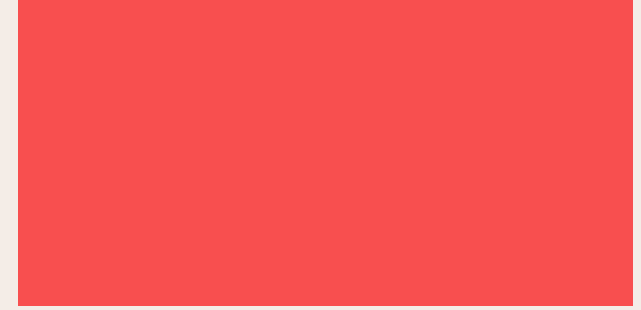


June 2023

Session: Alternative mechanism to improving infection prevention and control in health facilities through onsite production of Chlorine



THE REPUBLIC OF UGANDA
MINISTRY OF HEALTH



June 2023

Onsite chlorine generation for Ugandan health care facilities

MOH and PATH collaboration on evidence generation and national introduction of the Aqua Research STREAM Disinfectant Generator



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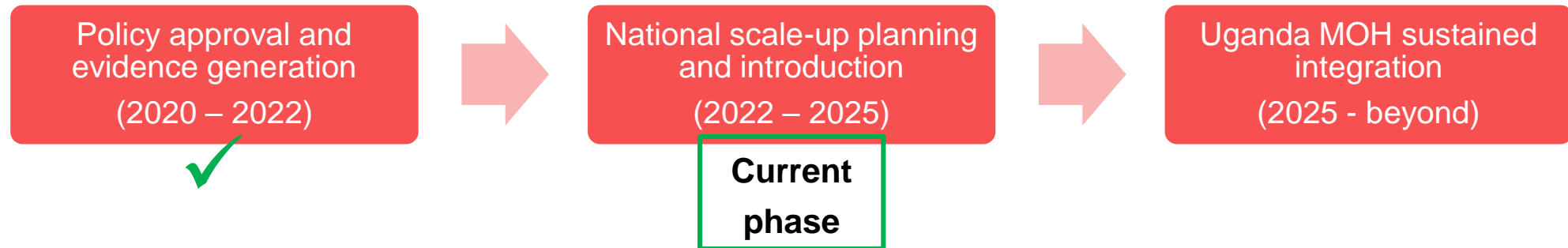


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7. Acknowledgement

Introduction

The Uganda MOH Clinical Services Department in partnership with PATH have been working to strengthen Infection Prevention and Control practices and reduce the burden of hospital acquired infections by **introducing and evaluating** the Aqua Research STREAM disinfectant generator (STREAM) into the Ugandan healthcare system through an initial pilot.



Primary question we were addressing:

- **Can the STREAM improve IPC practices in health facilities and to what degree?**

→ To answer this question, PATH and the MOH/CSD piloted 10 STREAM units in 10 health facilities in Central, Western & South Western regions to evaluate performance, chlorine availability, cost, and device acceptability.



Background

- HAI prevalence rates have been shown to range from **28-34%** in Uganda healthcare facilities.^{1, 2}
- Some HAIs reported in Uganda include; surgical site infections, pneumonia, gastroenteritis and episiotomy infections([Saito et al 2015](#); [Saito et al 2017](#))
- **Nosocomial pathogens like S. aureus & VRE** are primarily transmitted directly (delivery bed, linen) or indirectly (provider hands, instruments, etc). These pathogens can be inactivated by chlorine and proper IPC practices. ([CDC 2019](#); [Suleyman et al 2018](#)).
- **Most HAIs are preventable** and can be reduced by up to **70%** with effective IPC programs³
- Chlorine is recommended in the **Uganda National Guidelines for WASH in Health Facilities (2022)** for disinfection of surfaces, patient environments, medical equipment, linen and water treatment.⁵



NATIONAL GUIDELINES FOR WASH IN HEALTH CARE FACILITIES

IN UGANDA



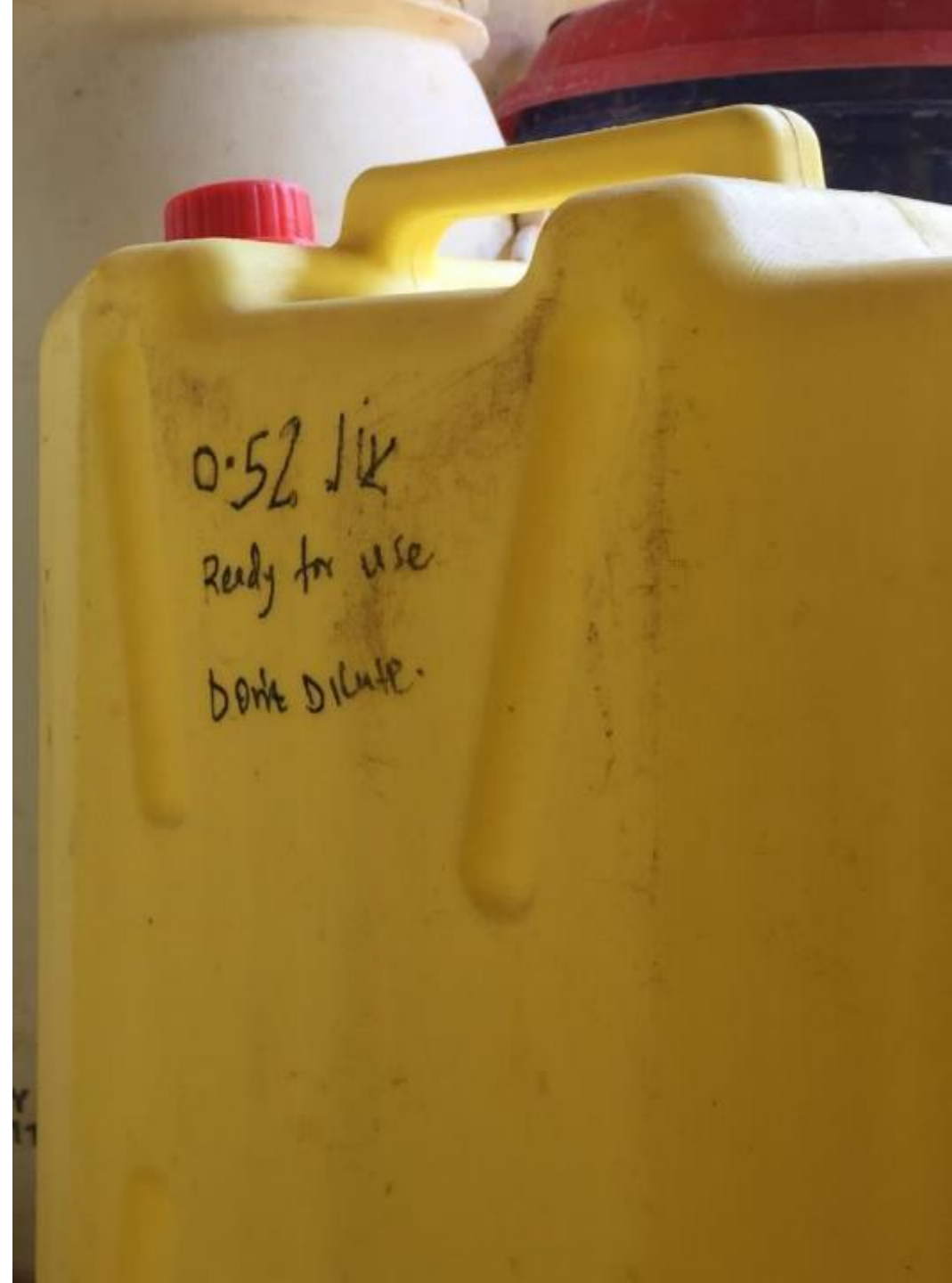
2022

PATH
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Background

- Yet, despite these guidelines, chlorine is **not consistently available**
 - A survey of 10 Ugandan HCFs in 2019 found they face on average of **74 days per year (25.8 – 132.3 days)** without chlorine.
- **Chlorine quality** (degradation of concentration) and **challenges with dilution calculations** due to varying chlorine stock concentration (3% to 70%) pose additional challenges.
- **Root causes** include erratic supply chains, transportation challenges, limited forecasting and insufficient budgets, varying concentrations and dilution calculation challenges.



Aqua Research STREAM Disinfectant Generator

The STREAM Disinfectant Generator provides a continuous flow of 0.5% hypochlorite solution generated from common salt (NaCl) and water through electrolysis.

Chlorine concentration (FAC)	0.5%
Brine salinity	15 g/L
Chlorine production rate	4.8 L/hour
Chlorine generation mode	Continuous
Drinking water treatment rate	Up to 230,000 L per day
Input power	110/220 V AC, 2 A, 50/60 Hz, 12 V DC, 16 A
System weight	8.2 kg
Dimensions	42 x 33 x 17.3 cm

Abbreviation: FAC, free available chlorine.



Photo credit: Aqua Research, LLC

STREAM evaluation

A total of 10 STREAM devices were launched in 10 HCFs* in the Central, Western and South Western regions of Uganda

Objectives

1. Validate the performance of the STREAM
2. Assess the level of acceptability of the STREAM
3. Assess effect of the STREAM on chlorine availability and stock outs
4. Assess effect of the STREAM on chlorine supply costs

Location

Facility level	Western	Central	TOTAL
Regional referral hospital	0	1	1
District hospital	1	2	3
Health centre IV	2	1	3
Health centre III	3	0	3
TOTAL	6	4	10

Period: December 2020 - present

Key study participants

- Health facility administrators
- In-charge nurses
- STREAM device operators
- STREAM chlorine users
- STREAM maintenance staff

Study approvals

- MHREC 2076 (22 APR 2021)
- UNCST HS1467ES (28 JUL 2021)



***As part of Ebola response in 2022, two additional devices was deployed to Entebbe RRH and Mulago NRH**

Abbreviations: HCF, health care facility; MHREC, Makerere University, School of Health Sciences Research and Ethics Committee; UNCST, Uganda National Council for Science and Technology.



Results

Results

1. Health facilities face significant chlorine stockout periods

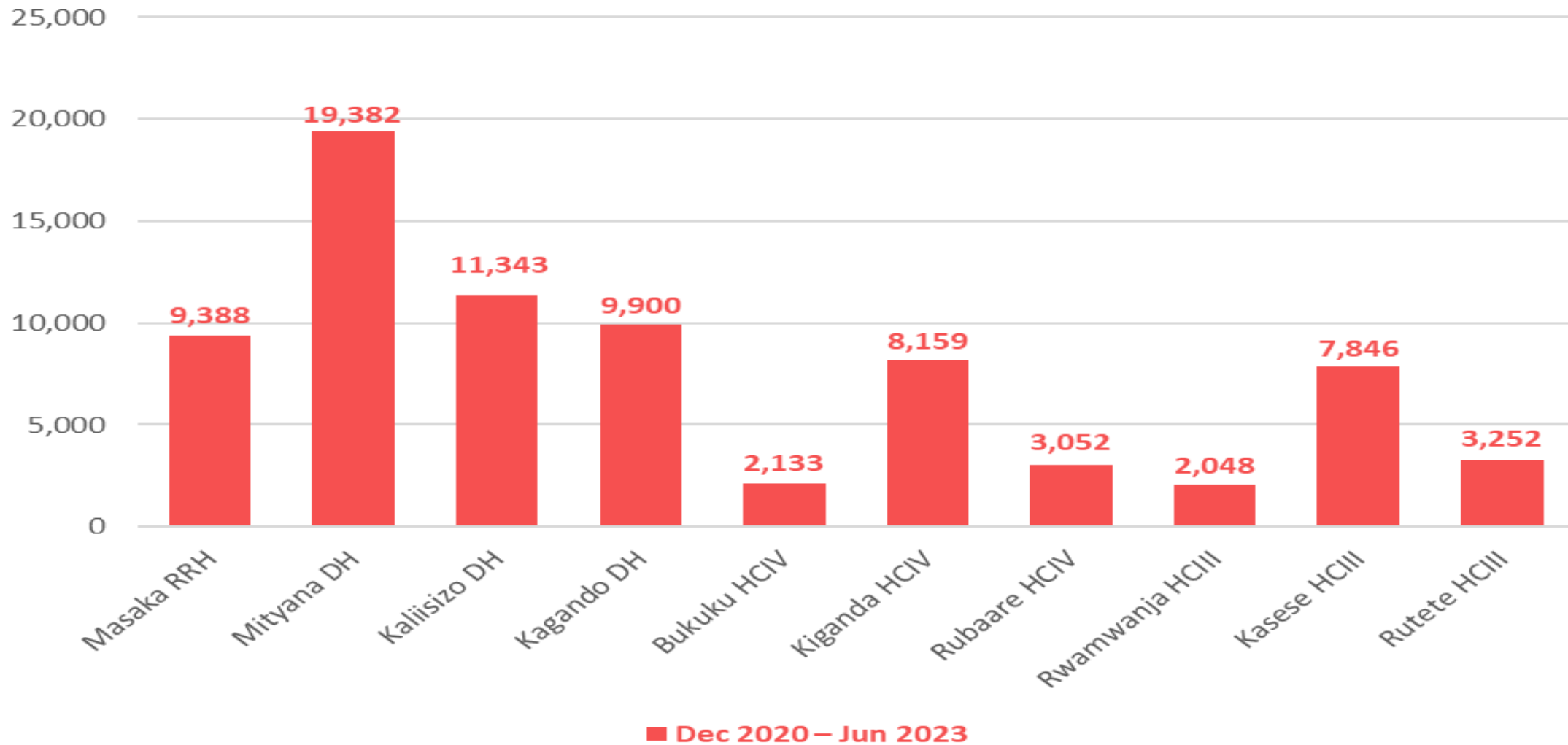
- 74.3 days per year: average duration that HCFs operated without any chlorine stock [25.8 to 132.3 days]
- Stockouts lead to rationing, over/improper dilution, asking patients to bring in chlorine, or using inadequate cleaning supplies (e.g., laundry detergent)

2. STREAM units can eliminate chlorine stockouts

- **76,501** liters of 0.5% chlorine disinfectant produced onsite by STREAM units to date (December 2020 to June 2023; total value of **48,908,583 UGX**)
- During the evaluation, none of the ten HCFs experienced a chlorine stockout



Cumulative volume (L) of 0.5% chlorine disinfectant produced and used (2 years & 6months)



Results (con't)

3. STREAM units generate significant cost savings for HCFs

- Average cost savings of 35% in chlorine supply costs across facilities due to STREAM

	Commercial chlorine	STREAM	Cost savings USD (%)
Average cost per liter of 0.5% chlorine	\$0.1727 639 UGX	\$0.1118 413 UGX	\$0.0610 (35%) 226 UGX

4. High acceptability and workflow improvements resulting from STREAM

- 100% of DHOs, hospital administrators, and users agreed the STREAM improved IPC practices by:
 - Increasing IPC practices and cleaning due to increased chlorine availability
 - Safer, more hygienic patient and staff environments
 - Simplified chlorine distribution processes and cost savings



National support and approvals

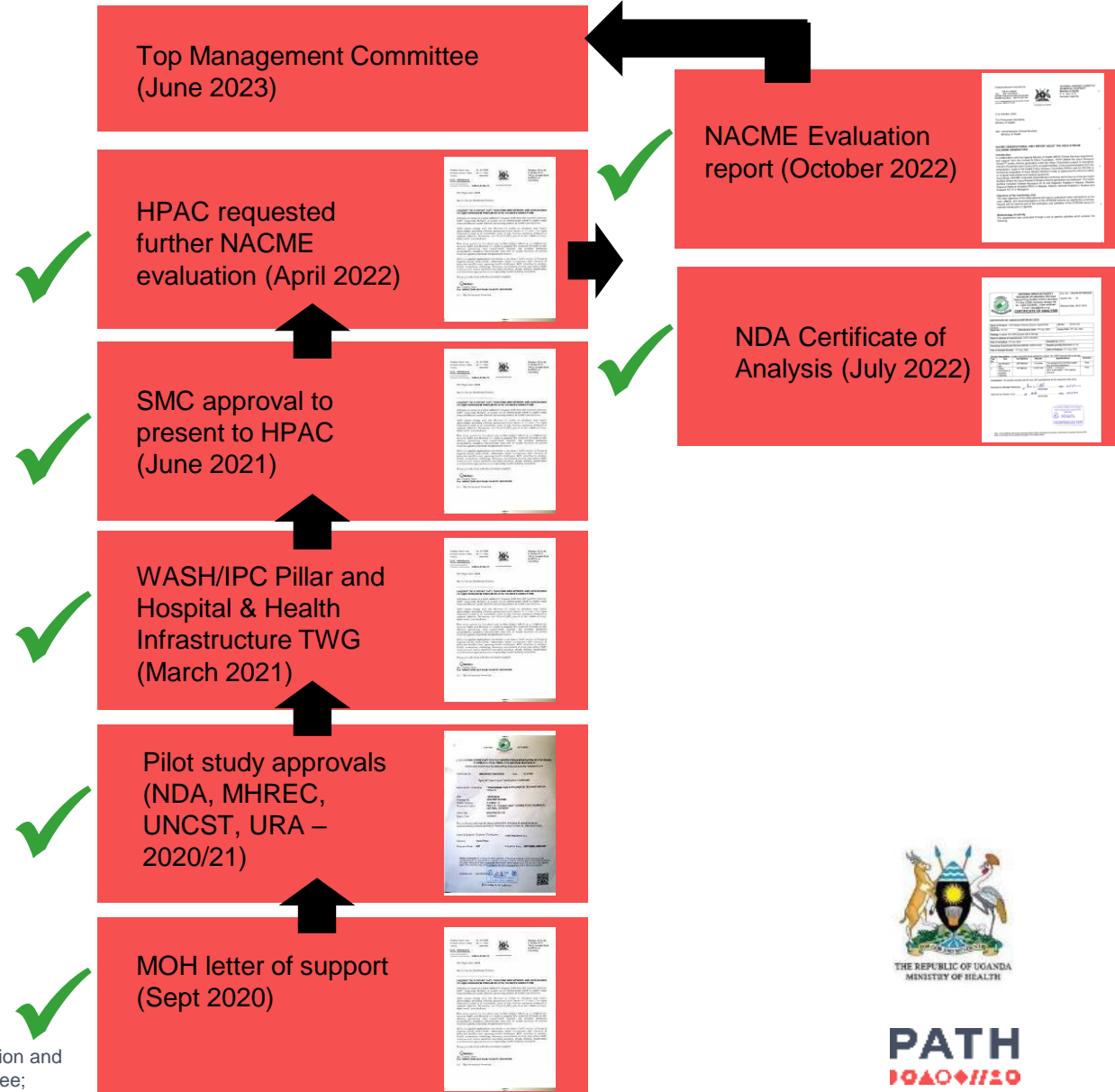
Pilot results led to several MOH approvals

- Strong and close collaboration between PATH and the Ministry of Health's Clinical Service Department has resulted in steady and continued momentum for strengthening IPC practices in HCFs.
- Evidence generated through operational studies has driven confidence and success.

Spotlight on recent evaluations

- **NACME:** "The device can ably be deployed to lower Health facilities but it has also addressed chlorine demands at higher level health facilities."
- **NDA:** "The [STREAM chlorine] complies with BP and USP specifications for the respective tests done."

Approvals received to date



STREAM advantages

The Aqua Research STREAM addresses several gaps compared to other chlorine generators, as well as other chlorine products used by health facilities. Future work on maintenance/repair plans will strengthen the long-term sustained use

	STREAM	Other chlorine generators	Liquid sodium hypochlorite	Chlorine powder	Chlorine tablets
Chlorine dilution ease	●	●	●	●/●	●
Product quality	●	●	●/●	●	●
Cost	●	●	●	●	●
Supply chain barriers faced	●	●	●	●	●/●
Corrosion of instruments	●	●	●	●	●
Health staff acceptability	●	●	●	●	●/●
Maintenance	●/●	●/●	--	--	--
Health system resiliency / outbreak response	●	●	●	●/●	●

Quotes / feedback from stakeholders

- “It will ably address issues of delayed supply, stock out, and inadequate supplies.” – Asst District Health Officer- Ntungamo
- "The device eliminates the need to dilute chlorine. This is very beneficial since some people may not know the dilution calculations." – Medical Supritendent – Kalisizo General Hospital
- “We have a registered a reduction in neonatal sepsis partly due to increased availability of disinfectant brought about by the machine” – Nursing in-charge Kasese Municipal HCIII
- "Disinfection is done on a daily basis [with the STREAM] compared to before when it was done after three days." – Mid wife Kiganda HCIV
- “Onsite chlorine production is a way to go and a good measure to cut cost on procuring disinfectants” Director- Masaka RRH.
- “We have not registered any corrosion of medical equipment while using chlorine from this device” – Device user at Mityana General Hospital

Results: Device hardware issues

- The STREAM devices experienced three main hardware issues.
- Aqua Research redesigned these components, and all STREAM devices that were experiencing challenges were upgraded with the redesigned components in December 2021.

Issue	Cause	Mitigation strategy
Leaking reaction chamber	Scaling in the reaction chamber and/or the outlet ports led to clogging and buildup of pressure inside the cell, which led to leaking.	<ul style="list-style-type: none"> • Internal cell housing strengthened by adding boss sections to the bolts. • Emergency pressure relief rupture disk added to the brine inlet port of the cell. • Outer titanium plate added to the cathode housing to prevent warping.
Power supply and voltage stabilizers failed	Severe power surges led to tripped thermal switches, damaged power supplies, and failed surge protectors.	<ul style="list-style-type: none"> • 10,000 V surge protector and 42A connector added to the power supply.
Control box issues	Weak connections in the circuit boards.	<ul style="list-style-type: none"> • Stronger socket connections and click-to-connect connectors added to prevent accidental shorts and wires becoming dislodged during transport. • 42A connector added to power supply to control box to prevent overheating; all connections will be soldered.

Acknowledgements

- 1. MOH Leadership** for overall project support and enabling the introduction, piloting, and continued advancement of STREAM devices in the public health system.
- 2. MOH Curative Services Directorate and Clinical Services Department** for steadfast, expert input and collaboration in deployment of devices to selected health facilities
- 3. Other MOH Structures, Departments and autonomous bodies** –HPAC, SMC, NDA, NACME, Infrastructure Department



THANK YOU



Backup slides



Results: Cost analysis

Average cost savings of 35% across facilities due to STREAM

Cost analysis methodology

- Commercial chlorine cost represent actual chlorine cost paid by the HCF and water costs (for chlorine dilution)
- STREAM chlorine costs calculated by sum of following inputs
 - STREAM device cost (\$2,650 USD), amortized over 5 yrs
 - Device shipping cost and customs duties (\$160 USD)
 - Salt (15g/L of chlorine produced; 1,900 UGX per 0.5 kg)
 - Vinegar (1 liter for cleaning; 18,000 UGX per liter)
 - Water (vary by location; 0 UGX – 1,060 UGX per m3)
 - Electricity (vary by location; 748 – 1,880 UGX per kWh)
 - Wooden stir spoon (20,000 UGX)*
 - Measuring cup (7,000 UGX)*
 - Bucket (20 L; 25,000 UGX)*
 - Jerry can (20 L; 8,800 UGX)*

Cost of chlorine: commercial chlorine vs STREAM

- We compared the cost to produce 63,828 liters of 0.5% chlorine using actual commercial and STREAM cost inputs (see left). The result is the STREAM has a 35.3% reduction on per liter cost, translating into 35.3% chlorine cost savings for the HCF.

	Commercial chlorine (UGX)	STREAM	Cost savings USD (%)
Total cost of 62,946 Ls of 0.5% chlorine volume produced to date	\$55,129 204,032,435 UGX	\$35,664 131,993,088 UGX	\$19,465 (35%) 72,039,347 UGX
Average cost per liter of 0.5% chlorine	\$0.8637 3,197 UGX	\$0.5588 2,068 UGX	\$0.3050 (35%) 1,129 UGX

Note: A total cost of ownership analysis will be generated in 2023.

1 USD = 3,701.00 UGX; * One-time purchase



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