Vaccine supply chain system design: An overview of promising developments in Benin.

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Abstract
A December 2008 external review of Benin's Expanded Program on Immunization (EPI) found that at least 15% of children were not receiving the complete set of recommended vaccinations. The introduction of pneumococcal conjugate (PCV13) vaccine in 2010 further strained the system and forced the country to increase transport methods in order to cope. When faced with new vaccine initiatives in 2012, the Ministry of Health decided to comprehensively review the vaccine supply chain – this was a case of system design intervention.

The vaccine supply chain was analyzed using HERMES – Highly Extensible Resource for Modeling Supply Chains software, to explore optimal system design interventions. Computer simulations were used to determine the effect of alterations in supply chain levels, number and location of storage points, transport devices and routing on cost and availability of vaccines. Four simulation scenarios were documented namely; consolidating the commune level to a health zone level, removing commune levels completely, removing the commune level and expanding to twelve department stores and adding shipping loops during delivery.

Overall, the option of completely removing the commune level stores had the same capital costs as the option of consolidating the commune level stores into health zonal stores but the health zonal store scenario had lower operating costs and was a preferred option.
Following stakeholder consultations, two major system design interventions were agreed for the country: consolidation of fragmented commune stores into one vaccine storage point at health zone or district level and informed push distribution model and delivery loops for vaccine distribution to centers. These interventions were piloted in Come district of Benin as a proof of concept. Evaluation of this pilot is underway.

Therefore, computational modeling facilitated vaccine supply chain system redesign to address challenges of low vaccine coverage and increased infrastructure capacity requirements which could arise from introduction of new vaccines in Benin.

Key words

- Commodity
  - Vaccines
- Industry
  - Pharmaceutical
- System Design Strategy
  - Network redesign
  - Informed push
- Country- Benin
- Key Partners and stakeholders
  - UNICEF
  - GAVI
  - AMP
- Supply Chain Level
  - National
  - Provincial
  - Sub-regional

1. Background

A December 2008 external review of Benin's Expanded Program on Immunization (EPI) found that at least 15% of children were not receiving the complete set of recommended vaccinations, as measured by estimated coverage of diphtheria tetanus pertussis (DPT) third dose. The introduction of pneumococcal conjugate (PCV13) vaccine in 2010 further strained the system and forced the country to increase transport methods in order to cope. When faced with new vaccine initiatives in 2012, the Ministry of Health decided to comprehensively review the vaccine supply chain – this was a case of system design intervention. By then, the vaccine supply chain consisted of four levels; one (1) national warehouse, seven (7) departmental stores one of which was run as a regional store, eighty (80) commune level stores, and seven hundred sixty three (763) health posts. Each of the lower level health facilities and stores was responsible for picking vaccines from the upper storage points. Figure below illustrates the original vaccine supply chain structure in Benin.

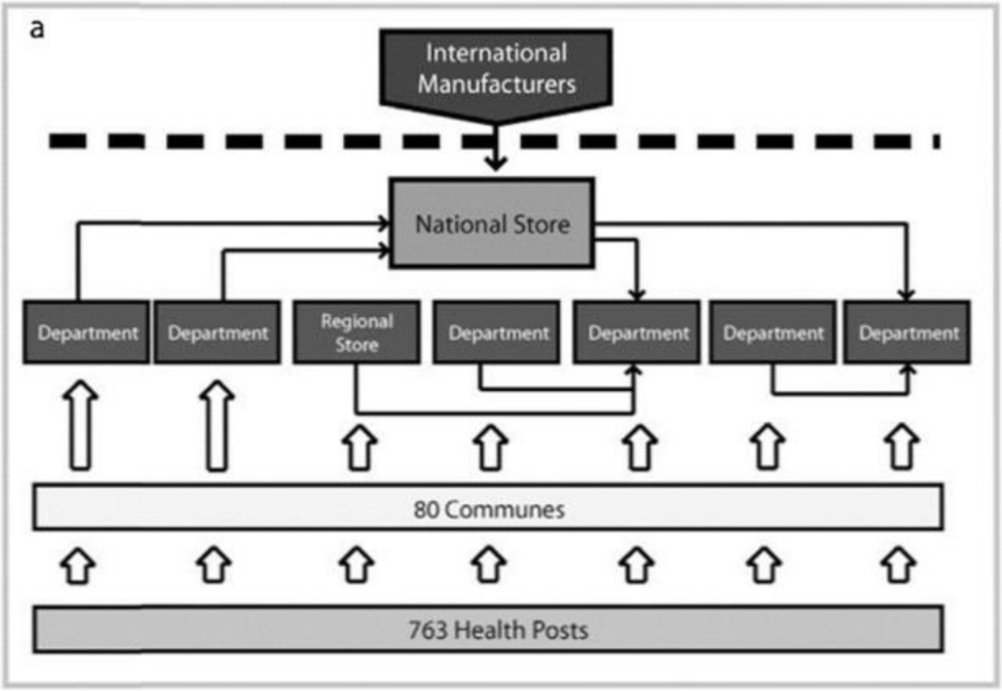

Figure 1: Original vaccine supply chain in Benin

2. System Design intervention

The vaccine supply chain was analyzed using HERMES – Highly Extensible Resource for Modeling Supply Chains software, to explore optimal system design interventions. Computer simulations were used to determine the effect of alterations in supply chain levels, number and location of storage points, transport devices and routing on cost and availability of vaccines (Brown, et al., 2014). Four simulation scenarios were documented:

a) Consolidating the commune level to a health zone level

The first scenario explored was consolidating the 80 commune stores into 34 health zone level store that were already under use for other health commodities. This scenario would keep the supply chain levels at four but reduce on the number of storage points at level 3 of the supply chain. Figure 2 below illustrates this scenario.

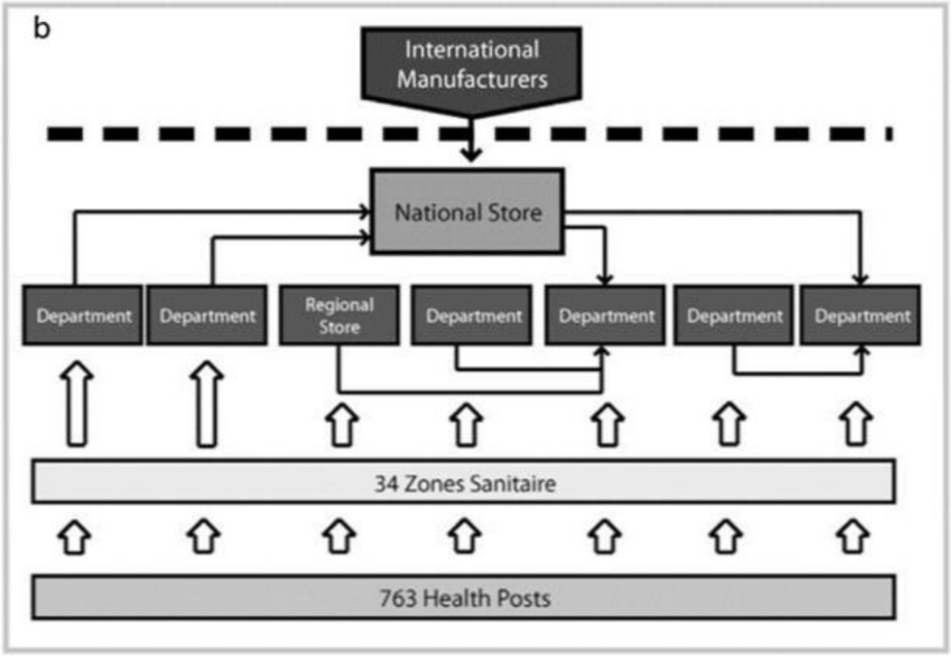

Figure 2: Consolidating the commune stores into zonal stores

b) Removing commune levels completely

The second scenario completely removed the commune level such that the health posts were directly served by the departmental stores. This reduced the levels of the supply chain from four to three because it removed level 3 of the supply chain. Figure 3 below illustrates this scenario.

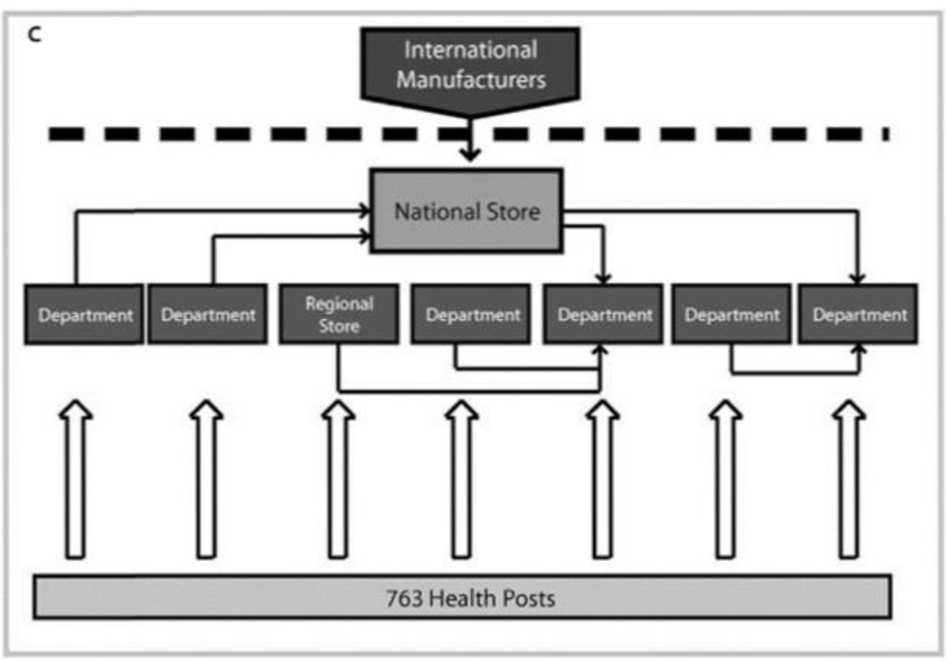

Figure 3: Removing the commune stores

c) Removing the commune level and expanding to 12 department stores

The third option looked at the impact of increasing the number of department stores to 12 on top of removing the commune level. This would involve creation of 5 more departmental stores. Figure 4 below illustrates this scenario.

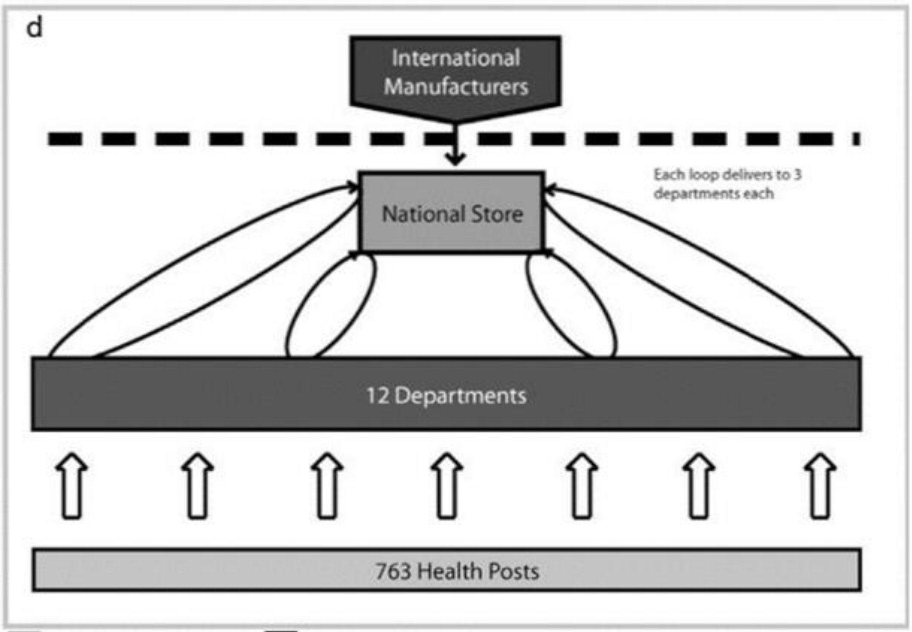

Figure 4: Removing the commune store and increasing departmental stores to 12

d) Adding shipping loops during delivery

For each scenario network configuration, they explored the impact of replacing current transport routes at the lowest level (i.e. motorcycles to pick supplies from the health post and lower storage points to pick vaccine and supplies from above) with a 4X4 truck that would start at the higher storage point and serve multiple health posts and storage points while following a shipping loop.

3. Key performance indicators

The indicators used to measure performance of the vaccine supply chain were capital expenditure, operational expenditure, logistics cost per dose and vaccine availability.

a) Capital expenditure

Estimates for capital expenditure were obtained from the 2009 Benin comprehensive multiyear plan (cMYP). Estimates were made of what it would cost to set up new storage points and change transport devices, using figures included in the existing multiyear plan.

b) Operational expenditure

Operational expenditure was estimated from the 2009 Benin cMYP and other data collected including information on Human Resource, vaccine stock over one year, cold chain equipment type and specifications, transport mode, distribution frequency, and routes followed through the supply chain.

c) Logistics cost per dose

Logistics cost per dose of vaccine was estimated using annual cost of labor, storage, transport and building. Please see illustration below:

Logistics cost = total annual logistics cost / annual number of vaccine doses administered to persons arriving at a health post for vaccination

Total cost = Annual cost of labor + Annual cost of storage + Annual cost of transport + Annual cost of building.

Annual unit labor cost = cost of employee annual salary & benefits X % of time dedicated to vaccine logistics

Annual unit storage cost = cost of storage device unit energy + cost of storage device unit maintenance + cost of storage device unit depreciation.

Annual unit transport costs:
Cost of transport route = cost per km X distance traveled + cost of perdiems per route

Cost per km = Cost of vehicle maintenance per km + cost of vehicle depreciation per km + cost of fuel per km

Cost of fuel per km = cost of fuel per litre / distance covered per litre

Annual unit building costs = (cost of annual depreciation + annual utilities) X % of building utilized for vaccines

d) Vaccine availability

Vaccine availability was taken as the proportion (percentage) of number of people vaccinated to total number of vaccination opportunities.

Vaccine availability = number of people vaccinated / Total number of vaccination opportunities

4. Results

a) Baseline

New vaccine introductions would increase logistics cost per dose from USD0.23 to USD0.26. It would also drop vaccine availability to 71%. Adding shipping loops to the current structure did not yield cost savings.

b) Consolidating the commune level to a health zone level

Consolidating the 80 commune stores into 34 zonal stores slightly increased overall vaccine availability and raised logistics cost from USD0.23 to USD0.29. Replacing lower transport system with shipping loops dropped logistics cost to USD0.18 to USD0.19 depending on the number of health posts served per truck.

c) Removing commune levels completely

Simply removing the commune level increased vaccine availability from 93% to 96% and the logistics cost dropped from USD0.26 to USD0.25. Replacing lower transport system with shipping loops at lower level would decrease logistics cost to between USD0.22 to USD0.19 depending on the number of health posts served per truck.

d) **Removing the commune level and expanding to 12 department stores**

Expanding to a total of 12 department stores on top of removing the commune level stores increased vaccine availability to 99%. However, the capital expenditure associated with this option was unfavorable.

5. Lessons Learned

- Simulations using computational modeling identified the best combination of structural configurations to optimize supply chain performance.
- The best option for optimizing supply chain performance involved a combination of variations of storage points, transport devices and routing.

6. Next steps

Two major system design interventions were agreed for the country: consolidation of fragmented commune stores into one vaccine storage point at health zone or district level and informed push distribution model and delivery loops for vaccine distribution to centers. These interventions were piloted in Come district of Benin as a proof of concept. Evaluation of this pilot is underway.

7. Conclusion

Overall, the option of completely removing the commune level stores had the same capital costs as the option of consolidating the commune level stores into health zonal stores but the health zonal store scenario had lower operating costs and was a preferred option. Therefore, computational modeling facilitated vaccine supply chain system redesign to address challenges of low vaccine coverage and increased infrastructure capacity requirements which could arise from introduction of new vaccines in Benin.

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