasup.pdf
12. Raghunathan, K., Shaw, A., Nathanson, B., Stürmer, T., Brookhart, A., Stefan, M. S., Diaby, V., Heflin, M., Corey, G. R., & Lindenauer, P. K. (2014). Association between the choice of IV crystalloid and in-hospital mortality among critically ill adults with sepsis. Critical Care Medicine, 42 (7), 1585–1591. https://doi.org/10.1097/CCM.0000000000000305
13. World Health Organization. (1987). The rational use of drugs: Report of the Conference of Experts, Nairobi, 25–29 November 1985. World Health Organization, Geneva. Available at: https://apps.who.int/iris/handle/10665/37174
14. World Health Organization. (2016). Medicines shortages: Global approaches to addressing shortages of essential medicines in health systems. WHO Drug Information, 30 (2), 180–185. Available at: https://iris.who.int/handle/10665/331028
15. World Health Organization. (2019). WHO Model List of Essential Medicines (21st ed.). World Health Organization, Geneva: https://www.who.int/publications/i/item/WHOMVPEMPIAU201907

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