

Strengthening cold chain maintenance systems in resource-constrained environments: insights from Nigeria

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VIEWPOINT

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Maintaining vaccines at optimal temperatures in resource-constrained environments, like Nigeria, presents significant challenges [1]. Strengthening cold chain systems is vital for ensuring reliable vaccine delivery to all communities, thus achieving universal health coverage, and reducing zero-dose children [2]. This article presents findings from a recent assessment across 12 Nigerian states and insights from the Cold Chain Data Hackathon Workshop held in Kenya [3], to offer advice on addressing the challenges of cold chain systems in low-resource settings.

Immunization is one of the most cost-effective public health interventions [4], yet vaccine-preventable diseases account for over 22% of childhood deaths in Nigeria and other low- and middle-income countries [5,6]. Inefficient cold chain systems lead to vaccine spoilage and wastage, undermining immunization efforts.

CHALLENGES IN COLD CHAIN MAINTENANCE: INSIGHTS FROM NIGERIA

Cold chain maintenance in Nigeria faces structural issues common to resource-limited settings. Aging equipment frequently fails to maintain optimal temperatures, with only 55.2% of state and 63.2% of local facilities currently functional [7]. Shortages of skilled technicians impede timely repairs, and lack of regular training can cause suboptimal use of tools and spare parts. Limited funding further restricts routine maintenance, reducing the availability of functional equipment. Additionally, poor data integration hampers diagnostics, and the absence of a decommissioning plan for unserviceable equipment further decreases efficiency. A phased approach prioritizing foundational maintenance, capacity building, and data integration is critical to reinforcing vaccine delivery and supporting continuous immunization across Nigeria.

PHASED APPROACH TO STRENGTHENING COLD CHAIN SYSTEMS

Countries must first invest in procuring high-quality cold chain equipment and replacing aging, obsolete models to establish a foundation of reliable, current-generation equipment. With this base in place, the next priority is to maintain the proper function of equipment through consistent maintenance, training, and reliable funding. Programs like the Gavi Cold Chain Equipment Optimization Platform [8] demonstrate how targeted investments in both equipment renewal and ongoing upkeep can reinforce long-term cold chain performance.

Next, the focus should shift to building a dependable maintenance capacity. This involves increasing the number of trained technicians, bolstering their skills through ongoing capacity-building initiatives, and maintaining an adequate inventory of spare parts.

Once equipment is in place and a regular maintenance schedule established, data integration becomes essential for optimizing maintenance efforts. Real-time data and system-wide analytics can enable predictive maintenance, enhance vaccine logistics and inventory management, and increase the overall efficiency and value of maintenance activities. This phased approach ensures cold chain systems operate at peak performance to safeguard immunization programs.

LEVERAGING DATA AND INNOVATIVE APPROACHES FOR MAINTENANCE

The Cold Chain Data Hackathon Workshop held in Nairobi, Kenya in 2024 illustrated the importance of combining foundational maintenance with data solutions to strengthen system resilience. Experiences from other countries highlight that digital tools are effective only when integrated with a solid maintenance foundation, for example:

- ▶ In Tanzania, real-time temperature monitoring succeeded because a maintenance infrastructure was in place, allowing swift responses to data-identified issues.
- ▶ In Uganda, the inventory system, based on ODK-X (free, open-source software), improved data collection and coordination in low-resource settings but relied on trained technicians and established maintenance protocols.

These examples reinforce that while data and predictive maintenance tools enhance efficiency, they cannot replace essential maintenance capabilities.

KANO STATE'S FLOATING ASSEMBLY MODEL: AN INNOVATIVE SOLUTION

Kano State in Nigeria has pioneered the Floating Assembly Maintenance Model to address cold chain maintenance challenges, with impressive results. In December 2020, the equipment functionality rate stood at 71%. After the Floating Assembly team began maintenance in three zones, this rate improved to 76% by December 2021, and between January and December 2022, equipment uptime reached a high of 89%. Although functionality dipped to 69% in 2023, likely due to resource constraints and system strain, it rebounded to 85% by October 2024.

The Floating Assembly team, consisting of 10 mobile engineers equipped with vehicles stocked with diagnostic tools and spare parts, enables efficient on-site repairs for over 1,400 facilities. By establishing a foundation of reliable equipment and a dedicated maintenance team, Kano's Floating Assembly exemplifies the phased approach required to build resilient cold chain systems. This initial investment in maintenance capacity has

driven sustainable improvements in functionality, even without advanced data tools. Now, with a strong foundation in place, Kano is well-positioned to integrate predictive analytics and real-time data tools as the next phases in cold chain optimization.

SCALING THE FLOATING ASSEMBLY MODEL

The Floating Assembly Maintenance Model could help optimize the cold chain maintenance landscape in Nigeria and beyond. Nigeria's cold chain infrastructure follows a hierarchical structure, with the National Strategic Cold Store at the top, supported by six Zonal Cold Stores, State Cold Stores, and over 19,000 health facilities. This extensive network, staffed by technicians across multiple levels, ensures operational continuity but requires robust maintenance strategies to remain effective.

Implementing the Floating Assembly Model at a national scale could strengthen each level of this structure, enhancing operational efficiency and reducing equipment downtime across all facility types.

To achieve this, it is essential to advocate for a well-resourced effort involving government agencies, donor organizations, and local communities. By demonstrating the model's success in Kano State and its potential to improve cold chain performance nationwide, Nigeria can take a leadership role in securing the necessary funding, equipment, and personnel to scale this model effectively.

Proper resourcing includes dedicated budgets for spare parts, fuel, maintenance supplies, and specialized training programs, as well as a reliable supply chain to ensure timely availability of necessary components. By investing in resources to support the Floating Assembly Model across Nigeria's hierarchical infrastructure, the country can establish a robust, sustainable maintenance system for its cold chain network.

REFERENCES

1. Ergetie FS, Kassaw AT, Sendekie AK. Vaccine cold chain management practices in primary health centers providing an expanded immunization program in Northwest Ethiopia: self-reported and actual practice observational study. *Front. Public Health* 2023; 11, 1194807.
2. Cattin M, Jonnalagedda S, Makohliso S, Schönenberger K. The status of refrigeration solutions for last mile vaccine delivery in low-income settings. *Vaccine X* 2022; 11, 100184.
3. Prosser W. Reimagining the last step of the cold chain in Africa. *JSI Health* Oct 11, 2024. <https://jsihealth.medium.com/reimagining-the-last-step-of-the-cold-chain-in-africa-a314a2bf86f8> (accessed Oct 2024).
4. Ashok A, Brison M, LeTallec Y. Improving cold chain systems: challenges and solutions. *Vaccine* 2017; 35(17), 2217–2223.
5. Immunization Agenda 2030 Partners. Immunization Agenda 2030: a global strategy to leave no one behind. *Vaccine* 2024; 42(Suppl. 1), S5–S14.
6. National Bureau of Statistics (NBS), UNICEF. Multiple Indicator Cluster Survey/National Immunization Coverage Survey Report. Aug 2022; UNICEF. <https://www.unicef.org/nigeria/reports/2021-multiple-indicator-cluster-survey-national-immunization-coverage-survey-report> (accessed Oct 2024).
7. Aina M. *National Cold Chain Equipment Inventory and Assessment—2023*. National Primary Healthcare Development Agency (NPHCDA).
8. Gavi. Cold Chain Equipment Optimization Platform (CCEOP) Evaluation. Sep 23, 2022. <https://www.gavi.org/our-impact/evaluation-studies/cceop-evaluation> (accessed Oct 2024).

BIOGRAPHY

TAHIR BUHARI is a global health program manager with over a decade of experience in leading high-impact health projects across Sub-Saharan Africa. Specializing in health systems strengthening, cold chain optimization, and immunization infrastructure for low-resource settings, he applies a phased approach, data-driven strategies, and sustainable maintenance models to enhance vaccine security and distribution systems. His recent work provides actionable insights into improving cold chain reliability and advancing safe vaccine delivery in challenging environments.

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AUTHORSHIP & CONFLICT OF INTEREST

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