Strengthening Vaccination Delivery with Geographic Information System In Northern Nigeria

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Abstracts

In many developing countries, poor infrastructure, late deliveries of life-saving communities, cumbersome paper-based systems for reporting and logistics, make health systems unable to ensure availability and distribution of vaccines and other commodities to health facilities.

Another biggest challenges face are effective and efficient distribution of vaccines and dry commodities from state coldstore to health facilities at the ward level. The service provides quality data and reporting to aid decision making regarding planning, scheduling and routing optimization which improve general vaccine management and reporting.

One of the primary challenges facing routine immunization (RI) in northern Nigeria is a poor vaccine supply chain system which causes consistently high stock out levels. High stock out levels occur when vaccines are not delivered on time and are exacerbated by limited cold chain equipment (CCE) to keep the vaccinations viable. High stock out levels cause low RI coverage because there are fewer vaccines available when needed.

By leveraging on Geographic and information systems (GIS) capabilities to optimize delivery routes, vehicle routing problems, and monitoring vaccination process with the integration of geospatial data for planning effective and efficient distribution of vaccines from National coldstores, zonal coldstores, state coldstores, primary facilities and child facilities to health facilities at the ward level. Over 26,000 vaccines has successfully been delivered and about 22 Million antigens and dry goods moved from inception, in the Northern Nigeria.

Keywords:
Vaccines, Route Optimization and Geographic and Information Systems

Brief Introduction:

Vaccination and Immunization are two of the most important public health interventions and constitute a cost effective strategy to reduce both the morbidity and mortality associated with infectious disease and an intervention critical to assuring the health of children and communities. In 2015, about 86% (116 million) of infants worldwide received 3 doses of vaccines, protecting them against infectious diseases that can cause serious illness and disability or be fatal.

In Nigeria, routine vaccination coverage for all recommended vaccines has remained poor though there has been gradual rise in vaccination coverage from 21% of eligible children in 2003 to 25% a decade later. Factors that seem to have contributed to poor routine immunization performance include; ineffective supply chains, poor delivery of services, scarce human resources, low demand for health services, funding gaps, accountability issues and weak governance, not to mention poor data quality.

GIS help make the communities where these children live visible and accounted for in the health system, and therefore offers an important tool to fulfil the rights of children and achieve equitable vaccination coverage. The full potential of GIS for planning, monitoring, and evaluation of immunization programs is far from being realized.

Equation, Mathematics

The formation of the TSP by Dantzig, Fulkerson and Johnson was extended to create the two index vaccine flow formulations for vaccine routing problem.

$$\min \sum_{i \varepsilon v} \sum_{j \varepsilon v} c_{ij} x_{ij}$$

subject to

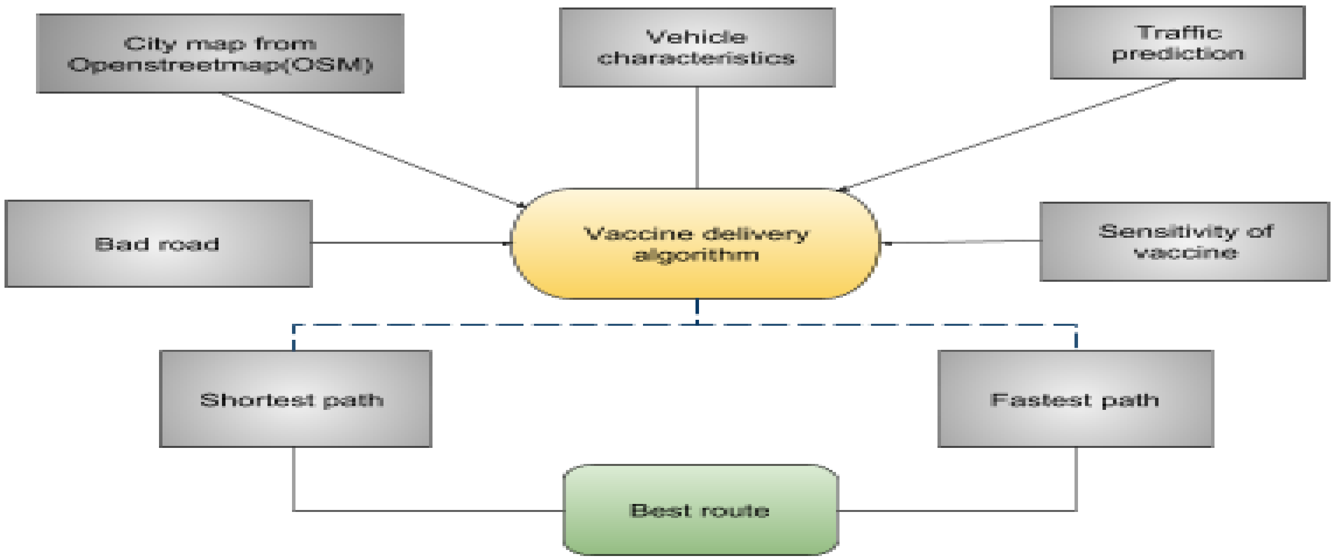
$$\sum_{i \varepsilon v} x_{ij} = 1 \; ; \; \sum_{j \varepsilon v} x_{ij} = 1 \; ; \; \sum_{i \varepsilon v} x_{i0} = \mathrm{k} \; ; \; \sum_{j \varepsilon v} x_{0j} = \mathrm{k}$$

$$\sum_{i \in S} \sum_{j \varepsilon S} x_{ij} \geq \mathrm{r(S)}, \; \forall S \subseteq V \setminus \{0\}, \mathrm{S} \neq \theta$$

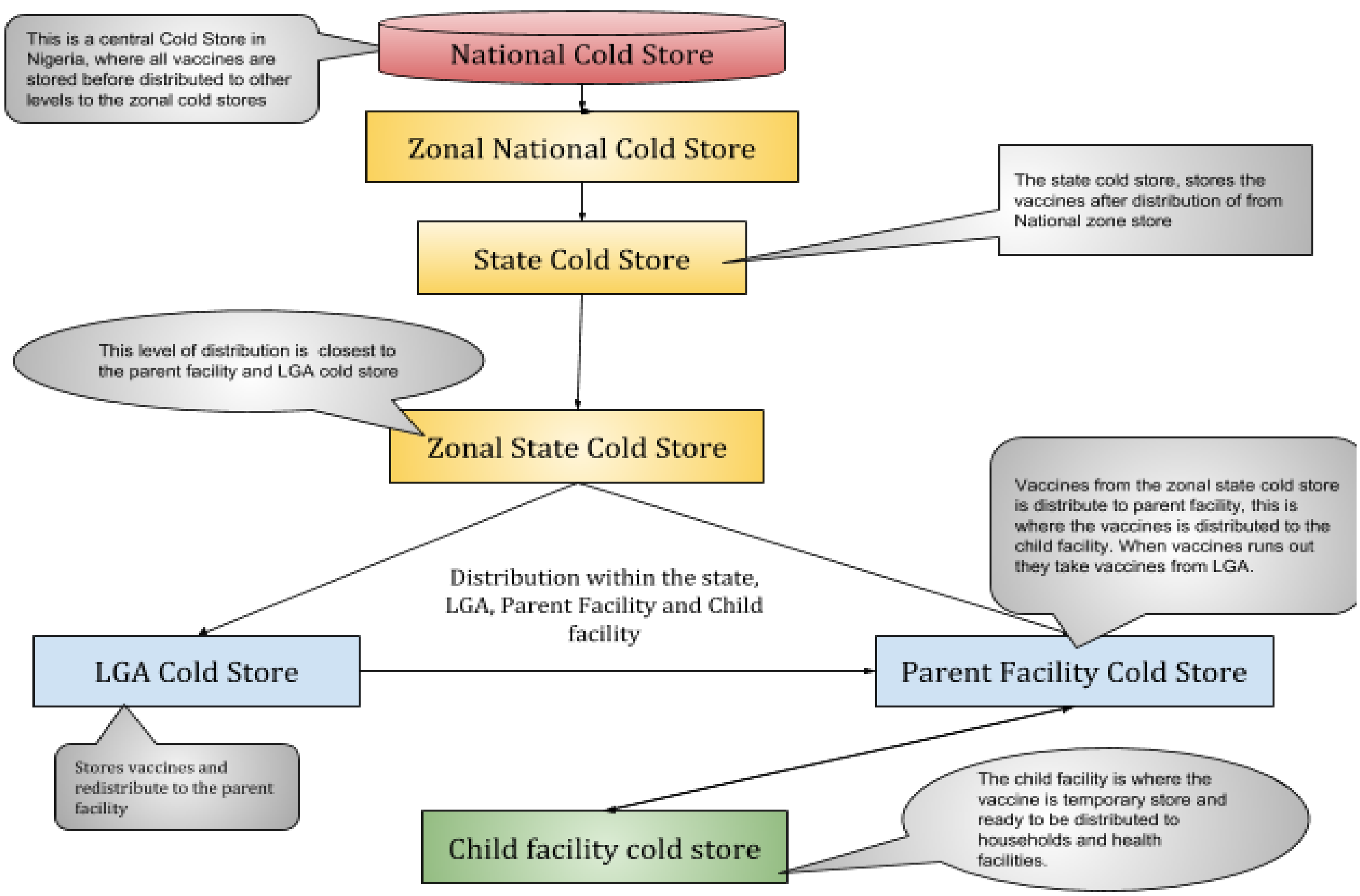
$$x_{ij} \varepsilon \{0, 1\} \quad \forall i, j \; \varepsilon \; V$$

Constraints 1 and 2 state that exactly one arc enters one leaves each vertex associated with a health facilities, respectively. Constraints 3 and 4 say the number of vehicle leaving with vaccines from the cold store is the same as the number entering.

Conceptual Framework

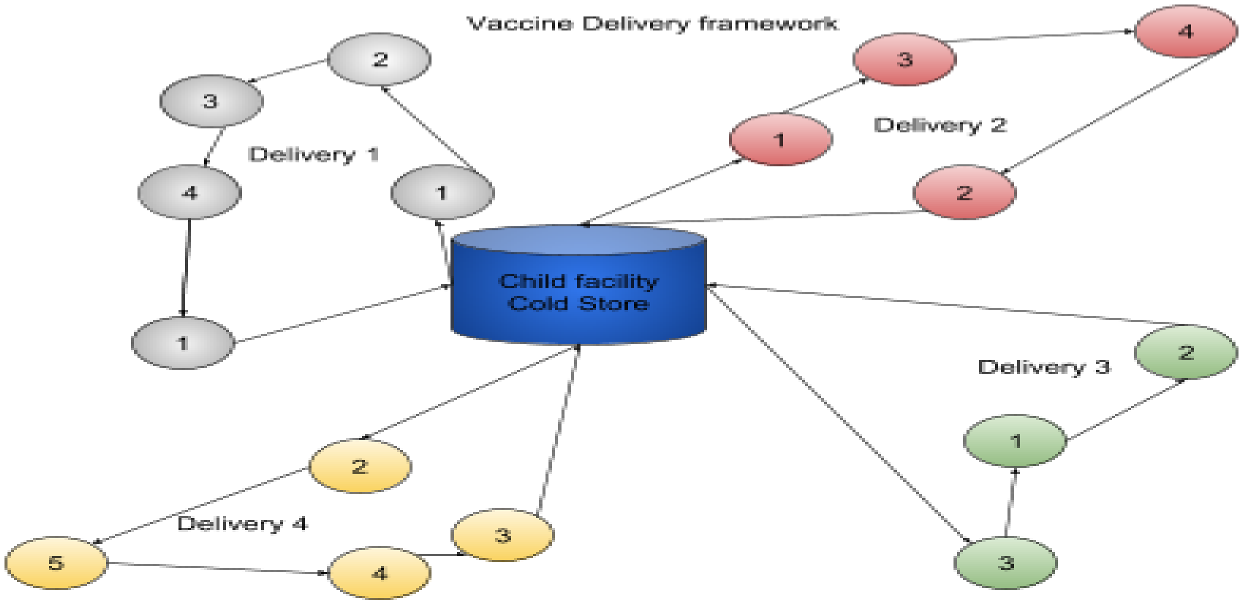


Vaccine storage and distribution amongst cold store across various regions:



The child facility is the cold store where the vaccination/immunization delivery collects vaccines from. When it run out of vaccines, it goes to the LGA cold stores to collect vaccines.

Vaccine Logistic delivery framework



The logistics of vaccine delivery:

The child facility cold store is most of the time situated at the center of the region of the vaccination campaign. With a proximity buffers to assist in the decision. Routing optimization, assist in determination of estimated delivery time, cost allocation, distance covered and total time taken for the vaccination.

How is the Vaccine delivery Coverage estimation?

The Geographic coverage on VTS actually gathers 2 indicators:

- The Cumulative % Visited (for the various settlement types) means the percentage of smallest denominators (i.e. grid squares for urban areas, or buffered points for small settlements and hamlets) that have intersected at least once with a team's GPS tracks.
- The Total % Visited calculates the average Cumulative % Visited across all settlement types.

GPS positions are collected every 2 minutes, but only GPS tracks that satisfy the following rules are considered valid:

- Urban and small settlements areas:
  - tracks are within the campaign days, and
  - between 5AM and 6PM, and
  - the speed at the capture time is less than 1 meter per second.
- Hamlet areas:
  - tracks are within the campaign days, and
  - between 5AM and 6PM

Reference

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