

What Works Series: Rapid Evidence and Insights to Overcome Entrenched Obstacles to Immunization Coverage & Equity



ABOUT THIS SERIES

The goal of the What Works Series is to identify, review, synthesize, and share ways to overcome entrenched obstacles to improving immunization coverage and equity. We achieve this using root cause analysis (RCA) and rapid evidence synthesis.

Root cause analysis: Starting with an entrenched obstacle, bottleneck, or challenge, our team performs an RCA to identify its causes and root causes. Root cause analysis is a problemsolving tool that continually asks 'why?' about an observed challenge, drawing from multiple evidence sources to establish causes. This process helps us to identify a subset of root causes that, if resolved, could lead to significant improvements. In the RCA for supply chain challenges, we found that inadequate CCE maintenance was a significant cause of other problems.

Rapid evidence synthesis: This brief aims to collate and synthesize evidence on what works to overcome the identified root cause. We define evidence broadly, but start with a search of existing systematic reviews that relate directly or indirectly to the issue. We supplement this with grey literature, case studies, and tacit knowledge. We use a 'realist' lens to interpret and synthesize evidence that often comes from diverse sources and contexts.



Background

As immunization programs expand with the introduction of new vaccines and technologies, the role of the supply chain to ensure vaccines are available when and where they are needed has become even more critical. Immunization supply chains (iSC) consist of more than just the cold chain equipment (CCE) required to ensure vaccines are kept in their ideal temperature range. Human resources, data for action, transportation for distribution, cold chain maintenance, information management systems, and financial flows and management all work together to ensure that potent vaccines are available when and where they are needed.

The results of assessments from 90 countries over the last 10 years indicate that many of these supply chains are unreliable, inefficient, and under-performing.¹ One consistent trend across the countries is that the performance worsens the further down the supply chain, which ends at the health facility. The supply chain is unreliable not only because cold chain equipment capacity is constrained, but also due to human resource or process weaknesses, including inconsistent or inadequate maintenance, inconsistently monitored temperatures, and unreliable distribution systems. These poorly performing aspects of the iSC create obstacles to improving immunization coverage and reaching all zero-dose and under-immunized children.^{2,3}

Over the past decade, in recognition of the importance for an optimized iSC, significant investments have been made to improve its performance.⁴ Some of the improvements in areas such as new and optimal CCE have also revealed remaining gaps and obstacles in the supply chain system.

This brief focuses on a key entrenched obstacle to ensuring vaccine availability at the facility level: maintaining the cold chain system. Cold chain equipment maintenance is a particular challenge as it depends on many factors to ensure vaccines are kept in the ideal temperature range. It involves preventive maintenance, such as regularly cleaning the equipment, defrosting when necessary, and tracking the temperatures for reporting. This is often done by health care workers involved in the immunization program. In addition, well-trained cold chain technicians are needed to perform corrective maintenance when the equipment fails, shows signs of failure, or requires replacing parts.





ACTIONS NEEDED

Investments in cold chain equipment and immunization programs must go hand-in-hand with ongoing investments in maintenance to ensure that vaccines are kept in the ideal temperature range. Current maintenance systems and processes are falling short of expectation due to lack of funding, spare parts, and management. This requires immunization supply chain leaders to question the current systems and facilitate change for improvements. It is time for forward-thinking, disruptive maintenance models that apply new technologies and interventions based on a thorough understanding of the gaps in the current cold chain maintenance systems.

The Components of a Cold Chain System

Improving the maintenance system will not magically ensure that highquality vaccines are always available through an efficient and reliable supply chain, because there are many other influencers. However, this brief should complement the multiple efforts that focus on the other components of the cold chain system.

What Are the Root Causes of Inadequate CCE Maintenance?

This brief focuses on two key questions related to maintenance of the cold chain system:

- What are the key challenges to CCE maintenance?
- What are innovative approaches to strengthening the maintenance system to ensure highly performing CCE?

To set the context, Figure 1 (Components of a Cold Chain System) shows our working definition of a cold chain system. Cold chain equipment is at the center, yet multiple components are required to ensure it is functioning. The figure highlights many of the root causes of the failure of the different components of the system.

COMPONENTS

	MAINTENANCE PLAN	Often not adopted at sub-n	ational level
*	SPARE PARTS	Multiple brands of CCE req No inventory system Hard to get Unknown need	uire different spare parts
J	TEMPERATURE MONITORING	New technologies not avail	able or optimally used
î	DATA VISIBILITY & USE	Data on CCE are not used to Delays and/or inaccuracies	o drive action in reporting
.	LEADERSHIP/GOVERNANCE/POLICIES	Policies fall short of reinfo	rcing best practices
=	TRANSPORT	Often unavailable	
***	TRAINED TECHNICIANS	Parallel technicians across Inadequate system to supp Location of technicians	the MOH complicates maintenance ort technicians
	UPDATED CCE INVENTORY	Inventory is often outdated	or inaccurate
	FINANCIAL FLOW	Unknown CCE maintenance Maintenance plans do not l Funds are often unavailable	e costs nave budget e

COMMON FAILURES AND CAUSES

Findings and Successes to Date

Maintenance approaches have evolved, and immunization programs and partners supporting those programs have introduced different approaches and techniques to overcome these entrenched obstacles. Many of the efforts build the capacity of ministry of health (MOH) and Expanded Immunization Program (EPI) cold chain technicians and the system support "in-sourced" approach to maintenance. Other efforts use outsourcing to contract installation and/or maintenance services to private sector providers. The approaches highlighted here have been tried and tested; we include them so that others can consider and learn as they pursue similar goals.

Better Training and Capacity Strengthening for Technicians

Evidence from systematic reviews indicates that comprehensive approaches to capacity building (e.g., a job support aid plus training plus supervision) using adult-learning techniques are more effective at improving skills than single approaches alone.⁶

ColdTech in Malawi: An Accessible and Interactive Digital Job Support Tool

<u>VillageReach</u> and the Malawi MOH, with support from digital learning agency <u>Bull City Learning</u>, hosted a design workshop with cold chain technicians (CCT) from across central Malawi. The session pinpointed gaps in technical knowledge as a key barrier to equipment functioning. CCTs then helped design and develop an interactive video-based maintenance and repair application called ColdTech.

snapshot

RESULTS OF A CCE MAINTENANCE ASSESSMENT IN TANZANIA

This assessment was conducted in 2020 in 33 facilities in seven regions to understand maintenance practices and gaps in performance. Key findings include:

- Almost two-thirds of facilities (66%) reported that breakdowns generally get resolved within 3 days. If a breakdown escalates, it takes up to a month or more before being repaired.
- Many District Immunization and Vaccine Officers who are not CCE technicians are able to resolve minor corrective maintenance issues, such as replacing the cooling unit, electric heaters, banner, thermocouple, thermostat for absorption CCE, and gasket.
- The biggest barriers to maintenance, as reported by respondents, are lack of spare parts (47%); technical issues beyond expertise (22%); and lack of funds to support technicians to travel to the facilities (17%).⁵

ColdTech is designed through Moodle, a flexible, open-source learning platform that facilitates content addition and removal. The ColdTech application and content are loaded onto tablets or smartphone devices, providing videos and reference documents that can guide CCE maintenance activities anytime. The ability of ColdTech to be used offline once the content is downloaded makes this application suitable for use in last-mile settings where network connectivity is limited and inconsistent.

Technicians involved in the development of ColdTech and those who have begun using it appreciate the availability of this job support at their fingertips.

Immunization Academy Training Resources: Refresher Videos to Reinforce Formal Trainings

Immunization Academy (IA) has developed a series of short videos, which provide practical information on maintaining different types of CCE, basic preventive maintenance, and how to monitor CCE temperatures at a facility level.

The IA provides a wealth of information and practical guidance for CCE maintenance. Users need reliable internet access for the 2–6 minute videos, which reinforce knowledge and expertise gained through more formal training and experience. IA's Facebook page comments indicate that viewers appreciate the information and are sharing it with colleagues.

🗴 ព័ះរ៍ Temperature Monitoring, Data Visibility, and Use

Data are more likely to be used to inform program decisions when they are timely and available to decision-makers. Strategies that make real-time temperature data easily available with clear cues to action are most likely to result in the right decision.⁷

Temperature monitoring technology has advanced dramatically in the past decade, providing more opportunity for real-time data into temperature excursions in the cold chain and supporting more evidence-based decisions:

- Vaccine vial monitors (VVM) register cumulative heat exposure over time, informing health workers, when monitored, whether the vaccine can be safely used for immunization.
- Remote temperature monitoring devices (RTMDs) send SMS alerts to health workers when there is a temperature excursion outside the ideal temperature range, which can drive immediate action. Data are sent to a dashboard for real-time reporting and monitoring. Cold chain equipment with built-in RTMD is becoming more widely available; RTMD that are installed separately are also prominent and useful for existing equipment.
- 30-day temperature recorders (30DTR) have been the norm for more than 10 years and provide a reliable and relatively inexpensive way to monitor temperatures. New applications, such as the <u>Varo</u> and the <u>Pogo apps</u>, allow data from the 30DTR to be easily shared using a smart phone and uploaded to a dashboard for visualizations and reports that can drive action.



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Systems Approach: Trained Technicians, Data Visibility and Use, Leadership & Governance, Spare Parts, Maintenance Plans

Complex systems—such as cold chain systems—benefit from multi-component intervention packages designed using systems thinking and an implementation science lens. To improve a cold chain system, it is essential to understand all the challenges and how they relate.

- The national immunization program in Uganda has paid particular attention to strengthening its CCE maintenance system. With support from <u>PATH</u>, the government has increased staffing and training of district technicians and technical assistants; developed maintenance plans, checklists, and tracking system for spare parts utilization; and established WhatsApp groups for peer networking and problem solving.
- To complement these efforts, the University of Washington, with PATH and VillageReach, has developed the <u>Cold Chain</u> <u>Application</u> using the ODK-X platform. The application manages CCE inventory and maintenance at health facilities across the country. It helps keep cold chain inventories updated in near real-time to provide actionable data such as CCE location, functional status, and spare parts needed. The tool unifies facility, CCE, and maintenance and repair logs in one app and helps enforce data standardization across the program.

Leadership, Governance, and Policies

There is limited evidence on the effects of contracting health systems functions to the private sector, but there is agreement that the outcomes depend on a variety of factors related to context, the underlying health systems performance, and the structure of the contract.^{8,9,10}

- In 2010, the Vietnam National Immunization Program <u>outsourced</u> CCE preventive and corrective maintenance services to a private contractor. One of the goals was to assist the immunization program with the development and implementation of a countrywide EPI equipment maintenance plan to ensure functionality and sustainable management, and to establish planned preventive maintenance (PPM) services to ensure the cost-effective operation of the CCE. An additional responsibility of the contractor was training more than 1,400 district- and community-level EPI staff on CCE maintenance services. The services provided annual scheduled PPM visits and as-needed corrective maintenance. Stakeholders noted that maintenance data gained from the three-year contract helped EPI plan maintenance costs and required human resources for a sustainable maintenance system as the government took back maintenance responsibility at the end of the project.
- In Nigeria, <u>Project Last Mile</u> used the cold chain expertise of Coca-Cola and an outsourced private-sector maintenance company to improve uptime and maintenance of vaccine CCE. The outsourced company trained government CCE technicians in preventive maintenance, repaired the non-functional CCE in Lagos state, and provided preventive maintenance to the large majority of other units in the state. Repairs from the pilot contributed to a 16% increase in available capacity and 100% equipment uptime across the 15 areas where the pilot was conducted. Despite these achievements, efforts have shifted to building internal capacity for technicians and the maintenance system.
- Through Gavi's Cold Chain Equipment Optimization Platform, UNICEF has developed a service bundle provider approach by which CCE manufacturers are responsible for arranging in-country providers for CCE installation, training government staff, and responding to equipment warranty issues. The concept has shown to ensure quick installation and staff training on the new equipment.

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Emerging Ideas for Re-designing Maintenance Systems

With new technologies and learnings from previous experience maintaining the cold chain, we have the opportunity to challenge our current thinking and approaches to CCE maintenance to push for an efficient and effective system that will protect investments in immunization programs and cold chain systems. Presented here are emerging ideas and areas to explore for re-designing maintenance systems. This is not to say these approaches will work in every country or every region of a country; tailored approaches, even at subnational level, that take into account technical capacity, resources, and all of the components of the cold chain system are always preferred and more likely to succeed. All changes must be based on a clear understanding of the gaps in the current maintenance system and the areas needing improvement. Artificial intelligent technologies can find patterns and interdependencies between variables that would otherwise be missed by traditional methods. Leveraging AI through real-time performance monitoring will optimize maintenance, minimize downtime, and, ultimately, maximize productivity.

– Deloitte

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Emerging ideas and areas to explore for both incremental and disruptive change to improve maintenance:

Predictive maintenance

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With 30DTR and RTMD widely in use, a wealth of real-time or near real-time accurate data are available but currently underused. Most immunization cold chain systems are based on preventive maintenance or run-to-failure modes, as described by Deloitte.¹¹ With the amount of data that decision makers can now access, however, maintenance can shift from reactive to predictive. Advanced technology and analysis can transform these data into decision-driven insights on equipment performance. Analyzing complex patterns and trends in the data, while linking to the relationships between the components of the cold chain system, can identify immediate maintenance actions that need to be taken, in addition to predicting future failures before they happen. This analysis can be supported in the backend of software with the aim of sending timely cues to action to key decision-makers. This approach has been applied in a practical study in Uganda and Mozambique, bringing together CCTs and data analysts to identify maintenance issues.¹² Predictive maintenance can improve planning, budgeting, and response time to increase equipment uptime and avoid breakdowns.

Linking across sectors to optimize cold chain use and maintenance.

The immunization supply chain was initially created in a somewhat siloed approach tailored to the cold chain requirement of vaccines. Unfortunately, this created blinders to the many other resources that could be leveraged to strengthen the cold chain system and maintenance. For example:

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Technical capacity. Immunization programs have largely focused on building capacity of their in-house technicians for cold chain
preventive and corrective maintenance, working in parallel to other government entities responsible for all health equipment
maintenance. Often, the contracting mechanism between government entities for this type of service can be too complicated and
bureaucratic to be efficient, which hinders collaboration.

Beyond government technicians, private sector technicians could also be used for maintenance. Private sector entities maintain refrigerators, air conditioners, and walk-in cold rooms for the agriculture sector and other health areas and markets. Outsourcing maintenance to private sector companies has largely focused only on vaccine cold chain. Economies of scale, however, could be found through geographic-focused technicians across the equipment spectrum.

There is technical capacity for maintaining the cold chain and there are many regional opportunities to increase that capacity, including the non-traditional approach with USAID's <u>Youth Workforce Development and Higher Education</u> program, which could be tailored to develop the skills of CCTs with a market creation approach for skilled technicians across types of equipment. We need to leverage that expertise and build the market for qualified technicians across the range of equipment for a paid-for-service approach, and build the government's capacity to manage outsourced contracts.

• Leveraging CCE. Immunization programs have procured and installed new equipment to greatly scale up their cold chain capacity, especially over the past five years. While extremely beneficial for mitigating cold chain constraints, this new equipment adds to long-term maintenance requirements and cold chain system support. While there has been some integration of other cold chain pharmaceutical products (such as oxytocin)¹³ into the vaccine cold chain and some talk of integrating vaccines into central medical stores, the talk falls short of the broader availability and use of CCE across sectors. One example is the agriculture sector, particularly the flower industry, which requires a cold chain. With the right standards in place and adherence to WHO's performance, quality, and safety (PQS) standards for procurement of immunization supplies, immunization programs could leverage these other cold chain spaces or lease unused vaccine cold space to other sectors (with the proper standards for sanitizing for any transition of products) as a business-generating activity. This would bring economies of scale to the overall cold chain system in a country and reduce the maintenance burden on the immunization program.

A different approach to outsourcing

When immunization programs have outsourced CCE maintenance, private sector companies with trained technicians are hired and managed by the company to ensure CCE performance. While this can be effective, it often leaves the government technicians without work yet still on the government payroll due to hiring policies. The challenge with an 'in-sourced' system is the system itself, not the technicians. The system lacks the ability to schedule and implement regular preventive maintenance trips or respond to a break down and have a vehicle, per diem, and spare parts available when and where required. Instead of outsourcing maintenance, consider outsourcing the project management aspect of CCE maintenance, using the government-trained technicians while using a private sector firm to provide the "nuts and bolts" required for maintenance to happen. Managed service providers, flexed staffing models, and software solutions have been used in the private sector for this type of approach. Very different from current approaches, it would require some proof-of-concept to demonstrate the benefits, challenges, and potential utility of outsourcing the project management side of maintenance while leaving the technical expertise in the hands of the government.

Understanding true costs of a maintenance system

As noted, often countries lack an budget that reflects the true need of annual PPM visits and corrective maintenance costs. While tools exist to estimate these costs, such as PATH's Total Cost of Ownership Calculator, the next step is to validate the estimates against reality. Data visibility must be factored into what is available and develop forward-looking budgets that weigh the cost benefits of investing in CCE maintenance to ensure the performance of the cold chain for its entire expected lifetime, thus reducing costs overall.

Expanding global cold chain partnerships

CCTs and immunization programs can learn a lot about CCE maintenance and management from a larger group of partners. Groups like the <u>Global Cold Chain Alliance</u> convene experts and industry specialists to share ideas and innovations, network and educate, and contribute to a stronger cold chain. While this group and others are mostly focused on agriculture and the food industry, its technical knowledge and innovations are applicable to the vaccine cold chain.

COUNTRY-LEVEL DECISION MAKERS	GLOBAL STAKEHOLDERS				
Predictive Maintenance					
Incorporate RTMD and 30DTR data into regular data review processes Work with CCTs and data analysis team to identify trends in CCE performance to improve maintenance practices	 Support use of data for predictive maintenance Track key indicators for improved maintenance practices Develop practical guidance for CCE maintenance based on data analytics 				
Leveraging Technical Capacity					
Explore contracting mechanisms across government sectors to leverage expertise Build capacity to outsource maintenance and manage contracts	 Design projects that encourage cross-sector collaboration for equipment maintenance Provide support and guidance for managing outsourced contracts Track key indicators for private sector engagement for outsourcing 				
Leveraging Cold Chain Equipment					
Map cold chain equipment across existing sectors; establish clear standards and protocols if shared equipment is an option Conduct market analysis for potential collaboration and/or lease options as a business-generation model	 Design projects to leverage equipment across sectors 				
Different Approach to Outsourcing					
Develop a proof-of-concept for managed services provider	 Develop guidance and support managed services provider for maintenance 				
True Costs of Maintenance					
Conduct a cost analysis of CCE maintenance	 Require accurate and evidence-based budgets for maintenance in any project 				
Global Cold C	hain Partnershins				

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- Explore the possibility of engaging in global alliance groups as an institution or as individuals
- · Engage in global alliance groups to broaden knowledge and expertise on CCE

Final Thoughts

What we have seen time and time again is that when global attention and resources are focused on a topic, improvements can be made. Mostly this has been seen with big challenges such as reducing malaria, ending HIV, and eradicating polio. These have been big topics that easily grab people's attention. With all the investments in CCE and vaccines, resources are needed to improve maintenance, which extends equipment life and minimizes disruptions in vaccine availability. It's time to invest attention and resources into CCE maintenance to ensure the cold chain stays cold. This requires forward-thinking and innovative models to remove entrenched obstacles for cold chain maintenance.



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