

Learning brief: Financing national adoption of the Aqua Research STREAM™ Disinfectant Generator in Uganda

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In Uganda, a health care worker uses the Aqua Research STREAM™ Disinfectant Generator, a reliable, cost-effective solution for producing chlorine. STREAM has the potential to significantly improve infection prevention and control as well as generate substantial financial savings.

Millions face preventable infections due to lack of chlorine in health care settings

Health care–acquired infections (HAIs) affect hundreds of millions of individuals worldwide and lead to significant patient treatment costs for health systems. Available data show a 28 percent HAI rate in Uganda, which is substantially high.¹ The total economic cost of HAIs in the country in 2022 was US\$580 million, which equates to 1.43 percent of gross domestic product.² Most HAIs are preventable and can be reduced by an estimated 35 to 70 percent following effective infection prevention and control (IPC) practices.^{3–5}

Chlorine is a widely used and effective chemical disinfectant recommended for IPC in health care settings. However, despite its proven effectiveness, the lack of consistent chlorine availability and quality limits the ability of health care workers to provide a safe and hygienic environment for patients. In Uganda, an analysis of chlorine stock records from ten health facilities over a year found those facilities faced an average of 74 days per year without chlorine. The primary factors that contribute to such supply gaps include weak supply chains; burdensome forecasting, procurement, and transportation processes; and insufficient budgets.^{6,7} Furthermore, long exposures to sunlight and warm temperatures due to improper storage and

This document is part of the STREAM learning brief series and presents cost-effectiveness estimates and financial information to inform national adoption and scale-up of the Aqua Research STREAM™ Disinfectant Generator (STREAM) across national health care systems. Using Uganda as an example, this brief explores how the STREAM can be a financially attractive solution supporting the delivery of safe and effective infection prevention and control services.

¹ Greco D, Magombe I. Hospital acquired infections in a large north Ugandan hospital. *Journal of Preventive Medicine and Hygiene*. 2011;52(2):55–58. <https://doi.org/10.15167/2421-4248/jpmh2011.52.2.250>

² Costs of healthcare acquired infections due to inadequate water, sanitation and hygiene (WASH) in healthcare facilities in Uganda. WaterAid; 2024. <https://washmatters.wateraid.org/sites/g/files/jkxoo256/files/2024-04/Costs-healthcare-acquired-infections-Uganda.pdf>

³ Schreiber PW, Sax H, Wolfensberger A, et al. The preventable proportion of healthcare-associated infections 2005–2016: systematic review and meta-analysis. *Infection Control and Hospital Epidemiology*. 2018;39:1277–1295. <https://doi.org/10.1017/ice.2018.183>

⁴ Dancer SJ, White LF, Lamb J, et al. Measuring the effect of enhanced cleaning in a UK hospital: a prospective cross-over study. *BMC Medicine*. 2009;7. Article No. 28. <https://doi.org/10.1186/1741-7015-7-28>

⁵ Umscheid CA, Mitchell MD, Doshi JA, et al. Estimating the proportion of healthcare-associated infections that are reasonably preventable and the related mortality and costs. *Infection Control and Hospital Epidemiology*. 2011;32(2):101–114. <https://doi.org/10.1086/657912>

⁶ Opollo MS, Otim TC, Kizito W, et al. Infection prevention and control at Lira University Hospital, Uganda: more needs to be done. *Tropical Medicine and Infectious Disease*. 2021;6(2):69. <https://doi.org/10.3390/tropicalmed6020069>

⁷ US Agency for International Development (USAID). Improving the Quality of Health Care Services by Strengthening IPC at Centers of Excellence: Technical Report. USAID; 2021.

transportation can lead to degradation of the chorine concentration. Finally, health care workers have reported challenges with calculating accurate dilution ratios to

convert commercial chlorine solutions, which range from 1.25 mg/L to 70 mg/L, down to a 0.5 mg/L solution as recommended in IPC guidelines.

The STREAM Disinfectant Generator: An innovation for the Uganda health system

PATH and the Uganda Ministry of Health (MOH) Clinical Services Department (CSD) are collaborating to introduce the Aqua Research STREAM™ Disinfectant Generator (STREAM) into the Uganda public health system. Results from a 2019–2022 evaluation found that STREAM units could eliminate chlorine stockouts, generate a 36.9 percent cost savings over a 5-year period compared to commercial chlorine, and significantly improved IPC practices in health facilities, as reported by staff. Findings in this learning brief draw heavily from our recently published article.⁸ In June 2023, the MOH Top Management

Committee approved use of the STREAM in the Uganda health care system.⁹ More on the device can be found [here](#).

In parallel with these successes, PATH and MOH/CSD leaders sought to estimate the effect of on-site chlorine production using the STREAM on HAI rates and treatment costs, while also generating financial data to inform national scale-up strategies for the Uganda health care system. By addressing these challenges and providing a reliable, cost-effective chlorine supply, STREAM has the potential to significantly improve IPC and generate substantial financial savings.

Cost-effectiveness

Using a decision model, we evaluated the STREAM’s potential for reducing HAI prevalence rates, HAI treatment costs, and associated disability-adjusted life years (DALYs), exploring two scenarios: (1) in which chlorine is commercially purchased at a health facility and (2) in which chlorine is produced on-site using the STREAM device. Effectiveness primarily focused on change in availability of chlorine as the result of on-site chlorine production. This was measured as a reduction in chlorine stockout days with the assumption that disinfection efforts are not effective during stockout periods. Primary data from the 2019–2023 evaluation in Uganda were used to estimate changes in chlorine stockout days at a health facility. Among the range of HAIs, we focused on surgical site infections as the most relevant condition whose infection and prevention pathways are associated with environmental cleanliness and medical equipment reprocessing/disinfection.

Use of STREAM devices across 50% of HCFs could avert 14,087 HAIs and \$5,512,067 HAI treatment costs and productivity loss

Reductions in HAI incidence due to increased chlorine availability was estimated using international studies on the efficacy of chlorine and IPC. We also accounted for other risk factors for HAIs, such as non-adherence to IPC disinfection standards and quality of chlorine used for disinfection. Finally, the evaluation focused on two costs: that of chlorine production and that of HAI treatment.

Analysis shows that in Uganda, 50% of health facilities relying on a STREAM device for on-site chlorine production could generate an annual reduction of 14,087 HAIs from surgical site infections (see Table 1). Average DALYs averted equals 40,097, and the annual cost savings is estimated to be

\$5,512,067. Cost savings of every DALY averted range from \$93 to \$285.

Findings indicate the STREAM device has the potential to significantly reduce HAI and treatment costs in Uganda. The effect of STREAM use varies by health facility level, where

TABLE 1. Cost-effectiveness estimates resulting from STREAM use in 50% of health care facilities in Uganda.

Reduction in HAIs	Averted DALYs	DALY cost savings
SSIs potentially averted as the result of using effective IPC practices and high-quality chlorine	DALYs for every case of SSI were based on Global Burden of Disease estimates for maternal sepsis	Treatment cost savings were estimated as the averted costs associated with length of stay due to SSI multiplied by cost per inpatient day
14,087	40,097	\$5,512,067

Abbreviations: DALY, disability-adjusted life year; HAI, health care-acquired infection; IPC, infection prevention and control; SSI, surgical site infection.

⁸ Drolet A, Mugumya T, Hsu S, et al. Performance and acceptability of the STREAM Disinfectant Generator for infection prevention and control practices in primary health care facilities in Uganda. *Antimicrobial Resistance and Infection Control*. 2024;13(1):77. <https://doi.org/10.1186/s13756-024-01433-1>
⁹ PATH. Learning brief: The role of government champions in national adoption of the Aqua Research STREAM™ Disinfectant Generator. PATH; 2024. <https://tinyurl.com/learningbriefs>

greater HAI cost savings per DALY averted are seen in health center level IVs (HCIVs) compared to district and referral hospitals. STREAM is more cost-effective for health facilities

with higher chlorine demand volumes, as the up-front cost of the STREAM is outweighed by the long-term cost savings from fewer chlorine purchases.

Budgeting for national scale-up: Rationale and cost estimates

Along with understanding the potential health benefits that could result from STREAM use, we sought to calculate the financial requirements and benefits for the Uganda health system of national STREAM introduction. We compared the annual and 5-year costs of STREAM chlorine production with those of locally available commercial chlorine, determining both annual cost savings and break-even points. STREAM chlorine costs include up-front costs, such as device, shipping, taxes, and additional items (e.g., spoon, cup, bucket, jerrycans), and operational costs, including cleaning, vinegar, salt, water, and electricity. Commercial chlorine costs include chlorine and water for dilution. Large health facilities, such as regional referral and national

referral hospitals, were excluded from this analysis due to their higher chlorine demand, which requires either larger-capacity chlorine generators or multiple STREAM devices, each allocated to a specific ward. Instead, the results focus on district hospitals (n = 54) and HCIVs (n = 1,094), as their chlorine demand volumes align more closely with the STREAM's production capacity. The break-even analysis identifies the point at which the accumulated cost of purchasing commercial chlorine equals the total accumulated cost of STREAM chlorine, which includes up-front and recurrent costs. Beyond this point, STREAM chlorine offers annual cost savings.

District hospitals

- Annual district facility cost savings: \$536
- Total savings for all districts over 5 years: \$262,818

Impact in individual district hospitals:

District hospitals require 13,000 liters of 0.5 mg/L chlorine solution per year, on average. To meet this demand, at least two STREAM units would need to operate for 8 hours daily. Under these assumptions, district hospitals can expect cost savings of \$536 per year compared to

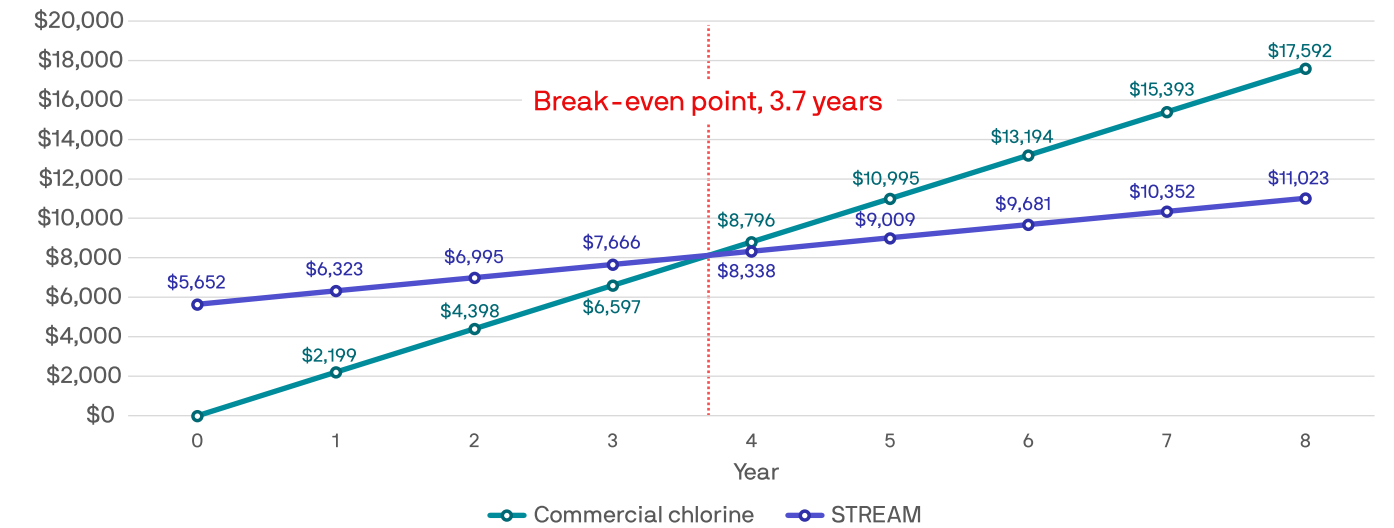
purchasing commercial chlorine (see Table 2). Excluding the initial capital cost investment, recurrent STREAM chlorine production costs would generate even greater savings, amounting to \$1,101 annually. Factoring in capital costs, the STREAM devices at district hospitals would reach the break-even point in an average of 3.7 years (see Figure 1). These savings demonstrate STREAM's potential as a cost-effective solution for district hospitals.

TABLE 2. Chlorine costs and years to the break-even point at the district level in Uganda.

Annual cost of commercial chlorine	Annual cost of chlorine using STREAM	Annual cost savings	Years to the break-even point
\$2,199	\$1,662	\$536	3.7

Green: Highlights the positive financial outcomes of using the STREAM device, including the annual cost savings compared to commercial chlorine and the number of years it would take to reach the break-even point.

FIGURE 1. Incremental cost of commercial chlorine compared to STREAM chlorine.



Impact across all district hospitals:

At the national level, the introduction of STREAM units across all 54 district hospitals would require an up-front investment of \$305,208. The recurrent annual cost is expected to average \$543 per facility to produce 13,000 liters of 0.5 mg/L chlorine, compared to \$2,199 for commercial

chlorine procurement. This equates to \$0.13 per liter for STREAM-produced chlorine, compared to \$0.17 per liter for commercial chlorine. Over 5 years, the total cost savings from STREAM implementation is projected to reach \$262,818 (see Table 3)—a total that would nearly cover the initial capital cost of the devices.

TABLE 3. STREAM chlorine costs and estimated annual expenditure in Uganda hospitals.

Annual chlorine demand per hospital	Capital cost per liter	Recurrent cost per liter	Total up-front cost	Annual recurrent cost	Total savings over 5 years
13,000 liters	\$0.09	\$0.0418	\$305,208	\$29,317	\$262,818

Chlorine demand extrapolated from data reviewed from chlorine stock cards and capital costs per liter = up-front costs of STREAM amortized over 5 years and divided by the number of liters per facility. We assume that hospitals will require two STREAM devices each and health center level IVs will require one STREAM unit per facility.

Health centers

Health center levels III and IV have annual chlorine demands of 1,700 liters and 3,000 liters, respectively, but they do not currently reach the cost savings threshold for use of the STREAM device. Instead, they incur additional costs of \$211 and \$413 per year. However, excluding the initial capital investment, the recurrent costs would result in average annual savings of \$354 for HCIIIs and \$152 for HCIVs.

To improve cost-effectiveness for these facilities, adopting novel production and distribution models such as a **hub-and-spoke system** could be transformative. In this model, general hospitals or well-equipped HCIVs (hubs) produce surplus stabilized chlorine and distribute it to lower-level facilities (spokes), such as HCIIIs and other

Breakeven within 5 years with the STREAM device: Producing at least 5,000 liters annually

HCIVs. This approach not only reduces costs but also improves availability by reducing stockouts and logistical delays.

For HCIVs and HCIIIs with limited chlorine demand, breakeven within 5 years is unlikely under current conditions. However, increasing production at HCIVs to more than 5,000 liters annually or adopting a hub-and-spoke model could lead to cost savings for these health facility levels. For instance, meeting the combined demand of one HCIV and two HCIIIs under this model could reach breakeven in 3.8 years, with annual recurrent costs of \$325, compared to \$2,743 for commercial chlorine (see Table 4).

TABLE 4. Chlorine costs and years to the break-even point.

Facility type	Average annual chlorine demand	Annual cost of commercial chlorine	Annual cost of chlorine using STREAM	Cost savings	Years to the break-even point
Health center hub-and-spoke model (2 HCIIIs + 1 HCIV)	6,400 liters	\$2,743	\$1,993	\$750	3.8
HCIV	3,000 liters	\$497	\$709	-\$211	8.2

Abbreviations: HCIII, health center level III; HCIV, health center level IV. Green: STREAM provides cost savings when compared to commercial chlorine. Red: STREAM is more costly when compared to commercial chlorine.

Financing approaches for STREAM scale-up in Uganda

While the initial investment in STREAM is important, it is also important to carefully consider and budget for the costs of capital equipment, operation, and maintenance and repair. The STREAM device requires a one-time capital investment of \$2,826. This includes the device cost plus shipping, taxes, spoon, cup, bucket, and jerrycan costs. Operating costs primarily consist of consumables, such as salt, vinegar, and jugs. These supplies are relatively inexpensive and can be sourced locally.

In 2025, PATH and the MOH/CSD will use existing data and results from an upcoming STREAM evaluation across an additional 19 health facilities to generate a total cost of ownership analysis that incorporates maintenance, repair, and spare parts into the overall costing calculation. The costing tool, break-even analysis, total cost of ownership, and cost-effectiveness models are available upon request. 📌

For more information

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This project directly contributes to the Sustainable Development Goals 3 and 6, as well as global WASH in health care facility targets.



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