Strengthening WASH services in Ghana and Uganda health facilities using the STREAM Disinfectant Generator

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Gaps in environmental hygiene services in health facilities contribute to negative health outcomes

Water, sanitation, and hygiene (WASH) services are fundamental for the delivery of quality health care services. Worldwide, an estimated 36% of health facilities (HCFs) are not able to provide basic environmental hygiene services.[1] These service gaps contribute to health care–associated infections (HAIs) rates, which affect an estimated 15% of in-patients in low- and middle-income countries (LMICs).[2]

Chlorine availability, quality, dilution challenges

Chlorine is an effective chemical disinfectant, widely recommended for infection prevention and control practices in HCFs. However, health facilities face perennial challenges regarding consistent access to chlorine, due to include fixed or limited budgets, competing priorities for budget allocation, inaccurate inventory forecasting and management challenges, and unpredictable supply chains. Commercial chlorine received by health facilities has also been shown to be degraded and the varying concentrations of chlorine products pose challenges to health workers on how to accurately prepare chlorine disinfectant solutions.[3]

Onsite chlorine generation: STREAM Disinfectant Generator

PATH collaborated with the Ghana Health Service (GHS) and Uganda Ministry of Health (MOH) to introduce and evaluate the Aqua Research STREAM™ Disinfectant Generator (STREAM) in public health facilities in both countries. The STREAM is an onsite chlorine generator that produces a continuous flow of 0.5% ± 0.1% chlorine using common salt and water. The automated internal controls ensure the device generates a consistent 0.5% ± 0.1% concentration solution. The STREAM eliminates any dilution processes for surface and equipment disinfection applications, as the concentration aligns with national infection prevention and control recommendations.

Evaluation in Ghana and Uganda HCFs

From December 2020 to June 2021, PATH evaluated 24 STREAM devices in 18 HCFs in Ghana and Uganda. The primary objectives of the evaluation were to assess the STREAM's effect on chlorine availability and chlorine supply costs and validate the technical performance of the STREAM.

Chlorine availability	● Total volume of commercial chlorine received by HCF and frequency and duration of chlorine stock outs in last 12 months taken from chlorine stock cards ● Cumulative STREAM production volumes tracked every two weeks by checking an internal run-time clock
Chlorine costs	● Commercial chlorine costs collected from procurement records in each HCF ● STREAM-related chlorine costs were based on raw materials (i.e., salt, vinegar, water, electricity), the STREAM device itself, and chlorine production materials (i.e., stir spoon, bucket, ect.)
Technical performance	● Hours of STREAM use to derive chlorine production totals ● Number/nature of STREAM components malfunctioning

Results

Chlorine availability: Analysis of chlorine inventory for the 12 months prior to the start of the study (November 2019 – November 2020) revealed health facilities in Ghana (n=8) face an average of 44.8 days per year without chlorine, while HCFs in Uganda (n=10) average 74.3 days annually without chlorine. Health centers in Ghana faced nearly double the average chlorine stock out duration compared to district hospitals (61.8 days vs 32.9 days), whereas health centers in Uganda more than four times the average chlorine stock out durations compared to district hospitals (106.3 days vs 25.8 days).

During the project period, no health facilities reported chlorine stockouts while using the STREAM device to produce chlorine onsite. HCFs in Ghana generated a total of 14,859 liters of 0.5% STREAM chlorine, while those in Uganda produced a total of 20,389 liters in the study period.

Cost savings: A comparative cost analysis of commercial chlorine procured by health facilities with the cost of generating STREAM chlorine found the STREAM generates a cost savings of 29% to 32% per liter modeled over five years (minimum device lifetime). The greatest cost savings occur in district hospitals, due to the relatively higher chlorine demand compared to health centers: $36,278 (70%) in Ghana and $45,998 (119%) in Uganda.

Technical performance: A total of 65% of the initial STREAM systems deployed were repaired or replaced due to one or more mechanical issues caused by contextual and user-related factors. Principally, three STREAM components (reaction chamber, power supply, control board) were affected.

- Leaking reaction chamber: High calcium content in HCF source water led to scaling in the reaction chamber, clogging of outlet ports, and pressure build up.
- Mains power surges: Spikes in mains electricity voltage tripped thermal switches, damaged power componentry, and cause surge protectors to fail.
- Control board wiring: Weak wiring connections led to shorts and dislodged wiring

Leaking in the reaction chambers was caused by high calcium content in HCF source water, leading to scaling in the reaction chamber, clogging of outlet ports, and pressure build up. Power surges in mains electricity in the HCFs led to tripped thermal switches, damaged power componentry, and failed surge protectors. Weak wiring connections in the control boards led to accidental shorts and dislodged wires.

In response to these issues, Aqua Research redesigned all three components and added electrical surge protection, to eliminate the original design issues, and to better reflect the contextual and use requirements. All affected systems were repaired or replaced with support from the manufacturer and user instructions were modified to place a greater emphasis on prevention (e.g., increasing the frequency of reaction chamber cleaning). Reliability testing of the redesigned components is planned for 2023.

Conclusion

The STREAM enables health facilities to provide improved environmental hygiene services by:

1. Addressing chlorine supply chain challenges
2. Reducing chlorine supply costs
3. Simplifying chlorine use and application for disinfection.

Results have led to national level support in Ghana and Uganda, with the GHS calling for national introduction of the STREAM and the Uganda MOH's Health Policy Advisory Committee approving national introduction.

Next steps

PATH will continue supporting the GHS and Uganda MOH with evaluating the reliability of the STREAM's redesigned components, as well as expand the evidence base on total cost of ownership and model the health impact of STREAM use on patient outcomes. With additional funding, PATH aims to support the GHS and Uganda MOH with national introduction of the STREAM in both countries.

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Contact

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References

1 Cronk R, Bartram J. Environmental conditions in health care facilities in low- and middle-income countries: Coverage and inequalities, *International Journal of Hygiene and Environmental Health*. 2018;221(3):409–422. https://doi.org/10.1016/j.ijheh.2018.01.004.

2 World Health Organization. *Global report on infection prevention and control: executive summary*. Geneva: WHO; 2022. https://apps.who.int/iris/handle/10665/354553. Accessed June 3, 2022.

3 Duvernay PG, de Laguiche E, Campos Nogueira R, Graz B, Nana L, Ouédraogo W, Sauter Y, Sauvageat E. Preventing nosocomial infections in resource-limited settings: An interventional approach in healthcare facilities in Burkina Faso. Infect Dis Health. 2020 Aug;25(3):186-193. doi: 10.1016/j.idh.2020.04.003. Epub 2020 May 11. PMID: 32417112; PMCID: PMC7211687.