Center for Global Safe Water, Sanitation, and Hygiene

Evaluation of Decentralized Water Treatment Systems in Rural Healthcare Facilities in Rwanda

GE Foundation

INTRODUCTION

Access to and the availability of safe water in healthcare facilities (HCF) is a fundamental component of quality healthcare. Adherence to infection prevention and control protocols, the provision of medications, the use of certain medical devices, and even access to drinking water all require an adequate supply of safe water. A recent article drawing data from nearly 130,000 HCF in 78 low- to middle-income countries (LMIC) found that nearly 50% of these HCF lacked access to piped water[1], highlighting a serious need for safe water interventions in these settings. In small and medium-sized HCF with access to a reliable water source, decentralized on-site water treatment systems have the potential to provide sufficient volumes of safe water.

Decentralized water treatment systems using membrane ultrafiltration (UF) are increasingly available and have been found to be appropriate for use in low-resource settings, like those often present in HCF in LMICs. Bench evaluations and trials of membrane UF water treatment systems have shown efficacy in providing clean water when managed by research teams, but little data exists on the feasibility and sustainability of these water treatment systems in real-world settings. This brief provides a summary of a prospective performance evaluation of 10 membrane UF water treatment systems installed in HCF across Rwanda, which were managed and operated by local HCF staff. These systems were donated by the General Electric Foundation through their Safe Water Program. The program's research arm was conducted by The Center for Global Safe Water (CGSW) at Emory University.

THE TECHNOLOGY

The water treatment system technology evaluated was decentralized membrane UF followed by residual chlorine disinfection. Membrane ultrafiltration treatment uses the force of water pressure to push water from the outside in through a fiber membrane filter, which removes contaminants such as potentially pathogenic bacteria and viruses. Secondary treatment consisted of residual chlorine disinfection. This step is especially useful in settings where frequent water and service interruptions results in storing water and recontamination from storage containers. The two water treatment system technologies were installed into the HCF water distribution systems with site-specific plans tailored to existing infrastructure.

Decentralized water treatment system at Rwandan HCF

EVALUATION OF THE GENERAL ELECTRIC FOUNDATION'S SAFE WATER PROGRAM

The membrane UF and residual chlorine water treatment systems evaluated for this study were donated through GE's Developing Health Globally program. The water treatment systems are considered low tech, and with training, easily maintained and operated by local hospital maintenance staff. With technical support from Assist International, the GE program trained on-site staff to perform daily operations and maintenance on both the membrane UF and residual chlorination disinfection technology. The water treatment systems were installed in 10 rural HCFs in Rwanda. The HCFs which received the water treatment systems were selected based on the following criteria: infrequent power outages, access to a regularly available water source, water quality below World Health Organization's (WHO) standards, and cooperative and engaged HCF management.

Assist International trains HCF staff on water treatment system maintenance

The prospective performance evaluation of the GE donated water treatment systems by CGSW took place over a 22-month period. The evaluation assessed the feasibility of the water treatment systems to improve water quality in low-resource settings when placed in an institutional setting, and to identify determinants of system sustainability. Data were collected through weekly monitoring of the water treatment system and monthly facility surveys. The data collected included information about any water or service interruptions, the types of failures causing interruptions (i.e. failure of existing pump, failure of new switch, etc.), and water quality (i.e. microbial contamination). Water samples were collected from each main HCF point of use, including sinks and storage containers. All of the systems were also surveyed for water availability.

RESULTS

When operational, water samples collected from points of use after UF and residual chlorine treatment met WHO standards for microbial contamination 89% of the time (measured by presence of fecal coliforms and E. coli). Overall, when both water and power were available, the system functioned properly 82% of the time. Figure 1 displays the functionality time and interruption time by category recorded across the 10 HCF study sites. The most frequent cause of the treatment interruptions was a chlorine dosing failure due to a mechanical gasket malfunction, which occurred 12 times across seven sites. Water interruptions, commonly caused by water source shortages at municipal water supply centers,were responsible for 32% of total service interruptions. Mechanical malfunctions were responsible for 19% of water interruptions, and were caused by an existing pump failure, new pump failure, new switch failure, or new solar energy system failure. For all technical-related water and treatment interruptions, the average downtime for repairs was 30 days, with pump failures taking the most time to repair (55 days on average).

Summary of Key Findings

- The water treatment system performed well overall, consistently delivering water which met WHO's drinking water standards for chlorine residual and presence of E.coli and coliforms
- In 74% of observations, the water treatment systems were fully functioning; for observed occasions where the water system system was not fully functioning, 64% were due to water interruptions, while the remainder were due to treatment interruptions

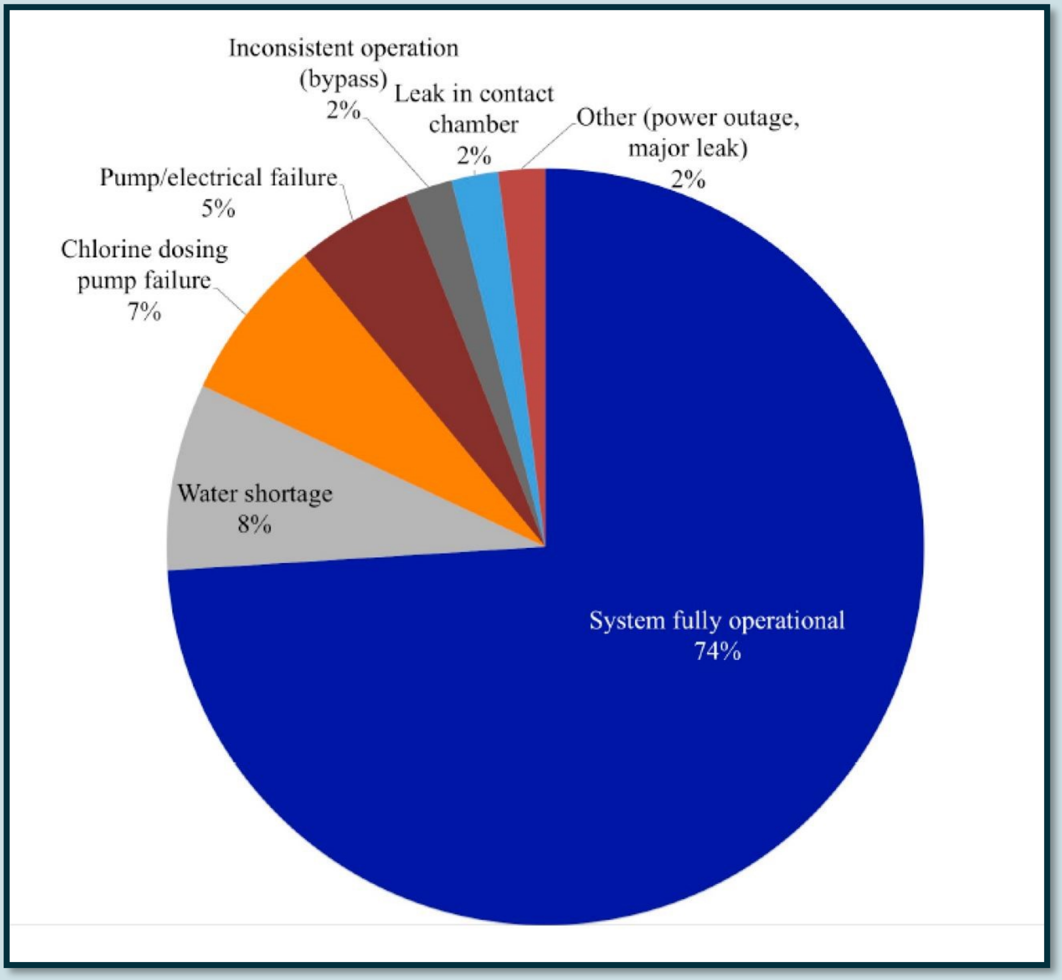

Figure 1. Functionality and interruptions across the HCF study sites. (Huttinger et al., 2017)

LESSONS LEARNED

In summary, though intermittent service and treatment interruptions occurred, the membrane UF and residual chlorine water treatment technologies were highly effective in improving water quality services in rural HCF in Rwanda. These decentralized water treatment systems provided a feasible means for consistent provision of adequate volumes of high quality water. Challenges to consider for those interested in implementing similar water treatment interventions are largely contextual issues that impact maintenance and operation, such as access to supply chains and technical experts.

Important Take-aways

- The feasibility of the water treatment systems to provide safe water in Rwandan HCF illustrates the potential for similar application in other low-resources settings in LMICs
- Supply chain issues for replacement parts were a major barrier to timely repairs
- Advanced repairs should be outsourced to technical experts to ensure functionality
- Power and water availability are crucial to the system functionality
- The residual chlorine component is essential to sustain safe water provision in settings where service interruptions are expected

LESSONS LEARNED CONTINUED

Especially for donor-based programs, costly and/or inaccessible replacement parts for the water treatment systems could prolong service interruptions. The HCF management team should ensure that they have access to a supply chain for system parts and that long-term maintenance and repairs are included in the budget Ensuring the sustainability of water treatment systems may require outsourcing advanced repair needs to technical experts or providing advanced training to hospital maintenance staff, both potentially costly expenditures. Installment of these type of water treatment systems must occur in concert with future budget and planning efforts to ensure the sustained functionality of the system in the post-donor phase.

While this study does support the feasibility of decentralized membrane UF water treatment systems in low-resource settings, not all resource-limited contexts are appropriate for this technology. Occasional power outages and water source interruptions are to be expected in any setting, but the feasibility of this technology is dependent upon power and water being consistently available with few interruptions. Therefore, these systems are not suitable for HCF with intermittent electric power and water availability. Furthermore, when implemented in settings that experience occasional service interruptions, the residual chlorine treatment is needed to reduce the risk of recontamination of stored water and continue the provision of safe water during service interruptions. Lessons learned from this study can aid researchers and practitioners in implementing similar systems in other low-resource settings and LMICs, but the availability of supportive infrastructure must be considered.

**This brief is a summary of the following research publication:

Huttinger, Alexandra, et al. "Evaluation of Membrane Ultrafiltration and Residual Chlorination as a Decentralized Water Treatment Strategy for Ten Rural Healthcare Facilities in Rwanda." *International journal of environmental research and public health* 12.10 (2015): 13602-13623.

About the Center

The Center for Global Safe Water, Sanitation, and Hygiene (CGSW) focuses on increasing access to safe drinking water, adequate sanitation, and appropriate hygiene as part of a global strategy to break the cycle of poverty and disease in low– to middle-income countries. For more information, please visit **www.washconhcf.org** or email **WinHCFaction@emory.edu**

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