System redesign of the immunization supply chain: Experiences from Benin and Mozambique ☆

Wendy Prosser [a,*], Philippe Jaillard [b], Emmanuelle Assy [c], Shawn T. Brown [d], Graça Matsinhe [e], Mawutondji Dekoun [f], Bruce Y. Lee [g]

[a] VillageReach, Seattle, WA, USA
[b] Agence de Médecine Préventive (AMP), Paris, France
[c] Agence de Médecine Préventive (AMP), Cotonou, Benin
[d] Pittsburgh Supercomputer Center, Carnegie Mellon University, Pittsburgh, PA, USA
[e] Mozambique Ministry of Health, Maputo, Mozambique
[f] UNICEF, Cotonou, Benin
[g] Department of International Health, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD, USA

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ABSTRACT

Introduction: Evidence suggests that immunization supply chains are becoming outdated and unable to deliver needed vaccines due to growing populations and new vaccine introductions. Redesigning a supply chain could result in meeting current demands.
Methods: The Ministries of Health in Benin in Mozambique recognized known barriers to the immunization supply chain and undertook a system redesign to address those barriers. Changes were made to introduce an informed push system while consolidating storage points, introducing transport loops, and increasing human resource capacity for distribution. Evaluations were completed in each country.
Results: Evaluation in each country indicated improved performance of the supply chain. The Effective Vaccine Management (EVM) assessment in Benin documented notable improvements in the distribution criteria of the tool, increasing from 40% to 100% at the district level. In Mozambique, results showed reduced stockouts at health facility level from 79% at baseline to less than 1% at endline. Coverage rates of DTP3 also increased from 68.9% to 92.8%.
Discussion: Benin and Mozambique are undertaking system redesign in order to respond to constraints identified in the vaccine supply chain. Results and learnings show improvements in supply chain performance and make a strong case for system redesign. These countries demonstrate the feasibility of system redesign for other countries considering how to address outdated supply chains.

1. Background

Evidence suggests that immunization supply chains (iSC) are becoming outdated and unable to deliver needed vaccines due to growing populations and new vaccine introductions. According to the Gavi Vaccine Alliance analysis of recent Effective Vaccine Management (EVM) assessments in 57 countries, the majority do not meet the WHO recommended 80% score across most of the nine categories of supply chain management, with results particularly low for the categories of stock management, maintenance, and distribution [1]. Studies also show that the standard four-tier design of the iSC could be simplified and tailored to the country context

to reduce operating costs and reduce redundancies of storage locations and transport routes [2]. Interest in improved iSC is gaining traction globally as thought leaders have called for vaccine supply systems to be strengthened and optimized in order to be more efficient and effective to respond to current growing populations and vaccine demand [3]. A system redesign can alter the structure of the supply chain through reducing distribution tiers, shifting warehouse locations, or changing transport routes to create a dynamic, efficient, data-driven supply chain [4].

The Ministries of Health (MoH) in Benin and Mozambique have undertaken system redesign activities to address the underperforming iSC. In Benin in 2011, the MoH was faced with a strained iSC with insufficient cold chain capacity due to the introduction of pneumococcal conjugate vaccine (PCV) and the impending introduction of Rotavirus vaccine [5,6]. In Mozambique in 2002, according to administrative data, the northern province of Cabo

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Table 1
Original design of the vaccine distribution system, Benin and Mozambique.

Benin	Mozambique
National depot	National warehouse
7 department stores and one regional store	9 provincial level stores
80 sub-district level stores	128 district level stores
763 health facilities	1392 health facilities

Delgado had a vaccine coverage rate lower than the national average and was reportedly experiencing challenges in the iSC including frequent health facility vaccine stockouts, unreliable transportation, uncoordinated vaccine supply requirements, and lack of data.

The distribution systems in both countries were originally designed with four tiers (Table 1). In Benin, the national level uses cold trucks to deliver to some department stores with the remaining department stores using 4 × 4 trucks to fetch vaccines from the national level. The sub-district level stores use 4 × 4 trucks to fetch from the department level, and the health facilities use motorbikes to fetch from sub-districts. In Mozambique, the national level uses air cargo to deliver the vaccines to the six central and northern provinces while the three southern provinces use 4 × 4 trucks to fetch the vaccines from the national warehouse. Provinces are responsible for delivering to the district level using 4 × 4 trucks; the district level is responsible for ensuring vaccine availability at health facilities, either through delivery with 4 × 4 or health workers fetching the vaccines using public transport.

This paper documents the system redesign process from introduction of demonstration projects through evaluation and compares results between these two countries to estimate the feasibility for replication in other countries.

2. Benin

2.1. Benin: methods

The MoH's National Agency for Vaccination and Primary Healthcare (ANV-SSP) engaged a technical team, including Agence de Médecine Préventive (AMP), the HERMES Logistics Modeling Team, PATH, and Transaid, for system redesign. A baseline assessment of iSC performance was conducted using the EVM assessment, updated national cold chain equipment inventory, a cost analysis including EPI staff time related to logistics, and assessment of the MoH transport management capacity. During a July 2012 workshop, national and global partners used the baseline assessment to identify three alternative supply chain designs to model [7].

The HERMES (Highly Extensible Resource for Modeling Supply Chains) simulation modeling tool was used to explore the impact of the three alternative designs on product availability and logistics cost per dose in the hypothesis of Rota vaccine introduction. The

HERMES tool generates detailed discrete-event simulation models to compare efficiencies across system designs as described in previous publications [8–11]. Modeling results demonstrated that the most efficient system redesign for Benin involves consolidating sub-district vaccine stores to one district vaccine store and introducing truck loops. As previously reported, the modeling results predict that this design would increase vaccine availability from 71% to 99% and reduces the logistics cost per dose from $0.26 USD to $0.19 USD [5].

Following MoH approval and using the modeling results, a demonstration project started in November 2013, in Comé district in Mono-Couffo department with the approved supply chain design. The project installed highly performing cold chain equipment and introduced the informed push system with monthly direct delivery from district to the 37 health facilities using real-time data from those facilities for determining the required quantity of vaccines. To build a cadre of supply chain managers, a district level logistician was trained and tasked with collecting vaccines from the regional store; conducting monthly visits to each health facility for vaccine distribution, safety box collection and data collection; providing supportive supervision; and analyzing data for improved distribution planning. Eighty health facility vaccinators also received refresher training.

After a year of implementation, an external EVM assessment was conducted in 2014 by UNICEF in Comé and a control district to evaluate the impact of the system design changes to iSC performance. The EVM uses a survey tool to monitor and assess in-country iSC performance in order to provide guidance for improvements. These results were compared to the 2012 EVM as baseline. A cost analysis study, using ingredient based approach and a stratified random sample, was conducted to evaluate the costs associated with implementing the alternative design. A qualitative anthropologic assessment was conducted in 2015, using 62 semi-structured interviews of a purposive sample of key stakeholders at central, region and service level, to evaluate the professional changes introduced by the demonstration project.

2.2. Benin: results

The results of the evaluation indicated improved EVM scores in comparison with the control district and with the baseline. The EVM performance score at the district level significantly improved between baseline and endline in Comé, particularly in the focus criteria of the pilot: the distribution score increased from 40% to 100%; vaccine management practices increased from 58% to 94%; and infrastructure increased from 55% to 94% with the procurement of improved cold chain equipment. Comé district also scored higher than the control district in all criteria areas, most notably in distribution (100% compared to 32%) and vaccine management practices (94% compared to 63%) (Table 2).

Improvements were also noted at the health facility level in seven out of eight criteria, and results exceeded the recommended

Table 2
Consolidated performance score of EVM at district level, Benin.

EVM criteria	2012: Baseline sub-district depot Comé district (%)	2014: Endline district depot Comé district (%)	2014: District depot control district (%)
Temperature monitoring	74	81	67
Storage capacity	52	89	75
Infrastructure	55	94	94
Maintenance	64	79	6
Stock management	54	70	63
Distribution	40	100	32
Vaccine management practices	58	94	63
MIS & supportive functions	73	71	53