Routine and On-Demand Medical Drone Delivery to Remote, Hard-to Reach Health Facilities in DR Congo: Endline Evaluation Results

Prof Joel Konde / Kinshasa School of Public Health
Louis Tshituka & Gabriella Ailstock / VillageReach
Location: Equateur Province (103,902 km²)

Scope: Began in Dec 2020, now supplying 40 health facilities via 24 landing sites

- Bi-directional drone network is one of the largest in the world: 37,445 km²
- Drone hub ~30 min by road from provincial warehouse
- BVLOS flights of 15-60 min, landing at the remote facilities
- Drone battery change (stopover) for longer distances (> 115 km)
DRC Routine Drone Transport: Primarily 20 Immunization Products & Lab Samples

**Monthly & on demand transportation for 40 communities:**
1. Exclusive drone transportation for immunization products
2. Lab samples & reports
3. Emergency orders of other products

**Outsourcing drone transportation to Swoop Aero:**
- Bi-directional, electric, VTOL drones
- 3 kg & 5.4 L capacity
- 90-115 km/hr, 115km range
- **Satellite connectivity and visual targets for areas without mobile access**
- Fully local drone team

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Results to Date: Jan 2021 - Oct 2022

4,216 flights in 329 days
1,637 product deliveries both ways

1,907 flight hours
192,263 km flown

40 health facilities served via 24 drone-landing sites

1,592 kg of health products delivered

287,367 vaccine doses delivered
105,634 diluents + 172,538 syringes + 17,462 adaptors

353 lab samples collected

In addition to supplying the full monthly quantities of Routine Immunization products needed in 40 communities, drones delivered yellow fever vaccines on-demand during a mass vaccination campaign & picked-up samples during Ebola outbreak.
Drone transport: Evaluations in DRC

VillageReach’s approach to evaluating the Drones for Health solution

Performance evaluation

Robust holistic evidence

Economic evaluation
Performance Evaluation: Drones in DRC

Presenters
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Louis Tshituka / VillageReach

Co-authors
Luciana Maxim, Dr Archimede Makaya, Freddy Nkosi, Dr Olivier Defawe / VillageReach
Dr Gabriel Kyomba Kalombe / KSPH
Dr Nicole A Hoff / UCLA
Evaluation Objectives & Methodology

Study type: Single-group, with before and after (drone) measurements; mixed methods

1. Routine (or on-demand) deliveries of vaccines
   - Does the drone transport system perform as expected in delivering products to and from remote health facilities?

2. Supplementary delivery of other products (lab samples, PPE, medicines)
   - How effective has the introduction of drones been in improving the productivity and capacity of health workers?

3. Health staff capacity
   - How does the use of drones to transport health products influence attitudes of community members and patients?

4. Community perceptions
   - Has the drone program contributed to improved timeliness of supply chain data & to evidence-based decision-making?

5. Data for decision-making
   - Does the usage of drones influence the number of children being vaccinated?

6. Vaccination coverage
Evaluation Objectives & Methodology

1. Routine deliveries of vaccines

2. Supplementary delivery of other products (lab samples, PPE, medicines)

3. Health staff capacity

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Does the drone transport system perform as expected in delivering products to and from remote health facilities?

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How does the use of drones to transport health products influence attitudes of community members and patients?

Has the drone program contributed to improved timeliness of supply chain data & to evidence-based decision-making?

Does the usage of drones influence the number of children being vaccinated?
Data Collection Plan & Timelines

Baseline
Completed
Nov-Dec 2020

Midline 1
Completed
June 2021

Midline 2
Completed
Jan-Feb 2022

Endline
Completed
July-Aug 2022

Drone flights started
end Dec 2020

April-Sept 2021 (6 months)
25 drone landing sites

Jan-May 2021 (3-5 months)
12 drone landing sites

Jan-Dec 2021 (3-12 months)
19 drone landing sites

Jan 2021-Jun 2022
(6-18 months)
24 drone landing sites

Served indirectly:
16 satellite sites
(total 40 health facilities)

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Results: Higher availability of immunization products in remote facilities + faster transport after drone introduction

### KEY INDICATORS

<table>
<thead>
<tr>
<th>Hard-to-reach health facilities (drone landing sites)</th>
<th>Baseline Apr – Sep 2020</th>
<th>Target</th>
<th>Endline Jan – Jun 2022</th>
<th>Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vaccine availability (last 3 months)</td>
<td>65%</td>
<td>80%</td>
<td>98%</td>
<td>↑</td>
</tr>
<tr>
<td>% facilities with stockouts</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Pentavalent</td>
<td>6%</td>
<td>0%</td>
<td>0%</td>
<td>↑</td>
</tr>
<tr>
<td>• Measles</td>
<td>12%</td>
<td>0%</td>
<td>4%</td>
<td>↑</td>
</tr>
<tr>
<td>• Yellow fever (last 3 months)</td>
<td>18%</td>
<td>0%</td>
<td>0%</td>
<td>↑</td>
</tr>
<tr>
<td>% facilities taking 2+ days to get vaccines</td>
<td>65%</td>
<td>0%</td>
<td>0%</td>
<td>↑</td>
</tr>
<tr>
<td>% facilities stocked according to plan</td>
<td>32%</td>
<td>80%</td>
<td>98%</td>
<td>↑</td>
</tr>
<tr>
<td>% AFP samples received at provincial EPI within 2 days (Drones and ground transport)</td>
<td>35%</td>
<td>80%</td>
<td>69%</td>
<td>↑</td>
</tr>
</tbody>
</table>

Endline evaluation results are consistent with prior trends seen in the 1st and 2nd midterm evaluations (data collected over 18 months)
Results: High product availability & satisfaction with drones, but vaccinations depend on many other factors

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<th>KEY INDICATORS</th>
<th>Baseline Apr – Sep 2020</th>
<th>Endline Jan – Jun 2022</th>
<th>Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of vaccination sessions conducted according to plan</td>
<td>85%</td>
<td>85%</td>
<td></td>
</tr>
<tr>
<td>Vaccine coverage</td>
<td>94.2%</td>
<td>92.3%</td>
<td></td>
</tr>
<tr>
<td>Health workers satisfaction • Very satisfied &amp; satisfied</td>
<td>n/a</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>Community satisfaction</td>
<td>n/a qualitative indicator</td>
<td>Strong support</td>
<td></td>
</tr>
</tbody>
</table>

- Key challenge: 6-month health worker strike (Aug 2021-Jan 2022) meant fewer vaccinations happening, even though products were available
- Although there was no change in % of vaccination sessions conducted according to plan, more vaccination sessions were planned and conducted after drone introduction.
Evaluation Limitations

- No control group
  - However, drones were the exclusive means of transport for RI products in these communities, plausibly linking improved availability to drones
- Small sample size of facilities
  - 3 rounds of data collection over 18 months showed same trends increased confidence in results
- Availability & quality of health facility data
  - Triangulation of data from: Household surveys, health worker interviews, community FGDs

Results Limitations

- Ebola, COVID and 6-month strike of health personnel impacted vaccination indicators
- Ground transport as back-up for drones during temporary pauses in service helped maintain high product availability
- Lack of drone equipment, inconsistent flight authorizations, among other factors led to ~60% OTIF deliveries
Economic Evaluation Methodology

1. **Start-up costs**
   - Secondary analysis of VillageReach financial records to identify costs of introducing the D4H intervention uncaptured in iSC costing.

2. **iSC Costing**
   - Adapted USAID | DELIVER activity-based supply chain costing of the D4H network pre and post intervention.

3. **Cost-effectiveness Analysis (CEA)**
   - Cost-effectiveness analysis conducted utilizing a multi-component performance metric, weighted based off DRC stakeholder preferences.

4. **Non-EPI transport services**
   - Secondary analysis of VillageReach financial records and performance evaluation results to estimate cost of additional services beyond EPI product transportation.

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### Component

<table>
<thead>
<tr>
<th>Component</th>
<th>Scope</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administrative level</td>
<td>- Sub-national: Equateur Province</td>
</tr>
<tr>
<td>Supply Chain Type</td>
<td>- Routine Immunization Supply Chain</td>
</tr>
<tr>
<td>Analysis Period</td>
<td>- Baseline: April - Sep 2020</td>
</tr>
<tr>
<td></td>
<td>- Endline: Jan - June 2022</td>
</tr>
<tr>
<td>Facilities in drone network</td>
<td>- Provincial EPI warehouse: 1</td>
</tr>
<tr>
<td></td>
<td>- Health Zone EPI (district equivalent): 18</td>
</tr>
<tr>
<td></td>
<td>- Hard-to-reach health centers: 23</td>
</tr>
<tr>
<td></td>
<td>- Hard-to-reach satellite health centers: 16</td>
</tr>
</tbody>
</table>
iSC cost summary: pre and post D4H intervention

Total Annual iSC Cost Comparison – Traditional vs. Complementary Drone Transport (pre vs. post)

<table>
<thead>
<tr>
<th>Cost and Performance Summary</th>
<th>iSC Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baseline</strong></td>
<td><strong>Endline</strong></td>
</tr>
<tr>
<td>Total cost</td>
<td>$150,368</td>
</tr>
<tr>
<td>Cost/dose</td>
<td>$0.58</td>
</tr>
<tr>
<td>Vx availability</td>
<td>65%</td>
</tr>
</tbody>
</table>

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Drone transportation introduced cost savings at the Health Zone and Health Center Levels

Baseline Zone n=18
- Management: $6,005
- Storage: $13,549
- Transport: $8,039
- Total: $27,593

Endline Zone n=18
- Management: $1,651
- Storage: $8,921
- Transport: $0
- Total: $11,573

Baseline Health Center n=39
- Management: $0
- Storage: $36,174
- Transport: $59,434
- Total: $95,608

Endline Health Center n=39
- Management: $0
- Storage: $0
- Transport: $19,650
- Total: $19,650

Cost savings: 70%
Cost-Effectiveness Analysis: Stakeholder Weighted Performance Metric
### Cost-Effectiveness Analysis: Stakeholder Weighted Performance Metric

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<th>Endline 2022</th>
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<td>Speed &amp; Responsiveness</td>
<td>% of samples arrived on time</td>
<td>10%</td>
<td>69%</td>
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<td>Product Availability</td>
<td>Vaccine availability</td>
<td>65%</td>
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<td>Health Impact</td>
<td>% of FOSA with 2+ days of time required to collect/receive vaccines</td>
<td>65%</td>
<td>0%</td>
</tr>
<tr>
<td>Equity of Access</td>
<td></td>
<td>--</td>
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</tr>
<tr>
<td>Reliability</td>
<td></td>
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<tr>
<td>Data Quality &amp; Visibility</td>
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<tr>
<td>Cost Efficiency</td>
<td>Cost per dose</td>
<td>$0.58</td>
<td>$1.84</td>
</tr>
<tr>
<td>Scope of Activities &amp; Outputs</td>
<td>Average throughput</td>
<td>$265,916</td>
<td>$268,847</td>
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<td>Risk of Product/Potency Loss</td>
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<td>--</td>
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<td>Effectiveness</td>
<td>Multi-metric score (%)</td>
<td>21%</td>
<td>48%</td>
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The current drone iSC configuration (endline) has higher total effectiveness score but also a higher cost per unit effectiveness, equating to baseline being more cost-effective.

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<tr>
<td>Cost-Effectiveness</td>
<td>Cost ($K) per % of effectiveness</td>
<td>7.16</td>
<td>10.04</td>
</tr>
</tbody>
</table>
Potential for cost-effectiveness through optimized supply chain design
Potential for cost-effectiveness through optimized supply chain design

If operational bottlenecks causing low asset utilization are addressed, it can provide us the flexibility to optimize the supply chain design to reduce cost, with a high potential for future cost-effectiveness.

<table>
<thead>
<tr>
<th></th>
<th>Baseline 2020</th>
<th>Endline 2022</th>
<th>Improved Endline (bi-monthly delivery)</th>
<th>Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cost</strong></td>
<td>$0.58</td>
<td>$1.84</td>
<td>$1.19</td>
<td>~x2</td>
</tr>
<tr>
<td><strong>Cost per dose</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>6.50</td>
<td></td>
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<td><strong>Cost ($K) per % of</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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25
Reaching cost-effectiveness through new market development strategies

CURRENT STATUS

Drone logistics are **not financially sustainable** for public health markets

- Public health
- Customers funding start-up costs (MoH or donors)
- Single customer paying for all recurring costs
- One-pricing strategy for customers
- Small scale leading to high unit costs
- No economies of scale

NEW STRATEGY

Cost-competitive & sustainable pricing for the public health market

- Public & Private health, agriculture, logistics, postal, maritime, disaster response, etc.
- Drone service providers **fund** start-up costs in new markets
- **Multiple customers** to spread recurring costs amongst
- **Market-driven pricing strategy** for cost-sensitive customer
- **Large scale** leading to lower unit costs
- **Economies of scale**
Utilizing this Evidence for Action
Interpretation & Conclusion

- Eliminated stockouts and ensured more consistent availability of vaccines in remote facilities
- Decreased duration of transport
- More timely arrival of lab samples
- More vaccination sessions conducted
- Drones are well accepted by health workers, community members and community leaders
- Possible to achieve results in very remote areas with no communication
- Drone performance expected to continue to improve
- System not optimized for cost but large potential for reductions
DRC Strategic recommendation:
Drone technology & transport utilization must continue improving to reach optimal performance and cost-efficiency

-----Challenges-----

- Non-flexible scheduling
  - Connectivity makes on-demand transportation unrealistic
  - Weather limitations

- Regulatory processes

- Asset availability

-----Mitigation-----

- Optimized scheduling & drone network configuration for flexibility
  - Utilize more on-demand transport for facilities with connectivity
  - Increase technology robustness

- Annual approvals & move drone hub closer to provincial warehouses

- Improved maintenance & supply chain capacity
Global strategic recommendations

**Products Suited for Drone Delivery:**
- Light Weight
- Cold Chain Dependent
- Short Shelf Life
- High Cost

**Products Suited for Land-Based Delivery:**
- Bulky
- Not Cold Chain Dependent
- Long Shelf Life
- Low Cost

Hard-to-Reach and Remote Facilities

Frequent & On-Demand

Less Frequent & Scheduled
Thank you to our sponsors

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