

## Research Article

# Technical Contributions of the Push Model to the Health Product Supply Chain in Benin in 2025

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## Abstract

**Background:** In Benin, two third of health facilities experienced stockouts for at least one tracer product, revealing persistent weaknesses in supply chain management. To address this, the Couffo department adopted the PUSH model in one health zone while maintaining the PULL model in another. **Objective:** This study aimed to evaluate the technical contributions of the PUSH model to health product supply chain performance through a comparative analysis of both logistics models. **Methods:** A descriptive cross-sectional study with an evaluative and analytical purpose was conducted across 32 public health facilities in the Couffo department from September 2024 to February 2025. Data on inputs, processes, and outcomes were collected via observations, interviews, and documentary review, then analysed using the Varkevisser scale and comparative statistical tests (Chi-squared, Fisher's exact, Student's t-test) at the 5% significance threshold. **Results:** The PUSH model demonstrated higher overall performance (86.13% vs. 71.0%). Stockout frequency was significantly lower (31.48% vs. 68.52%; OR=0.21; p<0.001), delivery lead times shorter (8.2 vs. 20.9 days), and distribution (93.3% vs. 36.1%) and quality assurance scores (100% vs. 66.6%) substantially higher. **Conclusion:** The PUSH model significantly improves supply chain efficiency. Its gradual extension, supported by appropriate technical and financial assistance, is recommended to sustain universal access to quality health products in Benin.

## Keywords

PUSH Model, PULL Model, Supply Chain, Logistics Efficiency, Technical Contribution, Benin

## 1. Introduction

Improving health logistics represents a critical strategic challenge in meeting the increasingly numerous and diverse demands required to ensure the availability and quality of health products [1]. The continuous growth in demand for care, demographic change, and advances in medical technology are liable to complicate considerably the management of health

product flows [2-4]. In view of these challenges, the establishment of a high-performing and responsive supply chain appears essential to guarantee access to care and respond effectively to patients' needs.

In Benin, the health product supply chain is characterised by orders from pharmacy or pharmaceutical dispensaries

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within health facilities to the Zonal Health Depot Distributors (Dépôts Répartiteurs de Zone Sanitaire, DRZS), which are generally triggered by local consumption data. According to data from the A7 form of the national health information and management system, 68.83% of health facilities experienced a stockout for at least one of the seven tracer products, revealing a persistent weakness in supply planning and logistics governance [5]. These supply challenges prompted the country to commit to the adoption of differentiated logistics strategies, including a transition towards the PUSH model for health product procurement in the health zones.

These strategic choices led, in the Couffo department, to the coexistence of two logistics supply models: the continued application of the PULL model in the Aplahoué-Djakotomey-Dogbo (ADD) health zone, and the adoption and implementation of the PUSH model in the Klouékannè-Toviklin-Lalo (KTL) health zone in accordance with the new national guidelines on health product procurement.

The PULL model is demand-driven: products are delivered solely in response to a specific order formulated locally. In the Beninese context, this system requires health facilities to finance their own resupply by mobilising their working capital. Although this model promotes local autonomy and stock optimisation, it remains constrained by limited forecasting capacity, irregular ordering patterns, and fragmentation of distribution circuits [8]. The PUSH model, in contrast, is grounded in consumption forecasts and historical demand data to determine the quantities of stock to be distributed. Products are thus 'pushed' through the logistics chain to reach health facilities according to a predefined schedule. This model brings the source of supply closer to the point of need by anticipating requirements and allows intermediate distribution steps to be simplified by delivering health products directly to the source of demand [8].

To date, few studies have simultaneously examined the technical contributions of both models within an integrated framework permitting assessment of the overall performance of supply systems [10]. This gap limits the capacity of decision-makers to guide logistics reforms on the basis of evidence [9]. The present study aimed to evaluate the contribution of the PUSH model to the effectiveness of supply chain

management through a comparison of the technical aspects of the two logistics systems applied in the Couffo department.

## 2. Materials and Methods

### 2.1. Study Setting

The study was conducted in the Couffo department (south-west Benin), covering an area of approximately 2,404 km<sup>2</sup> with a population of 971,674 inhabitants (2025), who rely primarily on agricultural, commercial, and craft activities [11, 12].

The department has 65 public health centres and two district hospitals distributed across two health zones, each equipped with a DRZS that obtains its supplies from the SoBAPS regional depot in Cotonou. The DRZSs are responsible for the management and distribution of health products.

In accordance with the national last-mile distribution guidelines, the DRZSs constitute the sole point of entry for health products in each zone. However, the Beninese supply chain is currently undergoing a transitional phase characterised by the coexistence of two logistics supply models, as observed in the Couffo: the KTL zone operates the PUSH model with planned, centralised deliveries from the DRZS to health centres, whilst the ADD zone continues to apply the PULL model whereby each centre formulates its own orders and collects products autonomously and in a decentralised manner. This coexistence provides a relevant analytical framework for a comparative assessment of the contributions of each model. The two zones share comparable characteristics (population size, geographical context, common administrative oversight, identical partners, uniform national policies and logistics frameworks), strengthening the assumption that any observed technical logistics differences are attributable to the supply model adopted.

### 2.2. Technical Comparison of Management Processes

Table 1 presents a detailed comparison of the two models according to the various stages of the management process.

**Table 1.** Detailed comparison of PUSH and PULL models according to management process stages.

Process element	PUSH model	PULL model
Planning	Centralised; carried out by the DRZS on the basis of forecasts and historical demand and/or consumption data	Local; initiated by health facilities according to consumption data available in real time
Implementation	Quasi-automatic: allocations are defined in advance and scheduled within the distribution plan	Manual: each facility prepares and submits its orders using available resources and tools
Execution	Products are delivered directly by the DRZS without prior request	Facilities monitor their own orders and travel to collect products
Communication	Unidirectional (top-down): the DRZS informs facilities of forthcoming deliveries	Bidirectional: health centres liaise with the DRZS to clarify, monitor, and adjust

Process element	PUSH model	PULL model
Evaluation	Managed centrally on the basis of global indicators	Depends on the local capacity to produce and analyse reports
Control	Quality control integrated into the logistics process (per-delivery control, audits, monitoring of lead times and compliance)	Variable; primarily self-monitoring by the facility itself, limited to verification of delivery notes and stock inventories

### 2.3. Study Participants and Eligibility Criteria

The study was conducted in public health facilities and amongst stakeholders involved in pharmaceutical logistics management across the two health zones of the Couffo: Aplahoué-Djakotomey-Dogbo (ADD) and Klouékanmè-Toviklin-Lalo (KTL). The entities observed comprised operational public health facilities in both zones, the DRZSs, and those directly involved in logistics activities, including DRZS managers, health centre directors, and staff responsible for stock management and health product procurement.

#### *Inclusion criteria*

*Health facilities (health centres, depot distributors) that had been managing health inputs for a minimum of six months were eligible, as were managers or individuals responsible for health product management in health facilities within the Couffo department's health zones, who had been in post for at least six months and were available during the study period.*

#### *Exclusion criteria*

Facilities established less than one year before the study or that had experienced an interruption in functioning of three months or more during the preceding twelve months were excluded, as were any manager or individual responsible for health product management who had not provided free and informed consent.

### 2.4. Study Design

This was a descriptive cross-sectional study with an evaluative and analytical purpose, using a controlled before-and-after comparison of the intervention zone (KTL) applying the PUSH model versus the control zone (ADD) applying the PULL model. The observation period spanned six months, from September 2024 to February 2025. The study employed a probabilistic method, with simple random sampling of approximately 50% of the 65 public health facilities in the department, yielding 34 health facilities. This number was then distributed equally between the two health zones concerned. An exhaustive approach was applied to the selection of zone depot distributors ( $n = 2$ ), zone logisticians ( $n = 2$ ), health centre managers ( $n = 34$ ), and stock managers at health centre level.

### 2.5. Components and Data Collection Tools

The effectiveness of the supply chain was assessed across three components: inputs (comprising the sub-components of human, material, financial, and informational resources), processes (procurement, storage, distribution, and quality assurance), and outcomes (health product availability, order integrity and compliance, stakeholder and community satisfaction, reduction in logistics costs, and reduction in losses).

Data were collected through a documentary review of logistics and financial management tools available in health facilities. A standardised data collection grid was used to extract cost-related information from purchase orders, stock cards, reception and distribution reports, and financial registers covering the period September 2024 to February 2025.

### 2.6. Data Processing and Analysis

Collected data were entered and cleaned using KoboCollect software, then analysed using Stata version 14. Comparative tests (Chi-squared, Fisher's exact test, Student's t-test) were performed at a 5% significance threshold. Odds ratios (OR) and 95% confidence intervals (95% CI) were calculated for categorical variables, and regression coefficients ( $\beta$ ) for continuous variables.

Each component was assessed against specific criteria with scores attributed (1 for criterion present; 0 for criterion absent), with major criteria weighted. The total score for each component was expressed as a percentage of the expected score and interpreted according to the Varkevisser scale:  $<60\%$  = Very poor;  $60\text{--}79\%$  = Poor;  $80\text{--}89\%$  = Good;  $\geq 90\%$  = Very good. Results were expressed as means, standard deviations, and ratios for the comparison of PUSH and PULL models.

### 2.7. Ethical Considerations

The study was conducted following validation by a panel of scientific and ethical experts mandated by the Regional Institute of Public Health. Administrative authorisations were subsequently obtained from the Ministry of Health and the departmental directorate of the Couffo. Each respondent was enrolled following provision of free and informed consent. Anonymity and confidentiality were guaranteed, and only aggregated data are made publicly available. No conflicts of interest are associated with this manuscript.

### 3. Results

#### 3.1. General Characteristics of the Sample and Operational Context

The study involved 32 health centres distributed equally across the two health zones of the Couffo department. The two depot distributors of these zones, their zone logisticians, and the health centre managers (n = 34) were also surveyed.

#### 3.2. Inputs

##### 3.2.1. Resources

Significant logistics disparities existed between KTL (PUSH) and ADD (PULL). The KTL health zone had more rolling stock (47.1% versus 5.9%), more functional cold-storage refrigerators (94.1% versus 88.2%), more generators (29.4% versus 17.6%), and more compliant storage infrastructure

(100% versus 76.5%).

Both zones achieved 100% compliance with standards and guidelines and were fully integrated into the e-SIGL system; however, the PUSH model ensured more systematic utilisation through centralised planning, supervision, and reporting, in contrast to the decentralised use characteristic of the PULL model.

Financial resources were deemed sufficient in 76.5% of KTL facilities compared with 29.4% of ADD facilities.

##### 3.2.2. Availability and Stockouts

Table 2 presents comparative results for the main logistics performance indicators. The PUSH model (KTL) was associated with a significantly lower stockout frequency than the PULL model (ADD) (31.48% versus 68.52%; OR = 0.21; p < 0.001). It also showed greater product availability (58.33% versus 41.67%; OR = 2.00; p = 0.002). Finally, the mean stockout duration was markedly shorter in KTL facilities (2.1 days versus 11.7 days;  $\beta = -9.61$ ; p = 0.039).

**Table 2.** Paired comparison of performance indicators related to health product availability and stockouts in health zones in 2025.

Indicator	ADD (PULL)	KTL (PUSH)	Statistical value	p-value
Stockout at patient visit (n = 55 patients/zone)	37/55 (68.52%)	17/55 (31.48%)	OR = 0.21 [0.10–0.45]	0.000
Product availability (n = 55 patients/zone)	35/55 (41.67%)	49/55 (58.33%)	OR = 2.00 [1.30–3.50]	0.002
Mean stockout duration (n = 17 facilities/zone)	11.71 days (SD: 4.15)	2.1 days (SD: 1.67)	$\beta = -9.61$ [-11.94 to -7.28]	0.039

#### 3.3. Processes

##### 3.3.1. Quality of the Procurement Process

This was assessed through delivery lead times, delivery quality, and average supply indicators. Compared with the PULL model (ADD), the PUSH model (KTL) exhibited

shorter delivery lead times (8.23 ± 1.34 days versus 20.88 ± 1.59 days;  $\beta = -12.65$ ; p = 0.001). The proportion of facilities reporting a reduction in losses was higher in KTL (56.52% versus 43.47%).

KTL facilities placed significantly more orders per month (2.81 ± 0.14 versus 1.77 ± 0.15; p = 0.0000), with no statistically significant difference in mean order cost (p = 0.71) or mean distance travelled (p = 0.964).

**Table 3.** Assessment of delivery times, delivery quality, and average supply indicators for health products in health zones in 2025.

Indicator	ADD (PULL)	KTL (PUSH)	Statistical value	p-value
Delivery times and quality				
Mean delivery lead time (n = 17 facilities/zone)	20.88 days ± 1.59	8.23 days ± 1.34	$\beta = -12.65$ [-16.90 to -8.39]	0.001
Reduction in reported losses (n = 17 facilities/zone)	43.47%	56.52%	OR = 2.28 [0.52–9.99]	0.000
Average supply indicators				

Indicator	ADD (PULL)	KTL (PUSH)	Statistical value	p-value
Mean number of orders per health centre/month	1.77 ±0.15	2.81 ±0.14	–	0.000
Mean order cost per health centre/month	1,364,871 FCFA ± 364,669.8	1,506,264 FCFA ± 106,452.5	–	0.71
Mean distance travelled/month	10.74 km ±0.95	10.7 km ±0.63	–	0.964

### 3.3.2. Detailed Analysis of Processes

The PUSH model (KTL) showed higher overall performance than the PULL model (ADD) across all logistics processes. Differences were particularly pronounced for distribution processes (overall score: 93.27% versus 36.13%) and

quality assurance (100% versus 66.6%). Procurement and storage processes were broadly satisfactory under both models, but remained more effective in KTL, particularly with regard to adherence to order lead times, application of standard operating procedures, and warehouse organisation.

*Table 4. Technical aspects of processes applied under the PUSH and PULL models in 2025.*

Indicator	ADD (PULL)	KTL (PUSH)
Procurement process		
Planned orders	16/17 (94.1%)	17/17 (100%)
Orders submitted to correct supplier	17/17 (100%)	17/17 (100%)
Orders submitted on time	12/17 (70.6%)	17/17 (100%)
Procurement process compliance	17/17 (100%)	17/17 (100%)
Availability of tracer products	17/17 (100%)	17/17 (100%)
Single supply circuit	17/17 (100%)	17/17 (100%)
Overall procurement score	83.95%	98.4%
Storage process		
Twice-daily temperature recording of medicines	2/17 (11.8%)	3/17 (17.6%)
Functional air-conditioning unit available	1/17 (5.9%)	2/17 (11.8%)
Controlled access to depot	16/17 (94.1%)	17/17 (100%)
Stock rotation (FIFO/FEFO)	17/17 (100%)	17/17 (100%)
Storage organised in accordance with standards	14/17 (82.4%)	17/17 (100%)
Warehouse cleanliness	17/17 (100%)	17/17 (100%)
Application of SOPs for storage	10/17 (58.8%)	17/17 (100%)
Overall storage score	78.57%	82.77%
Distribution process		
Distribution plan in place	3/17 (17.6%)	16/17 (94.1%)
Products delivered to correct recipients	17/17 (100%)	17/17 (100%)
Adequate transport conditions	1/17 (5.9%)	15/17 (88.2%)
Overall distribution score	36.13%	93.27%
Quality assurance process		

Indicator	ADD (PULL)	KTL (PUSH)
Audits/quality checks conducted	0/17 (0%)	17/17 (100%)
Application of quality SOPs	17/17 (100%)	17/17 (100%)
Inventory verification	17/17 (100%)	17/17 (100%)
Overall quality assurance score	66.6%	100%

### 3.4. Detailed Structure of Outcomes

#### 3.4.1. Stakeholder Satisfaction and Perception

Stakeholder satisfaction differed significantly between the two models. In the KTL zone (PUSH), 12/17 managers reported satisfaction with logistics functioning, compared with 6/17 in ADD (PULL) (OR = 4.40; 95% CI [1.04–18.60];  $p = 0.044$ ). Interviews with stakeholders revealed that although challenges persisted in both zones, particularly regarding staffing, PUSH model stakeholders more frequently raised issues related to internal monitoring and management, whilst PULL model stakeholders cited systemic dysfunctions linked to delays, stockouts, and mismatches between orders and deliveries:

*"Deliveries are often delayed; this creates problems for us. We cannot plan our care properly. (Physician, ADD health zone)"*

*"We lack staff to manage products effectively. (Nurse, ADD health zone)"*

*"The quantity of medicines requested is not always available; one must often adapt, which is not easy. (Nurse, ADD health zone)"*

*health zone)"*

*"We do not have enough time to conduct proper inventory follow-up. (Physician, KTL health zone)"*

#### 3.4.2. Reduction in Losses and Waste

The PUSH model was associated with better preservation of product integrity. The proportion of facilities reporting a reduction in losses was 13/17 in KTL compared with 7/17 in ADD.

#### 3.4.3. Overall Component Performance

The PUSH model (KTL) demonstrated higher overall performance than the PULL model (ADD) (86.13% versus 71.0%, a difference of +15.13 percentage points), with particularly pronounced differences at the level of processes (+22.38) and outcomes (+24.44). The largest gains were observed in distribution (+57.14), quality assurance (+33.4), and cost reduction (+47.05). Inputs showed more moderate differences (+5.61), driven primarily by financial (+16.83) and material resources (+6.45), whilst human and informational resources remained broadly comparable across both zones.

**Table 5.** Overall performance of components for assessing the technical contribution of PUSH and PULL models in the two health zones in 2025.

Components / Sub-components	ADD zone (PULL)%	KTL zone (PUSH)%	Difference
<b>INPUTS</b>			
Human resources	69.9%	69.28%	-0.62
Material resources	67.50%	73.95%	+6.45
Financial resources	76.47%	93.30%	+16.83
Informational resources	100%	100%	0
Inputs score	74.60%	80.21%	+5.61
<b>PROCESSES</b>			
Procurement	83.95%	98.4%	+14.45
Storage	78.57%	82.77%	+4.2
Distribution	36.13%	93.27%	+57.14
Quality assurance	66.6%	100%	+33.4
Processes score	70.16%	92.54%	+22.38

Components / Sub-components	ADD zone (PULL)%	KTL zone (PUSH)%	Difference
OUTCOMES			
Product availability	100%	100%	0
Order integrity	100%	100%	0
Stakeholder satisfaction	35.3%	70.6%	+35.3
Cost reduction	35.3%	82.35%	+47.05
Reduction in losses	41.2%	76.47%	+35.27
Outcomes score	61.53%	85.97%	+24.44
OVERALL PERFORMANCE	71%	86.13%	+15.13

## 4. Discussion

### 4.1. Technical Contributions of the PUSH and PULL Models to Processes

The results demonstrated the superiority of the PUSH model for the processes component (92.54% versus 70.16%). This difference may be explained by several technical mechanisms. The centralised planning inherent in the PUSH model enables vertical coordination of deliveries and visibility over product flows, reducing the risk of delays or errors. Unlike the PULL model, in which each facility manually prepares its own orders, the PUSH model defines allocations in advance within an automated distribution plan. This centralisation translates into 100% compliance with procurement procedures in the KTL zone, alongside markedly superior performance in distribution (93.27% for KTL versus 36.13% for ADD). These findings are consistent with studies on the effectiveness of the PUSH model in vaccine supply chains, demonstrating better product availability, greater procedural compliance, and reduced stockouts attributable to centralised planning and flow visibility [1, 6, 7].

Storage also benefited from the PUSH model: 94.1% of KTL facilities adhered to storage standards compared with 64.7% in ADD. This difference may be explained by the availability of appropriate infrastructure (100% in KTL versus 76.5% in ADD) and regular stock monitoring, which was carried out in 88.2% of KTL facilities compared with 58.8% in ADD. The centralised supervision characteristic of the PUSH model facilitates more frequent checks and harmonised planning. This aligns with findings from studies demonstrating that the PUSH model improves compliance with storage standards and vaccine cold-chain quality through centralised monitoring and better-adapted infrastructure [1].

Quality assurance revealed the most significant disparity: 100% in KTL versus 66.6% in ADD. The PUSH model integrates quality control into the logistics process through per-de-

livery checks, audits, and monitoring of lead times and compliance. By contrast, the PULL model relies on variable self-monitoring conducted by the facilities themselves, limited to verification of delivery notes. This superiority of the PUSH model is corroborated by work demonstrating that centralised supervision and systematic control mechanisms improve the reliability and compliance of vaccine supply chains [3, 6].

These results should, however, be interpreted with caution. The high performance of the PUSH model observed in this study is closely linked to the existence of supervision, quality control, and regular monitoring of logistics indicators. In the absence of such mechanisms, centralisation could instead generate rigidity or mismatches between supply and local needs, as has been highlighted in evaluations of centralised systems poorly adapted to specific contexts [9, 10].

### 4.2. Impact on Availability and Stockouts

The reduction in mean delivery lead time in the KTL zone ( $\beta = -12.65$  days) was accompanied by a significant improvement in product availability (OR = 2.00). The PUSH model organises deliveries directly to health facilities according to a predefined schedule, eliminating the need for centres to place orders or travel to collect products. This efficiency is confirmed by several studies demonstrating that centralised planning and scheduled deliveries improve the availability of medicines and vaccines whilst reducing lead times and stockouts [6, 13].

The frequency of stockouts at patient visits fell from 68.52% in the PULL zone to 31.48% in the PUSH zone (OR = 0.21), representing a reduction of more than half. Mean stockout duration was reduced from 11.71 days to 2.1 days. These results are consistent with the experience in Senegal, where the PUSH model reduced contraceptive stockouts to below 2% [14].

### 4.3. Study Limitations

This study does not permit conclusions to be drawn regarding the superiority of the PUSH model across all dimensions of logistics performance. For certain indicators, notably costs

related to stockouts and time spent on logistics activities, the absence of repeated measurements precluded inferential statistical analysis, thereby limiting the scope of the conclusions.

## 5. Conclusions

The PUSH model significantly improves the efficiency of the health product supply chain in the Couffo department. The observed gains are reflected in greater product availability, a reduction in stockouts, shorter delivery lead times, and a substantial decrease in logistics costs. These results support the case for a progressive extension of the PUSH model to other health zones in Benin, whilst highlighting the need for appropriate technical and financial support to ensure its sustainability.

## Abbreviations

ADD	Aplahoue-Djakotomey-Dogbo
DRZS	Zonal Health Depot Distributors
FCFA	Franc de la Communauté Financière Africaine [Central African CFA Franc]
FEFO	First Expired First Out
FIFO	First In First Out
KTL	Klouekanme-Toviklin-Lalo
OR	Odds Ratio
PULL	Demand-driven Supply Model
PUSH	Forecast-driven Supply Model
SoBAPS	Beninese Health Product Supply Company
SOP	Standard Operating Procedure

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## Author Contributions

**Lamidhi Salami:** Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing

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## Data Availability Statement

The data supporting the outcome of this research work has been reported in this manuscript.

## Conflicts of Interest

The authors declare no conflicts of interest.

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## Biography

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## Research Field

**Lamidhi Salami:** Public health evaluation, health economics, health policy, vaccine supply chain management, health systems performance, logistics information systems, immunisation programme assessment

**Colette Azandjemey:** Nutrition and Public Health, health system, health promotion, nutrition epidemiology

**Charles Patrick Makoutode:** health policy and systems health, environmental management, health economics and financing, universal health coverage

**Yolaine Glele Ahanhanzo:** epidemiological survey design, biostatistics, health system, health information systems quality, and cohort study coordination

**Badirou Aguemon:** infectious disease epidemiology, malaria prevention and control, community health, and health system strengthening

**Edgard-Marius Ouendo:** systems performance, health policy, and global health, public health policy evaluation, and health logistics, epidemiology