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2025 Abstracts Book

Note: Abstract titles in blue are within the Top 20 Abstracts

Monday Verbal Abstracts

Automated Classification of Sewage Infrastructure Vulnerabilities in Urban Salvador, Brazil
Christine Stauber, Georgia State University

Background:
Urban sewage infrastructure vulnerabilities pose significant public health risks in low- and middle-income countries, with direct implications for waterborne disease transmission, environmental contamination, and community well-being. Service providers face substantial challenges in identifying and prioritizing sewage system failures across vast urban areas with limited resources. While visual inspection is critical for identifying these risks, manual classification remains resource-intensive, inconsistent, and creates delays in addressing community concerns. Automated, computer-based classification systems offer promising solutions for accelerating this process, yet their application to sewage infrastructure in resource-constrained settings remains underexplored. As part of a study on simplified sewer interventions in four neighborhoods in Salvador, photographs were collected of sewage infrastructure and infrastructure vulnerabilities. We assessed the ability to categorize these photographs using an automated classification system.

Methods and Findings:
During our work, we selected and categorized 287 images of sewage infrastructure vulnerabilities previously identified and selected by the field research team across seven types: exposed plumbing (n=164), open sewage point (n=71), pipe outcropping (n=29), exposed connection (n=10), leak (n=5), damaged connection (n=3), and other (n=5). Several significant challenges were encountered during data preparation: (1) inconsistent image quality due to variations in resolution, orientation, and inclusion of screenshots taken under different lighting conditions; (2) class imbalance was due to significant skew in the number of samples per category limited model training options; and (3) overlapping categories as identified issue types were closely related. Due to these constraints, we focused on developing a binary classification model for the two most prevalent categories using only 104 training images (52 from each category). We implemented a transfer learning approach with a modified ResNet50V2 architecture, employing image enhancement techniques (contrast and sharpness enhancement), data augmentation (rotation, zooming, flipping, brightness variation), and a three-phase progressive training methodology with gradual unfreezing of network layers. Model performance was evaluated using stratified cross-validation with standard classification metrics. Despite the limited training data, our model achieved over 90% accuracy in distinguishing between the categories of exposed plumbing and open sewage points. The progressive unfreezing approach significantly improved performance compared to conventional training methods.

Visualization of model predictions revealed effective feature learning for infrastructure-specific characteristics. The model demonstrated robust generalization across different neighborhood contexts, though performance varied slightly based on image quality and environmental conditions.

Conclusion:
This study demonstrates the feasibility of developing accurate deep learning models for sewage infrastructure classification even with severely constrained training data. Our findings have implications for urban infrastructure monitoring in resource-limited settings, enabling more efficient identification of potential public health hazards. For service providers, this automated classification system offers multiple operational benefits: (1) rapid triaging of reported infrastructure issues through standardized vulnerability categories; (2) improved response prioritization based on public health risk assessment; (3) optimized resource allocation for maintenance and repairs; and (4) enhanced data-driven decision making for infrastructure planning. Additionally, the classification system could integrate with existing mobile health applications (mHealth) to create a feedback loop between community reporting and institutional response, ultimately improving service delivery transparency and community trust.

Breaking the hog lagoon cycle: Biochar as an effective and low-cost intervention for per- and polyfluoroalkyl substances (PFAS), antibiotics, and antimicrobial resistant genes (AMR) pollution

Ellen Marie, The University of North Carolina at Chapel Hill, Gillings School of Global Public Health

Concentrated swine feeding operations, predominantly located in rural and economically marginalized regions, often rely on lagoon-spray systems for waste management. Despite their cost-effectiveness and simplicity, these systems present persistent environmental and public health risks, including the release of partially treated effluent contaminated with antibiotics, per- and polyfluoroalkyl substances (PFAS), and antimicrobial resistance genes (ARGs). These contaminants are resistant to conventional treatment and contribute to antimicrobial resistance proliferation and long-term ecosystem degradation. Existing interventions, such as lagoon covers and anaerobic digesters, often overlook PFAS, antibiotics, and ARGs, and are financially and operationally unfeasible in low-resource settings. One viable solution is biochar, a pyrogenic material derived from waste biomass. However, to date, no study has successfully engineered biochar with enhanced adsorption capacity tailored for the efficient removal of refractory biological and chemical contaminants.

To address these challenges, we developed a novel hierarchical cationic biochar derived from digested sludge, engineered for the simultaneous removal of 40 PFAS compounds, 8 priority antibiotics, and ARGs from swine wastewater. The disgested sludge was pyrolyzed at 700 °C for 5 hours and subsequently graphitized via dual-metal (Zn–Fe) activation to enhance porosity, surface area, and antimicrobial potential. The resulting biochar was functionalized with a protic ionic liquid based on 3-(Dimethylamino)propylamine (DMAPA), imparting a permanent positive surface charge. The composite exhibited a surface area >1200 m^2/g, well-developed micro- and mesoporosity, a positive zeta potential, and a pH of 5.26.Adsorption tests demonstrated rapid contaminant removal within 12 hours. For eight antibiotics spiked at 200 ng/mL each, the average removal was 100 ± 10% for tetracyclines and 98 ± 12% for sulfonamides. These results highlight the potential of this engineered biochar as a robust, multi-contaminant adsorbent for complex wastewater matrices.

Ongoing research is expanding this work by (a) characterizing adsorption dynamics of PFAS and ARGs; (b) validating performance in swine wastewater using filter-based systems; (c) evaluating pollutant impacts on biofilm formation and microbial communities; and (d) elucidating adsorption and biodegradation mechanisms. Collectively, this research supports the development of scalable, low-cost, and decentralized wastewater treatment solutions tailored for rural agricultural systems. By converting waste into value-added treatment media, this platform advances circular sanitation, reduces contaminant burdens, and promotes equitable access to safe water. Ultimately, it offers a viable pathway to replace lagoon-spray systems with sustainable and resilient treatment technologies.

Enhancing black soldier fly larvae density for scalable swine waste treatment and environmental health protection
Zhihan Sun, The University of North Carolina at Chapel Hill, Gillings School of Global Public Health

Intensive swine farming, prevalent in many parts of North Carolina (NC), produces waste that is rich in nutrients but poses significant environmental risks. At present, there are no effective treatment methods in place for managing this waste. Instead, it is commonly stored in large open-air lagoons, which frequently fail to sufficiently remove contaminants such as pathogens, excess nutrients, and emerging pollutants. This inadequate treatment contributes to ongoing environmental degradation, public health concerns, and social challenges. Thus, there is a critical need for innovative, environmentally sustainable technologies that can effectively and significantly reduce the large volumes of swine waste at a commercial scale.. Black soldier fly larvae (BSFL) composting offers a sustainable solution by reducing the volume of swine manure and valorizing it. Two key factors influencing BSFL performance are larval density and feeding rate, which affect social

behavior, stress survival, metabolism and ability to be reared on large scale. While previous studies have examined how these factors influence growth and waste reduction, none have directly explored their effects on larval digestive physiology. We set up small bioreactors to treat swine waste with BSFL assessing the effects of larval density (low 2, and high 5 larvae/cm^2) and feeding rate (low 50, medium 100, high 200 mg/larva/day) on its growth, protein content, digestive enzyme activity, and swine waste contaminant removal efficiency. All treatment conditions showed a sigmoidal growth curve with an exponential phase from days 4–8, emphasizing period is critical for nutrient intake and biomass accumulation. Any modifications to feeding strategies should prioritize this phase to enhance larval growth. Higher larval densities promoted faster population-level biomass gains (max. growth rate 0.64 day -1) despite reduced individual size, while ad libitum feeding enhanced both growth and enzymatic activity. Contaminant removal was robust, with reductions in total organic carbon (TOC: 56.32–78.62%), total nitrogen (TN: 53.77–74.72%), and total phosphorus (TP: 42.73–54.14%). TOC removal was significantly influenced by density and feeding rate, while TN and TP removal were not. Correlations revealed consistent positive associations among larval mass, protease activity, and contaminant removal across densities. However, other relationships—like between protein and carbohydrate levels—shifted, suggesting density-driven metabolic tradeoffs. Mediation analysis showed larval density moderately correlated with protein content but not mass, indicating protein accumulation can occur independently of growth. Protease activity was key for protein production and nitrogen removal, whereas alpha-amylase had antagonistic effects. Our results show that high larval densities, while reducing individual size, enhance overall biomass accumulation and contaminant removal without signs of competition. This supports the feasibility of rearing BSFL at high densities for commercial-scale swine waste treatment. Significant reductions in TOC, TN, and TP demonstrate the system's ability to address nutrient pollution impacting environmental and public health. By linking larval physiology—particularly increased protease activity and protein content—to improved waste degradation, our findings highlight BSFL composting as a scalable, sustainable solution for intensive swine farming and reducing public health risks in surrounding communities.

A Simple, Rapid Field Culture Test to Enumerate Pathogenic Vibrio cholerae Bacteria in Drinking Water
Mark Sobsey, University of North Carolina

Introduction:
The waterborne disease cholera continues to be a global threat that occurs in many countries worldwide and has surged worldwide since 2022. Rapidly detecting and quantifying infectious Vibrio cholerae bacteria in 100-mL water samples has not been

possible and instead drinking water samples are analyzed for levels of E. coli bacteria, which is an imperfect fecal indicator for cholera presence in drinking water.

In this study a new ready-to-use, one-step culture method to directly enumerate V. cholerae strains 01 and 0139 in 100-ml water samples was developed and tested for performance against an existing but more complex multi-step method that requires days to produce results. The new test provides chromogenic and fluorogenic V. cholerae Colony Forming Unit (CFU) results in an ambient temperature gel medium that inhibits the growth of other bacteria. The new test can be done in the field after minimal training, does not require a lab, complicated equipment, or highly trained analysts and is usable in low resource, rural, remote, and emergency areas.

Test kit materials are minimal, portable and light-weight, comprised of clear plastic bags and packets of sterile powder growth medium. A portable incubator may be needed, depending on ambient temperatures. Time to results is 24 hours when samples are incubated at 35°Celsius. The growth medium shelf life is at least 2 years from date of manufacture.

Methods:
The perform this test, collect 100 mL water sample a sterile plastic bag containing sodium thiosulfate to neutralize residual chlorine. Then, add one sachet of sterile alkaline peptone (APW) powder to 100 mL water sample and mix well until the APW dissolves (several minutes). Incubate the sample at 35 oC for one hour to resuscitate V. cholerae bacteria. Transfer the sample to a clear plastic bag, add V. cholerae powdered self-gelling growth medium to the water sample, and massage the bag contents to dissolve the gel medium in the water sample. Then, incubate plastic bag containing the gelling growth medium horizontally and allow the gel to harden. Incubate the bag at 35°C for 20 hours or for longer times at somewhat lower temperatures. Count yellow colonies in sample bags to identify presumptive Vibrio cholerae colonies and then shine a long-wavelength UV light on the sample bag to visualize fluorescent colonies. Yellow colonies that fluoresce blue are positive for V. cholerae and reported as CFU/100mL.

Results:
The new test system was tested in ambient surface water samples in the USA to which several different type strains of V. cholerae (Vc) O1 and O139 were added. Colonies of Vc O1 and O139 were yellow in color and fluoresced blue in the spiked river water samples. Vc colonies were readily observed because non-target bacteria colonies were completely inhibited, and none were observed in the sample bags.

Discussion:
The new V. cholerae culture test is simple and quantitative, it inhibits the growth of non-V. cholerae bacteria, and it is usable outside of a lab. Test users will be able to easily and

reliably identify water sources that contain culturable V. cholerae bacteria. This new water quality field test for V. cholerae meets the urgent global need to expand environmental monitoring and surveillance for V. cholerae in drinking water and provides a practical tool to a global public health problem. Routine environmental water quality monitoring with this V. cholerae test will identify cholera hotspots, track sources of cholera, and help evaluate the effectiveness of WASH interventions such as drinking water chlorination. Such water quality testing will help prevent and control cholera outbreaks before they occur and help decelerate rapid disease spread during outbreaks. Ensuring cholera-free drinking water via water quality testing will help improve public health and human productivity in countries where cholera is present.

Evaluating drinking water quality in the rural areas of East Africa within the WHO water safety framework
Adrienne Lane, Water for Good

This study assesses the Water for Good drinking water quality status across implemented projects in East Africa, specifically Ethiopia, Uganda, and Tanzania, using the World Health Organization (WHO) Water Quality Index (WQI) calculation method within the WHO Water Safety Plan (WSP) framework. Within the program areas, Water for Good aims to reduce WASH-related diseases and improve the health of children and families through a dual approach: constructing sustainable WASH infrastructure (e.g., water points, latrines, handwashing stations) and promoting behavior change. All households in target areas receive health education, and schools are mobilized through teacher training, student engagement, and maintenance planning. Communities and schools initiate investment and governance via WASH committees, after which infrastructure is constructed. Local health workers are also trained in preventing WASH-related diseases.

Focusing on water quality as a key driver of health risk, this study employs a spatio-temporal approach to monitor drinking water safety in WFG program areas. It integrates project and national laboratory data and applies the World Health Organization (WHO) Water Quality Index (WQI) within the WHO Water Safety Plan (WSP) framework. The analysis concentrates on health risks to vulnerable populations, including pregnant women, children under five, and the elderly. The study evaluates drinking water quality over time by integrating WFG and national laboratory test data, from construction to endline and post-project evaluations.

The Water Quality Index (WQI) was developed to assess key water quality parameters, highlighting regional trends and temporal variations in water safety. Ten physicochemical parameters were analyzed: turbidity, pH, nitrate-nitrogen, nitrite-nitrogen, total chlorine, free chlorine, total iron, fluoride, electrical conductivity, and total hardness ($CaCO_3$). These

values were processed using the WHO WQI method, resulting in an overall WQI of 52.94, classifying the water as having good quality for drinking purposes from the completion of water point construction and during regular ongoing monitoring visits. Statistical analysis confirmed a significant association between individual water quality parameters and overall WQI (p = 0.023), with fluoride and hardness levels showing the most notable influence on water safety classification. The pH sub-index (3.375) suggests generally stable chemistry but also points to the need for continued monitoring to avoid corrosive conditions that could compromise infrastructure and introduce heavy metals.

By embedding water quality analysis within the WSP framework and local systems for operations and maintenance, this study demonstrates the value of systematic, evidence-based monitoring in rural WASH programs. Sub-index trends offer early signals of localized risk, enabling proactive interventions. The findings emphasize that safeguarding public health in East Africa's rural communities, particularly for at-risk populations, requires both infrastructure investment and sustained, quality-focused monitoring. This study underscores the importance of integrated monitoring systems, where sub-index analysis enables early detection of specific risks to vulnerable populations.

Assessing Household Water Insecurity Among Pastoralist Communities in Northern Kenya
Emmanuel Olela, Millennium Water Alliance Kenya

Background:
Pastoralist households in Kenya predominantly inhabit the Arid and Semi-Arid Lands (ASALs), regions classified as water insecure due to a complex interplay of limited or unreliable water access, frequent exposure to water-related disasters such as droughts and floods, and inherent natural water scarcity. In response, several development actors have implemented programs to address this chronic insecurity. Since 2021, the Millennium Water Alliance (MWA) has been working to improve water access across five ASAL counties in Kenya through the Resilient Arid Lands Partnership for Integrated Development Plus (RAPID+) program. As part of a recent mid-term review to assess progress, MWA evaluated the program's impact on household water security using the Household Water Insecurity Experiences (HWISE) Scale. The HWISE scale comprises 12 experiential items that measure various dimensions of water insecurity including accessibility, reliability, adequacy, and safety.

Objectives:
The study aimed to assess household water insecurity levels among pastoralist households benefitting from the RAPID+ program. Specifically, it sought to: i) evaluate the

validity of the HWISE scale for pastoralist households in Kenya's ASALs and ii) measure household water insecurity among households within RAPID+ implementation areas.

Methods:
A household survey was conducted involving a randomly selected sample of 1,485 households from villages where RAPID+ activities have been implemented. Data was collected through a structured questionnaire incorporating the 12 HWISE items. The analysis involved: i) Descriptive analysis to assess data completeness; ii) Item analysis (including difficulty, discrimination, and Cronbach's alpha) to evaluate the performance of individual HWISE items; iii) Principal Component Analysis (PCA) to confirm the scale's validity in the Northern Kenya context; and iv) Likert plot analysis to determine levels of household water insecurity among the sampled households.

Results:
Descriptive analysis showed a very low percentage of missing HWISE item responses (0.0–0.63%), indicating strong engagement. Item difficulty scores ranged from 0.11 to 0.16, suggesting the items were moderately challenging to respond to. Discrimination values ranged from 0.86 to 0.90, indicating the scale's effectiveness in distinguishing between water secure and insecure households. A Cronbach's alpha of 0.977 reflected high internal consistency. PCA results indicated a single-factor structure, confirming that all items measured the latent factor of water insecurity. Likert plot analysis revealed that 60.3–73.8% of households never worried about meeting their water needs, indicating high water security. A further 16.7–26% rarely worried (moderate security), while 7.8–13.1% sometimes worried (mild insecurity). Notably, 0% reported often or always worrying, indicating no severe water insecurity.

Implications:
The study confirms the validity of the HWISE scale for assessing household water insecurity in pastoralist and ASAL settings in Kenya. Findings also suggest that RAPID+ interventions have positively contributed to improving household water security in target areas. Lastly, the study supports the use of the HWISE scale as a valuable experiential tool that complements traditional quantitative metrics, such as those used by the Joint Monitoring Program.

What's in your network? A systematic supply chain mapping of LMIC drinking water infrastructure
Timothy Purvis, The Water Institute

Lead (Pb) is an important component of drinking water infrastructure. It is used in the brass fittings and galvanized and PVC pipes which form the basis of most rural drinking water

systems. These materials are commonly used in handpump systems, which have critical importance in Low- and Middle-Income Countries (LMICs) with 50% of Sub-Saharan Africa depending on such technology. There has also been evidence of potentially lead-containing materials in urban drinking water systems like centralized pipe networks. As these systems age, they have the potential to expose communities to lead, a toxic metal with substantial and irreversible negative health implications for individuals and societies. While these risks and exposures are known, the water and health sector does not have a coordinated method for addressing the contamination of systems. An important low-cost intervention point can be determined through supply chain mapping and subsequent policy. A supply chain map identifies the main actors and materials involved in manufacturing, distributing, purchasing, installing, and maintaining drinking water systems. The output allows national governments to determine points of leverage for intervention and for the global sector to coordinate efforts to prevent contamination.

Our study pioneered the application of supply chain mapping to drinking water infrastructure, with a focus on lead-containing materials and their lead-free alternatives. Documentation was analyzed across 10 countries and 50 manufacturers to determine the scope of material flows in LMICs. An integrated document and physical material evaluation with XRF materials was piloted for future use by national actors. As expected from prior literature, South Asia is a major manufacturing hub for handpump materials. These are built across South Asia, with limited availability of material certifications to ensure lead-free components are being exported. These exported, lead-containing materials then enter Sub-Saharan Africa through a handful of key ports, presenting an opportunity for intervention at an international level. For pipe materials, domestic manufacturers are far more prevalent, presenting a fragmented sector, increasing the degree of "invisibilization," obscuring the links between manufacturers and final purchasers. Integrated materials data, generated by X-Ray Fluorescence evaluation, indicates that even advertised lead-free materials still contain lead with the potential to leach into drinking water systems. Therefore, the framework for mapping the supply chain with material evaluation can be applied in a case-by-case basis to improve global efforts to decrease lead exposures.

Measuring the role of WaSH in healthcare workers' well-being: Survey pilot and validation study
Lucy Tantum, The Water Institute, University of North Carolina-Chapel Hill

WASH services in healthcare facilities – including water, sanitation, hygiene, waste management, and cleaning – are essential to patient and worker safety. When WASH is inadequate, healthcare workers and their patients may experience detrimental impacts on their physical safety, job satisfaction, and overall well-being. Evidence for the role of WASH in healthcare worker well-being has arisen from qualitative studies and non-validated

surveys; few high-quality, quantitative indicators are available for monitoring these impacts. This study aimed to develop, pilot, and validate a survey for measuring impacts of WASH on healthcare workers' physical and mental well-being in Zambia. The survey tool compiled pre-existing and new measures to assess healthcare worker stress, job satisfaction, burnout, safety climate, occupational injury, and out-of-pocket spending on WASH supplies. Data collection took place in urban and rural healthcare facilities in Lusaka and Northern Province, Zambia, in April-June 2025. During a survey pre-testing process, we conducted cognitive interviews with healthcare workers to identify clarity and comprehension issues and revise the survey tool (target sample size = 20). Subsequently, we administered the survey in a larger sample of healthcare workers (target sample size = 200). At each facility, we also collected data on WASH service levels to assess correlates of well-being. At the time of this abstract submission, data collection was underway. All data collection and analysis will be completed prior to the conference. Preliminary findings from survey pre-testing indicate that healthcare workers experience impacts from inadequate sanitation, a lack of hand hygiene supplies, and understaffing at healthcare facilities. Workers demonstrated motivation to protect themselves and their patients from infections but recognized poor WASH conditions as a safety threat. Statistical analysis of survey results will demonstrate survey items that can provide valid, useful insight into WASH-related well-being among healthcare workers in Zambia. The survey tool can be applied during baseline needs assessments or program evaluations. By monitoring changes in worker well-being, it is possible to understand whether programs are strengthening infection control, safety, and worker retention. Survey data could also contribute to more holistic cost-benefit analysis by incorporating worker satisfaction and health outcomes alongside conventional measures of healthcare-associated infection. These approaches can support effective, targeted investment to improve WASH in healthcare facilities.

Incentivizing Small Local Water Providers to Improve Water Quality in Low Income Areas of Nairobi, Kenya
Haleemah Qureshi, The Aquaya Institute

Purpose:
Globally, low-income urban populations living in informal settlements often rely on small, local providers (SLPs) operating kiosks, carts, tankers, or boreholes, instead of regulated water utilities. Recent studies found that SLPs provide drinking water to over 50% of Sub-Saharan Africa's urban population. Improving water quality among SLPs would promote more equitable access to clean water. Based in Nairobi, Kenya, this study aimed to: (i) understand SLP water quality and barriers to water treatment, (ii) identify SLP attributes driving household choices and, (iii) identify potential strategies to incentivize water quality improvements.

Methods:
This study opportunistically sampled 50 SLPs across six categories for water quality testing (11 handcarts, 10 tankers, 4 boreholes, 6 home resellers, 13 private kiosks/standpipes, and 6 utility-owned prepaid dispensers). We collected 76 water quality samples to analyze residual free chlorine levels and E. coli concentrations at SLPs' collection and distribution points. We also conducted 327 household and 50 SLP surveys in addition to 15 focus group discussions with households and SLPs. Household surveys included a Discrete Choice Experiment (DCE) to better understand how households value and rank hypothetical water quality certification compared to four other high-priority attributes (convenience, availability, social bonds, and price).

Findings:
Prepaid dispensers, kiosks, and home resellers largely sourced water from the piped network, while hand carts and tankers often sourced water from kiosks or boreholes. Most (78%) SLPs' water samples showed no presence of E. coli. However, only 33% of all samples met or exceeded the minimum requirement for free chlorine residual (0.2 mg/L) at distribution, increasing contamination risks during household storage. Kiosks and home resellers reported storing piped water for 2-3 days, likely contributing to residual chlorine degradation before distribution. Insufficient knowledge was a significant barrier to SLPs tracking water quality, with 60% of SLPs unaware that the government set water quality standards and only 12% (mainly tankers and boreholes) reporting that their water had ever been tested for fecal contamination or residual chlorine by authorities. Meanwhile, most households in informal settlements relied on SLPs, primarily kiosks (58.6%). 51% of households reported choosing SLPs based on convenience, but DCE results showed that when comparing convenience and other attributes to hypothetical water quality certification, certification had the highest influence on household choice, with households preferring certified water over uncertified water ($p < 2e-16$). Influencing household choice could incentivize SLPs to improve water quality, as market competition was the second most cited challenge by SLPs (22%), after water rationing (30%).

Discussion:
Based on our findings, we recommend leveraging challenges identified by SLPs to incentivize improved water safety management practices such as water quality trainings, regular self-testing and/or laboratory testing, and increased chlorination. Appropriate incentives could include transparent water quality certification to leverage consumer demand and to grow a customer base, and discounted or free storage containers to cope with piped water rationing in exchange for regular testing. Furthermore, interventions should prioritize kiosks, as they face chlorination challenges and represent the largest market share among SLPs in Nairobi's low-income areas.

A Cross-Sectional Study on Water and Sanitation Resilience of Urban Slum in Dhaka City, Bangladesh
Md Toriqul Islam, NGO Forum for Public Health

Urban slums face significant challenges due to inadequate and unsafe water and sanitation services, resulting in adverse effects on health, social and gender aspects. This study aimed to examine the resilience of water and sanitation systems in the West Agargaon slum of Dhaka, Bangladesh, with an emphasis on how gender influences access to these essential services. This study uses the Harvard Analytical Framework to examine water and sanitation conditions from a gender perspective, evaluating resilience in robustness, redundancy, rapid recovery, integration, inclusiveness, and justice & equity. Primary data was collected through structured questionnaires from respondents and captured socio-demographic information as well as detailed data on water, sanitation, and gender issues. The slum was divided into three zones based on proximity to water sources to explore regional variations in access. Data collection was guided by the principles of HAF, with questions organized to evaluate the resilience of the water and sanitation infrastructure in the community, considering both gendered and non-gendered aspects. The statistical analysis showed that the resilience of water and sanitation in the urban slums isn't great, and that it falls under suboptimal conditions, with the mean ranging from 54% to 68% indicating big gaps in all six dimensions of resilience. The most pressing issue identified was the inequitable access to clean water and sanitation facilities, especially for women, who experience heightened vulnerabilities due to traditional gender norms and power dynamics. According to the HAF analysis, women in the slum face distinct barriers, including longer distances to water sources, lower decision-making power in household water management, and greater exposure to the health risks of poor sanitation. Additionally, the Multi-Criteria Analysis (MCA) confirmed that women are more deprived of water rights compared to men, (Women 0.37 and Men 0.45), reinforcing the gendered nature of water insecurity in the slum.

The research addressed the importance of adopting a gender-sensitive approach to water and sanitation policies in urban slums in Bangladesh. It is not only about fixing infrastructure but also about changing social norms and policies to account for the differing needs and experiences of both women and men. The results indicate that integrating principles of gender equity can enhance resilience in these systems, ensuring equal access to resources, decision-making, and support services for both men and women.

To conclude, this study highlights the need for targeted efforts to improve water security and sanitation infrastructure in the West Agargaon slum, with a focus on gender equity. The low resilience scores across all dimensions necessitate immediate action from policymakers, local authorities, and stakeholders. There is a need to create inclusive, robust, and sustainable water and sanitation systems, considering gender as a crucial

factor for building long-term resilience and improving the quality of life for everyone in these marginalized communities.

Targeted pathogen and AMR analyses reveal microbial hazards in a maternal and child hospital in urban La Paz, Bolivia
Lindsay Saber, University of North Carolina at Chapel Hill

Introduction:
Healthcare-associated infections and antimicrobial resistance (AMR) remain significant challenges in healthcare, posing risks to patients and staff. Premise plumbing contains reservoirs for pathogens (+/- AMR) and has been implicated in hospital outbreaks. Disinfection and hygiene protocols are not always effective. This study took place in a maternal and infant hospital in La Paz, Bolivia, which presents unique environmental challenges, including elevated microbial hazards.

Objective:
Detect pathogens of concern and AMR markers within distinct wards and sample types in a Bolivian hospital through molecular (qPCR, 16S amplicon sequencing) and culture- based methods.

Methods:
There were three sampling time periods: molecular samples during May-July 2024 and culture samples February 2025 and May 2025. All sampling occurred in four wards: operating, delivery, reception, and a combined patient/reception area. Molecular samples included air, surface swabs, tap water, and P-trap water, collected in triplicate over 10 weeks (7 samples/event/ward). Samples were preserved in DNA/RNA Shield, transported to UNC laboratories, and analyzed via custom multi-parallel RT-qPCR for 48 gene targets. Culture samples included air, surface, and p-trap samples and were directly plated and grown overnight on selective media for AMR- prone pathogens.

Results:
Molecular: Positive reads were identified for 36/48 targets across sample types, highlighting diverse microbial presence. All the means reported are arithmetic mean copies/ sample (95% CI). If no CI is reported, only one sample detected the pathogen. Of note, all sample areas detected Aeromonas (Air:4/10 samples, 190(-130, 510) High Touch Swab:1/10, 55(-67, 180); Low Touch Swab:5/10, $1.2\times10^7(-1.5\times10^7, 3.0\times10^7)$; P-Trap:4/13, 4100(-4500, 1.3×10^4); Adjacent Sink Handle Swab:2/16, 39 (-24, 100); Sink Basin Swab:6/12, 169(7.3, 330); Tap Water:2/14, 1900 (-2200, 6000). Five sample types contained Salmonella (Air:2/10, $3.2\times10^7(-4.0\times10^7, 1.0\times10^8)$, Low Touch Swab:1/10, 140(-180, 460), P-Trap:3/12, 1.4×10^8 (-1.7×10^8, 4.5×10^8), Sink Basin Swab:1/13, 1.6×10^{10} (-1.8×10^{10},

5.0x1010), Tap water:3/14, 310(-150, 760). All sample types except air and tap water detected canine mtDNA (20/80 samples, 63(25,101), while an AMR marker and poultry mtDNA were found in all sample types except tap water (intl1:58/80 1.9x107(1.1x106, 3.7x107; poultry:42/78, 590(250,940).

Culture:
Of the three sampling occurrences in February 2025, we detected culturable ESBL bacteria (arithmetic mean: 1 colony/ 15cm3), Acinetobacter (2 colonies/ 15cm3), and Pseudomonas (31(-30,92) colonies/ 15cm3) in the sink basin samples. Air samples had detectable ESBL bacteria (2(-3,7) colonies/ 6,000 liters). We detected culturable ESBL bacteria (>300 colonies/ 50mL), Acinetobacter (>300 colonies/ 50mL), MRSA(2(0,4) colonies/ 50mL), and Pseudomonas (250(150,350) colonies/ 50mL) in the p-trap water. Sampling will continue in May, and we expect 12 additional sampling occurrences to take place during this period.

Conclusions:
Baseline data revealed the high prevalence of microbial hazards within the hospital across sample types, representing potential hazards in these spaces. Additional culture measurements of air and surface and 16S sequencing profiles of all sample types are forthcoming. These data can serve as the baseline for intervention strategies intended to reduce pathogenic risk in hospital settings.

Compact BioSand Filter Prototype Performance in Cambodia: Field Comparison with a FullSized Plastic BSF
Ellen Brisley, University of British Columbia & Clear Cambodia

Background:
Clear Cambodia, a Phnom Penh-based non-profit, has installed over 350,000 BioSand Filters (BSFs) to reduce waterborne illness in rural areas where diarrhea and related diseases are prevalent. BSFs are household-scale, intermittently operated, point-of-use slow sand filters.

A compact BSF prototype was developed to achieve three goals:
1. Compactness (~50% reduction in volume) for indoor placement;
2. Integrated post-filtration storage to reduce contamination risk from separate improperly cleaned storage containers; and
3. Aspirational design to improve user acceptance.

The prototype was designed so the raw water reservoir volume equaled the filter's pore volume, in line with the Centre for Affordable Water and Sanitation Technology (CAWST) guidelines aimed at enhancing viral removal.

This study evaluates the compact prototype against standard BSFs, asking: Can a compact filter perform comparably despite over 50% less sand volume and 25% less column height?

Methodology:
Two standard control plastic BSFs (sand column height: 45cm; top sand surface area: 830cm^2; pore volume: 12.4L) and two compact prototypes (column height: 33.8cm; top sand surface area: 529cm^2; pore volume: 7L) were operated in parallel over eight weeks, using the same source water collected from the Mekong River. All filters used fine sand (effective size: 0.17mm; uniformity coefficient: 2.12), consistent with CAWST guidelines and Clear Cambodia practice.

Filters were charged twice daily with one pore volume of water each time. Influent water characteristics included turbidity (median: 26 NTU; range: 18.0–64.5 NTU; n=44); E. coli (median: 160 CFU/100mL; range: 0-290 CFU/100mL; n=18); and total coliforms (median: 750 CFU/100mL; range: 290-3,800 CFU/100mL; n=18). Flow rates were measured three times per week; effluent samples were analyzed regularly using ISO 9308 membrane filtration.

Results:
Median hydraulic loading rate was 374 $Lh^{-1}m^{-2}$ for the prototype and 452 $Lh^{-1}m^{-2}$ for the control BSFs, both consistent with CAWST's recommended 400 $Lh^{-1}m^{-2}$. The results show similar turbidity and microbial reduction in the prototype and control BSFs. The prototype and control BSFs produced median effluent turbidities of 2.0 NTU (range: 0.1-6.0; n=44) and 2.0 NTU (range: 0.1-6.6; n=44), respectively—below the World Health Organization's guideline of 5 NTU. Both filter types achieved a median turbidity reduction of 91%. Microbial results showed filtered water median E. coli counts of zero in both prototype (n=18) and control filter (n=18), and median total coliforms of 155 (n=18) and 60 (n=18) in the prototype and control, respectively. Differences for both E. coli and total coliforms were not statistically significant.

Conclusions:
Results indicate that the reduced height and volume did not measurably compromise turbidity and microbial filtration performance. This may be because most removal happens at the top of the filter in the biolayer. The prototype's integrated storage container may improve end-user water quality and deserves further study.

The prototype's reduced size and integrated storage aims to improve portability, space efficiency, and aesthetic appeal. Further testing and user engagement are recommended to assess long-term usability and market viability.

Better Knowledge, Better Facilities, Same Behavior: Findings from a Cluster-Randomized Trial of WaSH-in-Schools Interventions
Gracie Hornsby, Stanford University

As of 2019, only 63% and 57% of schools globally had basic sanitation and hygiene services, respectively (JMP, 2020). WASH services are critical for a healthy learning environment, but realizing the health and non-health benefits of WASH in schools (WinS) requires that students use these facilities correctly and consistently. Existing WinS literature lacks consensus about the most effective strategies for promoting healthy WASH behaviors among students. In this trial we evaluated the individual and combined effects of WASH-related education and infrastructure operation and maintenance (O&M) interventions on both WASH service delivery and on students' WASH knowledge and behavior.

We implemented a 4-arm cluster-randomized trial in 200 government primary schools in rural Uttar Pradesh, India. Treatment arms received (1) a 12-session play-based WASH curriculum (n=47 schools), (2) enhanced WASH infrastructure O&M services delivered through a private 3rd party agency (n=53), (3) both interventions (n=52), or (4) neither (n=48). Within each school, we drew a random gender-stratified sample of 20 Grade 1 and 20 Grade 4 students (average of 7,338 students/round). Over 13 months, data collection at each school included 3 structured surveys of students and teachers, 9 unannounced infrastructure observations, and 8 unannounced student behavior observations. We used mixed-effects regression models with a difference-in-differences approach to analyze all data. We registered a pre-analysis plan with 3iE's Registry for International Development Impact Evaluations. Researchers were blinded to treatment identities until all pre-specified analyses were completed.

Student knowledge of critical handwashing times and germs increased significantly more in schools receiving the WASH curriculum than in control schools (both $p<0.01$). Toilets in O&M schools were more likely to be unlocked, drain properly, have anal cleansing water, and be clean during spot checks (all $p<0.001$). Despite these significant improvements in knowledge and infrastructure conditions, observed toilet use increased only modestly in O&M arms (OR 1.67-1.84) and lost statistical significance after multiple testing adjustment. No treatment showed an effect on observed student handwashing.

To better understand the null effects on student behavior, we leveraged time-series clustering to identify patterns of linear increase, no change, and non-sustained behavior change across subsets of schools. Linear increases in toilet use and handwashing rates were significantly more common in curriculum + O&M schools (p<0.05), suggesting that combined delivery resulted in sustained behavior change under certain conditions. Preliminary findings also indicate that regularity of infrastructure and consumable availability, but not student knowledge, is associated with sustained student behavior improvements.

This study demonstrates that dramatically improving both student WASH knowledge and the quality of the WASH facilities available at schools will not necessarily translate into meaningful impacts on student WASH behavior. This challenges much of the prior WinS literature linking such improvements to health and non-health benefits for students. A unique value of this trial is understanding why a subset of schools in our sample were able to out-perform others who had received the same interventions. Our remaining analyses will identify the school- and community-scale conditions under which well-designed school WASH investments actually achieve their goal of sustained health behavior change.

Long-Term Evaluation of a Backyard Poultry Management and Hygiene Intervention in Rural Bangladesh
Elizabeth Thomas, Johns Hopkins Bloomberg School of Public Health

Background:
Backyard poultry raising is common in rural households in low-resource settings, where it can contribute positively through nutritional and financial benefits, and negatively through fecal contamination of dwellings and courtyards. In 2020-21, we implemented a two-arm pre-post pilot study of a behavior change communication intervention to encourage improved poultry housing (i.e., multiple compartments and ventilation), feces management and hand hygiene practices among 80 households in rural Bangladesh. Through formative research, the intervention built on existing practices to promote separation of children from poultry feces. At the first evaluation in 2021, five months post-intervention, 58% of all study households had a poultry shed and significantly fewer households had visible poultry feces piles inside their household dwelling. In this current study, we investigated sustained uptake of the intervention recommendations.

Methods:
For this long-term evaluation, we re-enrolled all available households (n=75) in 2024, four years after intervention implementation. We administered a survey to the household's primary poultry raiser to assess poultry housing practices and satisfaction and poultry

feces management. An unannounced spot-check was conducted to verify poultry housing and enumerate piles of poultry feces inside the household dwelling.

Results:
At the long-term visit in 2024, 83% of households had a poultry shed and 76% were improved sheds. Of the improved sheds built during the intervention, most were still in use. Sixteen households built sheds between the first and long-term evaluation visits, 10 of which met the criteria for an improved shed. The percentage of households that reported confining all poultry outside the dwelling the previous night was 66% at the long-term visit, compared to 33% at the first evaluation visit and 2.5% pre-intervention. The proportion of households with no visible poultry feces piles inside the dwelling was lower at the long-term visit (67%) compared to the first evaluation (81%), but households were still visibly cleaner than they had been pre-intervention. Almost all (92%) of poultry raisers with an improved poultry shed reported that they were satisfied with their poultry housing. The most common reported benefits of a shed separate from the dwelling were having no smell inside (25%), less disturbance from poultry (20%) and fewer poultry feces inside (18%). One-third of households continued to follow the intervention recommendation to dispose of poultry feces in a specific pit, down slightly from 45% at the first evaluation visit. Significantly more households had soap present at their handwashing location at the long-term evaluation (77%) compared to the first evaluation (33%), though no households had a soapy water bottle, which was promoted during the intervention.

Conclusion:
We found sustained improved poultry housing and feces management, along with new uptake, four years after a behavior change communication intervention was delivered to reduce young children's exposure to poultry feces. Analyses are ongoing to explore intervention impacts on fecal contamination of the domestic environment and child health outcomes.

Cleaning Drinking Water Storage Containers - A Systematic Review of Practices and Water Quality
Mastura Morshed Nawmi, Lehigh University

Introduction:
Waterborne diseases pose a public health challenge, exacerbated by climate change and inadequate water, sanitation, and hygiene practices, particularly in low-resource contexts. Despite treatment, recontamination of drinking water during storage is well known and has been linked to health risks including diarrhea and cholera. About 74% of the global population has access to a safely managed water supply. However, many households do not have access to tap-based service on-plot and must collect and store their drinking

water. Recommendations for safe drinking water storage include using covered, opaque containers with a tap/ladle for access. Yet, biofilms containing potentially pathogenic bacteria grow on container surfaces. Our aim is to synthesize existing evidence on container cleaning and safe water storage to identify practices that may improve stored water quality.

Methods:
We conducted a systematic literature review to understand global safe drinking water storage cleaning practices and their influence on water quality. We used a systematic search strategy including, keyword development; database search in PubMed, Web of Science, and Google Scholar; de-duplication using Covidence software; title, abstract, and full-text screening using predefined inclusion/exclusion criteria following the PICOS framework; data extraction; quality assessment; and analysis. All screening was completed in duplicate by two trained researchers and conflicts were resolved by the PI. Household data on cleaning and storage practices and water quality were analyzed.

Results and Conclusions:
Database searches through March 2023 yielded 133,363 articles, reduced to 75,751 after deduplication. After title and abstract screening, 2,884 papers were included for full-text review, resulting in 112 studies for data extraction. In total, 75 studies (67%) recorded water storage container type, of which >6,000 households used jerricans; 39 studies (34%) recorded if households cleaned their containers, and 62% affirmed. 66 studies recorded water storage container cleaning frequency, the majority of households reporting daily cleaning (50.5%) or cleaning 2-3 times a week (32.4%). Fewer households cleaned their containers weekly (22.5%), monthly (5.1%), or never (10.5%). Importantly, the most commonly reported cleaning frequency overall was "regularly" or "frequently" (23.7%) which is imprecise and difficult to interpret. Of the 15 studies that reported cleaning materials, 12 studies recorded water only, with 34.7% of households affirming use; 10 studies reported soap and water, with 33.5% of households affirming. Fewer studies reported on the use of chlorine (n=2), natural abrasives (n=6), or sponges/brushes (n=3) with households reporting use rates of 49.3%, 8.4%, and 4.1%, respectively. Importantly, only 12 studies (10%) provided microbiological water quality data linked to container cleaning, which were not comparable due to different recorded indicators. Overall, the lack of uniformity in reported outcome parameters made broad comparative analysis challenging. To better understand the extent and effectiveness of container cleaning practices to improve water quality, it is recommended that researchers report on associated parameters like cleaning material, frequency, and water quality.

Moving Beyond Rhetoric: Effectively Engaging Governments in WASH Co-Financing — Evidence from a Positive Deviance Study
Fiker Abebe, Splash

Government co-investment is frequently cited as a best practice in WASH programming, yet few studies explore how to secure and sustain meaningful financial commitments from national and sub-national governments. This presentation shares findings from the Project WISE Engagement Framework, a positive deviance study conducted by Splash and Causal Design from 2023–2024, which investigated why and how the Government of Ethiopia (GOE) committed co-financing to Splash's Project WISE in Addis Ababa and Bahir Dar—resulting in 100% citywide WASH coverage in public schools.

Using qualitative methods including 12 key informant interviews and document review, the study examined stakeholder motivations, engagement strategies, and coordination mechanisms that led to successful and sustained government investment. Unlike most analyses that focus on outcomes, this research provides a detailed process map of the engagement journey—starting with early advisory roles, to pre-MOU data collection, pilot projects, iterative co-funding negotiations, and formal project agreements. It surfaces the concrete steps taken across four stakeholder engagement phases and identifies success factors that other implementers can replicate.

Key findings include the importance of: (1) co-funding as a differentiator among NGOs, (2) data-driven advocacy to make the severity of the school WASH crisis visible to political leaders, (3) consistent, multi-level engagement with unlikely but critical government actors (e.g., finance bureaus), (4) early alignment with existing government priorities and planning cycles, and (5) visibility of implementation success through monitoring, site visits, and impact storytelling.

The study also details how donor influence, particularly from "backbone funders" like CIFF, played a catalytic role by requiring government co-financing as a condition of grantmaking. Additionally, the research identifies the role of local CSOs, particularly in Bahir Dar, as strategic partners in demonstrating community support and bridging trust between Splash and regional authorities.

Participants in this session will come away with practical guidance on how to move beyond high-level calls for government participation to tangible, replicable strategies for engagement that unlock public resources, strengthen accountability, and enable citywide scale. As global attention shifts toward systems-strengthening and government leadership in WASH, this case offers timely and actionable insights for implementers, donors, and policymakers committed to making sustainable WASH in Schools a reality.

Predictors of Latrine Subsidy Uptake: Gender, Poverty, and Household Dynamics in Rural Ethiopia

Crystal Huang, IDinsight

Background:
Understanding the factors that influence household uptake of sanitation subsidies is critical for designing equitable and effective programs. Existing literature suggests that wealthier and more educated households are more likely to adopt sanitation improvements, while social and logistical constraints often inhibit uptake among the poorest. In rural Wolayita, Ethiopia—where only ~8% of households own improved latrines – identifying predictors of subsidy uptake can help accelerate progress towards the Sustainable Development Goals (SDGs) for sanitation.

Methods:
We analyzed data from 664 households offered a latrine subsidy as part of a larger randomized controlled trial conducted by IDinsight and iDE in three woredas of Wolayita Zone, South Ethiopia Region. Between February and April 2025, market-based sanitation sales agents visited eligible households to offer either a partial (standard) subsidy or full subsidy based on a poverty-targeting algorithm. Standard subsidy households (n=482) were required to contribute 22-41% of the latrine cost (ETB 2,034/USD 16.40) through cash and in-kind labor. Households deemed ultra-poor (n=182) were offered the latrine at no cost. Data collected included household demographics, subsidy uptake decisions, and reasons for refusal. We used multivariate linear probability models to examine associations between household characteristics and subsidy acceptance.

Findings:
Overall, 79.7% of households accepted a subsidy. Take-up was 74.9% among standard subsidy recipients and 93.1% among those offered a full subsidy. Households with female decision-makers for the uptake decision were 12.8 percentage points less likely to accept the standard subsidy (p=0.006), suggesting persistent gender-related barriers. Each additional household member increased the likelihood of uptake by 2.8 percentage points (p=0.001), consistent with evidence that larger households have greater need and available labor. Higher poverty likelihood scores were marginally associated with lower uptake of the standard subsidy (-7.9 pp, p=0.061), while food security indicators were not significant predictors. Among full subsidy households, uptake was nearly universal, and no household characteristic significantly predicted refusal.

Discussion:
Our findings are consistent with prior studies in Ethiopia and globally, which show that affordability, gender norms, and household capacity influence sanitation uptake (Crocker et al., 2017; Tiruneh et al., 2021). The strong uptake of fully subsidized latrines reinforces the role of cost as a barrier, particularly for the poorest. The lower uptake among households with female decision-makers underscores the need to consider gendered constraints in sanitation delivery, such as women's reduced financial autonomy or access

to labor. Larger households may benefit from economies of scale or heightened sanitation needs.

As Ethiopia and other countries pursue pro-poor, area-wide sanitation goals, these findings suggest the need for tailored program designs that address both affordability and implementation barriers for marginalized groups. Future work should explore additional strategies—such as labor facilitation or decision-making support—to improve access for women and ultra-poor households.

Rethinking how national drinking water safety is evaluated in the United States
Katherine Alfredo, University of South Florida

Despite federal initiatives such as the Infrastructure Bill to address sub-par drinking water concerns across the U.S., we still currently lack a consistent metric to compare the cumulative relative health risk associated with drinking a glass of water in one location with that in another. For a long time, regulators have monitored U.S. drinking water delivery systems based on the number of violations of an individual contaminant. This focus on the history of contaminant-specific violation counts ignores the overall health burden from concurrent exposures to multiple chemicals. This research builds on the previous work creating a Relative Health Index (RHI), a cumulative risk metric that encapsulates cancer and non-cancer toxicity values, exposure concentrations, and severity scores, and applies this metric to over 30,000 Community Water Systems (CWSs) in the United States. The investigation includes CWS contaminant violation experience from 1982 to 2023 and over a decade of RHI calculations based on occurrence of contaminants.

Our goal was to answer two practical questions: (1) can we compare the relative safety of different glasses of water across the U.S.? and (2) are the most vulnerable populations protected by recent regulatory determinations? To explore these questions, we have created a database that merges data from publicly available datasets (i.e., SDWIS, ECHO, IRIS, UCMR5, 6YR4) and calculated the RHI values for each contaminant and aggregated the values by Public Water System ID (PWSID). This is the first national risk cup analysis for the entire country.

In addition to this assessment, we use the RHI metric to evaluate the outcomes of the Fourth Regulatory Determination to understand if a "meaningful health risk reduction" was obtained. We combined the RHI and Social Vulnerability Index (SVI) matrices on a subregion-scale, consisting of national occurrence data and relevant toxicological studies for contaminants included in the latest regulatory determination, to develop an understanding of the communities in the U.S. that may be experiencing a greater risk from this selection of emerging contaminants. This analysis aims to shift the policymaking frame

in a more comprehensive and equitable direction, accounting for the risks to vulnerable communities as well as the comparative risk across contaminants.

Willingness to Invest in Hand Hygiene Enabling Technologies: A Purchasing Experiment in Lusaka, Zambia
Katherine Davies, London School of Hygiene & Tropical Medicine

Handwashing with soap is critical for preventing respiratory and diarrheal disease. Access to a dedicated handwashing facility (HWF) improves behavior; however, coverage is limited in low-resource settings with affordability often cited as a barrier. Achieving universal hand hygiene in the least developed countries requires an estimated household-level investment of $17 for a handwashing facility. While subsidies may offset supply costs, households typically bear the majority. The ability and willingness of end-users to meet these costs requires further investigation. This two-phased purchasing experiment aimed to explore whether potential end-users of improved HWFs in peri-urban Lusaka, Zambia were willing to invest their own resources in improved facilities and aimed to quantify preferences for purchasing specific HWF designs. The study was conducted in two phases, we present the methods and results for each phase below. In Phase 1, three HWF (high cost premanufactured, low-cost premanufactured, and locally manufactured) were tested. Sixty households used two of the three HWFs over separate two-week periods (20 households per HWF combination). Households received a 300 Zambian Kwacha (ZMW) (~$10) gift and a random discount voucher (25%, 50%, 75%) before deciding whether to purchase a HWF at a discounted price. Sixty-seven percent (40/60) of households purchased a HWF, with higher discounts leading to increased uptake. The locally manufactured HWF called the Kalingalinga bucket (250 ZMW, ~$10), was preferred over both the high-cost (1000 ZMW, ~$38) and low-cost (100 ZMW, ~$4) premanufactured HWFs. In phase 2, a larger sample of 160 households used the Kalingalinga bucket for two weeks, then received a 50 ZMW gift (~$2) and a randomly assigned discount voucher (20%, 40%, 60%, 80%; 40 households per group), before deciding whether to purchase the HWF. Purchasing followed an inverse relationship with price: 98% (39/40) of households purchased a HWF at an 80% discount (effective price: 0 ZMW) compared to 30% (12/40) at a 20% discount (effective price: 150 ZMW). Effective price (amount paid for the HWF beyond the 50ZMW gift) was a negative predictor of purchasing behavior (β = –0.025, SE = 0.004, p < 0.001). For every 1 ZMW increase in effective price, the odds of purchase decreased by 2.5%. The model predicted that 50% of households would purchase at 106 ZMW, notably below the average retail price of 250 ZMW. Financial constraints (lack of funds and other priorities) were the main barriers to purchasing. This study offers insights into end-user affordability, emphasizing the need for financial interventions and affordable innovations to achieve universal hand hygiene.

Electoral Incentives and Trust in Water Utilities as Drivers of Local Government Participation in Performance Based Financing Program: Evidence from Indonesia
Silvia Landa, University of North Carolina at Chapel Hill

The escalating global water crisis, intensified by climate change, demands a shift from conventional governance approaches to innovative policy solutions. Despite numerous innovative policies in the water sector, their adoption by local governments remains slow. National mandates alone are insufficient; effective implementation depends on how well local governments translate these policies into action—a crucial step in ensuring resilient water access for all citizens. Despite this urgency, there is no systematic synthesis of global experiences to identify key factors that accelerate the adoption of innovative water sector policies at the local level. An innovative policy refers to a policy that is new to a specific jurisdiction, even if it has been implemented elsewhere, while scale-up refers to the diffusion or expansion of a policy beyond its original implementation site, often across multiple jurisdictions or levels of governance.

To address this gap, we conducted a systematic review to develop a novel framework for enhancing local government's adoption of innovative water policies. We searched multiple databases, including PubMed, ProQuest, Scopus, and citation tracking of peer-reviewed articles published until February 2024, and are updating the study to include current work and grey literature to ensure a comprehensive and representative evidence base. Most studies that met our inclusion criteria focused on high-income countries, with few examining policies at the state or provincial level. Additionally, few studies have explored policy diffusion related to equity, inclusion, or rural water.

Our findings suggest that while local context plays a crucial role in policy adoption, national governments, donor agencies, and civil society can influence the process. First, strategic policy attributes can enhance local adaptability by structuring policies, so they remain flexible and suitable for various local government contexts. Second, institutional learning networks can foster knowledge-sharing, best practices, and peer learning among local governments. Third, strategic advocacy by coalitions and the optimization of policy windows can increase the uptake of innovative policies. Together, these strategies can create an enabling environment that facilitates policy adoption and increases the likelihood of innovation diffusion across diverse governance settings. Our framework offers a strong foundation for scaling up innovative water policies and supports program designers in accelerating innovative policy adoption. Flexibility, institutional learning networks, and strategic advocacy are enablers of local policy adoption, which will be vital to water sector resilience in a changing climate.

Associations between animal exposure and child health outcomes in rural Bangladeshi households
Sumaiya Tazin, NC State University

Background: Living in proximity with domestic animals is associated with increased risk of infections and child growth faltering, especially in settings where access to water, sanitation, and hygiene (WASH) infrastructure is inadequate and animal fecal waste is unsafely managed. Failure to achieve expected health benefits in recent WASH trials has been hypothesized to be partly due to ongoing disease transmission from domestic animals. Despite growing evidence on zoonotic health risks, there is no standardized metric to quantify animal exposure among young children. This study aimed to (i) develop an animal exposure index using data from a randomized controlled trial in rural Bangladesh and (ii) examine associations between animal exposure and child health. Methods: Data on animal ownership, animal management practices and child health outcomes were collected from 5551 households enrolled in the WASH Benefits Bangladesh trial (NCT01590095), with multiple rounds of data collection over approximately 3.5 years. We will combine data across different domains of animal exposure to develop a scored index encompassing: the reported number of animals and observed number of animal feces in the compound (in tertiles), roaming frequency of animals in the compound (never, sometimes, always), location where animal feces are disposed (fully contained, somewhat contained, left in the open), presence of a dedicated scoop or similar instrument to handle animal feces (binary), reported handwashing frequency after handling animals and animal feces (never, sometimes, always), and child's father's occupation being poultry raising (binary). Categorical metrics will be scored as 1/2/3 and binary metrics as 0/1, with higher scores indicating higher exposure. Scores for individual metrics will then be summed to generate a composite score. We will assess associations between the composite animal exposure score and the prevalence of child diarrhea, ARI, stunting, underweight, and wasting, and Z-scores for length-for-age (LAZ), weight-for-age (WAZ), and weight-for-length (WHZ). Generalized linear models will be used with robust standard errors to account for cluster-randomization and repeated measurements. Models will control for potential confounders (study arm, child sex and age, mother's age and education, number of children <18 years in the household, number of individuals living in the compound, asset-based wealth index, floor and wall materials, and minutes to primary water source). Caregiver-reported abrasions/bruising will serve as a negative control outcome. Additionally, we will repeat the analyses using a simplified metric of animal exposure based on the number of animals in the compound for comparison against the composite index. Conclusion: Most studies assessing zoonotic health risks from domestic animals to date have used simple indicators such as the presence/number of animals or animal feces near the dwelling. A composite index may better capture the complex relationship between animal exposure and child health whereas the conventionally used measures of animal or feces presence may fail to capture the multidimensionality of the exposure.

Positive and Negative Resilience Strategies for Energy, Water, and Nutrition amid Kenyan Droughts and Floods
Emily Ogutu, Emory University

Background:
In Kenya, childhood morbidity and mortality, driven by respiratory illnesses, infectious diseases, and under-nutrition, are driven by limited access to clean energy, safe water, and sufficient nutritious food and exacerbated by climate-driven disturbances like floods and droughts. Initiatives targeting improvement in these areas would benefit from utilizing a water-energy-food nexus approach while also considering resilience perspectives to ensure sustainable access to these resources amid disruptions.
Objectives: We aimed to assess how droughts and floods affect access to energy, water, and nutrition, and to identify resilient behaviors in arid and semi-arid lands (ASAL) and non-ASAL communities in Kenya. We explored planning, coping, and recovery strategies, as well as aspirational practices households are unable to implement due to resource constraints.

Methods:
We conducted a qualitative study in five Kenyan counties—Isiolo, Samburu (ASAL), and Bungoma, Homa Bay, Siaya (non-ASAL). We used focus group discussions (FGDs) and key informant interviews (KIIs) to explore how droughts and floods impact household access to clean energy, safe water, and nutrition, and to identify resilient behaviors. Sixty FGDs with men and women and 44 KIIs with community leaders were conducted across 15 communities. Participants were purposively selected with support from local leaders. Data collection occurred in local languages, with transcripts translated and thematically analyzed using MAXQDA 2024. Analysis combined deductive and inductive coding, supported by regular team debriefs and consensus-building sessions to ensure rigor and consistency.

Results:
Participants across ASAL and non-ASAL counties reported that droughts and floods severely disrupted access to clean energy, safe water, and nutritious food. These disruptions led to diminished agricultural and livestock productivity, food insecurity, health risks, infrastructure damage, and financial hardship—particularly for women and children. Households adopted a range of planning, coping, and recovery strategies: stockpiling firewood and water, adjusting diets, preserving food, and relying on solar lighting. Women bore the primary responsibility for water and firewood collection, often at personal risk. Some behaviors were positive and adaptive (e.g., rainwater harvesting, improved cookstoves), while others were negative or anti-resilient (e.g., use of unsafe water, open

defecation, skipping meals). Resource limitations, gender norms, and poor infrastructure constrained long-term resilience, especially in ASAL communities.

Discussion and Conclusion:
Findings show that droughts and floods disrupt access to clean energy, safe water, and nutritious food, with limited household capacity to plan, cope, or recover—particularly in ASAL communities. Barriers include weak early warning systems, gendered responsibilities, infrastructure challenges, and lack of resources. While some households adopted positive resilience practices—like solar lighting, rainwater harvesting, and drought-resistant crops—these were constrained by affordability, access, and limited awareness. Women faced disproportionate burdens in water and fuel collection, often at personal risk. Building resilience to climate shocks requires strengthening communication of early warnings, expanding access to clean energy and water technologies, promoting adaptive food practices, and addressing gender inequities. Integrating water-energy-food nexus thinking into interventions and supporting community-driven solutions will be key to sustaining WASH and nutrition outcomes amid increasing climate variability.

Drinking Water Sources, Contaminants, and Salivary Antibody Responses: A Prospective Cohort Study in Central Appalachia
Alasdair Cohen, Virginia Tech

BACKGROUND:
Relatively little is known about exposures to waterborne pathogens and the associated burden of disease in Central Appalachia, USA, including the counties in far southwest Virginia that are part of the Central Appalachia region. Although there is evidence of disparities in safe water access for many rural regions of the USA, and particularly in rural areas of the Appalachian Region (~420 counties across 13 states in the eastern portion of the USA), our understanding of which subregions, communities, and populations may have higher risks of exposure to contaminated drinking water is severely limited.

OBJECTIVE:
Our objective was to assess associations between drinking water sources, use, and reported and measured health outcomes over time for individuals living in lower-income households in rural Central Appalachia.

METHODS:
We conducted three rounds of data collection in two adjacent rural counties in southwest Virginia (sharing borders with Kentucky and Tennessee). We collaborated with a regional non-profit organization for outreach and recruitment, targeting low-income households with utility-supplied and private (well and spring) water sources across the two counties. At

each data collection round, we administered surveys and collected water and saliva samples. First draw and five-minute flush water samples were analyzed for physicochemical parameters, free chlorine, fluoride, nitrate, sulphate, total coliforms, E. coli, and heavy metals. Saliva samples were assayed for antibody responses to potentially waterborne infections. We calculated the incidence of infections at baseline, and across rounds by identifying antibody responses that increased 4-fold and were also above the 75th percentile.

RESULTS:
We enrolled 33 households (83 individuals), 82% (n = 27) with utility-supplied water and 18% with well or spring water (n = 6). Across rounds, total coliforms were detected in water samples from 27% (n = 20) of homes; E. coli was detected in 11% (n = 7), all with well-or-spring water. We shared water testing results and comparisons with drinking water quality standards with households (as well as contact information for relevant agencies and non-profits). Diarrhea was reported for 14% of individuals (n = 27). A majority of individuals who were at home during our visits consented to provide saliva samples. At baseline, 34% (n = 15) of saliva samples had detectable antibody responses for Cryptosporidium, Campylobacter, and Hepatitis E. Three individuals had changes in antibody responses across rounds indicating additional post-baseline infections with Cryptosporidium and Campylobacter. After controlling for covariates and clustering, individuals in households without utility supplied water had significantly higher antibody responses for Campylobacter (and two norovirus genotypes), pooled across all three rounds.

CONCLUSIONS:
The incidence of reported diarrhea and measured enteric pathogen infections were both relatively high compared to available data from other settings in the USA. More research is needed to better quantify waterborne pathogen exposures and infections for rural households will well and spring water in this region of Central Appalachia and to better differentiate exposure pathways and the burden of disease from foodborne and waterborne pathogens in such settings.

Insights from Rural Practitioners: A Thematic Analysis of Implementation Challenges in Solar Powered Water Systems
Tess Brodie, Global Water Center

Solar Powered Water Systems (SPWS) have emerged as a promising solution to provide clean water in remote and underserved regions. However, the successful implementation and sustainability of these systems face several challenges. The 2021 UN Water Summary Progress Update states that a lack of technical capacity and human resources is slowing down the progress toward safe water for all. Global Water Center (GWC) is filling that gap

by developing world-class virtual, classroom, and field-based training programs that make expert education more accessible. GWC has interacted with hundreds of rural water professionals and identified pain points experienced in various regions of the world to provide effective and contextualized capacity development.

This study identifies and categorizes common issues in SPWS from rural water professionals by asking the question "What has the experience been like installing SPWS in your region?". This research is based on data from groups of participants in GWC's online solar power water courses in 2024 and 2025, with a thematic analysis on comments provided by 453 individuals. The most common issues identified include (1) community ownership and willingness to pay, (2) operation and maintenance capacity, (3) financial sustainability, (4) vandalism and theft, (5) technical design and siting, (6) environmental and disaster risks, (7) policy and regulation gaps, and (8) training and knowledge sharing. The overall analysis of the comments shows the following key findings: Community ownership and willingness to pay are hindered by the perception that water should be free, low community involvement in planning, and lack of user accountability. Operation and maintenance capacity face challenges due to the scarcity of local technicians, inadequate training for operators, and the unavailability of service providers in rural areas. Financial sustainability is compromised by insufficient user fees for major repairs, unclear financial management, and dependence on donors or NGOs. Vandalism and theft of solar panels and wires, coupled with the lack of security or community protection mechanisms, further disrupt the functionality of SPWS. Technical design and siting issues include poor system sizing, inadequate hydrogeological studies, and misaligned panel placement. Environmental and disaster risks such as damage from lightning, landslides, drought, and source water drying due to climate change also pose significant threats. Policy and regulation gaps are evident in the absence of specific SPWS legislation and unenforced operation and maintenance obligations post-installation. Finally, training and knowledge sharing are weakened by the limited capacity of water user committees and the lack of follow-up or refresher training.

These themes will be presented in more detail and with regional focuses to highlight the most critical themes for each geographic area. The findings underscore that technical performance alone is insufficient to ensure the sustainability of SPWS. Achieving long-term success requires integrated strategies that encompass community engagement, financial planning, and context-appropriate system design. Addressing these multifaceted challenges necessitates coordinated efforts in capacity building and policy support. This study contributes a foundational basis to GWC for designing targeted, evidence-based interventions to enhance SPWS sustainability across diverse geographic contexts.

Meta-Analysis of Holistic WaSH Programs on Access, Behavior, and Diarrhea in East Africa

Adrienne Lane, Water for Good

Efforts to reduce child diarrhea in endemic areas may produce greater results if interventions integrate water, sanitation, and hygiene improvements, rather than focusing on improvements for individual components (such as improved water infrastructure). While previous research has observed the individual benefits of improvements to each WASH component in reducing diarrhea, studies examining the efficacy of combined WASH interventions (targeting water, sanitation, and hygiene conditions) have produced mixed results. Water for Good implements three-year combined WASH interventions in rural districts of East Africa, with the goal of reducing the prevalence of WASH-related illnesses. This program targets the WASH conditions of households, local institutions, and villages, so that communities are equipped to impede the spread of diarrhea through all of its common transmission pathways at various levels of society. To accomplish this, Water for Good provides or trains households and communities to build safe WASH infrastructure (such as improved water sources, latrines, and handwashing facilities), educates community members about disease transmission and preventive practices (such as handwashing), and integrates communities into sustainability systems for reliable WASH access.

Objectives and Methods:
The purpose of this study is to contribute to the limited body of research regarding the efficacy of combined WASH interventions (targeting aspects of water, sanitation, and hygiene) in diarrhea reduction for rural, WASH-poor areas. To do this, we investigated the changes in basic WASH access, behaviors, and WASH illness prevalence in areas where Water for Good's WASH programs were implemented. This study used historical program evaluation data from all program evaluations completed after 2019 to measure the changes in child diarrhea prevalence, basic WASH access, and WASH practices before and after program implementation. For each study, a representative sample of households were randomly selected to complete a household WASH knowledge, attitudes, and practices (KAP) survey before program activities began (baseline) and directly after program activities were completed (endline). A random-effects meta-analysis of the relative changes in key indicators between baseline and endline was conducted for all East Africa programs (including programs in Ethiopia, Tanzania, and Uganda), adjusting for variations in sampling methods, sample size, and precision across the studies.

Results and Conclusion:
A preliminary analysis of changes in child diarrhea prevalence across the studies found an average -74% relative change between baseline and endline in the percentage of households with children under five experiencing diarrhea in the week prior to the survey (95% CI: 64% to 84% reduction), with a 57% relative risk reduction (95% CI: 41% to 73%) at endline. This result shows a greater diarrhea risk reduction than the WASH Benefits Bangladesh trial, which found a relative risk reduction of 11% for the water-only

intervention, 39% for the sanitation-only intervention, 40% for the handwashing-only intervention, and 31% for the combined WASH intervention. These findings may contribute to the body of evidence that combined WASH intervention models have the potential to deliver greater contributions to child diarrhea reduction than single-component WASH interventions in rural, low-WASH resource communities.

Transforming Schools Through WaSH: Integrating Hygiene, Sustainability, and Climate Action
Priya Kothari, Centre for Youth Development & Activities (CYDA)

Diseases caused by unsafe water and inadequate sanitation remain a pressing global concern, particularly for children aged 5 to 9, with over 50,851 annual deaths attributed to diarrheal diseases (WHO). Handwashing with soap at critical times can reduce this risk by more than 40%. However, as per the UNICEF data, significant gaps persist in WASH infrastructure—1 in 4 primary schools lack access to drinking water, and 1 in 3 have no handwashing facilities. In India, the ASER 2023 report highlights that 33.6% of schools lack functional drinking water facilities, while 25.2% do not have usable toilets. To bridge these gaps, CYDA's WASH in Schools initiative has been implemented across 7 states and 25 districts, impacting 343 schools and 55 Ashramshalas. The program has upgraded sanitation facilities in 328 schools, trained 2,11,700 adolescents in hygiene practices, and educated 84,680 adolescent girls on menstrual health and hygiene (MHH). Additionally, 426 WASH Mitras (young WASH entrepreneurs) have been trained to ensure long-term sustainability, while 35 schools have been equipped with renewable energy solutions and 15 schools with rainwater harvesting systems for borewell recharge. To promote environmental stewardship, 1,800+ trees have been planted using the Miyawaki method. This study employs a mixed-methods approach, integrating quantitative data on infrastructure enhancements with qualitative insights from stakeholders. Findings indicate that improved WASH infrastructure and behavior change communication (BCC) interventions have boosted hygiene compliance, reduced absenteeism by 2%, and developed environmental consciousness among students. The innovative 'WASH Mitra' model has strengthened operation and maintenance (O&M), ensuring sustainability. Schools with renewable energy solutions and green skilling programs have demonstrated higher student engagement in climate action and eco-friendly practices. To amplify impact, this study recommends scaling up interventions through multi-stakeholder collaborations, embedding green education into WASH programs, and strengthening institutional frameworks for long-term sustainability.

Keywords: WASH in Schools, Behavior Change Communication (BCC), WASH Mitra, Operation & Maintenance (O&M), Green Skilling and Climate-Resilient WASH

A tale of two services: Why India's school lunch program succeeds where WaSH services fail
Anvesh Badamikar, Stanford University

Background: The built environment in schools significantly influences a child's health and educational achievement. Core to this environment are clean, safe, and functional Water, Sanitation, and Hygiene (WASH) facilities such as toilets, handwashing stations, and drinking water points. Alongside WASH infrastructure, basic nutrition through school lunch programs, is essential for fostering positive health and educational outcomes in primary schools and ultimately for future economic success.

Problem Statement:
The Uttar Pradesh (UP) government has built WASH infrastructure in roughly 90% of schools in the state. However, policy guidelines don't support the continued operations and maintenance (O&M) of these facilities. The absence of WASH O&M leads to extended periods of breakdown, often rendering these facilities dirty, unsafe, and unusable. Ironically, schools in UP serve more than 19 million students a warm, nutritious meal every day of the school year under the school lunch program. Both WASH and nutrition delivery require daily investment of schools' time, resources, and coordination with the government. Why, then, does the school lunch service perform successfully while WASH service delivery fails in the same primary government schools?

Objective:
The objective of this study is to compare and contrast school lunch and WASH service factors that enable regular provision of services in government primary schools.
Methods: We conducted a qualitative study consisting of 64 in-depth interviews with 81 key informants relating to school public service delivery. Using a grounded theory (inductive) approach, we iteratively coded respondent interviews on NVivo to find themes of interest and narrowed our findings to major themes that differentiated the two service deliveries.

Results:
The school lunch program receives exclusive daily operational funding, while WASH services are bundled into broader infrastructure grants, often lacking clear accountability - resulting in lower investment and upkeep. Whereas lunch program funding is tied to self-reported daily attendance, incentivizing overreporting, WASH funding is based on fixed annual grants determined by student enrollment brackets. Rigid, enrollment-based funding hits WASH O&M harder compared to the proportional, attendance-based funding of the lunch program. Enrollment brackets also disproportionately disadvantage some schools in their ability to maintain infrastructure due to significantly lower $/child than other schools receiving the same funding amount. The relative success of the lunch program may also

reflect its higher perceived social value among voters, making it a more politically salient priority for incumbents.

Conclusions:
We find that differences in funding mechanisms shape stakeholder incentives, directly influencing the continuity and quality of each program. At the heart of these differences lies the higher perceived value of the school lunch program among end users—reflected in the strict accountability and perceived consequences for service lapses, which are largely absent in WASH delivery. Given the complementary roles of nutrition and hygiene in supporting a child's well-being and educational outcomes, our findings provide a pathway to advocate for a more integrated policy approach. Rather than treating these services in silos, we argue for a unified framework that recognizes and reinforces the interdependence of school lunch and WASH services to better serve children's holistic needs.

The Hidden Importance of Waterpans: Mitigation of Human Health Risks using a One Health Approach
Claire Furlong, IHE Delft Institute for Water Education

Abstract:
Individuals in humanitarian settings have heightened susceptibility of contracting faecal-oral diseases due to factors such as stress, poor socio-economic status, mal- or undernutrition, and inadequate or absent water, sanitation and hygiene (WASH) services etc. These diseases, such as cholera, are of major concern in humanitarian settings, especially in camps where conditions are suitable for their rapid spread. Sanitation is the primary barrier to the transmission of faecal-oral diseases, hence this is the focus of this study. Within humanitarian settings, actors need to tailor public health approaches and interventions for sustainable, reliable and safe provision of WASH services. Achieving this requires evidence and tools to aid decision making.

This poster will present the conceptual approach taken in the RISK-WASH project. In RISK-WASH, there are two camps as case study areas: Cox's Bazar (Bangladesh) and Imvepi (Uganda). Risk-based sanitation assessment tools will be further developed or adapted and implemented together with the humanitarian and refugee communities across five faecal sludge treatment plant (FSTP) catchment areas, which are sections of the camp served by the specific FSTPs.

Four risk-assessment tools, which have been widely used in other sectors, are adapted and trialled for the humanitarian context:
1. SaniPath-like approach assesses dominant exposure routes related to faecal-oral pathogens. This tool is expanded beyond the public domain to the domesticdomain

and risk profiles are being developed for specific vulnerable groups e.g. the elderly, people with disabilities.

2. Sanitation Safety Planning (SSP) approach assesses risks across the sanitation value chain using QMRA and semi-quantitative risk assessment. This tool is expanded beyond a health risk assessment by including environmental risks. As a part of this process, the performance of the FSTPs as well as the receiving aquatic environment is being monitored. This will generate risk profiles for groups who have contact with faecal sludge, and for the environment.

3. Population pathogen surveillance of faecal-oral pathogens is being conducted using the polymerase chain reaction (PCR) method for both the influent and effluent of the FSTPs. This is an adaptation of the approach used in high-income countries in wastewater treatment systems. This will generate an overview of the pathogens which are circulating within the populations of the FSTP catchment areas and will demonstrate the pathogen removal efficiency of each FSTP.

4. QMRA will use data from the population pathogen surveillance and the adapted SaniPath and SSP tools to estimate the risk of infections from pathogen exposure for those working with faecal sludge along the sanitation value chain and for the dominant pathways for different groups identified via the SaniPath-like approach.

This poster will discuss this conceptual multipronged approach e.g. how the data and tools are interrelated and the rationale behind the further development of the tools. It will describe how the data will be used to generate sanitation risk profiles of each FSTP catchment area and how this data can be used for targeted public health and WASH interventions in humanitarian camps.

Impacts of Rainfall and Chlorination on Contamination at Groundwater Sources in Kenya, Sierra Leone, and Uganda
Catherine McManus, University of North Carolina at Chapel Hill

The escalating global water crisis, intensified by climate change, demands a shift from conventional governance approaches to innovative policy solutions. Despite numerous innovative policies in the water sector, their adoption by local governments remains slow. National mandates alone are insufficient; effective implementation depends on how well local governments translate these policies into action—a crucial step in ensuring resilient water access for all citizens. Despite this urgency, there is no systematic synthesis of global experiences to identify key factors that accelerate the adoption of innovative water sector policies at the local level. An innovative policy refers to a policy that is new to a specific jurisdiction, even if it has been implemented elsewhere, while scale-up refers to the diffusion or expansion of a policy beyond its original implementation site, often across multiple jurisdictions or levels of governance.

To address this gap, we conducted a systematic review to develop a novel framework for enhancing local government's adoption of innovative water policies. We searched multiple databases, including PubMed, ProQuest, Scopus, and citation tracking of peer-reviewed articles published until February 2024, and are updating the study to include current work and grey literature to ensure a comprehensive and representative evidence base. Most studies that met our inclusion criteria focused on high-income countries, with few examining policies at the state or provincial level. Additionally, few studies have explored policy diffusion related to equity, inclusion, or rural water.

Our findings suggest that while local context plays a crucial role in policy adoption, national governments, donor agencies, and civil society can influence the process. First, strategic policy attributes can enhance local adaptability by structuring policies, so they remain flexible and suitable for various local government contexts. Second, institutional learning networks can foster knowledge-sharing, best practices, and peer learning among local governments. Third, strategic advocacy by coalitions and the optimization of policy windows can increase the uptake of innovative policies. Together, these strategies can create an enabling environment that facilitates policy adoption and increases the likelihood of innovation diffusion across diverse governance settings. Our framework offers a strong foundation for scaling up innovative water policies and supports program designers in accelerating innovative policy adoption. Flexibility, institutional learning networks, and strategic advocacy are enablers of local policy adoption, which will be vital to water sector resilience in a changing climate.

Trachoma in rural Ethiopia: water scarcity and poor hygiene harm health in Yokass Village
Dr. Daniel Gelan Arsedi, UNICEF

Trachoma, the leading infectious cause of preventable blindness, is a neglected tropical disease transmitted through contact with infected ocular and nasal secretions, facilitated by poor hygiene and inadequate Water, Sanitation, and Hygiene (WASH) infrastructure. Chronic infection leads to trachomatous trichiasis (TT), a debilitating condition in which eyelid deformities cause inward-turning lashes to abrade the cornea, resulting in progressive opacification and irreversible blindness. Ethiopia carries the highest global burden of trachoma, with hyperendemic transmission concentrated in rural and arid regions, particularly in northern Amhara, where structural deficiencies in WASH access perpetuate transmission cycles. Population-based surveys reveal that over 30% of children aged 1–9 in rural Amhara exhibit active trachoma (trachomatous inflammation-follicular, TF), far exceeding the WHO elimination threshold of less than 5%. The endemicity of trachoma in Amhara is sustained by interconnected environmental, socioeconomic, and health system factors. Harsh climatic conditions, including prolonged aridity and dust

exposure, create an ecological niche for Musca sorbens flies, mechanical vectors for Chlamydia trachomatis. Concurrently, poverty-driven overcrowding, limited health literacy, and entrenched cultural practices impede the adoption of preventive behaviors such as regular face-washing and safe waste management. Compounding these challenges is the chronic under-resourcing of rural health systems, which restricts the delivery of mass drug administration (MDA) campaigns and community-based surveillance.

This study examines the impact of a targeted intervention in Yokass, a high-prevalence district in East Amhara, where baseline surveys documented a 43% TF prevalence among children—one of the highest recorded rates in the region. The area's extreme water scarcity, pervasive fly populations, and poor sanitation practices created an ideal environment for sustained transmission, with an average household of seven individuals typically including three active trachoma cases.

To disrupt transmission, the Amhara Bureau of Health and UNICEF implemented an integrated elimination strategy anchored in the WHO's SAFE framework. Critical interventions included the construction of large-scale water supply systems to ensure reliable access to clean water, the training and deployment of community health workers to deliver hygiene promotion and case detection, and behavior change campaigns emphasizing facial cleanliness and latrine use. Post-intervention monitoring demonstrated striking outcomes: active trachoma cases reported by health facilities fell to zero, underlining the intervention's epidemiological impact. Secondary benefits included improved school attendance, enhanced agricultural productivity, and measurable growth in household savings evidence of the intervention's socioeconomic multiplier effect. A cost-recovery analysis projected full recoupment of initial infrastructure investments within three years, reinforcing the economic viability of such interventions.

These findings underscore the necessity of multisectoral approaches in trachoma elimination, combining WASH infrastructure development with robust health system engagement and community mobilization. The success in Yokass provides a replicable model for other hyperendemic regions, particularly those with similar environmental and demographic risk profiles. Future implementation research should focus on optimizing intervention scalability and assessing long-term sustainability under real-world health system constraints.

A One Health Examination of Backyard Poultry Operations
Emily Bailey, Campbell University

This pilot study aimed to characterize husbandry practices of a sample of North Carolina backyard poultry owners and the prevalence and antimicrobial resistance profiles of

Salmonella sp., Escherichia coli. and Campylobacter sp. isolated from their flocks' environments. Increased resistance to commonly used antimicrobial drugs, like fluoroquinolones and macrolides, pose a challenge to managing human and animal infections alike. This project had a two-fold approach combining interviews with backyard poultry owner participants and bacterial cultures and antimicrobial susceptibility testing of fecal, soil, and environmental samples from participants farms. A semi-structured questionnaire was developed to facilitate discussion of backyard poultry practices, flock interactions and medication usage with participants. Adult participants were recruited via online backyard poultry groups. From January 2024 to June 2024, focus groups and individual interviews were held with a total of 18 participants from the Triangle and eastern regions of North Carolina. Thematic analysis of the interviews revealed that backyard poultry owners raised poultry primarily for egg production and companionship. Biosecurity practices and medication usage varied amongst participants. Most participants reported overall good health in their backyard poultry and primarily relied on social media and online communities for information sharing and support. A total of 99 samples were collected, including 17 nasopharyngeal swabs, 15 fecal matter swabs, 31 environmental swabs, 12 water bowl swabs, 14 soil samples, and 10 bedding samples across the 15 participating farms. Analysis of resistance by Kirby-Bauer disc diffusion showed that 41% (41/99) tested positive for E. coli and 46% (46/99) tested positive for Campylobacter, with 91.3% (42/46) of Campylobacter strains exhibiting resistance to erythromycin, a member of the macrolide antibiotic family. Erythromycin resistance could contribute to the spread of resistant Campylobacter strains resulting in harder to treat infections in poultry and potentially humans due to it being a first-line treatment. These findings inform understanding of the husbandry practices of backyard poultry owners and the interactions between owners and backyard poultry. Future studies, including additional participants and serial environmental sampling could help inform backyard poultry-related public health interventions like enhanced husbandry practices and biosecurity.

Assessing Multidimensional WaSH Inequalities in Uganda: Impacts, Drivers, and Pathways to Equity
Comfort Hajra Mukasa, WaterAid Uganda

Background/Introduction:
Uganda faces persistent inequalities in Water, Sanitation, and Hygiene (WASH) access despite progress toward Sustainable Development Goal 6 (SDG 6). Pre-study assessments revealed stark disparities: rural areas lagged in sanitation coverage (34% vs. 77% urban), while schools and healthcare facilities grappled with inadequate infrastructure. For example, 58% of primary schools lacked menstrual hygiene management (MHM) facilities, and 85% of rural healthcare facilities (HCFs) had limited sanitation services. These gaps

disproportionately affected women, girls, persons with disabilities (PWDs), and low-income households, perpetuating cycles of poverty and disease.

Purpose and Research Questions:
This study aimed to:
- Quantify the extent of WASH inequalities across households, schools, and HCFs.
- Identify systemic drivers of disparities, including geographic, socioeconomic, and institutional factors.
- Propose evidence-based solutions to advance equitable WASH access.

Key questions included:
- How do urban-rural divides and wealth quintiles shape WASH access?
- What institutional barriers hinder equitable service delivery?

Study Design:
A mixed-methods approach was employed across 16 districts (4 regions), including:
- Quantitative surveys: 438 households, 64 institutions (32 schools, 32 HCFs), and analysis of Uganda Demographic and Health Survey (UDHS 2022).
- Qualitative data: 31 interviews with local officials, 28 Focus Group Discussions (FGDs), and policy reviews.
- Systems analysis: Evaluated infrastructure, governance, and financing using a multidimensional framework.

Key Findings:
- Geographic disparities: Rural households were 6.44 times less likely to treat water than urban counterparts. Northern Uganda had the lowest HCF water access (50% vs. 100% in Central region).
- Socioeconomic inequities: The wealthiest quintile had 3.18 times higher handwashing access than the poorest. Only 35% of rural schools met clean toilet standards vs. 85% urban.
- Institutional gaps: Pupil-to-latrine ratios reached 1:176 in rural schools (vs. 1:63 urban). Over 30% of HCFs lacked disability-friendly sanitation.
- Intersectional barriers: Rural girls with disabilities faced triple disadvantages—limited MHM access (30%), unsafe facilities, and 2-hour water-fetching journeys.

Discussion:
The study validated the utility of multidimensional frameworks in diagnosing systemic WASH inequities, particularly climate-resilient infrastructure needs. It exposes flaws in decentralized governance, advocating for equity-focused budget allocation (e.g., targeting northern regions) and enforcing accessibility standards. And lastly, the study highlights scalable solutions: community-led maintenance models, MHM facility co-design with students, and disability-inclusive infrastructure.

Conclusion:
This research provides a replicable model for addressing WASH inequalities in low-resource settings, emphasizing the need for integrated, equity-centered approaches. Its insights are critical for achieving SDG 6 and informing global strategies to leave no one behind.

Invisible Hands, Illegal Dumps: Sanitation Work, Informality, and the Legal Paradox in Alleppey town and its peri-urban areas
Hariprasad V M, Indian Institute of Technology Bombay (IIT Bombay)

Despite international, national, and local efforts to improve sanitation, small towns in India continue to rely heavily on labour-intensive services provided under highly informal conditions. This study, conducted in Alleppey town and its surrounding peri-urban areas in Southern India, examines how sanitation work, particularly pit and septic tank emptying is shaped by deep-rooted informality, social marginalization, and legal contradictions. Alleppey, a flood-prone coastal town lacking sewered sanitation infrastructure, presents a critical case for understanding the lived experiences of those who fill the gaps left by inadequate state services. Sanitation workers, many of whom are Dalits, migrants, and women, operate without legal protections, access to healthcare, or the ability to bargain collectively. Despite performing essential services that are central to achieving Sustainable Development Goal (SDG) 6.2, which calls for access to adequate and equitable sanitation, and SDG 8.8, which promotes safe and secure working environments for all, these workers remain largely invisible in policy and urban planning. The study tries to understand how sanitation work, especially pit-emptying work, is shaped by informality, social marginalization, and legal paradoxes.

Our qualitative research employed multiple methods, including 24 key informant interviews, three focus group discussions, participant observation during pit-emptying activities, and document analysis. The study engaged diverse participants, such as manual and mechanized pit-emptiers, government officials, sanitation experts, and local residents. The study reveals that informal sanitation workers using vacuum suction methods fill a critical gap in densely populated urban areas where state-run treatment infrastructure is inadequate. Despite their essential role, these workers face criminalization due to improper waste disposal practices, underscoring the legal and moral contradictions of a system that relies on their labour while denying them recognition or support. Lacking access to formal treatment facilities, they often dump fecal sludge in peri-urban water bodies or open spaces, triggering public opposition driven by Not In My Backyard (NIMBY) sentiments and subsequent police crackdowns. Peri-urban areas, integral to Kerala's rural-

urban continuum, serve as both sources of cheap labour and unofficial dumping sites, exacerbating environmental and public health risks. While communities depend on sanitation services, they resist local treatment infrastructure due to NIMBYism, perpetuating a cycle of blame and marginalization. This paradox highlights systemic failures in urban sanitation governance, where informal providers remain indispensable yet stigmatized, reinforcing their invisibility within the broader waste management ecosystem. In Alleppey, sanitation work transcends mere technical or infrastructural concerns—it is a political issue intertwined with labour rights, legality, and state accountability. Informality is not a temporary flaw but a systemic feature, exploited by private contractors and local authorities to evade responsibilities while shifting risks onto marginalized workers. The study highlights how legal ambiguities, stigma, and policy neglect define sanitation workers' precarious lives. It demands urgent recognition of their labour, but not by eliminating informality, but by ensuring dignity, safety, and legal protections. Without such reforms, progress toward SDG 6.2 and SDG 8.8 will remain exclusionary, perpetuating inequality.

Our records show you have access to safe water, but do you?
Katherine Alfredo, University of South Florida

Despite federal initiatives such as the Infrastructure Bill to address sub-par drinking water concerns across the U.S., we still currently lack a consistent metric to compare the cumulative relative health risk associated with drinking a glass of water in one location with that in another. For a long time, regulators have monitored U.S. drinking water delivery systems based on the number of violations of an individual contaminant. This focus on the history of contaminant-specific violation counts ignores the overall health burden from concurrent exposures to multiple chemicals. This research builds on the previous work creating a Relative Health Index (RHI), a cumulative risk metric that encapsulates cancer and non-cancer toxicity values, exposure concentrations, and severity scores, and applies this metric to over 30,000 Community Water Systems (CWSs) in the United States. The investigation includes CWS contaminant violation experience from 1982 to 2023 and over a decade of RHI calculations based on occurrence of contaminants.

Our goal was to answer two practical questions: (1) can we compare the relative safety of different glasses of water across the U.S.? and (2) are the most vulnerable populations protected by recent regulatory determinations? To explore these questions, we have created a database that merges data from publicly available datasets (i.e., SDWIS, ECHO, IRIS, UCMR5, 6YR4) and calculated the RHI values for each contaminant and aggregated the values by Public Water System ID (PWSID). This is the first national risk cup analysis for the entire country.

In addition to this assessment, we use the RHI metric to evaluate the outcomes of the Fourth Regulatory Determination to understand if a "meaningful health risk reduction" was obtained. We combined the RHI and Social Vulnerability Index (SVI) matrices on a subregion-scale, consisting of national occurrence data and relevant toxicological studies for contaminants included in the latest regulatory determination, to develop an understanding of the communities in the U.S. that may be experiencing a greater risk from this selection of emerging contaminants. This analysis aims to shift the policymaking frame in a more comprehensive and equitable direction, accounting for the risks to vulnerable communities as well as the comparative risk across contaminants.

Contextual approaches for hard-to-reach areas communities in Ethiopia
Adugnaw Tadesse/Kelly Alexander, CARE

The Global Sustainable Development Goals (SDGs) recognize universal access to safe water sanitation and hygiene services (SDG6) as essential for achieving the other goals. Despite significant investments and policy reforms in the WASH sector, approximately 60 million people in Ethiopia still lack access to safe drinking water, with many residing in hard-to-reach areas. Institutional barriers such as inadequate planning; inadequate participation of communities; lack of appropriate and reliable data; limited integration across sectors (such as water, education, health, and women and social affairs) and political influence hinders the prioritization and resource allocation for hard-to-reach areas.

To address these challenges, CARE Ethiopia designed contextual approaches from 2017 to 2023 in East and West Belesa of Amhara regional state. These approaches includes time series water mapping, platforms for sector integration, implemented community score card and introduced new technologies. The sector integration platform enhanced institutional coordination on the implementation and resources allocation for water sector through regular monthly meetings, annual planning, and quarterly joint supervision visits. Community scorecards increased community engagement by monitoring scheme distribution, functionality rate of the schemes, financial issues and the overall management of the schemes.

The new technologies and different strategies in the implementation process improved the functionality rate of schemes from 40% to 63% and water coverage from 26% to 55%. Budget allocation for operation and maintenance increased from 15% to 72%, and the capacity to cover expected operational costs based on the scheme's life cycle cost increased from 0 to 46%.

Therefore, to address water services for the communities living in hard-to-reach areas and equity distribution among kebeles, WASH actors should conduct regular water point inventories, mapping, and distribution analysis. These findings should be used to advocate for reducing water access disparity, improving management and allocating resources. In addition, adapting and scaling up appropriate technologies, strengthen integration, support supervision and coordination across sectors are essential.

Toward Thriving Communities: What Safe Water Alone Can't Achieve
Kimberly Gerken, Water Mission International

Background:
Over 2 billion people worldwide still lack access to safe drinking water, sanitation, and handwashing (WASH) facilities. Achieving Sustainable Development Goal 6 (SDG 6) requires equitable and sustainable WASH services that improve health, reduce poverty, and promote human rights. Although WASH interventions are commonly associated with improved community outcomes, there remains limited evidence on their broader impact beyond physical health.

Objective:
To test our hypothesis that when "improved" water and sanitation services are made safe and sustainable, they contribute not only to better physical health but also to improved community management, greater social cohesion, and an overall improved quality of life—including spiritual, emotional, social, and material well-being.

Methods:
This longitudinal study used Water Mission's Routine Evaluation of Sustainability and Transformation (Restore) Survey to assess changes in community-level outcomes over time. The Restore Survey, developed in 2016, includes 59 questions across three domains: Management Skills, Well-Being, and WASH Behaviors. These domains are further broken down into 11 factors:
- Management Skills: Water System, Financial, Human Resources, and Leadership
- Well-Being: Spiritual, Emotional, Social, and Material
- WASH Behaviors: Handwashing, Water Use, and Sanitation

It is administered at four key points during a project's life cycle (twice pre-intervention and twice post-intervention). From July 2018 to April 2023 (five-year study), data was collected from 15 communities through 4,517 survey submissions using SurveyCTO. Descriptive statistics and generalized linear mixed models (GLMMs) were used for analysis in R.

Results: Statistically significant improvements were observed in the WASH domain, including Handwashing, Sanitation, and Water Use. Within the Management domain, only the Water System factor showed statistically significant improvement; no overall change was detected across the full domain. Similarly, no statistically significant improvements were observed in any of the four Well-Being factors (social, material, spiritual, and emotional).

Discussion: Findings confirm that Water Mission interventions effectively improved WASH behaviors and strengthened water system management. But they challenge a core assumption of the WASH sector: that safe water access alone drives broader holistic development. While qualitative feedback points to perceived gains—particularly in Material Well-Being through reduced healthcare and water expenses—quantitative data show no statistically significant change in overall well-being. In short, the interventions achieved what they set out to do at the activity level, but their ripple effects on community flourishing remain limited.

This raises a critical question for the WASH sector: If safe water doesn't automatically lead to holistic well-being, what needs to change? Do we need more integrated approaches—or do we need to stop equating infrastructure with transformation?

Evaluating new and cost-effective wastewater-surveillance sampling methods to address pathogen signal loss in rural sewersheds
Marianne Beaulieu, Virginia Tech

Introduction:
Wastewater-based surveillance (WBS) is the practice of analyzing wastewater for pathogens. WBS gained popularity during the COVID-19 pandemic as a method for monitoring disease prevalence and even as an early warning system for outbreaks. In rural communities where clinical data is scarce or unreliable, WBS can provide a consistent avenue to track pathogen levels throughout whole communities. However, almost all current WBS research and work is based on urban areas that do not face the specific challenges associated with WBS in rural areas; sewer systems in economically distressed communities are often not sufficiently maintained. Cracks and breaks in sewer pipes can result in inflow and infiltration (I&I) from rainwater, surface water, and groundwater.

Objectives:
Previous research from our group indicates that dilution from I&I impacts pathogen signals and may render conventional WBS sample collection approaches (developed in urban areas) unsuitable for many rural systems. To build these findings, our objective was to

empirically evaluate new sampling and analysis methods that can be used to address and account for up-sewer viral signal degradation in small rural sewersheds impacted by I&I.

Methods:
Over the past two years, we have collected wastewater samples from two towns in rural Appalachia (populations ~2,800 and ~6,000). We collected monthly samples from each town's wastewater treatment plant (WWTP) and from several up-sewer nodes. These samples were analyzed for physiochemical parameters (pH, temperature, conductivity, dissolved oxygen, chemical oxygen demand, and metals) as well as for gene concentrations of target pathogens and human fecal markers via digital droplet polymerase chain reaction (ddPCR). We investigated which sites up-sewer are most impacted by I&I and compared viral detection of key viruses with support from the Virginia Department of Health's (VDH) statewide surveillance program (SARS-CoV-2, Influenza A, Influenza B, Respiratory Syncytial Virus, Hepatitis A).

Results:
We used chemical oxygen demand data as a partial proxy for dilution. Using ddPCR, in the ~2,800 population town, we found that dilution from I&I had a strong impact on the strength of pathogen signal and associations with case outcome data. Adverse impacts on target detection were heightened by significant precipitation events preceding sampling. We found also that the severity of the dilution effect varied by pathogen. However, we do not know how generalizable these findings are to other rural systems, and analysis for the larger town is on-going at this time. To account for signal loss in some areas of the sewershed, we are experimenting with novel sampling and analysis methods.

Implications:
Currently, there are no established guidelines on best practices for WBS in rural settings. This research is intended to provide data to address research gaps and inform a basis for the best practices in this specific area of the field. Ultimately, we hope to find a method to efficiently and effectively conduct WBS in rural areas such that these towns can be integrated into the VDH's statewide surveillance system.

Cholera Trends and Environmental Risks: Insights from Lake Kivu Bordering Areas in Western Rwanda
Uwimana Uwimana Martha, WaterAid Rwanda

Cholera remains a persistent public health challenge in Rwanda's Western Province, particularly in the districts bordering Lake Kivu. This study aimed to assess the temporal trends of cholera outbreaks and explore environmental risk factors contributing to its endemicity in areas surrounding the lake. The key objective was to provide scientific

evidence to inform targeted, sustainable interventions for cholera control and prevention. A retrospective and ecological study design was used, drawing on five years of surveillance data (2017–2021) from five districts, including Rubavu, Nyamasheke, Rutsiro, Karongi, and Rusizi. The study analyzed cholera case records reported through the national surveillance system and included environmental sampling for microbiological and physicochemical analysis. Totally, 2,532 cholera cases were recorded during the study period, with females accounting for 60% of the cases. While a general declining trend was observed from 897 cases in 2017 to 232 cases in 2021, Rusizi and Rubavu districts showed atypical peaks in 2019 and 2020, respectively. Seasonal patterns revealed a recurrent surge in cases during the first quarter (January–March), stabilization in the second quarter, followed by a peak again in the third quarter (July–September). To scientifically understand environmental exposure, 215 water samples were collected from Lake Kivu, its tributaries, and other sources such as household tap water, rivers, springs, and surface runoffs at locations commonly used for domestic, recreational, and economic activities. Laboratory analysis focused on the detection of Vibrio cholerae, Escherichia coli, and Salmonella species, as well as measurement of key physicochemical parameters (pH, salinity, conductivity, turbidity, temperature, and dissolved oxygen). Findings revealed that all Lake Kivu samples were positive for V. cholerae and E. coli, indicating fecal contamination and the presence of pathogenic organisms in commonly used water sources. Moreover, Lake Kivu water tended to range from brackish to saline, an environment conducive to the survival and persistence of V. cholerae. These results underscore the environmental dimension of cholera transmission in the region, where daily human-water interactions create high exposure risks. The presence of V. cholerae in multiple water sources points to a continuous environmental reservoir that supports endemic transmission. The study also highlighted spatial and seasonal variation in outbreak patterns, calling for localized and time-sensitive responses. From a policy and practice perspective, this study provides critical evidence to support the prioritization of water quality monitoring, public health education on safe water use, and the integration of Water, Sanitation, and Hygiene (WASH) services in cholera hotspot areas. It further suggested the need for cross-sectoral coordination between health, water, and environmental authorities to reduce cholera risks and vulnerability in lake-bordering communities. Strengthening environmental surveillance and implementing targeted interventions can significantly advance Rwanda's goals of cholera elimination and health security.

How Risky Are Domestic Shallow Wells to Public Users? The Evidence from Peri-Urban Communities of Tanzania
Tula Ngasala, Michigan State University

Nearly 1.77 billion people worldwide rely on groundwater as their primary drinking water source. Many peri-urban areas of low-income communities lack access to a public water supply and rely heavily on hand-dug wells. These shallow wells are often unprotected and poorly constructed, causing physical harm or health threats to well users. The development of water safety interventions to reduce hazards and risks that has been a constant challenge due to limited knowledge, tools, and lack of resources. To improve the safety of self-supply domestic shallow wells, we assessed the level of risks associated with shallow wells that can cause physical harm or health threats. The aim was to identify and assess hazardous events and risk factors that can cause physical harm and health threats to domestic shallow well users. The study was conducted in peri-urban areas of Pwani, Tanzania. The qualitative risk assessment methodology included site observation of 40 public shallow wells and semi-structured interviews with well owners to identify hazardous events, their causes, and negative impacts on domestic wells and well users. The hazardous event technique was used to conduct qualitative risk evaluation where the frequency of occurrence of every identified hazardous event (scale of 1 to 5) was linked with the negative impact expected from the hazard-generating event (scale of 1 to 5). The risk score was then calculated as a function of the likelihood or frequency of occurrence of hazardous events and the projected impact. Out of 40 public domestic wells observed, 17 hazardous events were identified, 52% were physical condition or construction-related, 38% were related to proximity to sources of contamination, and 15% were operational and usage-related. The three top-ranked physical hazardous events out of 17 events were 1) introduction of contaminants directly into the well, 2) percolation of fecal contaminant, and 3) ponding around the wellhead. Twenty-six causes of physical hazardous events were identified. The qualitative risk scores (QRS) showed 51% of the wells were high risk (QRS >55<=100), consisting of well collapsing, fecal contamination, and injury from children or animals falling into the well, which could cause morbidity or death. The 12.5% were medium risk (QRS between 50 - 55), which included the possibility of fecal contamination and high turbidity caused by trash, debris, and surface runoff. Lastly, 35% were low risk (QRS >10<=50), which included non-fecal contamination from trash and debris, as well as small household objects falling into wells. The risk assessment from our study revealed the most significant risks that can be given priority when controls are considered. Poor physical condition of the wells and the proximity of the wells to contamination sources were the most significant water safety hazards identified. Water and public health professionals as well as policymakers at the national and local levels in Tanzania should prioritize protocols for domestic well construction, operation, and effective wellhead protection. The tools identified coupled with training and education can be used to develop water safety interventions to minimize these risks.

Applications of an in situ E. coli contamination sensor for drinking waters in east Africa

Whitney Knopp, University of Colorado Boulder

An estimated 4.4 billion people lack access to safe drinking water across 135 low- and middle-income countries around the world. Fecal contamination remains a primary factor contributing to this gap in access, most severely impacting existing vulnerable populations and exacerbated by climate change and conflict. Significant gaps in water quality data, particularly in rural areas of Africa, limit proper identification of sources and communities at risk of contamination and inhibit institutional actions toward improved access to safe drinking water. This gap in water quality data is in part due to lack of sufficient technology and capacity to adequately monitor microbial contamination in drinking water.

Monitoring microbial water quality requires time for sample collection and incubation, training of personnel, and consumables. Additionally, samples only provide retroactive data at a specific location and time, which is not always representative of the quality of a water source or its variability. In response to the need for more spatially and temporally dense microbial water quality data, our team has developed an in situ, near-time E. coli risk sensor. The sensor technology combines machine learning with measurement of tryptophan-like fluorescence (TLF), a fluorescing protein whose presence and light emission intensity are highly correlated to E. coli. The TLF E. coli sensors improve the capacity for long term collection of high spatial and temporal density water quality data on fecal contamination; water quality data are publicly available to support community and institutional actions to improve water quality and services.

This technology is currently being piloted in two contexts in east Africa. In the rural, arid regions of northern Kenya, the sensor has been installed to monitor borehole system functionality for both the in-line chlorination systems that treat water prior to consumption and the pumps extracting groundwater for community use. Through a collaboration with the Millennium Water Alliance and local partners, critical gaps in safe water that threaten the health and livelihood of pastoralist communities during the dry season are avoided by monitoring and repairing treatment and supply systems. These borehole systems are also registered to earn carbon credits as an innovative way to finance their operation and maintenance, for which the TLF sensor is crucial in monitoring exposure (or, ideally, lack thereof) to fecal contamination. In the rural regions outside Kigali, Rwanda, the TLF sensors have been deployed in water filters in schools to monitor exposure to fecal contamination prior to treatment and consumption. Measuring exposure with the TLF sensor provides continual baseline exposure to fecal contamination and supports carbon credit generation by treating the impaired source waters.

In the future, the TLF E. coli sensor network will continue to be expanded, gathering data to refine the machine learning model across diverse contexts. We also look to combine this in situ monitoring with geospatial data to develop models for water quality variability across

space, time and seasons. It will contribute to data-driven public and institutional actions toward universal sustainable access to safe drinking water.

Interaction between Environmental and Human Health in North Jordan Valley
Ziad Al-Ghazawi, Jordan University of Science and Technology

Establishing base-line data through measuring the concentration of Escherichia coli, fecal coliforms, total coliforms, and fecal streptococci in Zarqa River-Jordan prior to evaluation of the riverbank filtration (RBF) technology

The Zarqa River within Jordan, is heavily contaminated with treated domestic and industrial wastewater principally from the city of Amman, but still serves as the source for irrigation water. For the purposes of evaluation of riverbank filtration (RBF) for protection of Jordanian surface and ground water resources project, and to achieve its objectives through establishing base-line data on Zarqa river water quality prior to evaluation of the RBF technology, surface water samples were taken for analysis of microbial pathogen contamination through measuring the concentration of Escherichia coli (E. coli), fecal coliforms, total coliforms, and fecal streptococci or enterococci. These were taken every six months (June/2022 to Jan/2023) from station I (2 km from the main wastewater treatment plant in Jordan, Kherbit Al-Samra) and station II (the RBF site which is downstream and 30 km from station I) along the river as well as from the RBF extraction well. Following the membrane filtration (MF) technique, number of E. coli of June/2022 samples was 9.1 x 103 and 20.0 x 103 cfu/100 ml at station I and II, respectively. In January/2023 these numbers were increased by > 85% with 1.57 x 105 and 1.35 x 105 cfu/100 ml at the above stations, respectively. For the intestinal enterococci bacteria, June/2006 analysis from station I and II revealed values of 16.0 x 102 and 2.5 x 102 cfu/100 ml, respectively. By Jan./2023 and at station II, these bacteria increased to > 90% with a concentration of 5.0 x 103 cfu/100 ml. By the multiple tube fermentation (MPN) technique, numbers of fecal coliforms, E. coli and intestinal enterococci of Jan./2023 at station II were 18.8 x 103, 12.3 x 103 and 2.4 x 103, respectively. However, the numbers after one year (Dec./2023) increased with concentrations of 4.6 x 105, 9.3 x 104 and 2.7 x 103, respectively. As far as the bacteriophages are concerned, high concentrations (105 – 106/100 ml) were found in the river. For the chemical parameters at station I/II, COD, BOD, TSS and TDS analysis indicated values of 265/95, 48/216, 2024/1987 and 1691/1662 mg/L, respectively. Analysis of Vibrio and Clostridium perfringens indicated the presence of both pathogens at station I and II.

A Systematic Analysis of Toxic Metals in Ghana's Drinking Water Systems

Sarah Hwang, The Water Institute

Lead (Pb) is an important component of drinking water infrastructure. It is used in the brass fittings and galvanized and PVC pipes which form the basis of most rural drinking water systems. These materials are commonly used in handpump systems, which have critical importance in Low- and Middle-Income Countries (LMICs) with 50% of Sub-Saharan Africa depending on such technology. There has also been evidence of potentially lead-containing materials in urban drinking water systems like centralized pipe networks. As these systems age, they have the potential to expose communities to lead, a toxic metal with substantial and irreversible negative health implications for individuals and societies. While these risks and exposures are known, the water and health sector does not have a coordinated method for addressing the contamination of systems. An important low-cost intervention point can be determined through supply chain mapping and subsequent policy. A supply chain map identifies the main actors and materials involved in manufacturing, distributing, purchasing, installing, and maintaining drinking water systems. The output allows national governments to determine points of leverage for intervention and for the global sector to coordinate efforts to prevent contamination.

Our study pioneered the application of supply chain mapping to drinking water infrastructure, with a focus on lead-containing materials and their lead-free alternatives. Documentation was analyzed across 10 countries and 50 manufacturers to determine the scope of material flows in LMICs. An integrated document and physical material evaluation with XRF materials was piloted for future use by national actors. As expected from prior literature, South Asia is a major manufacturing hub for handpump materials. These are built across South Asia, with limited availability of material certifications to ensure lead-free components are being exported. These exported, lead-containing materials then enter Sub-Saharan Africa through a handful of key ports, presenting an opportunity for intervention at an international level. For pipe materials, domestic manufacturers are far more prevalent, presenting a fragmented sector, increasing the degree of "invisibilization," obscuring the links between manufacturers and final purchasers. Integrated materials data, generated by X-Ray Fluorescence evaluation, indicates that even advertised lead-free materials still contain lead with the potential to leach into drinking water systems. Therefore, the framework for mapping the supply chain with material evaluation can be applied in a case-by-case basis to improve global efforts to decrease lead exposures.

Rapid Market Formation in Urban Madagascar: Evidence from the USAID Dio Sera Sanitation Project
Elise Mann, iDE Madagascar

Purpose: This research investigates whether market-based sanitation (MBS) approaches can be effectively implemented in the challenging urban context of Madagascar, where only 12-20% of households have access to safely managed sanitation. The study addressed three critical questions: (1) Can urban consumers be motivated to invest in improved sanitation through market mechanisms? (2) Can local entrepreneurs build viable sanitation businesses with appropriate support? (3) Can governance structures evolve to enable market-based solutions?

Study Design: Within a shortened timeline, the Dio Sera project employed a three-pathway market development approach in the cities of Fianarantsoa, Toamasina, and Mahajanga. Baseline research included quantitative household surveys (n=1,479), human-centered design research with key stakeholders, price sensitivity analysis, and governance assessment. Implementation utilized a unified, locally-led approach spanning access to toilets through fecal sludge management. Despite early termination after just 13 months of project implementation, including a three-month sales trial, robust monitoring and post-project follow-up enabled assessment of market sustainability.

Key Findings: The research revealed three significant findings that challenge conventional assumptions about MBS implementation in challenging urban contexts:

First, demand formation occurred more rapidly than in comparable MBS initiatives, with sales teams achieving a 13.49% conversion rate from product presentations (compared to typical 5-8% rates in early-stage markets). This occurred despite no subsidization of products, suggesting latent demand can be activated through appropriate marketing approaches.

Second, local entrepreneurship demonstrated remarkable viability, with the primary sanitation business partner increasing monthly toilet installations by 400% (from 7 to 83 units) during the implementation period. Most significantly, this business continued operations after project termination, maintaining approximately 20% profit margins per installation without ongoing support.

Third, governance integration proved more achievable than anticipated, with national-level recognition through Decision No. 438/2024 establishing institutional mechanisms for sustained coordination beyond project timelines.

Discussion: These findings significantly inform sanitation practice by demonstrating that: (1) Market-based approaches can function effectively in challenging urban contexts with appropriate demand activation strategies; (2) Local entrepreneurs can rapidly scale viable sanitation businesses when provided with targeted business development support; (3) Market-based approaches can integrate with governance structures through strategic engagement.

The research challenges the conventional assumption that market development in challenging contexts requires long-term external support before commercial viability emerges. The continued business activity after project closure provides compelling evidence that with appropriate design, market-based approaches can rapidly achieve sustainability.

These findings suggest future urban sanitation programming should prioritize: (1) Sales approaches utilizing participatory techniques that enable households to assess sanitation risks; (2) Comprehensive business development support for local entrepreneurs with demonstrated potential; (3) Strategic governance engagement to create enabling environments; and (4) Appropriate financing mechanisms to extend market reach across income segments.

Tuesday Verbal Abstracts

Graduating Latrine Entrepreneurs to Sustain Market-Based Sanitation: Insights from iDE Bangladesh's SanMarkS II Project
Elise Mann, iDE Bangladesh

Background:
Despite Bangladesh's progress in reducing open defecation, persistent gaps in rural sanitation access threaten public health and equity. Over 30 million people still lack safe facilities, with marginalized communities disproportionately affected. The Sanitation Market Systems in Bangladesh (SanMarkS II) project—funded by UNICEF and the Embassy of Switzerland, implemented by iDE—addresses this systemic challenge through a market-based approach, targeting 4.5 million people across 35 districts. By shifting households from beneficiaries to customers, the project has catalyzed 900,000+ improved latrine sales via 3,000+ local entrepreneurs, proving that sustainable sanitation solutions must align with market dynamics and community agency.

Objective:
This study evaluates the graduation readiness of Latrine Producers (LPs)—trained entrepreneurs critical to sustaining sanitation access—using a novel 5-pillar framework to assess post-project independence.

Methodology:
The SanMarkS II project employs a first-of-its-kind graduation approach to assess the readiness of Latrine Producers (LPs) for independent operation post-project. The framework evaluates LPs across five pillars:

1. Business Status: Sales performance, record-keeping, and profitability.
2. Product Quality: Compliance with construction standards, durability, and safety.
3. Marketing Initiatives: Outreach strategies, branding, and customer engagement.
4. Market Linkages: Relationships with suppliers, local government, and financial institutions.
5. Future Plans: Innovation, workforce training, and scalability.

Each pillar includes defined criteria assessing LPs' business experience. A structured questionnaire (single/multiple-choice and open-ended responses) enables data collection through interviews, document reviews, and physical verification. The model categorizes LPs into four performance tiers.

Using decision theory, a transparent scoring system assigns numerical values to criteria and weights pillars by importance for project implementation and LP sustainability.

Initial Findings:

- Heterogeneous Performance: 20–30% of LPs achieved "Tier 1" (fully independent), demonstrating strong business acumen and market networks. 40–50% required moderate support (e.g., marketing training, supply chain access).
- Critical Success Factors: Tier 1 LPs had strong local government partnerships (e.g., inclusion in municipal sanitation plans) and high product consistency (verified via spot checks).
- Sustainability Gaps: Lower-tier LPs struggled with financial literacy (e.g., pricing strategies) and supply chain fragility (e.g., material shortages).

Implications for WASH:
- Fills a Critical Gap: SanMarkS II's graduation approach provides a roadmap to transition from donor-driven projects to self-sustaining markets, addressing the "last-mile" sanitation crisis.
- Equity: By empowering LPs—including women and youth entrepreneurs—the model fosters inclusive local ownership of sanitation solutions.
- Scalability: The tiered support system (e.g., targeted training for lower-tier LPs) is adaptable to other LMICs.

Conclusion:
The SanMarkS II graduation model bridges short-term gains with long-term market resilience. By assessing entrepreneur readiness across business, technical, and systemic dimensions, it provides a replicable blueprint to phase out support sustainably. In flood-prone Bangladesh, this addresses urgent sanitation backsliding risks. The model's emphasis on public-private collaboration and customer-centric design ensures contextually relevant solutions. These insights are crucial for achieving SDG 6 in resource-constrained settings where market-based sanitation is underutilized.

Household and environmental factors associated with detecting cefotaxime-resistant Escherichia coli in soil in peri-urban Malawi
Emma Budden, North Carolina State University

Background: Soil is an important reservoir for antimicrobial-resistant pathogens and is gaining recognition in disease transmission pathways. We aimed to understand household and environmental factors associated with the prevalence and abundance of cefotaxime-resistant E. coli (CR-EC) in yard soil.

Methods: We conducted a cross-sectional study with 237 households in peri-urban Bangwe, Malawi. Enumerators from Mzuzu University and Malawi University of Science and Technology employed structured surveys and collected samples of yard soil from a 30x30 cm area. We used IDEXX Quanti-Tray/2000 with Colilert-18 and cefotaxime supplement to enumerate the most probable number (MPN) of CR-EC per dry gram of soil. We conducted bivariate regression to assess associations between the log10-transformed MPN/binary prevalence of CR-EC and sanitation practices (e.g. latrine access, child defecation), animal ownership and management characteristics (e.g. types of animals, daytime and nighttime confinement), child health (e.g. enteric/respiratory infections, antibiotic use), and environmental factors (e.g. sunlight, soil wetness). Variables that had a p-value <0.20 in bivariate models were included in a multivariate model that also adjusted for potential confounders, such as household's primary water source, education, socioeconomics, household size, and indoor floor material.

Results: Among 237 households, we successfully collected 228 soil samples. Of these, 69% (n=156) harbored CR-EC at a mean of 0.90 log10-MPN/dry gram. In bivariate models, samples had lower mean log10 MPN of CR-EC if animals were enclosed at night and if soil was dry at time of collection. Similarly, samples had lower CR-EC prevalence if animals were enclosed at night and if the sampled area was in sunlight and dry at time of collection, and higher CR-EC prevalence if the household owned poultry. In multivariable models adjusting for covariates, compared to households that did not own animals, households had higher abundance of CR-EC if they owned animals and did not keep them enclosed at night (Dlog10: 0.44 [0.16, 0.71]; p-value<0.005) and lower abundance of CR-EC if they owned animals but kept them enclosed at night (Dlog10: -0.47 (-0.80, -0.13); p-value=0.01). Samples had lower abundance of CR-EC if soil was dry at time of collection (Dlog10 -0.79 [-1.26, -0.31]; p-value<0.005). Samples had lower CR-EC prevalence if children <5 years in the household used antibiotics in the last four weeks (prevalence ratio [PR]: 0.82 [0.69, 0.98]; p-value: 0.03) and if soil was dry at time of collection (PR: 0.38 [0.28, 0.51]; p-value: <0.005). Poultry ownership, daytime confinement of animals, and sanitation characteristics were not associated with the abundance or prevalence of CR-EC in multivariable models.

Conclusions: Study findings suggest environmental variables and animal husbandry practices had stronger associations with CR-EC in soil compared to sanitation factors in our peri-urban study setting. Future studies should quantify soilborne child exposure to antimicrobial-resistant organisms and analyze the effects of animal enclosure types and other animal management behaviors on antimicrobial resistance in soil.

Association Between Sanitation Type and Soil Contamination With Culturable E. coli in a Rural Alabama Community
Olivia Harmon, The University of North Carolina at Chapel Hill

Approximately 30 million households in the United States rely on onsite wastewater treatment systems, typically septic tanks with subsurface discharge of aqueous effluent. The functionality of onsite systems varies widely and, under some conditions, onsite systems fail in ways that present potential exposure risks to people. One region with documented widespread failing or inadequate onsite systems is Alabama's Black Belt, where unsuitable soils can result in fecal waste discharges to the soil surface. This study aims to investigate the relationship between household wastewater infrastructure and environmental fecal contamination by comparing levels of culturable E. coli in surface soils near homes with different sanitation types: conventional sewerage, onsite systems, and straight piping (direct surface discharge of wastewater). We enrolled 52 households in an area with variable sanitation infrastructure and anecdotal reports of both failing septic systems and straight piping. Of the 52 households, 10 were served by sewerage, 20 used onsite systems, and 24 relied on straight piping. From these households we collected and cultured 104 soil samples from August 2024 to February 2025. Of the cultured soil samples E. coli was detected in 10/20 (50%) of sites served by sewerage, 21/38 (55.3%) of those served by onsite systems, and 41/46 (89%) straight pipe soil samples. There was no significant difference in concentration of culturable E. coli between households served by sewerage and onsite systems (p = 0.53). However, the concentration of culturable E. coli was significantly higher from soil samples collected from households with straight pipes when compared to households served by sewerage and when compared to households served by onsite systems (p = 4 x 10-7 and 1.3 x 10-9 respectively). All comparisons were made using the Wilcoxon Rank Sum test.

Revisiting Onsite Sanitation System Sizing Requirements in Light of Water Usage Trends
Andrea Stowell, LIXIL Corp.

Design parameters for onsite sanitation systems are the bedrock for system sizing, but vary widely across the US. Established to protect public health with redundancies, many are outdated, oversized and do not reflect current trends in household water usage. Oversizing increases costs which are most felt by low-income customers and are barriers to addressing the US's shortage of affordable housing.

Indoor water usage has declined significantly as the adoption of water optimization measures like low flow toilets, have increased. In the 1980s, per capita indoor water consumption stood at 112 g/d declining to 57.4 g/c/d in 2015 (EPA) and 40 g/c/d (Flume) in

2024. Based on typical occupancy rates this equates to an average of 98 total g/hh/d today, far below EPA's recommended 100 to 150 gallons per bedroom per day as suggested in the 2002 Decentralized System Manual. Furthermore, data from a 1000+ home IAPMO survey suggests per bedroom water usage rates between 30 and 60 gal/bed/day (2-6 bd hh).

Based on analysis of design parameters across the US, 21 state (41%) have stated onsite design parameters equal or greater to 200 gal/bed/day, with 14 states requiring systems be designed for a 2bd home at 200-350 gal/bed/day and 7 states requiring systems to be designed for a 3bd home at 330-400 gal/bed/day. The cost impact of this is significant with septic drainfield capex declining linearly with size.

In a changing world, onsite system sizing should include parameters that take in to account innovation, water efficient technologies and new water consumption patterns. This study reviews current design flow requirements by state and associated costs impacts, while proposing new considerations for system sizing to alleviate the cost burden oversizing puts on the customer.

Financial sustainability of rural water points: is committee management sufficient?
Catherine McManus, The Water Project

Introduction: Financial management and community engagement are essential sustainability factors for communal rural water supply systems in low- and middle-income countries, and they remain vital to rural water service delivery. However, these water points experience frequent breakdowns, and the rural water supply sector is debating management best practices to optimize functionality. Community-based water point committees are often established to manage local water sources, but evidence of their effectiveness in ensuring financial (and therefore technical) sustainability is limited. To better understand the drivers of the financial health of these committees, we examined how the composition of water point committees, particularly the inclusion of women and persons with disabilities, influences the self-reported sufficiency of funds for operations and maintenance in community-managed water systems.

Methods: We used multivariable logistic regression and Bayesian networks with a cross-sectional dataset comprising 2,710 community water points in 14 low- and middle-income countries across Sub-Saharan Africa, South Asia, and Latin America. Multivariable logistic regression was used to estimate adjusted associations between committee characteristics and financial outcomes. Bayesian Network Modeling provided predictive insights into these relationships under different scenarios. Key outcomes examined included the presence of fee collection systems, non-monetary community contributions, and the availability of sufficient funds for operations and maintenance.

Results: The presence of an active water committee was significantly associated with improved fee collection (nearly threefold higher odds of having a fee system) and greater non-monetary contributions from the community. In addition, committees with women in leadership or financial management roles achieved significantly higher performance on these revenue generation indicators. By contrast, including people with disabilities on committees showed no significant effect on financial outcomes. Bayesian network analysis further indicated that water points where women held leadership and finance roles had the highest predicted probability of sufficient funds for maintenance. Conversely, water points with no committee had the lowest probability of having sufficient funds. However, even with these positive correlations, such committee characteristics alone did not ensure sufficient funds for operations and maintenance. Only a minority of water points had adequate financial resources to support ongoing O&M needs, revealing limitations in community management models.

Conclusions: This work highlights the importance of empowering inclusive committee structures, primarily through greater female leadership, to enhance long-term, equitable water service sustainability. However, the rural water supply sector needs to re-evaluate rural water financing strategies. Even when current best practices (collecting fees, including women in financial management) are followed, water point committees do not necessarily have adequate financial resources, even for operating expenses. To ensure the sustainability of communal rural water points, the sector may need to consider formalizing external subsidies or alternative management models. Communal water points remain a vital component of the rural water service delivery portfolio, and current management approaches may be inadequate to financially and technically ensure that their users have reliable access to safe drinking water.

Household-Level Environmental Risk Factors for Animal and Human Fecal Contamination in Northwestern Coastal Ecuador
Viviana Alban, University of Washington

The household environment plays a critical role in the transmission of enteric pathogens to infants, particularly where water, sanitation, and hygiene (WASH) infrastructure is limited. Household surfaces, including floors where infants play, and infant or maternal hands can become contaminated with fecal matter from human and animal sources. We collected survey data on household demographics, WASH conditions, and animal ownership and exposure, along with environmental samples from household floors using swabs and from maternal and child hands using hand rinses in 141 households in Northern Ecuador with infants aged 6, 12, or 18 months. Five qPCR-based microbial source tracking (MST) markers were used to detect fecal contamination from human (HF183) and animal sources, including avian (GFD), canine (DG37), swine (Pig2Bac), and ruminant (Rum2Bac). We used modified Poisson generalized linear models, controlling for a priori defined covariates, to

estimate prevalence ratios (PR) between: A) demographic and WASH variables and human MST prevalence, and B) animal-related variables and animal MST prevalence. We found that, for human fecal contamination, child hands (PR 1.61; CI:1.10–2.27) and drinking water (PR 1.25; CI: 0.99–1.59) contaminated with E. coli were associated with higher prevalence of human MST markers on floors and any environmental sample. For animal fecal contamination, households with animal feces indoors (PR 1.63; CI:1.03-2.58) were associated with a higher prevalence of animal MST markers on floors. Owning more than five animals (PR: 1.51; CI: 0.96–2.38), as well as maternal (PR: 1.77; CI: 0.94–3.35) and infant (PR: 1.36; CI: 0.94–1.97) animal contact, trended toward higher prevalence of animal MST markers on floors, any environmental sample, and maternal hands. However, these associations did not reach statistical significance. Our findings highlight the need for household-level interventions that address both human and animal sources of fecal contamination to reduce infant exposure to fecal matter, potential transmission of enteric pathogens, and associated adverse child health outcomes.

Effect of two community-based interventions on sanitation and hygiene in Malawi: a controlled before-and-after trial
Robert Dreibelbis, London School of Hygiene and Tropical Medicine

Unlocking the health and development impacts of sanitation and hygiene interventions requires changing individual behaviours. There are limited robust evaluations comparing different implementation models of district-wide sanitation and hygiene behaviour change approaches using existing community structures. In this controlled before-and-after trial [clinicaltrials.gov (NCT05808218)], we assessed the effectiveness of a district-level Community-led Total Sanitation (CLTS) intervention with and without locally managed Care Groups (CG) on sanitation and hygiene behaviours in Chiradzulu District, Malawi. Sanitation and hygiene outcomes were surveyed in a total of 2,800 households across baseline (June 2023) and endline (May 2024). Hygiene behaviours were directly observed in a subset of 300 households at each data collection round. Both interventions were associated with improvements in private sanitation coverage (CLTS group adjusted odds ratio [aOR] 3.11 (95% confidence interval: 2.06—4.70) and CLTS+CG group aOR 2.16 (1.34—3.48)), but neither resulted in improvements in basic sanitation according to the Sustainable Development Goal (SDG) definition. We found evidence of an increase in the odds of having a basic handwashing facility in the CLTS+CG group compared to the control group (aOR 2.62, CI: 1.19 – 5.75). However, we found no evidence of differences in reported individual sanitation use among households in either intervention group. Neither intervention was associated with differences in observed handwashing with soap at key junctures. However, both interventions were associated with increases in hand rinsing (i.e., handwashing with water only) compared to the control group and compared to no handwashing (CLTS adjusted relative risk ratio [aRR] 1.76 (1.10—2.83) and CLTS+CG group

aRR 2.80 (1.81—4.33)). The CLTS+CG intervention was associated with a slight increase in hand rinsing compared to the CLTS group (aRR 1.65 (1.01—2.69)). Given their role and reach, CGs may be underutilised in current rural sanitation and hygiene programmes. The CLTS+CG intervention was more effective at changing routine behaviours, such as sanitation use, but did not result in improvements to basic sanitation. Hygiene promotion integrated into sanitation programming was associated with increases in hand rinsing at appropriate moments. More research is needed to better understand the prioritisation process in the home in this setting and how this may impact soap use for handwashing practice.

WaterStarters: A Novel Franchise Model for Sustainable Water Access in Resource-Poor Settings
Kennedy Omwaka, Amref Health Africa

Background: Globally, over two billion people lack access to safely managed drinking water services, hampering the 2030 Sustainable Development Goal target of universal access (WHO/UNICEF JMP, 2023). In Kenya, despite water being a constitutional right, over 18 million people (39%) still lack access to safe drinking water, with nearly half of rural households relying on unsafe sources. This contribute to more than 75% of the country's disease burden, disproportionately affecting women and children. Since 2022, Amref Health Africa and MegaGroup have implemented the WaterStarters Programme, a social enterprise built on a novel franchise model. Franchisees (local private or community-based organisations) co-invest and assume full operational responsibility. A hybrid financing mechanism requires a 15% upfront franchisee investment, with the remaining 85% structured as a 42.5% grant and 42.5% recoverable loan, repayable over four years at 10% interest. To enhance operational efficiency, the model integrates prepaid water meters, solar-powered pumping systems, equipment sensors, and an online dashboard for real-time performance monitoring. Amref provides ongoing technical support to strengthen business and infrastructure management. The long-term vision is to establish a revolving fund to scale coverage to 1.5 million people by 2030.

Problem Statement: About one third of rural water points are non-functional. Despite sustained investment in water infrastructure, many interventions in resource-poor communities are unsustainable due to limited community involvement, misaligned technologies, and weak governance.

Aim and Objectives: This study assessed the effectiveness, economic viability, sustainability, and scalability of the WaterStarters model, including its social and health outcomes. It also explored key challenges and opportunities for scaling in resource-constrained settings.

Methods: The study was conducted in Kajiado County, Kenya, across five pilot sites using a mixed-methods cross-sectional design. It included a household survey (n=1,209), 15 key informant interviews, 20 focus group discussions, and financial data review. Quantitative data were analysed using both descriptive and inferential statistics, while qualitative data were analysed thematically. Financial performance was evaluated through Net Present Value (NPV), Return on Investment (ROI), break-even analysis, and cost modelling. Triangulation across multiple data sources was employed to enhance the validity and robustness of the findings.

Key Findings and Discussion: Within two years, WaterStarters became the primary water source for 52% of households, with over 70% satisfaction. Access improvements reduced water collection time for 60.7%, with 57% saving at least 30 minutes per trip. Households reported increased hygiene, reduced fatigue, and modest income gains. Most (68%) found pricing affordable. Infrastructure downtimes were minimal and promptly addressed; only 24% reported breakdowns, with 98% resolved within 72 hours. Financial analysis showed strong viability, with ROI exceeding 14% in some sites. Minimum Viable Product (MVP) analysis confirmed financial viability; a USD 59,500 initial investment yielded a 3.24% ROI even with a leaner USD 51,000 start-up cost. Qualitative findings indicated community willingness to pay for reliable water.

Conclusion: The WaterStarters model demonstrates technical and financial viability for community-based water delivery. Its flexible financing, integrated technology, and stakeholder ownership make it a promising sustainable solution for addressing water access gaps in underserved areas.

Supportive supervision enables collaboration and enhances hygiene standards at public toilets—Nakuru, Kenya
Pallavi Kache, US Centers for Disease Control and Prevention

Standardized cleaning and disinfection (C&D) of public toilets, with effective training for cleaning staff, is needed to mitigate disease risk and improve dignity and accessibility for users. Given frequent turnover of cleaners and challenges in distributing instructional materials, training must be continually reinforced; additionally, resource constraints require that training programs easily integrate into existing public health systems. Supportive supervision—a training methodology proven to improve job performance and satisfaction in healthcare settings—emphasizes routine monitoring, one-on-one reinforcement training, skill-building, and two-way communication. We conducted a pilot intervention in Nakuru, Kenya, where public health officers (PHOs) had been conducting hygiene inspections of public toilets. We adapted materials for supportive supervision for

C&D in healthcare settings, and trained cleaners and facility operators (i.e., toilet staff) and PHOs. Post-intervention, we assessed job performance of cleaners and intervention acceptability among toilet staff and PHOs.

In April–August 2024, Washington State University, in collaboration with the Nakuru County Department of Health Services and with technical support from the US Centers for Disease Control and Prevention, led a pilot intervention at 18 toilet sites in Nakuru. In April, we conducted baseline assessments of cleaner performance of seven C&D skills. In May, 18 PHOs with public toilet inspection duties participated in train-the-trainer instructional sessions on C&D protocols and received supportive supervision training. Subsequently, PHOs conducted C&D training for cleaners, including protocol dissemination and demonstrations. In June and July, PHOs conducted three supportive supervision visits, approximately every two weeks. During the visits, PHOs evaluated cleaners' C&D performance of the same skills assessed at baseline using competency assessments forms; PHOs provided reinforcement training for skills requiring improvement. In August, we conducted post-intervention assessments, mirroring baseline and competency assessment metrics. Additionally, we conducted key informant interviews (KII) with cleaners, facility operators, and PHOs, gathering feedback on supportive supervision.

We observed C&D performance for 22 cleaners at baseline and 20 post-intervention. Cleaner performance improved from a baseline median score of 38% [15/40 required C&D steps; inter-quartile range (IQR): 25–45%] to a post-intervention score of 90% (36/40 C&D steps; IQR: 85–98%), with improvements in personal protective equipment donning and doffing, preparing detergent and disinfectant, C&D of key surfaces, and storing equipment. Seven cleaners, six facility operators, and eight PHOs participated in the KII. Prior to supportive supervision, cleaners and facility operators reported evading PHO inspection visits due to fear of fines and citations; however, post-intervention, toilet staff described PHO visits as a welcome opportunity for instruction and worker accountability. Toilet staff also reported benefits for the facility, including more frequent and thorough C&D, improved toilet conditions, and increased customer volume and satisfaction. PHOs reported that hygiene standards improved and that supportive supervision sessions built trust with toilet staff, helping to collaboratively uphold Nakuru's health and sanitation laws.

This intervention adapted supportive supervision training models from healthcare facilities to public toilets sites. Both cleaner performance and collaborative interactions among PHOs and toilet staff improved, suggesting supportive supervision is a promising approach for improving C&D in this and other community settings.

Household coping costs and adaptive management of intermittent water systems: A scoping review

Lauren Broyles, The Pennsylvania State University

Globally, one billion people are estimated to use piped water which is only available intermittently. Intermittent water systems (IWS) are shaped by multiple factors related to environmental change including population growth, lack of infrastructure financing, infrastructure decay, damage from extreme weather events, and overconsumption of existing water supplies. Multiple reviews have summarized the relationships between IWS, water quality, and related health effects, which continue to be the primary focus of research about the human impacts of IWS. An emerging literature, however, suggests that users of IWS bear additional—and sometimes invisible—burdens such as the time and money spent collecting, treating, and storing intermittent water; maintenance expenses for treatment and storage infrastructure; outlays for alternative water sources; social costs of missing events or enduring conflict; consequences of engaging in illegal activities to secure water; and caregiving and medical expenses related to any of these activities. To address these research gaps, we conducted a scoping review with a structured keyword search to identify 22,766 articles in Scopus, Web of Science, PubMed, ProQuest, and EBSCO Academic Search Complete. After removing 10,330 duplicate records and non-peer review articles, 12,436 records were screened by title and abstract, 351 full-text records were assessed for eligibility, and 152 articles were subject to data extraction. Our subsequent analysis synthesized the interdisciplinary literature on IWS characteristics, household impacts, coping strategies related to five sub-themes (intensification, modified consumption, migration, reprioritization and withdrawal, psychosocial and spiritual responses) and adaptive management responses. This review highlights key challenges for policy makers and engineers to limit the human impacts of IWS and inform resilience-building efforts for households and utilities.

Quantifying the Human Energy Cost of Water Fetching in Eastern Uganda
Camila Van Oost, Stanford University

Sustainable Development Goal (SDG) 6.1 prioritizes universal access to safely managed drinking water, yet in sub-Saharan Africa (SSA), women and girls continue to be responsible for head-hauling water from community water points to their compounds. Traditional metrics like time and distance fail to capture the full physical burden of this labor, leaving a critical gap in understanding its energy expenditure and health implications. This study quantifies the caloric costs of water fetching, storage, and treatment among adult females relying on improved community water points (e.g., boreholes with handpumps) in rural Eastern Uganda, where only 9% of rural households have on-premises water access.

The research addresses two questions: (1) What is the median/mean number of calories expended per cubic meter of water during water-related tasks? (2) What proportion of daily

caloric expenditure do these tasks represent for women using community water sources? Using a cross-sectional observational design, the study recruits adult women from households dependent on community water points in Kaliro and Iganga Districts. Participants' energy expenditure is measured via wearable biometric devices (Zephyr BioHarness and Garmin Forerunner 255) to track heart rate, breathing rate, and movement, complemented by GPS data and time-stamped activity logs obtained through structured direct observation. Energy expenditure during water fetching will be estimated using the obtained biodata (heart and breathing rate, as well as anthropometric measurements) through validated physiological equations.

Preliminary findings will provide empirical field estimates of human energy costs associated with water access in this context, highlighting the disproportionate physical burden placed on women. By shifting the focus from time savings to energy expenditure, this study advances a more holistic understanding of the health and economic trade-offs inherent in water-fetching labor. Results will inform policymakers and funders by quantifying underrecognized costs of community water access, enabling more nuanced cost-benefit analyses for water infrastructure investments. These insights are critical for advocating targeted interventions that address gendered health disparities and align with SDG 6.1's equity goals. Ultimately, the data aim to elevate energy expenditure as a key metric in water policy discussions, ensuring that the true physical toll of water insecurity is recognized and prioritized in SSA and similar settings.

Estimating the effectiveness of a household water filter on household water and household food insecurity among Maasai pastoralists in Kenya
Lauren Broyles, The Pennsylvania State University

Background: Water and food insecurity are two of the most pressing issues people face, and climate change exacerbates both. Globally, two-thirds of the world's population experiences some level of household water insecurity, and one-third experiences moderate to severe food insecurity. Extreme weather events, such as droughts and floods, and shifts in the timing and duration of seasonal rains and temperature worsens these conditions by damaging domestic water sources or by destroying crops and ruining food supplies. Traditional reliance on grazing and rainfed agriculture make Maasai pastoralists in Kenya extremely vulnerable to negative effects of climate change, for whom water and food insecurity are highly interrelated. Communities rely on seasonal surface water sources, which may be highly contaminated and unsafe, putting households at risk of waterborne diseases. Drought increases psychological and mental stress as water sources dry up and there is less water available to care for livestock and domestic needs, such as drinking water and preparing food. Increased frequency and severity of droughts affords less time for recovery and requires household-level food and water interventions to build climate

resiliency for adequate health and nutrition.

Objective: In response to these problems and against a backdrop of a severe drought from 2020-2023 followed by a heavy rainy season and flash-flooding in 2024, we measured food and water insecurity and evaluated the effectiveness of a household water intervention on reducing food and water insecurity in two Maasai communities. In partnership with Kenyan non-profit, Africa Hope, and social enterprise, Aqua Clara Kenya, we utilized variation in timing of household surveys and deployment of a household water filter sold by Aqua Clara Kenya to estimate the effectiveness of the household water filter at reducing food and water insecurity among 220 households across two Maasai communities.

Methods: Household surveys included questions on household demographics and livelihoods; Household Food Insecurity and Access Scale (HFIAS) to measure food insecurity; and the Household Water Insecurity Experiences Scale (HWISE) to measure water insecurity. With our panel data, we will utilize linear and logistic regression analyses with panel fixed-effects to estimate the effects of the household water filter on water and food insecurity.

Results: Baseline survey results from the beginning of the rainy season demonstrate that across the two communities, the average HFIAS score is 9.6 (SD=7.4, 95% CI: 8.6, 10.6), and the average HWISE score is 11.5 (SD= 9.5, 95% CI: 10.2, 12.8). Water filters were distributed in April 2025 and repeated surveys were collected during the dry season in June 2025. We anticipate that both water and food insecurity will decrease post-intervention, and we will further present on the results of household surveys after deployment of the household water filter.

Conclusion: This repeated measure intervention study indicates that at the beginning of the rainy season, the average household experienced low to moderate household food insecurity, and low to moderate household water insecurity. Climate-sensitive and seasonally- appropriate interventions to improve water and food insecurity are critical to assess to reduce the resulting health and well-being consequences associated water and food issues.

Association Between Household WASH Facilities and Menstrual Hygiene Management Among Filipino Women of Reproductive Age

Crystal Amiel Estrada, College of Public Health, University of the Philippines Manila

Background
Menstrual hygiene management (MHM) plays a significant role in the health and well-being of women and girls. MHM requires access to menstrual products, safe sanitation facilities,

and clean water for washing to ensure that women and girls who menstruate can manage their menstruation safely and properly. However, poor MHM remains to be a public health concern, which can lead to negative health outcomes for women and girls worldwide.

In the Philippines, studies on MHM and its relationship with water, sanitation, and hygiene (WASH) have been focused on schools and little is known about the role that household WASH facilities play in supporting MHM of Filipino women and girls. This study aimed to determine the association between household WASH facilities and MHM among Filipino women aged 15-49 years old using nationally representative data from the 2022 Philippine National Demographic and Health Survey (NDHS).

Methods

An analytical cross-sectional study was conducted using secondary data from the 2022 NDHS to determine the association between household WASH facilities and MHM among Filipino women. Simple logistic regression was conducted to determine the crude association between household WASH facilities and MHM. Confounders were screened using simple logistic regression and a change-in-estimate criterion was used in building the final model through multiple logistic regression.

Results

Among the women included in the study, 22.16% (n=5,664) did not have fully compliant household WASH facilities, while 4.36% (n=1,115) had poorly managed MHM. The odds of having properly managed MHM was higher in women with partially compliant (OR: 1.7264, 95% CI: 0.9410-3.1673, p=0.078) and fully compliant household WASH facilities (OR: 1.8667, 95% CI: 1.0113-3.4459, p=0.046). Only fully compliant household WASH facilities were found to have a statistically significant association with MHM. Highest educational level, household wealth index, and religion were identified as confounders.

Conclusion

The findings of the study highlight the importance of achieving at least basic sanitation and basic handwashing facilities for all households to address women's specific WASH needs, especially for MHM. Local government units must strengthen the implementation of WASH programs in the Philippines, such as the Zero Open Defecation Program, and monitoring of MHM by including more gender-sensitive WASH and MHM indicators in local data collection and monitoring systems. The results of this study can also support possible amendments to local laws and policies that specifically address menstrual health and household WASH facilities, such as the Responsible Parenthood and Reproductive Health Act of 2012. Menstrual hygiene management, an important facet of reproductive health, may be incorporated into the comprehensive reproductive health program aimed to address the needs of people throughout their entire life cycle. Future studies exploring other MHM indicators and other factors affecting WASH at the household level can provide a more comprehensive understanding of the various factors influencing MHM among women and girls.

The Missing Link: Evaluating the Role of Mothers in Menstrual Health Interventions in Ethiopia
Emily Cruz, Splash International

Menstrual health (MH) in Ethiopia is shaped by complex social norms and infrastructural challenges, particularly affecting school-aged girls. While interventions often center girls' experiences at school, the role of mothers—as primary caregivers and educators—has been largely overlooked. In many communities, deep-rooted gender norms surrounding menstruation, marriage, and motherhood limit open conversations, and mothers frequently lack the knowledge or support to guide their children through puberty. This study evaluates the impact of a holistic MH program in schools in Addis Ababa by Splash Ethiopia, which includes a specific mother-focused Engagement Session. By equipping them with accurate information and practical tools, the program seeks to strengthen the home environment and complement school-based efforts in MH education, shifting norms and increasing self-efficacy to initiate puberty-related discussions with children transforming norms across households and communities.

The study explores three core research questions, with a focus on maternal influence:
- How does parental education—particularly among mothers—affect knowledge, stigma, and self-efficacy in supporting children through puberty?
- What barriers prevent mothers from engaging in MH conversations with their children, and how can parent education groups help overcome these barriers?
- How does a multi-generational approach that includes mothers affect household and community attitudes toward menstruation?

The study collected survey data from 594 girls, 297 boys, and 292 mothers across 5 subcities and 10 schools in Addis Ababa, Ethiopia. The intervention included a peer mentoring program for girls, a puberty workshop for boys, and a parent support group aimed at increasing knowledge and reducing stigma around menstruation.

Findings reveal that 9 in 10 girls learned about menstruation at home—mostly from their mothers. However, one in five of these conversations happened after menarche, highlighting missed opportunities for early support. While mothers felt confident discussing menstruation with daughters and generally viewed it positively, they were less comfortable speaking to sons, creating a gender gap in MH education at home. Additionally, many mothers believed common myths—such as avoiding exercise or cooking during menstruation—more than their daughters did. These beliefs reflect a need for targeted education to challenge entrenched taboos. The parent engagement sessions proved effective, improving knowledge, reducing misinformation, and encouraging more

open communication—especially between mothers and daughters.

Mothers are often the first and most trusted source of MH information for girls, making their engagement essential. Strengthening their knowledge and confidence can improve early MH education and reduce stigma. However, delayed conversations and persistent myths underscore the need for programs to promote pre-menarcheal education and challenge harmful cultural beliefs. The exclusion of sons and fathers also highlights the importance of inclusive, family-centered MH education. When messages are reinforced both at school and at home, girls benefit from a consistent, supportive environment. This holistic approach aligns with global best practices and suggests that engaging mothers is a transformative, yet underused, strategy for sustainable MH impact.

Effect of Participatory Design for Urban Informal Settlement Upgrading on Women's Sanitation-Related Empowerment in Fiji
Allison Salinger, Emory University

Background:
The water, sanitation, and hygiene sector has strengthened its focus on women's empowerment in recent years, catalyzed by SDG 6.2 which calls for "paying special attention to the needs of women and girls." Poor sanitation perpetuates gender inequality and disempowerment by compromising women's safety, mental and physical health, and well-being. The Agency, Resources, and Institutional Structures for Sanitation-Related Empowerment (ARISE) Scales were developed and validated with adult women in five low- and middle-income countries but have yet to be used to measure intervention impact. The objective of this study was to validate the ARISE scales in a new country context and evaluate the impact of participatory design and community engagement on sanitation-related empowerment among adult women in urban informal settlements within the Revitalizing Informal Settlements and their Environments (RISE) trial in Fiji.

Methods:
RISE is a randomized controlled trial designed to assess the impact of a water-sensitive cities approach to upgrading water and sanitation infrastructure on environmental contamination, human health, and well-being. RISE has been working since 2019 in 12 urban informal settlements (6 intervention, 6 control) in Suva, Fiji. We conducted household surveys in April-June 2024 (prior to infrastructure installation) with 281 women across all 12 settlements. Four scales (decision-making, leadership, collective action, relations), along with menstruation-related decision-making and menstruation-related relations sub-scales, were selected from among the 16 ARISE scales based on relevance to the context and intervention. We used exploratory and confirmatory factor analyses to test dimensionality and validity of the scales, scored each scale 1-4 with higher scores

indicating more empowerment, and calculated a summary measure for each settlement. Cluster-level analyses utilized Wald tests of the ordinary least squares (OLS) regression to measure the impact of RISE on each of the empowerment sub-domains.

Results:
Factor analyses confirmed that the hypothesized factor solutions fit the data well for each of the six models (SRMR<0.05; CFI>0.98 ; TLI>0.96); all items had reasonably strong (≥0.5) and significant factor loadings. Cluster-level mean scale scores ranged from 2.86 to 3.29 among women in intervention settlements and 2.83 to 3.20 among women in control settlements. Wald tests of OLS regression showed that women in intervention settlements had significantly higher scores compared to women in control settlements for decision-making (mean difference (MD)=0.07; p-value=0.0269; 95% confidence interval (CI)=0.010-0.134) and menstruation-related decision-making (MD=0.11; p-value=0.0348; 95% CI=0.010-0.211) after adjusting for average settlement-level wealth scores. We observed no impact on other sub-domains.

Conclusions & Implications:
The RISE participatory design and community engagement activities positively impacted women's sanitation- and menstruation-related decision-making. Women's involvement in decisions around latrine construction, maintenance, and upgrading have implications for whether latrines are female-friendly and ultimately whether they are used. The selected ARISE scales held form and function in a new study setting and were sufficiently sensitive to capture differences between intervention and control groups even after adjusting for wealth and clustering. Researchers and practitioners can thus utilize ARISE scores to inform or evaluate intervention effect on sanitation-related empowerment as well as measure ARISE scores as predictors or mediators of health and development outcomes.

Women's and Men's Time Use in Rural Kenya: A Cross-Sectional Study
Sheela Sinharoy, Emory University

Background:
Women disproportionately shoulder the burden of unpaid care and domestic work, including water collection, globally. Time spent on unpaid work may impede women's engagement in income-generating activities, further exacerbating gender inequalities. Within Sustainable Development Goal 5 (Achieve gender equality and empower all women and girls), Indicator 5.4.1 is: "Proportion of time spent on unpaid domestic and care work, by sex, age and location". However, data for this indicator are not regularly tracked or reported, and large gaps exist in our knowledge of how women and men spend their time across global settings. To address this knowledge gap, our study objectives were to: (1) measure and compare women's and men's time use in a rural area of Kenya; and (2)

compare time use between women in communities with and without an improved water source, focusing on time spent on water collection and income-generating activities.

Methods:
Data were collected through in-person surveys with 96 participants (48 women, 48 men) across six rural communities in Wamba region, Kenya, in July-August 2024. Three of the six communities had received an "improved" water source (borehole) from World Vision, while the other three had not. The surveys included a 24-hour time use recall module that was adapted from the time allocation module in the Women's Empowerment in Agriculture Index. Survey participants were asked to recall their activities over the previous day and night, and activities were recorded in 15-minute increments. We calculated descriptive statistics, including average time in minutes spent on each activity, by sex and by type of water source.

Results:
Among survey participants, 33 women and 3 men reported spending time on water collection in the previous 24-hour period. Of these, the average self-reported time spent on water collection was 90.4 minutes, with no difference between women and men (women: 90.5; men: 90.0). 14 men and 10 women reported spending time on paid activities; average time spent was 166.3 minutes, though this differed between women and men (women: 121.5; men: 198.2). Among communities that had received an improved water source, women's average self-reported time spent on water collection was higher (79.0 minutes) than for women in comparison communities (45.0 minutes). Women in communities that had received an improved water source also reported spending more time on paid activities (N=6; 147.5 minutes) than women in comparison communities (N=4; 82.5 minutes).

Conclusions & Implications:
In our study population, water collection remains women's responsibility, with several important nuances. First, those men who carried out water collection activities spent the same amount of time on this task, on average, as women. In communities that had received improved water sources, women reported spending more time on both water collection and paid work compared to women in communities without an improved water source. It is possible that women in communities with improved water sources may be collecting additional water for the purpose of income-generating activities. We will discuss the potential for improved water infrastructure to generate returns on investment in the form of women's engagement in income-generating activities.

Evaluation of a Fluorescence-Based Sensor for Simultaneous Measurement of E. coli and Turbidity in Water

Mahboobeh Kasraee, University of Illinois Chicago

Background:
Fecal indicator bacteria (FIB) like Escherichia coli are often analyzed using time-consuming and expensive culture methods to assess the microbial quality of drinking and recreational water. New developments in in-situ fluorescence sensors, especially those that target humic-like fluorescence (HLF) and tryptophan-like fluorescence (TLF), offer opportunities for rapid detection of microbial contaminants. The effects of turbidity, dissolved organic matter, and background fluorescence from non-microbial sources on TLF are not well-characterized. To address this gap, a research team at UIC independently evaluated the performance of a portable fluorescence-based device (realtimeWAS, Phutung Research Institute, Nepal) that simultaneously estimates concentrations of TLF as a proxy for Escherichia coli and HLF, as well as turbidity in a given sample of water, in about 2 minutes.

Methods:
The U.S. EPA's "Method Validation of Microbiological Methods of Analysis" to evaluate sensitivity, specificity, precision, accuracy, linearity, and limits of detection were used in this evaluation of laboratory-prepared water samples. Dilution series of calibration standards as well as kaolin, humic acid, and E.coli prepared in distilled water alone, and in combination, were analyzed. Sensor measurements of E.coli were compared to culture-based results (Colilert). Turbidity measurements were compared to those from a benchtop Hach turbidimeter. Quality assurance included the use of blanks and triplicate measures of samples.

Results:
Results from the first 90 samples showed that the sensor demonstrated a strong linear relationship for turbidity measurements, with an R^2 of 0.98 between standard NTU solutions and sensor readings with limit of detection (LOD) of 0.74 NTU. Coefficients of variation were generally well below 10%. When evaluated separately, kaolin and humic acid turbidity measurements showed R^2 values of 0.98 and 0.99, respectively. Analyses of quinine (the HLF standard) showed an R^2 of 0.87, and for L-tryptophan (representing TLF), the R^2 was 0.67. Humic acid and kaolin had additive effects on the TLF signal without evidence of amplification or interference. Sensor-derived TLF values for measuring E. coli concentrations were strongly correlated ($R^2 = 0.99$) with culture-based measurement with minimal bias (~0) and a calculated LOD) of 1.9 MPN, supporting the sensor's potential as a near-real time method of monitoring fecal bacteria in water samples.

Conclusion:
Measurements of turbidity and E. coli were accurate, precise and sensitive. Although humic acid and kaolin produced additive effects on L-tryptophan measurement, there was

no evidence of interference or amplification of TLF. Ongoing work will evaluate potential interference between turbidity-causing materials and E. coli. Testing of surface water samples (as opposed to laboratory-prepared samples) will useful, as will analyses of sensitivity and specificity of TLF metrics in relation to water quality standards.

A Systematic Review of Toxic Metals Exposures through Drinking Water in East Africa
Clay Burgess, The Water Institute

Lead (Pb), Arsenic (As), and Manganese (Mn) present substantial and irreversible health concerns to exposed populations. Prior evidence suggests that drinking water is an important exposure route for each of these contaminants. Lead primarily enters drinking water systems through anthropogenic means: either through the intentional installation of lead-containing infrastructure like pipes and handpumps, or through source contamination from industrial waste. Arsenic and Manganese are predominantly geogenic contaminants, though substantial contamination through manufacturing waste is also seen in the literature. These three contaminants may produce significant public health burdens as East Africa continues to improve its drinking water infrastructure. As communities transition to "improved" sources such as deep boreholes, communities may increase their exposure to geogenic contaminants. If the materials used in borehole systems are poorly managed, they may introduce communities to Pb through drinking water. Additionally, rapid urbanization may lead to a worsening of source contamination through industrial waste. Given the potential risk to substantial populations, we sought to understand the existing exposures of populations to Pb, As, and Mn through drinking water.

A systematic review approach is being used per the PRISMA statement items. Inclusion criteria include peer-reviewed studies published in English since 1969 reporting a toxic metal of concern in drinking water in a Low- and Middle-Income Country (LMIC). PubMed, EBSCO Global Health, and Web of Science were searched. 24,000 studies were identified from these databases, with 3,908 proceeding to data extraction. Of this set, 108 studies took place in East Africa, comprising a total of 1700 data points across Pb, As, and Mn. Analysis determined the percentage of samples exceeding the WHO guideline values for Pb, As, and Mn in drinking water at 10, 10, and 80 ug/L, respectively.

Evidence from this analysis suggests that across the region, 30%, 25%, and 16% of improved, urban sources have Pb, As, and Mn above their WHO guideline values. This is substantially higher than in rural settings, though there are insufficient studies to conclude significance. Similarly, there seems to be an increase in geogenic contamination when switching to an improved source in rural areas. A current limitation is the lack of nationally representative and high-fidelity water quality data for toxic metals in the region, suggesting a gap for future research. This study concludes that while more work is needed to

determine the final levels of exposure, there is substantial evidence that toxic metals should be integrated into national drinking water strategies to prevent population-wide exposures.

Improving water quality data by optimizing CompactDry ECO plate use.
Charlotte Smart, Fort Lewis College

Background
The UNICEF Multiple Indicator Cluster Survey (MICS) is a primary data source that the World Health Organization (WHO) and UNICEF Joint Monitoring Programme (JMP) uses to monitor Sustainable Development Goal 6.1 . MICS typically uses a membrane filtration technique with dehydrated CompactDry ECO agar plates to enumerate Escherichia coli (E. coli). However, rehydrating ECO plates with the recommended 1.0mL can lead to colonies smearing together leading to inaccuracies and data loss. ECO plates also have a limited shelf life leading to unused resources as national surveys frequently experience delays. The objective of this research is to improve the quality and quantity of results obtained with CompactDry ECO plates by testing the reliability of expired plates and optimizing rehydration volume to reduce smearing.

Methods
To evaluate smearing, 68 trials of six membrane filtrations (n=408) with different rehydration volumes (0.4-0.8mL and 1.0mL) were completed across a range of E. coli concentrations (<1-163 CFU/100mL). After incubation in either an electric incubator or an incubator belt, plates were classified as readable, somewhat smeared or smeared and colonies were counted where possible.
Expired plates were evaluated using 120 paired samples evenly distributed across four different concentration ranges (n=240) and batches of 12 replicate plates at five targeted concentrations (n=120). The paired samples were completed with membrane filtration of Ringer's solution spiked with E. coli K-12. The batchwise plates were completed by directly dispensing 1.0mL of Phosphate Buffered Saline (PBS) solution spiked with isolated and cultured environmental E. coli onto each plate. This was done for 12 expired and 12 non-expired plates for each batch. All expired plates were 4 years out of date.

Results
The Shapiro-Wilks normality test found colony counts were non-normal ($p<0.01$) for all studies. For the rehydration study a Friedmans test revealed that there were significant differences ($p=0.0285$) in the counts between rehydration volumes for all plates ($p=0.0285$), and for plates incubated in an incubator belt ($p=0.0026$). A post-hoc Dunn-Bonferroni test found a significant difference between 0.4 and 0.7mL ($p=0.0173$) for all plates ($p=0.0173$) and incubator belt plates ($p=0.0009$), as well as 0.4 and 1.0mL for the

incubator belt (p=0.0217). Preliminary categorization revealed that 39-52% of the 0.8mL and 1.0mL plates were readable and 74-100% of the 0.4mL-0.7mL plates were readable. Wilcoxon signed rank tests found a significant difference (p=0.005) between expired and non-expired plate counts in the paired sample high risk category. There were no significant differences in the overall datasets, other risk categories, or individual trials for both the paired and batch tests. The expired plates in the paired and batch tests had a high sensitivity (99% and 91%, respectively) and high specificity (97% and 100%, respectively).

Conclusion
A reduced rehydration volume of 0.5-0.7mL for ECO plates reduces smearing and does not significantly change results. Also, the accuracy, sensitivity, and specificity of the expired (4 years past) and non-expired plates were comparable. Overall, this research can be used to advise changes to MICS protocols, the use of CompactDry plates, and improve the data quality and quantity that policymakers rely on.

Balancing precision and sample size: Comparing low vs. high-precision methods for measuring E. coli in drinking water in low-resource settings.
Andrea Sosa-Moreno, University of Michigan

Measuring drinking water quality is crucial for monitoring access to safe water, particularly in low-resource settings where testing budgets and technical capacity are limited. Escherichia coli testing is a standard approach for assessing microbial contamination, but available methods vary in precision, complexity, and cost. Low-precision approaches are more affordable, faster, and simpler to implement in low-resource settings, though they may reduce the statistical power to detect associations. In this study, we evaluated the trade-offs between low- and high-precision E. coli testing methods by comparing their statistical power using data from 11 low-income regions covered by UNICEF's Multiple Indicator Cluster Surveys (MICS), and from a birth cohort study in Ecuador. Both datasets included continuous E. coli concentrations obtained through high-precision methods (IDEXX Quanti-tray®/2000 and membrane filtration). To simulate low-precision approaches (Colilert® presence-absence test, Compartment Bag test, and the combination of 100mL Colilert® presence-absence test with 1mL PetrifilmTM), we categorized E. coli concentrations. We assessed associations between water quality and two binary outcomes: water sample treatment (treated/untreated) and water sample storage (stored/ not stored), using logistic regressions. We then estimated the sample sizes needed to reach 80% power for detecting statistically significant differences between these groups using a bootstrap-based algorithm. We found that low-precision methods that rely on categorization of E. coli concentrations, required 10-90% larger sample sizes to achieve the same power as high-precision test that rely on continuous E. coli concentrations. However, in regions where water quality was relatively high, low-precision methods performed

comparably well. Our findings indicate that low-precision methods can reliably infer associations between water practices and water quality, but these approaches often require larger sample sizes. This trade-off is particularly important for large-scale monitoring programs like MICS, where a lower cost platform would allow for an increase in the number of households sampled. Recognizing and balancing these trade-offs is essential for selecting appropriate microbial water quality assessment methods in resource-limited settings that benefit from cost-effective and scalable approaches.

Environmental monitoring of community health in urban non-sewered catchments in Kampala
Seju Kang, Swiss Federal Institute of Aquatic Science and Technology (Eawag)

Infectious diseases continue to pose a significant burden on global public health, causing outbreaks and, in severe cases, pandemics. Wastewater-based surveillance (WBS) has emerged as a valuable, unbiased, and cost-effective approach to monitor infectious disease trends at the community level by analyzing wastewater flowing into centralized treatment plants. However, nearly half of the global population, particularly in densely populated urban areas of Asia, Africa, and South America, relies on non-sewered sanitation systems. In such contexts, traditional WBS frameworks are not applicable, leaving critical gaps in community-level disease monitoring.

This study aims to investigate a systematic framework for pathogen surveillance in urban areas with non-sewered sanitation, using drainage systems as proxies for community-level pathogen circulation. The study was conducted in Kampala, Uganda, where only 7.5% of the population is connected to sewers, while 92.5% rely on non-sewered sanitation. Multiple mapping datasets, including topography, population density, and income level, were used to identify candidate drainage points. The rationale was based on prior approaches such as Excreta Flow Diagrams (SFDs) and Quantity and Quality of fecal sludge (Q&Q), which help understand how human excreta are stored and flow into the sanitation infrastructure with demographic, environmental, and technical status. Through key informant interviews and field observations, these were narrowed down to 10 drainage sites, supplemented by two wastewater influent points at wastewater treatment plants. Daily grab samples were collected from all 12 locations over 10 weekdays in March 2025. Measured parameters included E. coli, total suspended solids (TSS), and volumetric flow rate. Nucleic acids were extracted and analyzed using digital PCR assays targeting respiratory viruses (SARS-CoV-2, Influenza A/B, RSV), gastrointestinal viruses (Norovirus G1), pathogenic bacteria (Vibrio cholerae), and Pepper Mild Mottle Virus (PMMoV)
To compare the fecal strength between drainage and wastewater, concentrations of E. coli, TSS, and PMMoV were analyzed. E. coli concentrations ranged from log 3.6 to 4.4 CFU/mL in drainage samples, while wastewater influents showed higher concentrations, log 4.8 to

4.9 CFU/mL. TSS values were log 1.4 to 2.4 mg/L in drainage and log 2.6 to 2.8 mg/L in wastewater. PMMoV concentrations were also higher in wastewater influents, log 3.9 to 4.7 gc/mL, than in drainage samples, log 2.3 to 4.4 gc/mL, supporting stronger fecal loading in wastewater.

Detection of pathogens in drainage indicates the viability of drainage-based surveillance approaches, albeit at potentially lower fecal strength than wastewater treatment influent. Norovirus G1 was detected in drainage samples at concentrations ranging from log 0.3 to 2.3 gc/mL and peaked at log 2.8 gc/mL in wastewater. Influenza A virus was frequently detected in both drainage and wastewater, while SARS-CoV-2 and RSV were below detection limits.

Ongoing analyses will assess whether differences among the drainage sites can be linked to upstream safely managed sanitation and population characteristics. This will help evaluate whether pathogen signals in drainage can serve as proxies for community health monitoring. Differences in safely managed sanitation and stored wastewater will also be explored to determine how they influence pathogen circulation.

Evaluation of the PICHA7 Chlorine mHealth and E-Voucher Program to Reduce Diarrhea Outbreaks in Congo
Christine Marie George, Johns Hopkins Bloomberg School of Public Health

Introduction
In the Democratic Republic of the Congo (DRC), diarrhea is attributed to 2 million inpatient diarrhea cases and 2.3 million DALYs annually. In partnership with the Ministry of Health, we developed the PICHA7 water, sanitation, and hygiene (WASH) mobile health (mHealth) program, which delivers quarterly in-person visits and weekly mHealth messages to diarrhea patient households. In our recent randomized controlled trial of 2,334 participants, the PICHA7 mHealth program significantly reduced healthcare facility visits for diarrhea. Building on this work, we are now adapting PICHA7 to serve millions more beneficiaries through a chlorine mHealth and e-voucher program in diarrhea outbreak areas.

Method
A pilot of the PICHA7 chlorine mHealth and e-voucher program was conducted in urban Bukavu in South Kivu province of DRC. This program is delivered in health areas (administrative unit ~10,000 individuals) with ongoing diarrhea outbreaks. Voice calls and SMS messages are sent from a doctor at a local cholera treatment center stating to phone subscribers that there is a diarrhea outbreak in their health area and it is important to treat household drinking water for the next 7-day high-risk period. A SMS message is also sent

with an e-voucher to redeem for free chlorine tablets at a local pharmacy.

Results
The pilot of the PICHA7 chlorine mHealth and chlorine e-voucher program was delivered in two health areas of Bukavu where there were ongoing diarrhea outbreaks to 961 individuals within 500 meters of suspected cholera patients. Fifty-four percent of phone subscribers redeemed e-vouchers for free chlorine tablets at a local pharmacy. During unannounced spots checks conducted on Day 7 of the high-risk period after the index suspected cholera patient was admitted to a health facility, 64% of households that redeemed e-vouchers had free chlorine >0.2 mg/L in stored drinking water samples compared to 21% in source water samples (p-value = 0.03), and 6% in stored water samples from control households (p-value=<0.0001).

Conclusion
The delivery of the PICHA7 chlorine mHealth and e-voucher program, resulted in the majority of phone subscribers redeeming e-vouchers for chlorine tablets at their local pharmacies and significantly higher chlorine concentrations in stored drinking water samples among households that redeemed chlorine e-vouchers. These findings suggest the PICHA7 chlorine mHealth and e-voucher program presents a promising approach to increase water treatment behaviors during diarrhea outbreaks in our study setting in the DRC. Future studies are needed to evaluate the health impact of delivering this program during diarrhea outbreaks.

Evaluating a Scalable, Community-Centered Subscription Model for Point-of-Use Water Treatment in Texas Colonias
Marcio Botto, Vida Water

Water access remains a critical challenge in Texas colonias - predominantly Hispanic, unincorporated communities that often lack access to affordable and reliable drinking water. Due to infrastructure limitations, many households rely on hauled and bottled water, incurring high costs to fill large storage tanks for daily use.

In response to this condition, a pilot project was implemented in Hueco Tanks, a colonia in El Paso County, Texas, with 144 occupied homes that rely on hauled water stored in 2,500-gallon tanks. The intervention aimed to evaluate the feasibility of delivering point-of-use (POU) water treatment through a scalable, service-based model.

The model consisted of a subscription service covering household water quality assessments (including 14 parameters), customized POU system installation, routine maintenance, and ongoing monitoring. Community engagement strategies included partnerships with promotoras (community health workers), development of local testing

capacity, and technician training programs. The selected POU units, Water Quality Association (WQA) certified multistage systems combining microfiltration, ultrafiltration, and activated carbon, were chosen based on site-specific assessments and community input.

During the initial six-month implementation period, 73 households received assessments and 20 systems were installed, achieving a 14% household penetration rate and exceeding the initial target. Post-installation monitoring demonstrated that 95% of samples had turbidity levels below 0.15 NTU, and all systems maintaining turbidity under 0.30 NTU and no detection of total coliforms or E. coli. Each system delivered an estimated 25,500 liters of treated water per household annually and generated average savings of $360 per year through reduced bottled water purchases and fuel use.

The subscription-based model addressed key implementation challenges, including resident engagement, ongoing maintenance, and performance monitoring. With a 37% lead conversion rate and 100% customer retention since the program's launch in August 2024, the pilot demonstrated the operational viability of a full-service model in an underserved community. The project also identified opportunities to refine logistics and engagement strategies.

These findings suggest that a subscription-based, community-integrated approach to POU treatment can overcome persistent barriers to trusted and affordable drinking water in colonias and similarly underserved communities. The project also demonstrates a scalable service delivery model that utilities, nonprofits, and local governments can adapt to address water insecurity in small and marginalized settings. Ongoing expansion into additional colonias will offer further insight into the model's adaptability and broader applicability.

Functionality of Arsenic-Iron Removal Plants in Water-Challenged Rural Areas of Bangladesh
Tanvir Ahmed, Bangladesh University of Engineering and Technology

Introduction: Ensuring a sustainable drinking water supply continues to be a significant challenge in rural regions of low- and middle-income countries like Bangladesh. Community-level Arsenic-Iron removal plants (AIRPs), a nationally promoted option for treating arsenic-contaminated groundwater, are experiencing reliability issues during operation and frequent malfunctions, often leading to total abandonment. Maintenance, costs, suboptimal system design, breakage of components, and scarcity of available groundwater could be some factors that have potentially contributed to service dysfunction. This study aims to determine the linkages between the functionality of the

AIRPs with such factors, and identify and prioritize factors associated with their long-term sustainability.

Methodology: A conceptual framework was developed to identify the various factors that may have a reasonable association with the functionality of an AIRP. A questionnaire survey was administered in 11 districts, covering 190 villages across 80 unions, where AIRPs were installed. Information was collected on installation age, sufficient yield of the well, tariff contribution, willingness-to-pay, repair responsibility, O&M, and external support received by the community. A multivariate regression analysis was performed to adjust for all independent variables outlined in the conceptual framework. Only those factors exhibiting a statistically significant ($p < 0.05$) association with the outcome were included in the final interpretation.

Results: AIRPs installed more than eight years ago were found 10 times less likely to remain functional compared to those installed 4-8 years ago (adjusted odds-ratio (AOR)=0.1; 95% confidence interval (CI)=0.0-0.4). AIRPs serving water for drinking and cooking were over 6 times more likely to be functional than those used solely for drinking (AOR=6.2; CI=1.1-33.9). AIRPs are 10 times less likely to remain functional when alternative water sources are available (AOR=0.1; CI=0.0-0.7). The absence of earthworms and/or insects in the AIRP aeration chamber and filter media has higher odds of being functional compared to the systems where they are present (AOR=14.3; CI=2.2-95.2). AIRPs connected to reliable wells were over 6 times more likely to remain functional compared to those drawing water from wells with insufficient yield (AOR=6.4; CI=1.1-36.6). AIRP systems that incorporate tariff contributions from users were 13 times more likely to be functional compared to those that do not (AOR=13.2; CI=2.2-79.8). Functional AIRPs were also associated with users having high willingness-to-pay (AOR=6.9; CI=1.1-42.1), AIRPs delivering water with good physical properties (AOR=8.9; CI=1.6-48.9), AIRPs having a professional cleaning team (AOR=6.9; CI=1.4-34.2), and where users receive regular capacity-building support by external agencies (AOR=4.7; CI=1.0-22.1).

Discussion: Functionality of AIRP was found to be closely tied to multiple interrelated factors, including system age, water source reliability, financial sustainability, professional maintenance, and community involvement. Older systems tend to be less reliable, underscoring the importance of durable construction and timely upgrades. Financial contributions through user tariffs provide maintenance resources and promote a sense of ownership. Professional cleaning and technical maintenance significantly enhance performance, while community training and involvement foster local capacity for sustainable operation. This study offers valuable insights into the underlying issues influencing the functionality of AIRP and provides directions for enhancing existing AIRP interventions with broader applicability to other decentralized water systems.

Tuesday Poster Abstracts

Toilets for All? Exploring the availability, accessibility, and characteristics of non-household sanitation in Atlanta, Georgia
April Ballard, Georgia State University

Sanitation access in public settings is a critical yet understudied public health issue in the United States (US). As government-operated public sanitation infrastructure has declined, reliance on private facilities as a public good has increased. This shift raises equity concerns, as people may face access restrictions based on perceived customer legitimacy, socioeconomic status, race, or gender. However, limited data exist on the landscape of public sanitation in urban areas, which impedes policy development and infrastructure planning. This study assessed the availability and accessibility of public sanitation facilities across Atlanta, Georgia, and compared facility characteristics by funding source (i.e., government-funded versus commonly used private options).

From February-April 2025, we conducted field-based audits across 15 high-foot-traffic geographic areas, each defined by a 500-meter radius buffer. We systematically canvassed each area to identify locations with at least one publicly accessible toilet and recorded characteristics in Qualtrics. At each location, if present, we audited one of each type of facility (i.e., women's, men's, gender-neutral/all-gender, and family) using an expanded version of the Menstrual-Friendly Public Toilet tool. The tool captured 86 toilet-specific and 32 location-specific features related to accessibility, cleanliness, safety, stigma, and health resources. To assess facility coverage, we calculated toilet density per square kilometer. Differences by funding source were examined using Mann-Whitney U, Chi-Square, or Fisher's Exact tests, as appropriate.

Across the 15 sites, 262 locations were identified, but only 45.0% had at least one toilet facility available for public use. The remainder were inaccessible due to lack of a toilet for public use (24.8%), "Customers Only" signage (16.8%), locked doors (11.8%), or being occupied for more than 10 minutes (1.5%). Among locations with an available facility (n=118), barriers to access were common: 25.4% required staff permission, 18.6% required a key or code, 16.1% required entry via turnstile or gate, and 10.0% required a purchase. Only 5.9% of facilities were confirmed to be accessible 24 hours per day, seven days a week.

We audited 207 toilet facilities across the 118 locations. The average density of accessible toilets across audit areas was 11.2 per square kilometer. Of these, 47.3% were government funded. Government-funded facilities had significantly more toilets (p<0.001), urinals (p=0.009), and sinks (p<0.001). In contrast, private facilities more frequently provided soap or hand sanitizer (p=0.009), had usable trash bins (p=0.006), were odor-free (p=0.023), and

included baby changing stations (p=0.027).

This study is, to our knowledge, the first to systematically evaluate commonly used private sanitation facilities that have become de facto public goods in the absence of robust public infrastructure. Our findings highlight the limited and inequitable availability of public sanitation in a major US city and demonstrate how funding sources shape both the quantity and quality of facilities. These insights underscore the need for renewed public investment and policy reform, as well as intentional partnerships with private entities to ensure equitable access, consistent standards, and sustainable maintenance of sanitation infrastructure. Equitable, 24/7 access to safe, clean, and functional sanitation is essential for advancing public health, dignity, and social inclusion in urban environments.

Rural Subsewershed Wastewater-based Surveillance for Multiple Pathogens and Wastewater-based Epidemiology for COVID-19, Norovirus, and Rotavirus
Amanda Darling, EPA (US Environmental Protection Agency) / Virginia Tech

BACKGROUND:
Many in-sewer dynamics that can impact the fidelity of wastewater-based surveillance results remain under-studied. Some conventional approaches for wastewater-based surveillance (WBS) and wastewater-based epidemiology (WBE) may not be appropriate when there is substantial inflow and infiltration (I&I), particularly in smaller, rural, systems.

OBJECTIVES:
To evaluate detection rates and trend estimation for a range of viral, bacterial, and protozoan pathogens across a rural sewershed and inform WBE for select viral pathogens for rural communities with compromised sewage infrastructure.

METHODS:
We collected wastewater samples from the WWTP influent and 11 up-sewer nodes in an I&I impacted rural sewershed serving <3,000 people at monthly (and weekly) intervals over a 12-month period. We enumerated 27 pathogen targets using TaqMan Array Card quantitative polymerase chain reaction (qPCR), followed by more sensitive droplet digital PCR (ddPCR) analysis of SARS-CoV-2, Norovirus GII, and rotavirus. Associations between wastewater pathogen signal and case data were analyzed using Spearman's correlations and generalized linear models (GLMs), with adjustment for I&I and other covariates.

RESULTS:
We detected 20 viral, bacterial, and protozoan pathogen targets total in the sewershed across sampling events. Although many pathogens were detected at the WWTP influent and up-sewer sites, shedding for 14 targets was not detected at the WWTP despite same

day subsewershed detection at up-sewer sampling sites (using qPCR). Clinical case data and pathogen measurements from the WWTP influent and some up-sewer nodes were statistically significantly associated (p<0.05) for SARS-CoV-2 and rotavirus, but not for Norovirus GII. Bivariate regression between case and wastewater data revealed statistically significant associations between wastewater and case data for all three viruses. After controlling for covariates using GLMs, viral signals for SARS-CoV-2 and Norovirus GII remained significantly associated with case data (coefficients = 0.06 and 0.68, 95% confidence intervals [CI] = 0.003-0.123 and 0.136-1.229, respectively), though not for rotavirus (coefficient = 0.47, 95%CI = -0.369-1.302; n = 95 for all models).

CONCLUSIONS:
Overall, our results demonstrate that for relatively ubiquitously circulating pathogens, including SARS-CoV-2, viral signal measured at the WWTP influent and aggregated from sewershed nodes provided a useful metric for assessing infection trends in a small sewershed with I&I challenges. However, our findings also underscore the importance of sufficient understanding of up-sewer dynamics and application of appropriate normalization methods. Although our study helps illuminate some of the key pitfalls, and promise, of WBE in small and heavily I&I-impacted rural systems, more research is needed to better understand how and when WBE may be responsibly implemented in such settings. In particular, more research is needed to empirically quantify the impacts of I&I on wastewater signals relative to sewer travel times, the number of individuals contributing to waste streams, and other in-sewer phenomena.

Evaluating the adaptation benefits of smallholder solar irrigation systems in Kenya
Ferran Vega-Carol, Duke University

This study evaluates the impacts of solar-powered irrigation systems on climate resilience, agricultural productivity, and rural livelihoods in Kenya. In partnership with SunCulture—a Kenyan company that provides off-grid solar irrigation technology—we investigate how improved irrigation access shapes smallholder farmers' adaptive capacity, income generation, and water resource management. SunCulture's solutions integrate solar water pumping with high-efficiency drip irrigation, offering farmers the potential to enhance productivity while reducing both water and energy costs.

A central question of the study is whether irrigation itself—enabled through renewable energy—can serve as a climate adaptation strategy. We focus not only on yields and income, but also on farmers' water security, intra-household labor dynamics, and their adoption of water conservation practices.

The study uses a panel design, combining baseline data collected in 2024 with a recently

completed follow-up survey. The sample includes 815 farming households across six counties (Makueni, Machakos, Uasin Gishu, Trans Nzoia, Bungoma, and Kakamega), divided into a treatment group (399 households that purchased SunCulture pumps) and a control group (416 matched non-users). The sampling strategy ensures balance on key observable characteristics, such as crop type, farm size, and household composition. Our primary empirical strategy is a difference-in-differences (DiD) approach, allowing us to isolate causal impacts of solar irrigation access on a range of outcomes. In addition to conventional survey modules on income, assets, and agricultural practices, the follow-up round incorporates experimental valuation questions, climate perception items, and a focused module on irrigation practices and water conservation behaviors.

Preliminary baseline results show high comparability between treatment and control groups. Most households rely on self-employment in agriculture, with solar home systems as the dominant energy source. Treatment households report higher likelihood of using irrigation and are more likely to grow high-value crops, such as vegetables and tubers. Early gender-disaggregated data also reveal that women in treatment households earn more than their counterparts in the control group, suggesting a possible empowerment effect from irrigation access.

We expect that access to solar irrigation will improve agricultural productivity and profitability, facilitate crop diversification toward higher-value, water-intensive crops, and enable better adaptation to rainfall variability. Additionally, we anticipate that irrigation access will enhance perceived and actual water security, influence long-term farming decisions, and promote adoption of sustainable water use practices. These outcomes are expected to have important intra-household effects, including changes in time use, labor allocation, and decision-making power.

This study contributes to the growing literature on sustainable energy and climate adaptation in agriculture by providing rigorous evidence on the multidimensional benefits of solar-powered irrigation. Importantly, it also evaluates behavioral shifts in water use and conservation, a critical but underexplored link in the resilience chain.

The findings can inform climate-smart agriculture policy by highlighting the potential of decentralized irrigation to reduce vulnerability, improve productivity, and promote gender-inclusive development. By demonstrating how irrigation access affects not only farming outcomes but also water management and household dynamics, the study offers actionable insights for governments and donors aiming to scale resilient irrigation in water-stressed regions.

Citywide inclusive Sanitation for Eqitable Urban Development in Pakistan
Aziz Ahmad, Integrated Regional Support Program

Citywide Inclusive Sanitation for Equitable Urban Development in Pakistan
Access to safe and sustainable sanitation remains a pressing challenge in Pakistan's rapidly growing cities, where inadequate infrastructure, rapid urbanization, and socioeconomic disparities leave millions—particularly in informal settlements—without proper sanitation services. Citywide Inclusive Sanitation (CWIS) offers a transformative approach by shifting from conventional sewerage systems to a holistic, service-oriented framework that ensures equitable access for all urban residents. This study examines the potential of CWIS in Pakistan, addressing key research questions: (1) What are the major barriers to inclusive sanitation in Pakistani cities? (2) How can CWIS principles be adapted to local governance and infrastructural contexts? (3) What policy and financing mechanisms can support scalable and sustainable CWIS implementation?

The study employs a mixed-methods approach, analyzing sanitation conditions in three major cities—Karachi, Lahore, and Faisalabad—through household surveys, stakeholder interviews, and institutional assessments. Secondary data from government reports and NGO studies were used to evaluate existing sanitation coverage, service delivery models, and public health impacts. A comparative analysis with successful CWIS models in South Asia (e.g., India, Bangladesh) provided further insights.

Key findings reveal that Pakistan's urban sanitation crisis stems from fragmented governance, insufficient financing, and over-reliance on centralized sewer systems that exclude low-income communities. Over 40% of urban households lack safely managed sanitation, relying instead on inadequate septic tanks, open drains, or unsafe manual emptying services. However, pilot CWIS interventions—such as decentralized fecal sludge management in Lahore and community-led toilet complexes in Karachi—demonstrated a 25-35% improvement in sanitation access when supported by local government partnerships and pro-poor subsidies. Public health benefits included reduced diarrheal diseases and groundwater contamination.

The study highlights the need for policy reforms that integrate CWIS into Pakistan's urban development frameworks, emphasizing:
- Strengthened governance: Clear institutional mandates for municipalities and water utilities to adopt inclusive planning.
- Financial innovation: Blended financing (public-private partnerships, microfinance) to support low-cost sanitation solutions.
- Community engagement: Participatory design of sanitation systems to ensure cultural acceptability and long-term sustainability.

These findings contribute to global sanitation discourse by demonstrating how CWIS can be tailored to high-need, resource-constrained settings like Pakistan. For policymakers, the study advocates revising the National Sanitation Policy to prioritize CWIS principles, while

practitioners must build capacity for non-severed sanitation technologies. By aligning CWIS with Pakistan's urban development goals, cities can advance equitable growth, public health, and climate resilience.

In conclusion, CWIS presents a viable pathway for Pakistan to achieve SDG 6.2 and foster inclusive urban development. Future research should explore gender-responsive sanitation designs and the role of digital monitoring in improving service delivery.

INVESTING in women members of WUSCs to empower in decision making role in WASH intervention

Chhabi Lal Goudel, Federation of Drinking Water and Sanitation (FEDWASAN), Nepal

Background and Problem Statement: The Federation of Drinking Water and Sanitation Users Nepal (FEDWASUN) is a prominent organization in Nepal, established in 2004, that serves as an umbrella organization for 45000 drinking water and sanitation user committees (WUSCs) across the country. FEDWASUN has made significant strides with approximately 10,25,000 WUSC members at community level (at least 33% female) out of the population of 2,91,64,578, of which the number of males is 1,42,53,551 (48.98 percent) and the number of females is 1,49,11. 027 (51.02 percent) . However, there are approximately 5000 WUSCs have been affiliated to the FEDWASUN. The women and marginalised peopel's representation in WUSCs is less than 10 percent , There is urgent need to change the behabiour of policy makers, planners and ensure the equal representation as well as decision making role of women and marginalised in WASH intervention in Nepal. The another big challenge is encourage the remaining 40000 WUSCs to affiliate in national system.

Purpose: The main purpose of the research is to discuss the current national WASH status, identify the users pressing needs, barriers of valuable representation with decision making role of women and marginalised (at least 33% as provision in the Act) in WUSCs and provide valuable insights/ignition about to be affiliated (the remaining 40000 WUSCs) in FEDWASAN with the objectives to empower about the policy advocacy for WASH program interventions.

Methods: FEDWASUN recently conducted two different research/events (1) Provincial level interaction- Decision making role of women members of Water User and Sanitation Committees(WUSCs) And (2) Metropolitan level -focus group discussions (FGDs) with WUSCs members . The research/interactions about the decision making role of women members of WUSCs was conducted in Gandaki province . There were 35 representatives of 11 districts . Also the Focus Group Discussion (FGD) with four different groups i.e. WUSC members (12), district level network of People with disabilities(10), sanitation workers and

Lesbian, gay, bisexual, transgender, intersex and queer (LGBTIQ (6) was carried out in Pokhara metropolitan city with the aims to identify the behavior and barriers of policy makers, planners at national and local level about WASH services intervention in Nepal.

Results/Outcomes: Research shows that the legal framework is a major barrier of women and marinalised people representation in WUSCs. The responsibilities have been given, however capacity development, accountability, authority of decision making is neglected. There is political interference, patriarchal thought always dominated, minimal access and control over the assets. The national water quality standards 2070 have not assured. The water safety plan, sanitation safety plan, FSM plan has to be inbuilt with the water and health scheme. The social barriers about behavior change in WASH in a major challenge.

Conclusion: The lesion learnt from these research may change the behaviours of policy makers and planners at national and local level. The women and marginalised members of WUSCs shall be empowered in decision making role, policy advocacy and approximately 40000 WUSCs shall be affiliated in FEDWASAN.

Improving Sanitation Subsidy Targeting: Comparing Methods for Identifying Vulnerable Households in Rural Ethiopia
Crystal Huang, IDinsight

Background
Targeted sanitation subsidies can increase latrine ownership among the poorest households, but accurately identifying these households presents challenges. Implementers often face the choice of using government-run identification systems that are (in theory) low-cost and scalable but may suffer from low accuracy, or using proxy means testing (e.g. Poverty Probability Index (PPI)), which better capture vulnerability but require costly primary data collection. Understanding how targeting methods compare on accuracy and scalability is essential to designing an effective subsidy program.

Methods
We leveraged baseline data from an ongoing randomized controlled trial conducted by IDinsight and iDE assessing poverty-targeted subsidies' impact on latrine uptake in three woredas in the Wolayita Zone, South Ethiopia Region. In October 2024, we surveyed all households residing in 104 villages in the three woredas (n=3,211), collecting sanitation and poverty indicators: Community-Based Health Insurance (CBHI) exemption status (a government-run poverty identification system), the Poverty Probability Index (PPI) survey, and a supplementary poverty measure using two questions from the Food Insecurity Experience Scale. We analyzed the extent of improved latrine ownership, the percent of households identified as poor across methods, and how households identified by CBHI

and PPI compare on socio-economic and sanitation variables. We documented key lessons on the feasibility of using CBHI.

Findings

Only 8% of households owned improved latrines. CBHI identified the most households as poor (32%), followed by PPI (23%, with bottom 2 quintiles classified as "poor"), and food insecurity (17%). Compared to non-poor households, poor households - whether determined by CBHI, PPI, or food insecurity - tend to have larger household sizes, lower land and cattle ownership rates, higher unemployment, and poorer sanitation outcomes. The overlap in households classified as poor by both CBHI and PPI was minimal (10%). CBHI-exempt and PPI-identified households were similar in terms of land ownership, employment status, and sanitation indicators. CBHI-exempt households have smaller sizes, exhibit higher levels of food insecurity, and possess fewer livestock compared to PPI-identified households. The low overlap suggests that CBHI and PPI capture different dimensions of household vulnerability: CBHI exemptions often reflect visible signs of destitution assessed by local committees (such as landlessness, chronic illness, or severe hardship), while the PPI captures broader indicators of material deprivation, such as assets, housing quality, and education.

CBHI lists required significant additional work to become usable. Key challenges included inconsistent records across gotts, handwritten Amharic documentation requiring digitization, and discrepancies between self-reported and official CBHI status—67% of self-reported exempt households weren't on official lists, and only 24.5% possessed CBHI cards. Community verification helped identify 64 erroneously included households. Mitigation strategies included adding verification questions to surveys, cross-checking with health centers, and conducting kebele-level outreach, which improved list reliability.

Discussion

In the Ethiopia context, the government-run poverty identification system CBHI is suitable for targeting poor households. Implementers should consider including simple food security questions to balance the cost of additional data collection and minimize errors of exclusion. When subsidy resources are limited, programs should prioritize larger, food-insecure households within CBHI-exempt populations. For effective implementation, involve local leaders in validating exemption lists, advocate for regular CBHI updates, and implement verification steps where data may be outdated.

Measuring Water Quality from an Innovative Rainwater Harvesting System in Santiago, Dominican Republic
Christine Stauber, Georgia State University

Background: The province of Santiago in the Dominican Republic faces a growing deficit in the supply of drinking water. This is exacerbated by poor quality and high costs associated with alternative sources such as tanker trucks and bottled water. Rainwater harvesting systems have been recognized globally for their potential to provide a reliable and sustainable source of drinking water. This research examines water quality parameters from samples collected during the pilot testing of a sustainable drinking water production system that leverages rainwater harvesting. In this pilot system, rain falls on a layer of gravel with a filter installed under the layer of gravel. This avoids contact with primary sources of pollution such as roofs or other catchment surfaces. In a field study in Santiago, we examined four filter designs to examine the filter composition association on water quality. The composition of the filters included proportions of 76%, 66%, 62% and 34% sand, the rest corresponding to silt and clay.

Methods: Four filters for each composition were installed in the Botanical Garden of Santiago in four different parcels for 16 parcels total with 4 replicates for each condition. From May 2024 to March 2025, we performed bi-weekly testing for heterotrophic bacteria, total and fecal coliforms, E. coli, Enterobacteriaceae, pH, biological oxygen demand (BOD), total dissolved solids (TDS), turbidity, electrical conductivity, nitrates, and sulfates. Analytical methods were in accordance with international standards (ISO) and Standard Methods. Descriptive statistics were performed to understand the distribution of parameters, including mean, standard deviation, and median. Parametric and non-parametric statistical tests were applied to compare the filter type and identify which filter composition produced the highest quality water.

Findings: A total of 1,724 physicochemical and 1,350 microbiological tests were carried out during the 10-month period. The average results for physicochemical parameters were as follows: pH was 7.8, turbidity was 0.41 NTU, TDS of 325.8 mg/L, electrical conductivity of 500 μS/cm, BOD5 of 3.52 mg/L, nitrates of 6.24 mg/L and sulfates of 64.7 mg/L. For the microbiological parameters, geometric mean heterotrophic bacteria were 2,000 CFU/mL and total coliforms of 1.7 CFU/100mL. Between 10% and 21% of the samples contained fecal coliforms, E. coli and Enterobacteriaceae in detectable concentrations. No statistically significant difference was found between the filters in terms of pH and BOD5. However, there were significant differences between the other physicochemical and microbiological parameters. The filter with 76% sand produced the best water quality in terms of the parameters analyzed.

Conclusion: These findings indicate that filters with a higher percentage of sand produce higher quality water and should be considered in the design along with cost and water production. Additional treatment such as chlorination would reduce bacteria and help maintain a chlorine residual to protect the water during storage.

Assessing health and dignity challenges, and evaluating the financial scheme's impact on sanitation workers' healthcare in Bangladesh
Md Tahmidul Islam, WaterAid Bangladesh

Introduction
Bangladesh is one of the fastest-urbanizing countries in South Asia, with 38% of its population now living in urban areas, a figure that continues to rise. In this rapidly urbanizing context, sanitation workers play a crucial role in maintaining cleanliness and protecting public health by performing essential tasks such as emptying septic tanks and unclogging sewer lines. Despite their vital contributions, an estimated 5 to 6 million sanitation workers remain among the most marginalized and discriminated groups in society. They often work without proper equipment, protective gear, or legal safeguards, undermining their dignity and basic rights. This study explores the challenges related to healthcare access, financial support, workplace hazards faced by sanitation workers and assesses the impact of the Shasthya Nirapotta Scheme (SNS); a financial safety net aimed at improving healthcare access.

Methods
A mixed-methods study was conducted in four city corporations and five municipalities of Bangladesh, including six focus group discussions, nine in-depth interviews, and 400 phone interviews. Additionally, eleven national policies, acts, and rules were reviewed to assess the legal framework for sanitation workers' rights.

Results
The legal and policy frameworks in Bangladesh inadequately protect sanitation workers due to a lack of specific recognition and targeted safeguards. While the Constitution, Labour Act (2006), and Labour Rules (2015) provide general labour protections, they do not address the unique occupational hazards sanitation workers face. Similarly, the Local Government Acts (2009) and national occupational health policies lack enforceable, sector-specific provisions. Qualitative findings revealed that sanitation workers are frequently exposed to hazardous environments without proper protective equipment, leading to injuries, infections, and chronic illnesses. This situation is further exacerbated by limited access to healthcare services and insufficient financial support for treatment. Workers often bear the financial burden of treatment themselves, with little or no assistance from employers. Compensation for accidents is minimal or in some cases non-existent. The absence of medical benefits, sick leave, and formal job contracts further increases their health risks. In response, WaterAid Bangladesh introduced the SNS in August 2022. For an annual fee of £1.46, the scheme provides over 10,000 sanitation workers and their families with life insurance and discounted healthcare services through a network of 250 partner facilities. This study identified that out of 10,000 premium holders, 73 death claims were submitted, totaling £14,600 (£200 per claim), with 43 claims settled

amounting to £8,600. Additionally, a sample survey of 400 sanitation workers revealed that 54.5% (n=218) were exposed to various diseases, among them 56.88% (n=124) visited hospitals for treatment after receiving the SNS card, with a median of 2 hospital visits. Among the respondent who visited hospital, 33.2% (n=41) used the SNS card for treatment. The median treatment spending was £2,000, with a median discount of £450. Furthermore, 88.2% (n=353) expressed satisfaction with the SNS card service.

Conclusion

These findings highlight a systemic failure in Bangladesh's legal and institutional frameworks to protect sanitation workers, leading to unsafe working conditions and limited healthcare access. Financial safety net programs like SNS present a promising model for addressing these gaps. Local government ordinances must enforce mandatory employer participation in financial safety net schemes to ensure sustainable mutual responsibility. Scaling up such initiatives nationwide and integrating them into formal labour policies could substantially improve the health, security, and dignity of sanitation workers.

Animal waste management with household biodigesters and exposures to antibiotic resistance and zoonotic pathogens in Nepal
Heather Amato, University of Maryland

In Nepal, nearly 500,000 biodigesters convert human and animal waste into fertilizer and provide renewable cooking fuel to rural households. Biodigesters require high contact with animal feces, especially if mechanical components of the digester break over time. However, the potential role of biodigesters in spreading pathogens and antibiotic resistance (AMR) is not well understood. We aimed to examine associations between animal ownership, waste management practices (including biodigester use), and household contamination with antibiotic-resistant Escherichia coli.

We conducted an observational study in 277 households across 28 toles in Kavre, Nepal. Surveys captured animal ownership and waste management practices. We collected household soil, caregiver and child hand rinses, and biodigester effluent. Third-generation cephalosporin-resistant (3GCR) E. coli were enumerated using IDEXX QuantiTrays with cefotaxime, and 3GCR-positive samples were cultured to detect extended-spectrum beta-lactamase (ESBL)-producing E. coli. We estimated adjusted prevalence ratios (PR) using modified Poisson regression for binary outcomes and mean differences using linear regressions for continuous outcomes (log_{10}MPN per dry gram or per two hands, or proportion of MPN E. coli that were 3GCR), with cluster-robust standard errors.

Most households owned cows (62%), goats (61%), buffalo (32%), or chickens (33%). Among the 51% of households with a biodigester, half (52%) reported adding animal

waste—exclusively cow/buffalo waste—in the past week. Broken components were reported in 63% of biodigesters, including 39% with a broken inlet agitator. Ten percent mixed slurry by hand; 42% used tools. Most households (75%) handled effluent with bare hands, and 61% applied it to household crops.3GCR E. coli was detected in 3% of child hands, 6% of caregiver hands, and 16% of soil samples. ESBL E. coli was found in 20% of soil samples. Biodigester effluent had a higher prevalence: 71% with 3GCR and 35% with ESBL E. coli. Chicken ownership was strongly associated with 3GCR (aOR: 2.59; 95% CI: 1.31–5.21) and ESBL E. coli in soil (aOR: 4.36; 2.33–8.35). Households that added animal waste to biodigesters in the past week (aOR: 0.35; 0.14–0.87) or applied effluent to crops (aOR: 0.36; 0.14–0.93) had lower odds of soil contamination with 3GCR E. coli. Biodigesters with broken components had a 15 percentage point higher proportion of 3GCR E. coli in effluent (95% CI: –0.10, 29.60). Handling slurry and effluent with bare hands were associated with greater levels of 3GCR E. coli on child hands, but not on caregiver hands.

Rural households with free-roaming animals had more resistant E. coli in soil, likely due to poultry-specific waste management practices. Using biodigesters for managing cow/buffalo waste and applying effluent to crop fields may reduce household soil contamination. When properly maintained and safely operated, biodigesters have the potential to serve as holistic WASH interventions—improving sanitation, reducing environmental contamination, and converting waste into usable fertilizer and renewable fuel. However, biodigester effluent is highly contaminated, and handling without protection may increase exposure risks. Microbial risks associated with biodigester inputs and outputs should be further investigated. To characterize AMR and pathogen burdens in effluent, we are using custom qPCR panels (TaqMan Array Cards) targeting 48 pathogens and resistance genes. Results will be completed by August 2025.

Animal Exposure is Associated with Diarrhea and Growth in Democratic Republic of the Congo (PICHA7)
Jean-Claude Bisimwa Rusanga, Université Catholique de Bukavu - Johns Hopkins University

Background: This objective of this study was to investigate individual- and household-level risk factors associated with diarrheal disease and growth among young children in informal settlements in eastern Democratic Republic of the Congo (DRC).

Methods: A prospective cohort study of the Preventative Intervention for Cholera for 7 Days (PICHA7) program was conducted in urban Bukavu, South Kivu, DRC from 2021-2023. During the 12-month follow-up period, diarrhea surveillance was carried out monthly, with the height and weight of children assessed at baseline and 12-months. Spot checks of the

household compound were performed at baseline and monthly to assess WASH risk factors including the presence of animals and feces on the household compound and the household sanitation options. We also collected caregiver reports on child mouthing behaviors. Logistic regression was used to assess associations between individual and household risk factors and diarrhea at the next surveillance visit for children under 5. The association between baseline risk factors and growth outcomes (stunting, underweight, and wasting) at the 12-month follow-up was also assessed.

Results: Seven hundred and ninety-four children under 5 years of age were in this study. Household animal ownership was associated with an increased odds of stunting [OR: 2.74; 95% Confidence Interval (CI): 1.17, 6.43]. The presence of animals in the child's sleeping space [OR: 1.77; 95% Confidence Interval (CI): 1.05, 2.97], consuming food outside the home [OR: 1.88; 95% CI: 1.16, 3.05], and unimproved sanitation [OR: 2.27; 95% CI: 1.19, 4.33] were associated with significantly higher diarrhea at the subsequent household visit. Conclusion: These results demonstrate the need for WASH interventions aimed at reducing pediatric exposures to animal and their feces in the household environment, and promoting food hygiene behaviors to improve the diarrhea and child growth in eastern DRC.

It's coming from inside the house: Does PFAS leach from drinking water infrastructure?
Kathleen Hohweiler, Virginia Tech

Per- and polyfluoroalkyl substances (PFAS) are of increasing concern to environmental and public health entities as the compounds are known to cause a variety of negative health outcomes, including cancers, at very low concentrations. Diet is considered a primary mode of human exposure, and an increasing body of research suggests both that PFAS detection in private and public drinking water supplies are common, and that the origins of this contamination, and therefore, the potential for control, is complex. Newly established US Environmental Protection Agency (USEPA) drinking water Maximum Contaminant Level Goals (MCLG) for both PFOA and PFOS are zero, indicating no safe level of exposure, although the MCLs for both are set at 4 ppt. The ANSI/NSF Standard 61 for Drinking Water System Components – Health Effects reduced the leachability certification limit for seven PFAS compounds to align with new USEPA regulations. However, data on the leachability of PFAS from specific products tested via NSF/ANSI are not available to the public. Furthermore, NSF/ANSI's compliance enforcement for the USEPA based MCLs does not begin until January 2028, indicating that materials used to build drinking water infrastructures in both public and private systems up to 2028 may still leach PFAS compounds in concentrations greater than health-based limits. An understanding of all

potential PFAS source contributions to drinking water is essential to design effective public health interventions and reduce adverse exposures.

The goal of this study is to quantify PFAS leaching from polytetrafluoroethylene (PTFE or Teflon) pastes used in premise plumbing under realistic private water quality conditions. This experiment relies on a modified protocol based on ANSI/NSF Standard 61 for Drinking Water System Components- Health Effects Section 6 for joining and sealing materials which examines leaching from all products that come into contact with water intended for human consumption. While full results from this 19-day leaching experiment are currently pending (available by early summer), an initial proof of concept study has confirmed that leaching from copper pipes joined with commerciality available PTFE paste does result in quantifiable concentrations of PFAS, specifically of PFOS. Results showed that the highest concentrations of PFOS leached from the joining paste was under the least aggressive water chemistry (500 mg/L alkalinity as $CaCO_3$ and pH 8.0). Other samples in the copper + PFTE paste group treated with increasingly more aggressive pH and alkalinities all exceeded the MCLG (0 ppt) for PFOS and PFOA. Although this initial proof of concept experiment only represents one time point under static conditions, it is important to note that exposure to PFOA and PFOS, even in very small concentrations, is considered by the USEPA to be harmful to human health. Considering the increasing frequency of PFAS detection in groundwater across the United States, this work indicates that in some cases PFAS leaching may be occurring in conjunction with groundwater containing PFAS to yield drinking water that contains total concentrations of PFAS exceeding health advisories limits for consumers.

Breaking Barriers: How Market-Based Sanitation is Transforming WASH Access in Northern Mozambique's Forgotten Towns
Elise Mann, iDE Mozambique

Introduction
In Mozambique's conflict-affected northern provinces, where just 37% of households access basic sanitation, the Aguanorte Program is testing whether market-based sanitation (MBS) can deliver equitable, sustainable WASH outcomes in fragile contexts. Led by UNICEF and funded by the European Union (2023–2026), this $22 million initiative addresses the interconnected WASH needs of households, schools, and healthcare facilities across some of the country's poorest districts.

Program Design and Innovation
Aguanorte's integrated approach combines WASH infrastructure investment with systems strengthening and private sector engagement. Its theory of change rests on the assumption that by enhancing institutional capacity, expanding access to infrastructure, and catalyzing

market-based solutions, the program can achieve long-term improvements in health, hygiene, and service sustainability.

The program features three core pillars:

- Private Sector Development: Supporting over 3,000 sanitation entrepreneurs—many of them women—through training, mentorship, and market linkages.
- Government System Strengthening: Embedding regulatory frameworks (CORALs), operational tools, and budget alignment within municipal governance.
- Equity-Driven Financing: Deploying targeted subsidies and inclusive financing to ensure access for internally displaced persons (IDPs), women, and low-income households.

Evaluation and Learning Framework

A rigorous quasi-experimental impact evaluation tracks changes over time across three treatment towns and a matched control town. Using a difference-in-differences (DiD) methodology, 1,600 households are surveyed at baseline and endline, complemented by structured observations, JMP-aligned assessments of schools and health facilities, focus groups, and key informant interviews.

Routine real-time monitoring captures WASH system performance, entrepreneurial activity, and behavior change. Data is disaggregated by gender, displacement status, and socioeconomic level to ensure vulnerable populations are represented. Embedded feedback loops—including annual reflection workshops and a structured learning matrix—support adaptive management and course correction throughout implementation.

Global Insights and Implications

Aguanorte offers four key lessons for the global WASH sector:

- Market systems require time and support: Supply chains and consumer demand take years—not months—to mature.
- Governance must be foundational: Sustainable market-based sanitation hinges on strong, locally owned regulatory systems.
- Equity does not emerge organically: Pro-poor design elements, such as subsidies and gender-responsive programming, are essential to avoid reinforcing exclusion.
- Monitoring must evolve: Traditional indicators (e.g., toilet coverage) must be expanded to track business viability, institutional performance, and consumer investment behaviour.

Conclusion

Aguanorte demonstrates that with thoughtful adaptation, MBS can work even in fragile, conflict-affected settings—provided it is embedded within strong government systems, supported by inclusive market strategies, and grounded in responsive, evidence-driven

implementation. Its model now informs Mozambique's $15 million ASWA III scale-up and offers valuable insights for WASH practitioners working in complex environments globally.

Situational analysis on urban water production through the Sustainable Cities Project in Northern Ghana
Daniel Sarpong, Accra Technical University

This situational analysis examined urban water production in six cities across Northern Ghana as part of the Sustainable Cities Project. The project aimed to improve urban resilience, equitable access to services, and sustainable development in rapidly expanding urban areas. Urbanization in Northern Ghana, particularly in cities such as Tamale, Yendi, Damongo, and others, have accelerated over the last two decades. This has presented some significant challenges to water production, distribution, and management. The purpose of the study was to identify key issues affecting water production, including outdated infrastructure, inconsistent supply, seasonal variability, and the growing gap between urban demand and available water resources.

The study highlighted the water production systems in these cities, which were initially designed to serve much smaller populations and are currently under considerable strain due to rapid population growth and urban expansion. It was observed that some cities have benefitted from improvements in water infrastructure. Many areas, especially those in peri-urban and informal settlements, continue to suffer from irregular water supply, high reliance on alternative sources and unsafe water sources and inadequate infrastructure to meet the growing population and demands.

The key challenges identified in the situational analysis included poor coordination between local authorities, the Ghana Water Company Limited (GWCL), community stakeholders, which hampers effective planning, investment as well as maintenance of water production systems. Furthermore, the study revealed a significant impact of seasonal changes on water availability, especially during the dry season, when water sources such as rivers and groundwater wells face substantial depletion. This has exacerbated by environmental degradation, including upstream pollution, land use changes, and poor management of catchment areas.

The report also emphasized the need for comprehensive, long-term planning to address both immediate water supply issues and sustainable urban water management in these cities. It suggested that key solutions involved enhancing the technical capacity of local authorities, improving infrastructure resilience, ensuring inclusive water service delivery. In conclusion, this situational analysis provided a basis for the development of strategic interventions through the Sustainable Cities Project Phase 1, to improve urban water production systems, enhance water access for underserved populations, and to ensure that cities in Northern Ghana are better equipped to meet future water demands. By

aligning with global frameworks such as the United Nations Sustainable Development Goals (SDGs), particularly SDG 6 on clean water and sanitation, the project aimed to foster inclusive, equitable, and sustainable urban development in the region.

Circular Economy for Sustainable Fecal Sludge Management in Rural India
Samrat Gupta, Water For People

Faecal Sludge Management (FSM) in rural India faces systemic challenges including high treatment costs, operational inefficiencies, weak regulation, and limited market demand for sludge-based products. Addressing these critical gaps, Water For People India is piloting an innovative circular economy-based FSM model that prioritizes resource recovery, economic value creation, and environmental sustainability. The approach is being implemented through a Faecal Sludge Treatment Plant (FSTP) in Mahdeiya, Bihar, operated by a private entrepreneur under a decentralized, locally managed system.
A central feature of this model is the integration of informal sanitation workers into the formal FSM value chain. Ten pit emptiers were identified and trained to safely and efficiently collect and transport faecal sludge. Furthermore, over 150 community members have been sensitized on WASH practices, FSM processes, and the agricultural value of the FSTP's by-products, thereby fostering community ownership and demand for reuse-based solutions.

The treatment process involves a combination of biological and mechanical stages—Screen Chamber, Sludge Storage Tank, Anaerobic Digester, and two Tiger Bio Filters. These filters utilize earthworms and bacteria to process sludge into two agricultural inputs: Sona Khaad (produced vermicompost) and Sona Taral (liquid soil enhancer). The outputs are nutrient-rich and tailored for rural agricultural application.

Initial results from the Mahdeiya and Muzaffarpur plants highlight both technical and financial viability. Over 500 kg of vermicompost and 170 litres of liquid fertilizer have been produced and marketed, generating ₹7,700 in revenue. If operated at full 2 KLD capacity, the plants could yield approximately 69 tons of compost and 1,44,000 litres of liquid fertilizer annually demonstrating strong potential to offset operational costs and reduce reliance on external funding.

Laboratory tests further validate the effectiveness of the treatment. Biochemical Oxygen Demand (BOD) reduced from 314 mg/L to 55.62 mg/L, and Chemical Oxygen Demand (COD) from 333.2 mg/L to 274.4 mg/L. While Total Suspended Solids (TSS) declined from 170 mg/L to 110 mg/L, further optimization is underway to meet Central Pollution Control Board (CPCB) norms. Additionally, vermicompost analysis confirms compliance with IS

16556:2016, with optimal pH (7.15), high nitrogen (6.25%) and phosphorus (1.72%), low conductivity, and agreeable odour, validating its agricultural safety and value.

A noteworthy innovation is the reverse tipping fee mechanism, which incentivizes pit emptiers to deliver sludge to the FSTP instead of disposing it informally. This not only ensures steady sludge supply but also dignifies the role of sanitation workers. To overcome cultural taboos and stimulate market demand, the project incorporates branding, community outreach, and farmer partnerships.

This initiative investigates the scalability of decentralized FSM models by evaluating treatment efficiency, financial viability, incentive effectiveness, and farmer adoption. It also explores policy integration through public-private partnerships and alignment with broader sanitation and agricultural frameworks.

By applying circular economy principles, formalizing sanitation work, and building community-driven market linkages, this model offers a climate-resilient, replicable solution that supports India's SDG 6 commitments—ensuring access to safe sanitation, water management, and resource recovery for all.

Impacts of a Novel Water Quality Assurance Fund Intervention in Rural Ghana: A Stepped-wedge Randomized Controlled Trial
Valerie Bauza, The Aquaya Institute

Background: Over two-thirds of the population in rural Africa is estimated to consume contaminated drinking water, which remains a leading cause of death for children. Regular water quality monitoring by water suppliers is essential for maintaining adequate treatment processes and safe water quality to protect public health. Yet, many small water suppliers are unable to conduct regular water quality tests due to financial, logistical, and capacity constraints. The objective of this study is to evaluate the effects of a novel financial and capacity strengthening water quality intervention (the 'Water Quality Assurance Fund' program). The program incentivizes established laboratories to extend their services to smaller water systems and, in parallel, provides capacity strengthening, technical guidance, and community sensitization activities to promote the use of water quality data for better water safety management.

Methods: We conducted a stepped-wedge randomized controlled trial to evaluate the effects of the Assurance Fund program over 24-months across 21 small piped water systems in Ghana. Water systems were randomly assigned to one of three groups which successively entered the Assurance Fund program at six-month intervals that coincided with their transition from control to an intervention group. We conducted household

surveys, focus group discussions, and interviewed local government officials and community leaders every 12 months (at baseline, midline, and endline). We also measured water quality at public taps and interviewed water operators every six months throughout the trial. Our outcome indicators include: free chlorine residual in water at the point of collection (the primary outcome), E. coli concentrations at the point of collection and in stored household water, free chlorine residual in stored household water, water system treatment practices, water quality knowledge among water system operators, and consumer satisfaction. In total, we conducted 1,260 household surveys and measured water quality in 399 public tap samples.

Results: At baseline, only 5% of public tap samples had detectable free chlorine (≥0.1 mg/L), and few water systems reported practicing regular chlorination. Almost half (44%) of tap samples were contaminated with E.coli and almost all (95%) with total coliforms. The Water Quality Assurance Fund intervention significantly improved water quality over time, with detectable chlorine measured in 56% of tap samples after 12-months and 79% of taps after 24-months of enrollment in the program. E.coli and total coliforms followed similar trends of improvement. Additionally, all water systems reported regular chlorination by the end of the program, and we measured improvements in water operator knowledge and water quality at the point of use. This presentation will give a detailed overview of the quantitative and qualitative impacts measured during our trial, presenting results from inferential analysis of our primary outcomes using Generalized Estimating Equations (GEEs) and qualitative analysis from interviews and focus group discussions.

Conclusions: This study is the first rigorous evaluation of the Water Quality Assurance Fund program, which improved water treatment, water quality, and operator knowledge for small water systems. The results provide policy-relevant evidence to inform local governments, practitioners, researchers, and donors looking for effective ways to improve water quality and monitoring.

Tracking sexually transmitted infections in the Detroit area by molecular analysis of environmental sample
Liang Zhao, Michigan State University

Background: Knowledge of wastewater surveillance methods and applications for estimating bacterial infections is limited. This study first describes one of the earliest investigations applying wastewater surveillance to monitor Chlamydia and Syphilis, and back-estimate infections in the community, based on bacterial shedding and wastewater surveillance data. In addition, wastewater surveillance covering communities with varying levels of social vulnerability and critical at-risk populations is needed. Therefore, a subsequent investigation describes one of the first studies demonstrating relationships

between the CDC Social Vulnerability Index (SVI) and both viral (SARS-CoV-2, Norovirus) and bacterial (Treponema pallidum) concentrations in wastewater for small and large sewersheds in the tri-county Detroit area (TCDA), Michigan.

Methods: Molecular biology laboratory methods were optimized, and a bacterial wastewater surveillance workflow was designed and implemented to track Chlamydia and Syphilis in TCDA. Untreated wastewater samples were collected weekly from the three main interceptors of Great Lakes Water Authority's Water Resource Recovery Facility that service TCDA. Additionally, untreated wastewater was collected from street manholes covering three neighborhood sewersheds in Wayne, Macomb, and Oakland counties, with varying socioeconomic characteristics and SVI. Centrifugation, DNA extraction, and ddPCR methods were optimized and performed, targeting Chlamydia trachomatis and Treponema pallidum. The limit of blank and limit of detection were determined experimentally. PEG, RNA extraction and ddPCR methods were implemented to test SARS-CoV-2 N1, N2, and SC2, norovirus GI and GII, and PMMoV in wastewater.

Results: First, C. trachomatis and T. pallidum concentrations observed in neighborhood sewersheds were higher compared to those observed in the interceptors. Second, incidences of Chlamydia and Syphilis were back-estimated through an optimized formula based on shedding dynamics and wastewater surveillance data. Third, Pepper mild mottle virus (PMMoV)-normalized SARS-CoV-2 and T. pallidum exhibited similar spatial patterns and trends with average SVI of the corresponding sewersheds. In contrast, PMMoV-normalized norovirus did not present similar patterns and trends with average SVI.

Conclusions and Importance: This study fills multiple important knowledge gaps in the field of wastewater surveillance. First, this study demonstrates one of the first wastewater surveillance applications in monitoring widespread STIs, particularly Chlamydia and Syphilis, in large urban and small neighborhood sewersheds. This study established a bacterial wastewater surveillance workflow to detect C. trachomatis and T. pallidum in wastewater. Second, C. trachomatis and T. pallidum concentrations in wastewater demonstrate disparities in corresponding contributing populations with varying socioeconomic demographics. Third, Chlamydia and Syphilis infections were back-estimated using a modified formula based on shedding dynamics of both bacteria in environmental and clinical samples, indicating potentially under-reported cases of both diseases in TCDA. Fourth, this study presents one of the first investigations on SVI relationships with wastewater concentrations of both bacterial (T. pallidum) and viral (SARS-CoV-2, norovirus). Finally, this study integrates vulnerable communities with greater SVI into wastewater surveillance for disease monitoring, contributing an example to address a critical future research direction outlined by the CDC NWSS Phase 2 report, emphasizing on incorporating wastewater surveillance sites with greater social vulnerabilities to advance health equity by prioritizing the needs of at-risk populations in disease monitoring.

Beyond Water User Committees: The Overlooked Role of Landowners in Spring Management in Western Kenya
Allison Gregory, The Water Project

Introduction:
Springs are a common community-level water source in Western Kenya. The Water Project (TWP) has worked with partner organizations to protect over 700 springs in Western Kenya since 2009. With each spring project, we work with communities to set up water user committees (WUCs), groups of community volunteers who are responsible for spring management. These protected springs are almost always situated on privately owned land despite being protected for public use. The Kenya Water Act of 2016 obligates landowners to manage natural resources like springs in a way that serves the public interest, making landowners important but often-overlooked stakeholders in water point management. We used a mixed methods approach to 1. examine the role that both WUCs and landowners play in promoting sustainable access to protected springs in Western Kenya and 2. identify barriers to participation and leadership in spring management.

Methods:
We identified 10 protected springs in Western Kenya that met our sampling criteria and visited each community to conduct focus group discussions (FGDs), in-depth interviews (IDIs), and short surveys involving the water users, WUCs, and landowners. Additional FGDs were conducted with field officers responsible for monitoring and maintaining the springs, providing further insight. We collected data from October 2023 to April 2024 and analyzed it using theoretical coding (memoing and code lists). The final codebook included 45 main codes and 188 sub-codes.

Results:
Key management barriers include lack of: 1. resources (funds and training), 2. WUCs' authority to enforce rules, 3. communication among stakeholders (landowner, WUC, water users, and implementing partners), 4. clarity on roles and responsibilities of stakeholders, and 5. landowner engagement and cooperation. While we expected management barriers to center around the WUCs, landowners played a part in almost all identified barriers. Most notably, we found that landowners were uncooperative or unengaged when they felt excluded from decision-making or due to conflict with water users. Uncooperative landowners can impede important management activities such as spring maintenance, repairs, and efforts to maintain access routes. Half the communities studied reported a conflictual relationship between the landowner and water users.

Conclusion:

Our study highlights the critical role that landowners play in managing protected springs and how their participation can support or hinder water access. While WUCs are the designated managing body, landowners often hold more practical authority, making them essential partners in spring management. Despite this, our efforts to support water point managers often focus on the WUCs and overlook the role of landowners. Changes in land ownership add additional complexity, as management systems must be designed to support changes in this role during the potentially decades-long lifespan of a protected spring. Landowners must be considered more comprehensively during project implementation and beyond, both in management training and by formalizing access agreements that persist beyond changes in ownership. Doing so could lead to more sustainable access to springs in the long term.

Health Risks Assessment on the Binational Pacific Ocean Coastline
Alhelí Calderón-Villarreal, California State University San Marcos

The shared coastline of the Pacific Ocean along the United States (US) and Mexico border faces escalating contamination challenges. Notably, the binational Tijuana River, subject to an international agreement, carries extremely high levels of pollutants that significantly impact nearby communities in Tijuana and Imperial Beach. Persistent contamination of coastal waters, stemming from Tijuana River discharges, wastewater outflows, storm runoff, and human activity in the San Diego and southern Tijuana regions, necessitates a thorough examination of its public health consequences. This research explored the association of these environmental factors on the health of individuals living near and interacting with the binational Pacific coastline in San Diego County, California, US, and the municipalities of Tijuana and Rosarito in Baja California, Mexico.

To achieve this, a cross-sectional survey was conducted between 2024 and 2025 with N=230 residents, workers, and visitors of this coastline in San Diego, Tijuana, and Rosarito. The survey explored their coastal interactions, reported health conditions, and community risk perception. The average age of participants was 37 years (±15.7), and 63% were women. The geographical distribution of participants was 43% in San Diego County, 40% in the Municipality of Tijuana, and 12% in Playas de Rosarito. Nationalities were almost evenly split, with 50% US nationals and 58% Mexicans. Daytime hours (41%) were the most common time for coastal visits, and the primary activities included walking/hiking (81%), sitting in public spaces (46%), and sunbathing (40%). Participants frequently observed urban garbage (70%) and wastewater discharges (46%) in the coastal environment. A significant proportion had direct contact with ocean water in the preceding month, with feet (35%), legs (22%), and the whole body (21%) being the most common points of contact. Notably, the study revealed a high frequency of respiratory diseases (52%), gastrointestinal diseases (23%), eye allergies/infections (21%), and skin conditions (11%)

reported in the last month, while asthma (9%) was the most frequent family diagnosis in the past year. Higher frequency of visits to the coastline, more frequent visitation to a specific beach, engagement in aquatic activities, and a greater number of outdoor activities in the area were associated with increased reports of negative health outcomes. Alarmingly, nearly half of the participants (45%) rated the environmental quality of their frequented beach or coastal area as poor or very poor, over half (55%) assessed the overall ocean water quality similarly, and 39% considered the overall air quality in the area as unhealthy for sensitive groups or the general population, very unhealthy, or hazardous.

This study represents the first binational investigation into the health risks associated with the US-Mexico border coastline. Our findings highlight that communities living, working, or visiting this shared Pacific Ocean coastline face similar vulnerabilities and express concerns regarding the public health implications of water and air pollution. The frequent reporting of respiratory and skin illnesses suggesting a potential link to water and air pollution, warranting further investigation. The impact of waterborne pollutants extends beyond aquatic ecosystems, potentially affecting respiratory health in coastal communities through aerosolization and the dispersion of harmful particulate matter. The insights from this research will be shared in collaboration with community-based organizations to facilitate the development of targeted prevention strategies across this binational region.

Effects of school menstrual hygiene management, water, sanitation, and hygiene interventions on girls' empowerment, health, and educational outcomes: Lasta District, Amhara Regional State, Ethiopia
Fisseha Andargie, Individual Consultant

This study assessed the effects of school-based menstrual hygiene management (MHM) and water, sanitation, and hygiene (WASH) interventions on the empowerment, health, and educational outcomes of menstruating girls using cross-sectional and experimental designs. It examined whether access to MHM education and WASH facilities could enhance girls' self-confidence, physical, emotional, and social health, class attendance, and academic performance. The results showed significant improvements in empowerment at intervention schools, with 54% of girls feeling confident purchasing sanitary products, compared to 18% in control schools, indicating better emotional well-being. Additionally, 21% and 22% of girls in intervention schools felt comfortable discussing MHM with boys and mothers, respectively, compared to just 9% in control schools, reflecting improved social health. Regarding physical health, 51% of menstruating girls in intervention schools practiced genital hygiene three to four times a day, compared to 33% in control schools. Educational outcomes were also improved, with 68% of girls in intervention schools attending class during menstruation, compared to 30% in control

schools, and 78% reporting adequate study time at home, compared to 41% in control schools. However, no significant difference in academic performance was found between the two groups. Overall, the findings suggest that school-based MHM and WASH interventions can significantly empower menstruating girls, improve their physical, emotional, and social health, and reduce menstrual-related absenteeism.

Identifying Sources and Environmental Drivers of Fecal Contamination in an Urban Creek Using Digital PCR and Explainable AI
Jianyong Wu, The Ohio State University

Despite extensive investments in wastewater treatment, stormwater control, and watershed restoration, the Rock Creek River (RCR) in Washington, DC continues to experience chronic fecal contamination, posing ongoing public health concerns and prompting restrictions on recreational water contact. This study applied machine learning coupled Microbial Source Tracking (MST) to identify the origins and unveil drivers of fecal contamination in RCR and its tributaries. Through integrating advanced molecular techniques and explainable artificial intelligence (AI), The study aimed to inform targeted interventions for water quality improvement and public health protection.
Over a 12-month monitoring period, six storm events and 26 bi-weekly baseflow events were sampled at three sites along the RCR mainstem and its tributaries. The concentration of viable E. coli, a common indicator for fecal contamination, was measured using the Colilert method, and four host-associated source tracking markers, HF183 (human), Rum2Bac (ruminant), GFD (avian), and DG3 (dog), were quantified using digital Polymerase Chain Reaction (dPCR) technology. In addition, in-stream physicochemical parameters, including conductivity, dissolved oxygen, pH, streamflow, temperature, and turbidity, along with land cover and climate data, were collected. The data were analyzed using a Random Forest model integrated with the SHapley Additive exPlanations (SHAP) algorithm, an explainable AI method, to identify source attribution and spatiotemporal patterns of microbial contamination in the water.

The results revealed consistently elevated E. coli levels during storm events at all sites. In contrast, during baseflow conditions, E. coli concentrations fell below the single sample value threshold of 410 MPN/100 mL for approximately 50% of the study period. The human-associated marker HF183 was the most frequently detected fecal indicator, present in 88% of all samples, with particularly high prevalence in one key tributary. This suggests the presence of a persistent human source in the watershed. However, the elevated detection of HF183 may also reflect background levels of DNA from viable, non-viable, and extracellular sources, as molecular methods do not distinguish between these forms. Other markers, including GFD, Rum2Bac, and DG3, were present at low to moderate levels and were more sporadically distributed. Correlation and regression analyses identified

turbidity and streamflow as significant predictors of both E. coli levels and molecular markers presence.

The SHAP global explanation revealed that dog sources significantly contributed to fecal contamination in the water, while weather patterns were the most influential environmental drivers. Other important factors included minimum vapor pressure deficit (VPD), conductivity, turbidity, and water flow. SHAP local explanations further illustrated the contributions of these five factors to microbial contamination at the individual sample level. For instance, stream flow emerged as a major contributor on February 16, May 5, July 2, September 1, and October 29 in 2021, as well as January 20, 2022, across three sampling sites.

This study demonstrates the value of combining molecular diagnostics, machine learning, and explainable AI to uncover complex drivers of fecal contamination in urban watersheds and to inform targeted management strategies.

Wednesday Verbal Abstracts

Formative Research for Adapting the CHoBI7 mHealth Program for Scalable Delivery in Rural Bangladesh
Fatema Zohura, Research, Training and Management (RTM) International

Introductions: Water, sanitation, and hygiene (WASH) programs promoting water treatment and handwashing with soap can significantly reduce diarrheal disease incidence. The Cholera-Hospital-based-Intervention-for-7-Days (CHoBI7) mobile health (mHealth) program is a targeted water treatment and handwashing with soap hygiene program for household members of diarrhea patients. The program is healthcare facility initiated and reinforced through weekly voice and text messages, and a recent RCT in Dhaka, Bangladesh found that this intervention significantly reduced diarrhea prevalence. The objective of this present study was to adapt the CHoBI7 mHealth program for scalable implementation in rural Bangladesh and promote construction of a self-made handwashing station.

Methods: We conducted a 3-month multi-phase pilot with 275 participants and 25 semi-structured interviews, 2 focus group discussions, and 10 intervention planning workshops with intervention recipients and program implementers. The pilot participants were evaluated through household structured observations, and unannounced spot checks. We recruited diarrhea patients from the Manikganj district hospital (tertiary level care) and five sub-district health complexes (secondary level care). Recruitment of diarrhea patients occurred from October 2022 to December 2023. Participants were selected using convenience sampling of patients that were admitted to healthcare facilities during the study and who met the screening eligibility criteria.

Results: High appropriateness, acceptability, and adoption of the CHoBI7 Scale-up program was observed, with most recipients constructing self-made handwashing stations (90%) and chlorinating drinking water. At the Day 7 follow-up, 56% of households had >0.2 mg/L free chlorine in their drinking water and observed handwashing with soap was high in all phases (>50%). The process evaluation of the mHealth program found that 73% of voice messages and 79% of IVR messages were fully listened to, and 88% of text messages were received in the final phase of piloting. At the recipient level, facilitators included videos on handwashing station construction and the use of voice and text messages which served as reminders for promoted behaviors. Barriers included perceptions that self-made iron filters removed microbial contamination from water, negating the need for chlorine treatment, and that mobile messages were not always shared among household members. High patient volume in healthcare facilities and high iron in groundwater which reduced chlorination effectiveness were also barriers.

Conclusion: These findings provide valuable insights into the process of adapting the CHoBI7 mHealth program delivery for a rural setting with a lower-cost, scalable design, and demonstrate the important role of formative research for tailoring WASH programs for infectious disease control to new contexts.

Integrating WASH Interventions Across Schools, Healthcare Facilities, and Communities: Evidence from Northern Uganda
Hajra Mukasa Comfort, WaterAid Uganda

Background/Introduction
Northern Uganda, recovering from two decades of conflict (1986–2006), faces persistent Water, Sanitation, and Hygiene (WASH) challenges exacerbated by poverty, rapid population growth, and climate vulnerabilities. Prior to the project, communities in three targeted districts (e.g., Kitgum, Gulu, and Pader) lacked access to basic WASH services, with 58% of households relying on unsafe water sources and 73% of schools having pupil-to-latrine ratios exceeding 70:1. Healthcare facilities (HCFs) grappled with inadequate sanitation, contributing to preventable infections and maternal health risks. Cultural norms limited institutional capacity, and fragmented governance further hindered progress toward SDG 6.

Project Interventions
The project, implemented by WaterAid Uganda and district authorities (2022–2024), adopted a cross-sectoral approach to integrate WASH interventions across schools, HCFs, and communities. Key activities included:

Infrastructure: Constructed 120 gender-sensitive latrines in 15 schools and 45 disability-inclusive sanitation facilities in 12 HCFs. Installed rainwater harvesting systems (10,000L–40,000L tanks) in 8 schools and 9 HCFs.

Behavior Change: Trained 350 healthcare workers to embed hygiene promotion into maternal health and immunization services. Conducted community-led campaigns on handwashing and menstrual hygiene management (MHM).

Governance: Strengthened district WASH coordination committees and supported the integration of WASH into 3 district development plans.

Purpose and Research Questions
The study evaluated the effectiveness of these integrated interventions, addressing:

- How does cross-sectoral WASH programming impact health, education, and governance outcomes?
- What barriers and enablers influence the institutionalization of WASH within local systems?

Study Design
A mixed-methods design included:
Quantitative surveys: 650 households, 15 schools, and 12 HCFs (baseline vs. endline).
Qualitative data: 18 focus group discussions (FGDs) with communities and 32 key informant interviews (KIIs) with district officials, healthcare workers, and teachers.
Systems analysis: Assessment of governance structures, budget allocations, and community engagement mechanisms.

Key Findings
Household WASH Access: Safe water coverage increased from 58% to 82%, while open defecation decreased by 45%.
School Outcomes: Pupil-to-latrine ratios improved from 73:1 to 48:1; MHM facilities reduced female absenteeism by 22%.
Healthcare Impact: Facility-based infections dropped by 32%, and maternal health outcomes improved by 21% (e.g., reduced sepsis cases).
Barriers vs. Enablers: Funding gaps and cultural resistance persisted, but district-led coordination committees and community ownership were critical success factors.

Discussion
The study validates the effectiveness of multi-sectoral WASH programming in post-conflict settings, emphasizing the role of institutional coordination.
It also advocates for integrating WASH into district health and education budgets, as demonstrated by the 5% increase in WASH allocations across target districts.
It highlights the scalability of school-HCF-community linkages, such as training teachers as hygiene ambassadors and leveraging HCFs for community outreach.

Conclusion:
This study provides a replicable model for achieving SDG 6 in fragile contexts, demonstrating how integrated WASH programming can drive systemic change across sectors. Its emphasis on governance, gender equity, and community ownership offers critical insights for global practitioners.

Health and non-health impacts of WASH in healthcare facilities: Systematic scoping review

Lucy Tantum, The Water Institute, University of North Carolina-Chapel Hill

WASH services in healthcare facilities include water, sanitation, hygiene, waste management, and cleaning. WASH plays an important role in patient and healthcare worker safety and well-being. Prior systematic reviews have examined the role of water, sanitation, and hygiene in healthcare-associated infection prevention and patient satisfaction but had narrow inclusion criteria and identified few eligible studies. This systematic scoping review aimed to (1) catalog individual-level impacts of WASH for healthcare workers and patients and (2) assess study designs, methods, and quantitative indicators used to measure impact. We included any study that measured physical, mental, social, and/or economic impacts of WASH in healthcare facilities in a low- or middle-income country. We extracted data on study settings and populations, impacts measured, impact indicators, and (where applicable for intervention studies) intervention components, evaluation approaches, and effect sizes. The original literature search in June 2023 identified 839 eligible studies. Screening for a search update conducted in January 2025 is currently underway. Of the studies identified to-date, 109 measured impacts in the context of an intervention, 579 were observational quantitative studies, and 99 were observational qualitative studies. Sixty-five percent of all studies, and 88% of intervention studies, examined impacts of hand hygiene or personal protective equipment in clinical care. Impacts of other WASH domains were relatively under-studied; 8% of studies measured impacts of water, 9% sanitation, 9% waste management, and 22% cleaning. Commonly-reported impacts included patient satisfaction with services; healthcare worker stress, anxiety, and job satisfaction; healthcare-associated infection; and occupational injury. Patient satisfaction and quality of care impacts were often measured in cross-sectional studies using non-validated survey indicators. Findings demonstrate the multitude of impacts that arise from safe, adequate WASH in healthcare facilities, while revealing evidence gaps in impact measurement for water and sanitation services. Research to develop high-quality, quantitative impact indicators would contribute to more effective intervention impact evaluation. Policy and program stakeholders may prioritize different types of impacts; engagement and consultation with these stakeholders should inform evaluation approaches. Evidence for impact can support advocacy for improving WASH and enhancing healthcare quality.

Modeling health risks from untreated hospital wastewater in Dhaka: A systems-based approach to sanitation planning
Nuhu Amin, University of Technology Sydney

Introduction: Hospitals in low-resource urban settings often discharge untreated wastewater containing fecal pathogens, creating significant but underrecognized health risks to surrounding communities. In Dhaka, Bangladesh, most healthcare facilities rely on

poorly maintained septic tanks or anaerobic baffled reactors (ABRs), which are often non-functional or bypassed, leading to direct contamination of open drains and surface waters. Despite the growing evidence on environmental contamination from hospital effluents, little is known about the associated community health burden. This study aimed to model fecal pathogen flows from a government hospital in Dhaka and quantify the annual disease burden under different sanitation scenarios using a systems-based risk assessment framework.

Methods: We selected a 250-bed government hospital in the Dhaka North City Corporation area and classified its neighboring areas into three community types based on sanitation infrastructure and socio-economic characteristics: a high-income area with septic tanks/ABRs (Community A), a densely populated government housing complex with multi-chambered ABRs (Community B), and a low-income community with direct discharge into open drains and rivers (Community C). Field observations, wastewater volume estimates, disease surveillance data, and literature-derived parameters were used to model exposure to five priority pathogens: Vibrio cholerae, Norovirus GII, Shigella/EIEC, Giardia, and Rotavirus A. Health risks were estimated using Quantitative Microbial Risk Assessment (QMRA) and expressed as annual Disability-Adjusted Life Years (DALYs) under six sanitation scenarios: unmanaged and managed base cases, no-containment, functional ABRs, ABRs with wetlands, and ABRs with tertiary treatment.

Results: The modeling revealed that the unmanaged base case resulted in an estimated 22.5 DALYs per year, while the no-containment scenario posed the highest burden at 24.7 DALYs. In contrast, a well-managed tertiary treatment system combined with ABRs reduced the burden to 8.7 DALYs-a 90% reduction. Within the hospital, managed ABRs reduced DALYs by 19%, and the addition of a constructed wetland further reduced the burden by 66%. However, downstream impacts in surrounding communities remained high across all scenarios, with Community C experiencing the greatest burden (6.10–6.20 DALYs/year). Even with hospital-level sanitation improvements, minimal changes in community DALYs were observed, underscoring persistent environmental exposure risks due to poor fecal sludge management and open drainage systems.

Discussion and conclusions: This research is the first in Bangladesh to use a systems modeling approach combining QMRA and DALY estimation to assess public health risks from hospital-origin wastewater. It demonstrates that hospital-only interventions are insufficient to reduce overall community health risks unless complemented by improved sanitation in surrounding neighborhoods. The findings underscore the urgent need for decentralized wastewater treatment systems in hospitals, along with integrated community sanitation planning. This evidence-informed framework can guide decision-makers in prioritizing health-based sanitation interventions and scaling decentralized treatment technologies in low-income urban settings across LMICs.

Willingness-to-pay for container-based sanitation services among vulnerable communities in northern Haiti
Maya Lubeck-Schricker, SOIL

Background
Access to safely managed sanitation services remains a significant challenge in Haiti, particularly in urban areas such as Cap Haitïen, where rapid unplanned settlement growth and worsening climate events have exacerbated health risks, including waterborne diseases. Despite these challenges, a Haitian container-based sanitation (CBS) service operating in the region since 2011 provides an affordable and sustainable solution. For a monthly fee of 350 HTG (less than $3 USD), households receive a toilet that requires no infrastructure and contains waste in sealable, removable containers that are collected each week. The household service has expanded rapidly, with 40% growth in 2024 and expected further expansion of 50% over the next three years. Despite successful expansion efforts, the CBS provider has found that the monthly fee is still cost prohibitive for the most vulnerable households, which may exacerbate inequitable risks of open defecation. This study explored household willingness-to-pay (WTP) for CBS services in the Cap Haitien region to identify the service subsidy amount necessary to achieve 80% sanitation coverage across the target population.

Methods
We conducted a household survey with 603 households in March-April 2025 across four zones in northern Haiti, collecting information on household socio-economic demographics, sanitation characteristics, wealth, vulnerability criteria, and WTP. We used a double-bounded dichotomous choice method to assess stated WTP for monthly CBS services, with initial randomly assigned anchor prices ranging from 100 HTG to 700 HTG. We also plan to follow-up with focus group discussions among community members in May 2025 to qualitatively explore trends observed in the data and better understand the factors underlying WTP results.

Results
Results showed that 80% of respondents were willing to pay at least 200 HTG per month for the service. Wealth and satisfaction with current sanitation services were key factors influencing WTP, with wealthier households more likely to be willing to pay higher payments. Moreover, households dissatisfied with their current sanitation facilities demonstrated higher WTP, while those with toilets offering privacy from others seeing or hearing them expressed lower WTP. Regression analysis indicated that wealth and satisfaction with current sanitation were significant predictors of WTP ($p < 0.05$), although the model explained only 4% of the variance. Adjusting for initial survey price points improved the model's fit, suggesting that price anchoring influenced respondents'

valuation of the service, though this was less significant at lower WTP costs. Interestingly, WTP showed minimal differences based on current toilet ownership, while households practicing open defecation had higher WTP at lower price points. This presentation will present detailed WTP findings from the household surveys and focus group discussions, and discuss methods used to identify vulnerable households requiring pro-poor subsidies.

Conclusions

These findings highlight the necessity for targeted subsidy mechanisms to ensure equitable access to sanitation services, particularly for vulnerable households. This study provides valuable insights for designing targeted sanitation subsidies in low-income settings, offering evidence to guide policy decisions that promote equitable access to essential services and contribute to improved public health outcomes for vulnerable populations.

Optimizing swine waste bioconversion with black soldier fly to protect public health in North Carolina
Chimdi Muoghalu, UNC Chapel Hill

North Carolina (NC) is the third-largest swine producer in the U.S.; while economically important, the swine industry faces major waste management challenges. Each year, NC swine generates over 10 billion gallons of waste, stored in large outdoor lagoons that often fail to adequately treat contaminants such as pathogens, nutrients, and emerging pollutants. This results in persistent environmental, public health, and social harms. Black soldier fly larvae (BSFL) composting offers an eco-friendly and effective method for upcycling swine waste, as the non-pathogenic larvae can significantly reduce large volumes of waste.   One key but often overlooked factor in BSFL performance is substrate moisture content, which influences metabolic processes, microbial activity, feed ingestion, and contaminant reduction. While studies have examined moisture content's impact on growth and contaminant removal, its effects on larval digestion physiology remain unexplored. Using lab scale bioreactors, we treated swine waste with BSFL. We assessed the impact of varied swine waste moisture content (low 65%, medium 75%, and high 85%) on BSFL digestive enzyme activity and waste conversion efficiency. Additionally, we examined how moisture content alters the diversity of the BSFL gut microbiome and how this relates to enzymatic activity and pathogen reduction in the swine waste. BSFL effectively reduced total organic carbon (TOC, 56.3–85.4%) and E. coli (89.4–92.3%) but had lower efficiencies for nutrients, total nitrogen (TN, 23.7–47.9%) and total phosphorus (TP, 19.3–47.7%). Moisture content showed an inverse correlation with treatment efficiency and larval growth; BSFL reared on 65% moisture content exhibited significantly higher TN ($p < 0.001$), TOC ($p< 0.001$) , TP ($p = 0.002$), E. coli ($p = 0.004$) and protein reduction efficiencies, along with the highest larval mass (73.7 mg/larvae), compared to those reared on higher moisture levels . Additionally, larval protein and fat content increased by 56%

(from 17 mg/g to 40 mg/g), making them suitable for animal feed processing. These findings indicate that 65% moisture content is optimal for BSFL swine waste treatment, aligning with typical swine waste moisture levels (55.2–68.8%). This reduces the amount of preprocessing required before BSFL composting implying that the technology can be easily adopted on most farms with minimal adjustments. Principal component analysis (PCA) further revealed moisture content significantly affects contaminant reduction and larval growth. The first component (29.9%) captured contaminant reduction factors, while the second (20.6%) reflected larval growth. The positioning of low moisture content in the PCA biplot confirmed its role in optimizing digestive enzyme activity (protease for protein metabolism and alpha-amylase for carbohydrate metabolism), their growth performance and nutrient composition, and contaminant reduction efficiency). The results from the microbial diversity analysis revealed that moisture content influences the dominant communities in BSFL gut microbiota which in turn influences digestive enzyme activity and contaminant removal. Our findings suggest that BSFL composting at 65% moisture efficiently reduces pathogens and contaminants, lowering risks of water and soil pollution. This scalable method also enhances larval feed quality, supporting sustainable agriculture.

A Modified Compact Dry Assay as a Rapid Alternative for ESBL E. coli Quantification
Fatema Akter Mahua, INDIANA UNIVERSITY BLOOMINGTON

Compact Dry EC media is a ready-to-use medium for growing E. coli sold commercially in pre-prepared plates. While traditional methods require media preparation and plate pouring, Compact Dry plates offer faster processing and fewer opportunities for contamination. Compact Dry plates are a promising alternative for antimicrobial resistance (AMR) surveillance because of their faster processing and lower cost relative to traditional media preparation. The WHO Tricycle protocol currently recommends Tryptone Bile X-glucuronide agar (TBX) with cefotaxime to isolate ESBL-producing E. coli, but this method requires labor-intensive preparation. Despite its potential advantages, Compact Dry has not been validated against the WHO protocol for ESBL resistant bacteria detection. We aimed to validate Compact Dry EC media as an alternative to TBX agar, for detecting and quantifying ESBL and non-ESBL bacterial strains.

We tested five strains of E. coli and Klebsiella to validate the modified assay, including four ESBL resistant strains (E. coli JJ1887, E. coli H4H, K. pneumoniae 1.53, K. pneumoniae BWH 2) and one ESBL susceptible strain (E. coli ATCC 25922). Each strain was cultured on Compact Dry EC plates (adapted manufacturer's protocol) and TBX (WHO Tricycle protocol). ESBL strains streaked on LB agar and isolates were cultured in LB broth with 4 µg/mL cefotaxime at 37°C to ensure plasmid retention. The susceptible strain was grown without cefotaxime. Cultures were standardized by optical density, then serially diluted. For Compact Dry, 0.5 mL diluted culture of resistant strains was mixed with 0.5 mL of 8 µg/mL cefotaxime, and the combined 1 mL was inoculated. A separate 1 mL without

antibiotic was also plated on separate Compact Dry plates. For TBX, 0.1 mL diluted culture was spread onto plates with 4 µg/mL cefotaxime. Compact Dry plates were incubated at 35°C and TBX at 37°C for 24 hours. We used independent t-tests to compare log10 transformed bacterial counts between media, and linear regression to assess correlation between Compact Dry and TBX results across strains and antibiotic conditions.

All resistant and susceptible strains were correctly identified, with Compact Dry showing 100% sensitivity and specificity compared to TBX with cefotaxime. Regression found no significant difference in bacterial counts on Compact Dry EC with vs. without cefotaxime (p = 0.756), indicating bacterial growth was unaffected by the antibiotic. Resistant strains maintained high counts (mean $\log_{10}$ CFU/mL ~9.0) across both media (p > 0.05). Regression analysis for resistant strains plated with cefotaxime showed a strong linear relationship between Compact Dry and TBX (R^2 = 0.99, p < 0.001), confirming equivalent bacterial recovery under antibiotic selection. In contrast, susceptible strains showed no growth ($\log_{10}$ CFU/ml = 0) on Compact Dry and TBX with cefotaxime, while growing similarly (mean $\log_{10}$ CFU/ml ~9.0) on Compact Dry without cefotaxime. Further, we are assessing ESBL E. coli in surface water near combined sewer overflows and results will be available to present by October.

This study demonstrates Compact Dry performs equivalently to TBX for quantifying ESBL-resistant and susceptible strains, supporting its use as a reliable alternative for AMR surveillance.

Enhanced Antibacterial Activity of Light-Activated Silver Nanoparticles Against Superbugs Through Sequential Light Exposure
Anjumana Jannati Nur, University of North Carolina at Charlotte

Antibiotic resistance (AR) has become one of the leading causes of increased mortality worldwide. The primary factor for the rise of antibiotic-resistant bacteria (ARB) or superbugs is the misuse of antibiotics in healthcare and agriculture. Current approaches, such as antibiotic combinations, antimicrobial peptides, and engineered bacteriophages to eliminate ARBs, face challenges like developing resistance and proteolytic degradation. Non-antibiotic approaches, such as using silver nanoparticles (AgNPs), have gained the attention of researchers for their broad-spectrum antimicrobial efficiency. The antimicrobial efficacy of AgNPs is mainly associated with the Ag+ release, which is a slow process. To enhance AgNP efficacy, we functionalized their surface with protoporphyrin IX (cysPPIX), a photosensitizer that accelerates Ag+ release under light exposure. The cysPPIX creates an oxidative environment around the AgNP, facilitating faster release of Ag+. Our study demonstrated that cysPPIX-AgNPs effectively inactivate Methicillin-resistant Staphylococcus aureus (MRSA), achieving >5 log reduction with single exposure and >6 log with sequential dual-step exposure (~1.34 log higher than single exposure) at 1.5 µg/mL. This approach enhanced the antibacterial activity of cysPPIX-AgNPs even at lower

concentrations in a shorter span, offering a promising strategy for combating antibiotic resistance. The findings of this study could contribute to the development of novel or advanced antimicrobial agents with broad applications in healthcare, agriculture, and water treatment plants for developing advanced water treatment methods. It may also provide valuable insights, contributing to designing future antimicrobial agents.

Validation and applications of an E. coli contamination risk sensor in US surface waters

Joshua Klaus, University of Colorado at Boulder

Today, 340,000 miles of rivers and streams in the United States are contaminated with pathogens and do not meet the Clean Water Act standards. The impairment of surface waters with fecal contamination, specifically from agriculture and farming practices, poses a significant public health concern and impacts environmental health and public water recreation. A lack of monitoring this exposure, particularly around nonpoint source pollution, is a major limitation toward improved water quality management. Increasingly, the public, non-profits, researchers, municipalities and utilities are demanding better data and action toward managing fecal contamination in our water.

Traditional microbial water quality monitoring requires time for sample collection and incubation, training of personnel, and consumables. Additionally, samples only provide retroactive data at a specific location and time, which is not always representative of the quality of a water source or its variability. In response to the need for more spatially and temporally dense microbial water quality data, our team has developed an in situ, near-time E. coli risk sensor. The sensor technology combines machine learning with measurement of tryptophan-like fluorescence (TLF), the presence of which is highly correlated to fecal indicator bacteria such as E. coli in natural water systems.

An ongoing preliminary test to validate the performance of the Lume is being conducted along Boulder Creek, Colorado. This testing supports compliance efforts towards meeting a Total Maximum Daily Load (TMDL) limit for E. coli in the river in a collaboration between the University of Colorado and the City of Boulder. Currently, water samples are taken alongside sensor deployments and tested for E. coli levels using traditional enumeration methods. The data is used to strengthen the machine learning model's regression, and is also provided to the city and the public. In a setting where contaminated water is frequently used for recreation, access to a real time network of sensors can inform public health decisions. The initial stages of this test have shown promising results; across all sites a predictive performance of 98% balanced median accuracy has been achieved, with about 142 CFU/100 ml mean average error over a range of 0 to 1,000+ CFU/100 ml. This precision demonstrates the ability to accurately predict contamination risks consistent with the WHO risk guidelines for E. coli.

The network of sensors is being expanded with several upcoming installations around the United States. In collaboration with local water utilities, stakeholders, and research groups, these efforts will provide data that is useful for both strengthening our regression model and informing water management practices in various contexts. These deployments will include the Chicago River in Illinois, Lake Erie in Ohio, Manchester on the Sea in Massachusetts, the Yampa River in Colorado, and Fort Myers in Florida.

Assessing Septic Systems, Flooding, Season, and Socioeconomic Impacts on Food- and Waterborne Illnesses in Maryland
Cameron Smith, University of Maryland, School of Public Health, Department of Global, Environmental, and Occupational Health

Around 420,000 Maryland homes rely on septic systems, and approximately 52,000 of these homes are within 1,000 feet of tidal water ("the Critical Area"). These homes are at risk of groundwater contamination because rising sea levels raise groundwater levels and generate more frequent flooding, creating additional pathways for pathogen exposure. However, there is currently a knowledge gap around how septic systems that are exposed to chronic flooding can impact food- and waterborne illness risks. The Foodborne Diseases Active Surveillance Network (FoodNet) conducts surveillance on eight pathogens in 10 states, including Maryland. Our study analyzed the impact of septic systems, flood risk, season, and socioeconomic status on the incidence of five FoodNet pathogens (Campylobacter, Cyclospora, Listeria, Salmonella, and Shiga toxin-producing E. coli (STEC)) in Maryland from 2010-2022. Among an initial analysis of 19,064 FoodNet cases reported for the five pathogens, the county with the highest average incidence rate when considering all five pathogens analyzed was Caroline County (53.2 per 100,000 population). Salmonella was the most frequently reported pathogen (n= 9,168; 48.1%). The county with the highest average incidence rate for Salmonella was Somerset County (36.5 per 100,000 population) which is also the county with the highest percentage of parcels in a floodplain (45%). In the Zipcodes in Maryland where at least one case was reported in FoodNet, we observed a higher average incidence rate of all five FoodNet pathogens during summer and a significant association between season and the number of Salmonella ($p<0.05$), Campylobacter ($p<0.05$), STEC ($p<0.05$), and Cyclospora ($p<0.05$) cases. Based on results from a multilevel negative binomial regression model, the incidence rate of Salmonella significantly increased as the percentage of parcels with septic systems ($p<0.03$), percentage of parcels in the floodplain ($p<0.001$), and percentage of Black or African American ($p=0.007$) or White residents ($p=0.003$) increased in a Zip code. These results demonstrate that as the percent of parcels on septic systems and percent of parcels in the floodplain increases, the risk of Salmonella also increases; season and socioeconomic factors may also play an important role in risks associated with these

infections. Our study provides novel results that can help policymakers prioritize areas for infrastructure upgrades to reduce public health risks.

Effect of WASH interventions on Giardia infection in Bangladesh: heterogeneity by exposure to seasonal monsoons
Pearl Anne Ante-Testard, Francis I. Proctor Foundation and the Department of Ophthalmology, University of California, San Francisco, San Francisco, CA, USA

Giardia is the most common enteric parasite among children in low-resource settings. It can cause diarrhea and lead to prolonged infection or asymptomatic carriage. This study assesses the impact of water, sanitation and handwashing (WASH) interventions in preventing seasonally driven increases in Giardia among rural Bangladeshi children. We hypothesize that WASH interventions will be more effective in reducing Giardia among children during the monsoon season. We conducted a secondary analysis of the WASH Benefits Bangladesh cluster-randomized trial (n=2,773 children). We restricted the analysis to index children who received any form of combined WASH (hereafter WSH) compared to those who did not (control and nutrition, hereafter no WSH). Using linear binomial model, we assessed the effect of WSH on Giardia by season (dry vs monsoon). Asymptomatic carriage of Giardia is common, making it challenging to determine the exact timing of infection. Thus, we also used the cumulative months that a child had been exposed to the monsoon from birth up to their measurement age to capture a child's previous pathogen-specific infection history. We assessed the effect of WSH on Giardia along the cumulative number of monsoon months using a generalized additive model while accounting for child's age. Although we found no evidence of effect modification by season, Giardia prevalence was higher during the dry season with lower prevalence among children in the WSH arm (28%, 95% confidence interval 24% to 33%) compared to no WSH (35%, 30% to 40%). The reduction in Giardia due to WSH was greater in the dry season (-7%, -11% to -3%) than the monsoon (-4%, -9% to 2%). We found that Giardia infection was consistently lower in the WSH arm compared to the no WSH across the range of monsoon exposure (10.4-17.0 months). The reduction in Giardia prevalence due to WSH was statistically significant for children with lesser exposure to monsoon between >10 and 14 monsoon months. Our results show that WASH interventions reduced Giardia prevalence, with the largest reductions observed in the dry season which may inform the timing of interventions to align with periods of greatest impact.

Effects of Extreme Weather Events on Cholera in the Democratic Republic of the Congo 2020-2024 (PICHA7 Program)
Kelly Endres, Johns Hopkins Bloomberg School of Public Health

Extreme weather events such as droughts and floods have increased cholera outbreaks to historical highs in sub-Saharan Africa this year. Furthermore, humanitarian contexts with protracted conflict such the eastern part of the Democratic Republic of the Congo (DRC) are highly vulnerable to extreme weather events because of poor water and sanitation infrastructure which increases their risk of cholera and other infectious diseases. However, there is limited evidence on the health impacts of extreme weather events in humanitarian contexts. The objective of this study was to examine the impact of extreme weather events on cholera through leveraging 4 years of surveillance data from 115 healthcare facilities from 2020-2024 in urban Bukavu, DRC. In total 1068 diarrhea patients with GPS data available had their stool screened for Vibrio cholerae by bacterial culture. Daily precipitation data was downloaded from CHIRPS (Climate Hazards Group InfraRed Precipitation with Station data), and daily temperature data from the CPC Global Unified Temperature dataset. Extreme weather events were defined as: (1) drought where precipitation <75% of the median for the region occurring for at least three months; and (2) precipitation or temperature over the 90th percentile of the daily average. The rainy season in our study setting was September to January. A test-negative design was used to investigate the association between extreme weather events and cholera confirmed by a positive result for V. cholerae by bacterial culture. During times of drought there was a significantly higher odds of cholera (Odds ratio (OR): 1.58, 95% confidence interval (CI): 1.12-2.20), and a significantly lower odds of cholera during the rainy season (OR: 0.63, 95% CI: 0.46-0.85). In the eastern DRC, cholera occurred significantly more during times of drought and less during the rainy season. Early warning systems which promote water, sanitation, and hygiene interventions will be important for promoting resilience to extreme weather events in humanitarian contexts such as eastern DRC.

Improving the Semiquantitative Screening of Total Lead Concentrations in Drinking Water using Affordable Test Strips
Ethan Chou, UNC Water Institute

Lead in drinking water can harm human health and cause irreversible developmental impairment in infants, fetuses, and young children. Suitable laboratory methods can quantify lead, but few wells in high-income countries are tested for lead after installation, and lead testing in some low/middle-income country settings can be challenging. Low-cost lead lateral-flow immunoassay (LFIA) test strips have been used to screen drinking water for lead but are only available in binary presence-absence formats, limiting their value. Studies have also questioned the ability of LFIA strips to detect particulate lead. This study attempted to address these issues by developing a process to analyze images of lead test strips to quantify lead concentration readings, as well as investigating acidification of water

samples to improve detection of particulate lead.

In this study, dissolved lead, particulate basic lead carbonate, and/or leaded brass filings were added to standard test water (pH 8.5 test water prepared per the NSF 61 protocol) at concentrations ranging from 0-30 µg/L. Some sets of water samples were acidified with 0.00335M citric acid. Test strips were exposed to each according to the manufacturer's instructions. Images of exposed lead test strips were collected using a mobile phone and analyzed using the open-source ImageJ software to quantitatively compare control and test lines on each LFIA strip. Pixel density ratios (control/test) were compared to nominal concentrations of dissolved and total lead added, as well as to measured concentrations of dissolved, particulate, and total lead in each sample, determined by ICP-MS analysis of unfiltered and 0.22-µm filtered samples.

For non-acidified samples, dissolved lead was detected in all samples but lead carbonate and brass yielded a false negative result on the test strips in all trials. Semiquantitative estimates of dissolved lead concentration were feasible, but not for particulate lead. R^2 values for pixel ratio over lead concentration were 0.6341, 0.0432, and 0.3806 for dissolved, carbonate, and brass lead respectively. The trendlines for lead carbonate and brass had negatives slopes.

For acidified samples, detection of dissolved lead did not change significantly from unacidified samples, while lead carbonate and leaded brass were able to be detected in all trials. Semiquantitative estimates of lead concentration were feasible for all three types of lead. R^2 values were 0.6652, 0.9496, and 0.8567 for dissolved, carbonate, and brass lead respectively, and all trendlines had positive slopes.

These results suggest that LFIA-based test strips can be adapted to obtain semiquantitative estimates of total lead in drinking water. While less precise than ICP-MS, this approach may be suitable for screening and identifying high-risk water supplies. A mobile application (WellAware) has been designed to automate image analysis, and further pilot work may determine the performance of this approach using real field samples. Additional work with differing acid types or concentrations may also yield a combination which provides the best detection of lead. If suitable for screening under field conditions, these tools may be promising and cost-effective screening options where laboratory analysis is not available, or where water users prefer the privacy of an at-home test method.

Developing Standardized Methods to Quantify Lead Composition of Drinking Water System Infrastructure using X-Ray Fluorescence
Kyle Rezek, UNC Water Institute

Lead is a toxic metal responsible for several long-term health effects. It accumulates in the body over time and is particularly harmful to children, but can also affect adults. To improve public health, reducing a person's lead exposure is critical. Toxic metal contamination in drinking water is a widespread issue in low- and middle-income countries (LMICs) due to infrequent testing and poor material regulation. A major source of lead contamination in these systems is from galvanized and brass parts, which contain lead for a variety of benefits, and are commonly used in rural groundwater systems. Both galvanized and brass parts have the potential to corrode over time, leaching lead into the drinking water. A standardized protocol for lead detection in these materials and others in use for drinking water infrastructure would be beneficial in ensuring that regulation compliance is consistent in LMICs. X-ray fluorescence (XRF) is a rapid and non-destructive analytical method for scanning outer surfaces of materials for elemental composition and can be used towards determining material lead content. A high throughput XRF scanning protocol for regulation of materials in the field can lead to mitigation of lead exposure through drinking water by preventing the use of high-leaded materials in water systems. Various sections of galvanized pipes were scanned since they have previously been shown to leach lead at levels above the World Health Organization guideline value at 10 ppb. PVC pipes were used as a control group since the PVC pipes were found to be homogenous and contained almost no detectable amounts of lead. The XRF was also used to test whether curved, uneven, or coated surfaces and materials played a factor in the role of detecting lead composition for the galvanized, brass, and PVC materials. In nearly all tested points of the galvanized pipes, lead concentrations exceeded the 0.25% threshold for lead percent composition set by the National Sanitation Foundation (NSF), and only one of the three galvanized pipes significantly varied in lead concentration across the pipe. Based on the results, XRF is a sufficient method for quantifying homogeneity of lead content in water system components. Scanning various sections of multiple galvanized pipes is recommended before installation to ensure the material is compliant with the NSF standard. This data and findings were used towards developing a working protocol to standardize the protocols and methods for detecting lead composition in parts and materials for use in drinking water systems. By using this protocol, lead containing parts would not be installed to prevent lead leaching into rural water systems.

Wastewater surveillance reveals patterns of antibiotic resistance across the United States
Sooyeol Kim, University of California, Berkeley

Antibiotic resistance (AMR) is a growing public health threat, with over 2.8 million antibiotic-resistant infections and 35,000 attributable deaths annually in the U.S. Traditional clinical surveillance for antibiotic resistant infections involves testing bacteria isolated from clinical specimens to assess antibiotic susceptibility. This method is

resource-intensive and only reflects antibiotic resistance genes (ARGs) in individuals seeking medical treatment, limiting our understanding of the true burden and diversity of AMR in the broader community. Recent advances in wastewater monitoring for pathogens have established data collection infrastructure that can be leveraged to monitor ARGs in a timely and comprehensive manner. Various interconnected drivers that contribute to levels of AMR in communities, such as improper use of antibiotics and socioeconomic factors that lead to disparities in access to healthcare, highlight the need for a comprehensive examination of multiple determinants of AMR. While there are a limited number of studies analyzing ARGs in wastewater to gain insights for AMR in communities, these studies either focus on global spread, characterizing and comparing the wastewater resistome globally, or are limited to one city or state and mainly uses metagenomics, which cannot detect rare targets and provide accurate quantitative estimates.

In this study, we sought to use wastewater monitoring to assess community-level AMR. This study quantified concentrations of ARGs by digital droplet PCR in wastewater solids obtained from 163 wastewater treatment plants across the United States. We measured 11 ARGs that confer resistance to beta-lactams (CMY, CTX-M, KPC, NDM, mecA, OXA-48, TEM, VIM), colistin (mcr-1), tetracycline (tetW), and vancomycin (vanA). We paired these data with national data sets including antibiotic use, social vulnerability, size of animal agriculture operations, density of healthcare facilities, and presence of airports to investigate potential drivers of resistance. In addition to the correlational analysis, we also generated predictive maps of ARG concentrations for every county in the United States based on non-clinical indicators.

We present evidence that the antibiotic resistance burden disproportionately affects low-income and disadvantaged communities. Increased levels of ARGs in wastewater were associated with limited access to health insurance, housing burden, and overcrowding. We also identified international travel and signs of recent immigration as significant drivers of increased ARG burden in domestic wastewater. NDM and colistin resistance (mcr-1) were significantly associated with the number of airports and the proportion of the population who speak limited English. On the other hand, antibiotic use itself showed weak or no correlation with presence of ARGs. This underscores a disconnect between antibiotic sales data and actual consumption, which likely reflects large antibiotic usage in food and companion animals and potentially non-prescription antibiotic use that is expected to play a large role in driving antibiotic resistance. This study presents a quantitative analysis of clinically relevant ARGs in wastewater, offering a valuable tool and baseline for understanding and monitoring resistance dynamics across the U.S. The use of wastewater to study ARGs allows for real-time, population-level insights into the presence and distribution of AMR, supplementing clinical data that may be underestimating the resistance burden.

Quantitative and Digital PCR-Based Detection of Antibiotic Resistance Genes in Rural Wastewater Systems
Nita Khanal, UNC Charlotte

Antibiotic-resistant genes (ARGs) are a growing public health concern, often reported as a silent pandemic because of their gradual spread and low public awareness. Wastewater treatment plants (WWTPs) are determined as the predominant source of accumulation and dissemination of ARGs. While urban wastewater treatment plants are well-documented sources of ARG dissemination, rural wastewater systems remain underexplored. This study primarily focused on the detection of four ARGs, blaKPC, blaVIM, Oxa-48, and VanA in six rural wastewater treatment plants by using two different molecular detection methods, quantitative PCR (qPCR) and digital droplet PCR (ddPCR). Weekly Influent samples were collected from May 2023 to December 2023 from two WWTPs in Charlotte, NC, and five in eastern NC, resulting in over 30 weeks of data. Samples were concentrated using electronegative membrane filtration and processed with the MagMax™ Wastewater Ultra Nucleic Acid Isolation Kit on the KingFisher™ platform to ensure high-quality nucleic acids for downstream analysis. Initial results show that blaKPC was consistently detected by both qPCR and ddPCR. However, vanA was not detected by qPCR but was found in 17 samples via ddPCR at concentrations below 3 copies/μL. Other targets are currently under analysis, with the expected results by June 2025. These findings demonstrate that ddPCR has significantly increased sensitivity and accuracy in ARGs detection and quantitation compared to qPCR. While qPCR remains an available alternative option for researchers with no access to ddPCR technology, ddPCR enhances detection capability, particularly in low-abundance ARGs.

Effectiveness of the PAASIM piped drinking water intervention for reducing children's enteric disease across different seasons and meteorological conditions.
Viviana Albán, University of Washington

Background & Objective: Drinking water interventions have the potential to interrupt transmission of enteric pathogens and reduce diarrheal disease, but seasonal changes in water delivery and impacts of extreme weather on water systems events may impact their effectiveness. We assessed how seasonality and heavy rainfall events (HREs) impacted the effectiveness of an urban piped water intervention for reducing enteric infections among 12-month-old children in Beira, Mozambique.

Methods: We matched data from household surveys and stool samples collected for the PAASIM study to data on precipitation and temperature from a nearby weather station. We used generalized estimating equations with a Poisson log link function and robust standard

errors to calculate risk ratio estimates comparing the difference in effectiveness of the PAASIM intervention (a) between rainy and dry season and (b) following heavy rainfall events and when there were no heavy rainfall events.

Results: We found no difference in the effectiveness of the PAASIM intervention between rainy and dry seasons for our primary outcomes of interest. However, we saw some evidence that having a direct connection to the piped water system in one's household was more protective during rainy season for any bacterial or protozoan infections [Rainy season: aRR: 0.93; 95% CI: (0.79, 1.09); Dry season: aRR: 1.05; 95% CI: (0.96, 1.14); Interaction term p-value = 0.08] and co-infections [Rainy season: aRR: 0.87; 95% CI: (0.62, 1.22); Dry season: aRR: 1.10; 95% CI: 0.89, 1.35); Interaction term p-value = 0.09]. When comparing the difference in the effect of the intervention following HREs 0-1 week before sample collection, compared to no HREs during the same period, people in intervention neighborhoods had a lower risk of any bacterial or protozoan infections [HRE: aRR: 0.84; 95% CI: (0.70, 1.01); No HREs: aRR: 1.00; 95% CI: (0.92, 1.08); Interaction term p-value = 0.04], co-infections [aRR: 0.71; 95% CI: (0.52, 0.98); No HREs: aRR: 0.98; 95% CI: (0.84, 1.15); Interaction term p-value = 0.02], and Cryptosporidium infections [HREs: aRR: 0.29; 95% CI: (0.09, 0.88); No HREs: aRR: 0.91; 95% CI: (0.59, 1.39); Interaction term p-value = 0.03] as well as a lower total number of infections [HREs: ab:-0.46; 95% CI: (-0.89, -0.03); No HREs: ab: -0.13; 95% CI: (-0.34, 0.09); Interaction term p-value = 0.08] compared to people in comparison neighborhoods.

Conclusions: Our results add to previous studies suggesting that seasonality may impact the effectiveness of drinking water interventions, though local water practices such as water storage which may negate the effectiveness of access to piped water infrastructure. We also show that access to an upgraded piped water supply may help reduce exposure to environmental contamination following HREs. Drinking water interventions should consider the role of weather and seasonality in order to develop more resilient intervention strategies.

WASH in Early Childhood Development Centres: Compliance, Practices, and Barriers in Malawi
Kondwani Luwe, Centre for Water, Sanitation, Health and Technology Development

Traditional water, sanitation, and hygiene (WASH) interventions often target households or primary schools, overlooking other settings where young children who bear the majority of the diarrheal disease burden spend time. In Malawi, over 54% of children aged 3 to 5 attend Early Childhood Development Centres (ECDCs), which serve as platforms for education and nutritional support. These spaces offer critical opportunities for infection prevention and health promotion. This formative study assessed the management, WASH

infrastructure compliance, hygiene behaviours, and their determinants in ECDCs in Blantyre, Malawi.

A mixed-methods approach was used between September and December 2024 to collect data in 30 ECDCs (10 each in urban, semi-urban and rural locations) from learners, caregivers and kitchen staff. WASH infrastructure was assessed and evaluated using a checklist (n =30) aligned with national ECDC standards. Compliance was scored per centre targeting different WASH domains (water access, sanitation, waste management, food and hand hygiene) and was categorised as low (0–49%), medium (50–74%), or high (75–100%). Quantitative data were analysed using descriptive statistics in STATA 17. Structured observations (n=30) captured hygiene behaviours (sanitation, water management, food and hand hygiene), while in-depth interviews (n=60) with staff explored management practices and hygiene behaviour determinants, which were analysed using the barrier and motive mapping frameworks.

Rural ECDCs failed to meet recommended caregiver-to-learner ratios of 1:15 (1:20 for rural vs. 1:15 in urban and 1:13 in semi-urban), and operational support was uneven—urban centres relied on parent contributions, while rural ones were more NGO-supported. Only 37% of staff had received ECD training, and awareness of national WASH standards was low (20%) across all settings. Two-thirds of ECDCs scored low across all WASH domains, with high compliance observed in only 5% of the centres—mostly in water access. Urban centres consistently outperformed semi-urban and rural ones in compliance. Despite toilet availability, children were frequently observed defecating (73%) or urinating (98%) outside, with faeces handled using tools that were not cleaned afterwards. Handwashing with soap at critical times was rare (21%), and drinking water was often accessed with unclean hands or cups. Meals were served on unclean surfaces (70%), and plates were frequently washed without soap (60%). Although staff cited motivations like disease prevention, disgust, and cleanliness, these were often outweighed by structural barriers (e.g., lack of tools & supplies) and competing priorities that reduced attention to hygiene behaviours.

ECDCs in Blantyre face major deficits in WASH training, infrastructure and hygiene behaviours, despite their importance for early childhood development and disease prevention. Theory-driven hygiene interventions alongside the provision of infrastructure should be incorporated in the daily operation of the ECDCs.

A global scoping review of Water, Sanitation and Hygiene (WASH) interventions for adolescents
Rossanie Malolo, Monica Nzanga

Background
Water, sanitation and hygiene (WASH) interventions need to take into account how a

person's age and situation affect their risks and chances for better health. Adolescence presents an ideal opportunity to lay the foundations for healthy living, yet this age group receive limited targeted health interventions. This scoping review aimed to identify the focus of existing WASH interventions for adolescents, their characteristics, the extent of adolescent participation and their effectiveness.

Methodology
The Arksey and O'Malley framework was used to conduct the review, and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) guidelines were used to enhance reporting quality. The extent of adolescent participation was measured using the Shier's 'Pathways to Participation' model, which categorizes children's participation in ascending levels from 1, where children are merely listened to, to 5 where they share responsibility with adults in decision making. The search was conducted in three electronic databases (Scopus, PubMed, and Research for Life) in January 2025 using keywords and Boolean operators, with additional reference list checks to identify relevant studies. Duplicates were removed, and studies were screened by title, abstract, and full text, based on the eligibility criteria. Studies included were original research reporting on WASH interventions from anywhere in the world, whose target population were females and/or males aged 10-19 years old published in English between 2013 and 2023.

Results
Screening and eligibility assessment of the 5432 sources resulted in 70 eligible studies. All were experimental studies, based in Asia (n=44) and Africa (n=20), Euro-Asia (n=4) and America (n=2). Only 32 of 70 studies targeted adolescents only, the rest combined them with other age groups. Of these 32, only two included both schools and households, the rest were in school. The most targeted WASH topic was oral hygiene (n=23) (all implemented in Asia), followed by Menstrual Hygiene Management (MHM) (n=18) and hand hygiene (n=10). The reviewed WASH interventions were mostly educational only (n=43), unlike infrastructure. The implementation period ranged from 5 days to 2 years with (n=39) being implemented within 5 days to 5 months. Adolescents' participation in interventions was low, with the majority (n=60) of the studies at Level 2 of the Shier's Pathway to Participation, where adolescents were merely involved as informants and recipients of the interventions. Inclusion of adolescents with disabilities was also low (n=13). The primary outcomes evaluated included: oral hygiene status (n=24), MHM knowledge & practice (n=14), handwashing practices (n=10), health-related outcomes (n=5), and educational outcomes (n=4); only one study evaluated psycho-social outcomes. Forty-nine studies were reported as effective, 15 partially effective, and 6 ineffective in achieving their primary outcomes.

Conclusion
Few WASH interventions specifically target adolescents, missing an opportunity to develop

life-long positive WASH skills and practices. WASH interventions need to prioritize delivery to vulnerable groups and regions, and balance education with infrastructure support. More active participation of adolescents in intervention development and implementation should be considered & out-of-school adolescents should also be targeted. Psycho-social outcomes must be prioritized along with the commonly evaluated WASH indicators.

Estimating the effectiveness of a household water filter on household water and household food insecurity among Maasai pastoralists in Kenya
Lauren Broyles, The Pennsylvania State University

Background: Water and food insecurity are two of the most pressing issues people face, and climate change exacerbates both. Globally, two-thirds of the world's population experiences some level of household water insecurity, and one-third experiences moderate to severe food insecurity. Extreme weather events, such as droughts and floods, and shifts in the timing and duration of seasonal rains and temperature worsens these conditions by damaging domestic water sources or by destroying crops and ruining food supplies. Traditional reliance on grazing and rainfed agriculture make Maasai pastoralists in Kenya extremely vulnerable to negative effects of climate change, for whom water and food insecurity are highly interrelated. Communities rely on seasonal surface water sources, which may be highly contaminated and unsafe, putting households at risk of waterborne diseases. Drought increases psychological and mental stress as water sources dry up and there is less water available to care for livestock and domestic needs, such as drinking water and preparing food. Increased frequency and severity of droughts affords less time for recovery and requires household-level food and water interventions to build climate resiliency for adequate health and nutrition.

Objective: In response to these problems and against a backdrop of a severe drought from 2020-2023 followed by a heavy rainy season and flash-flooding in 2024, we measured food and water insecurity and evaluated the effectiveness of a household water intervention on reducing food and water insecurity in two Maasai communities. In partnership with Kenyan non-profit, Africa Hope, and social enterprise, Aqua Clara Kenya, we utilized variation in timing of household surveys and deployment of a household water filter sold by Aqua Clara Kenya to estimate the effectiveness of the household water filter at reducing food and water insecurity among 220 households across two Maasai communities.

Methods: Household surveys included questions on household demographics and livelihoods; Household Food Insecurity and Access Scale (HFIAS) to measure food insecurity; and the Household Water Insecurity Experiences Scale (HWISE) to measure water insecurity. With our panel data, we will utilize linear and logistic regression analyses with panel fixed-effects to estimate the effects of the household water filter on water and food insecurity.

Results: Baseline survey results from the beginning of the rainy season demonstrate that across the two communities, the average HFIAS score is 9.6 (SD=7.4, 95% CI: 8.6, 10.6), and the average HWISE score is 11.5 (SD= 9.5, 95% CI: 10.2, 12.8). Water filters were distributed in April 2025 and repeated surveys were collected during the dry season in June 2025. We anticipate that both water and food insecurity will decrease post-intervention, and we will further present on the results of household surveys after deployment of the household water filter.

Conclusion: This repeated measure intervention study indicates that at the beginning of the rainy season, the average household experienced low to moderate household food insecurity, and low to moderate household water insecurity. Climate-sensitive and seasonally- appropriate interventions to improve water and food insecurity are critical to assess to reduce the resulting health and well-being consequences associated water and food issues.

Enhancing Water Security and Ecosystem Resilience through Integrated Water Resource Management in Amhara, Ethiopia.
Mussie Tezazu Asmare, Millennium Water Alliance

Background: Most rural communities in Ethiopia that depend on subsistence farming face many challenges such as soil erosion and degradation, water pollution, reduced flow, flooding and sedimentation, droughts, changing rainfall pattern, shortage of water, depletion of natural resources, and limited access to vital services. These factors exacerbate water and food insecurity, ecosystem instability, and poor health outcomes. To holistically address such issues, Millennium Water Alliance (MWA) and WaterAid implemented an Integrated Water Resource Management (IWRM) project in North Mecha district delineating 710 hectares of land using a digital elevation model. This Hilton Foundation supported project aimed to improve safe water access and water quality issues thereby improving water security and ecosystem resilience. Extensive community mobilization resulted in the contribution of over 4,500 labor days for physical conservation works and strong community engagement in gully rehabilitation, cropland and riparian zone restoration, and afforestation efforts. As part of this project, 200,000 high-value tree seedlings were planted to enhance ecosystem restoration and household livelihoods. Check dams were constructed, and a cut-and-carry system was adopted to replace open-grazing.

Methods: The study uses descriptive methods to capture and analyze project outcomes. The project followed an inclusive approach that enhanced a coordinated planning and implementation of activities for environmental restoration; flood and sediment control; water quality improvement; improvement of livelihoods through sustainable agricultural practices; and enhancement of water availability for drinking, sanitation, and agricultural

uses. This project aims to intervene at the nexus between water, land, and nature to optimize social and economic wellbeing with no harm to the ecosystem. Strategies implemented include improving water recharge and retention through catchment restoration, water source development and expansion, and applying sustainable agricultural practices.

Results: This project has shown remarkable environmental and community benefits. A total of 17,000 people accessed safe water from solar powered water supply systems; five schools serving 10,304 students and two health centers with 50,000 clients have access to clean water; the water service delivery improved through establishment of rural water utilities; several area closures and check dams were established; terracing intensified on private and communal lands; and 200,000 forest trees and cash-crops seedlings were planted. These measures stabilized the watershed and contributed to increased water infiltration, retention and recharge. The IWRM approach stimulated community involvement in sustainable water and land management. This enhanced local capacity to support the ongoing and future conservation activities. Overall, this initiative improved water quality and quantity, enhanced soil fertility, increased productivity through improved agricultural practices, improved household income to livelihood diversification, and enhanced community resilience to climate change.

Conclusion: The IWRM initiative has shown positive results in improving access to safe water, restoring degraded landscapes, and improving water management practices. Physical and biological conservation measures have revitalized farmlands and communal lands, fostering improved microclimates and potentially enhancing agricultural productivity. The project's success in stimulating community engagement and ownership of environmental conservation efforts provides a scalable model for similar geographies facing water and land management challenges. This study highlights the vital results from the IWRM approach in enhancing water security and ecosystems resilience.

Groundwater at Risk: Applying DRASTIC-GIS Modeling to Guide WASH Decision-Making in Ethiopia's Tana Sub-Basin
Kelly Alexander, CARE

Groundwater is a vital source of drinking water, irrigation, and livelihoods in the Tana Sub-Basin, Ethiopia. However, it faces escalating threats from both natural and human-induced contamination, placing water security and public health at risk. Protecting groundwater quality is essential to ensure resilient and sustainable WASH services. This study assessed groundwater vulnerability in 21 districts of the Tana basin using the DRASTIC model integrated with Geographic Information Systems (GIS). Seven hydrogeological parameters: - depth to water table, net recharge, aquifer media, soil media, topography (Topographic

Wetness Index), vadose zone impact, hydraulic conductivity and land use/land cover were analyzed.

Vulnerability maps were produced and validated using water quality samples for E. coli, phosphate, and nitrate. The DRASTIC model categorized groundwater vulnerability into four classes: very low (<101), moderate (101–140), high (141–200), and very high (>200). Notably, 56.2% of the study area falls into high-risk zones. Validation showed strong positive correlations between predicted vulnerability and observed contamination: 63.6% of E. coli-contaminated samples and 79.4% of phosphate-contaminated samples were in high-risk zones, confirming the model's predictive reliability.

The findings highlight critical zones where groundwater protection efforts must be prioritized. The DRASTIC-GIS framework offers a practical decision support system for WASH practitioners, enabling more informed site selection for new wells, thereby reducing the risk of contamination and optimizing resource allocation. By guiding well siting toward lower vulnerability areas, the approach supports significant cost reductions by minimizing borehole failures and reducing the need for expensive water treatment.

Integrating vulnerability mapping into WASH programs allows practitioners to better anticipate contamination risks and design proactive, evidence-based interventions. Groundwater vulnerability assessment using the DRASTIC-GIS approach provides actionable intelligence for strengthening climate-resilient and health-secure WASH services. Moreover, it enhances siting efficiency and reduces project implementation costs. This model can be scaled across other vulnerable regions to inform smarter WASH investments, groundwater management, and community resilience planning.

Evaluation of Aluminum Electrocoagulation Performance Indicators for Decentralized Drinking Water Treatment
Monica Castro Carias, University of South Florida

Background
Globally 180 million people are exposed to groundwater containing fluoride levels exceeding the 1.5 mg/L WHO guideline. Previous studies demonstrate the effective removal of fluoride with aluminum electrocoagulation (EC) as an affordable alternative for decentralized treatment. More than 200 EC treatment units have been installed in India to address geogenic fluoride contamination, which face operational challenges due to the lack of non-chemical indicators to determine the frequency of plate replacement. Additionally, limited studies have investigated the effect of electrode wear on treatment efficiency during long-term operation. The aim of this study is to correlate the coagulant dose (aluminum concentration), current density, electrode wear (pitting distributions and

passivation) in a bench-scale EC reactor to develop non-chemical methods of evaluating treatment efficiency.

Methods
Our study evaluates the effect of plate health on treatment efficiency using two coagulant doses by applying different constant voltages (8 V and 12 V) for 80 hours of treatment. In general, we assume that 1 hour of plate use corresponds to 1 day of use by a rural installation, therefore our system represents plate degradation over 80 days. The coagulant dose (total and dissolved aluminum concentration), pH, conductivity, and temperature are measured in 0.5-hour intervals for the first two hours of batch treatment for every 10-hour cycle in the bench reactor. The current density will be continuously monitored using a data acquisition system. Electrode pitting, passive film formation, and mass loss will be quantified every 20 hours.

Results
Preliminary results at a constant voltage of 10 V show a positive correlation between aluminum concentration and current density (R2= 0.68-0.99). This suggests that current density is a promising, non-chemical indicator for optimal aluminum dosing. The EC reactor produced sufficient aluminum for 72 hours of plate use (equivalent to 2.5 months of field use), after which the aluminum coagulant concentration remained less than 28.3 mg/L Al, the equivalent to 300 mg/L of alum required to treat 5 mg/L of fluoride. Following 72 hours of plate use, longer reaction times were required to produce the aluminum concentration of 28.3 mg/L required, translating to higher energy requirements.

Conclusions
Our results indicate that plate replacement may be required after 2.5 months of treatment in a buffered solution similar to groundwater. In discussions with district engineers and EC operators in the Yavatmal District of Eastern Maharashtra where many EC installations are located, plates are recommended for replacement every 3-4 months, however many installations have not exchanged the plates in over a year. The results suggest that treatment inefficiencies are occurring prior to this recommended and actual plate replacement period. This means water is not being adequately treated, potentially posing a health risk to residents. To address this issue, we propose the monitoring of current density as treatment efficiency indicator. Ongoing research is expanding on this study to evaluate plate pitting patterns at different stages of treatment to determine an additional qualitative indicator for required plate maintenance.

Primary prevention of lead in drinking water through substitution of lead-free plumbing components- preliminary results
Michael Fisher, The Water Institute at UNC; UNC Chapel Hill

Lead (Pb) occurs in drinking water and can cause organ damage, cardiovascular disease, cancers, and lifelong neurological and developmental impairment, with particular harm to infants and developing fetuses. No safe level of lead has been identified. WHO sets a guideline for lead in drinking water at 10 µg/L, based on technical achievability. Available evidence suggests that lead in drinking water is primarily derived from corrosion of leaded materials used in water systems and/or premise plumbing, and its occurrence can be prevented through the use of lead-free materials and/or optimized corrosion control. Since corrosion control has not been widely implemented in small and rural water systems in many low- and middle-income country (LMIC) settings, it is important to evaluate the effectiveness of primary prevention strategies such as refining supply chains to eliminate lead-containing parts. This work summarizes a field study evaluating such a prevention effort in rural Ghana.

In total, 577 first-draw water samples were collected from a total of more than 300 water systems (boreholes with handpumps and "mechanized" boreholes connected to one or more taps) over multiple sampling rounds (2 rounds completed to date). These included existing water systems using conventional parts and 100 newer "lead-free" water systems constructed using non-leaded (<0.25% lead) parts and materials co-located in the same 10 districts. Water samples were acidified and analyzed by ICP-MS for lead. Sample pH, conductivity, and alkalinity were measured in non-acidified samples to quantify water corrosivity. Selected water system components were characterized by handheld x-ray fluorescence (XRF) in each water system to quantify lead content. Quality assurance/quality control (QA/QC) statistics were calculated based on QC samples (blanks, duplicates, standards) and the distribution of results (continuity and symmetry of distributions, etc.) using a novel R package.

Overall, lead exceeded WHO guidelines in approximately 4% of samples. Lead content exceeded 0.25% in brass valves, cylinders and taps, as well as galvanized steel tanks, spouts, and other parts in several systems. Lead concentrations in drinking water samples were compared to water system age, type (borehole with handpump vs mechanized system), source water corrosivity, and study arm (existing vs "lead-free" water systems). The results of this work (to be finalized in August, 2025) are expected to highlight the importance of procuring and verifying lead-free parts in rural drinking water systems to prevent lead leaching into drinking water. These measures are particularly important for systems where corrosion control may not currently be implemented. Future work may explore the effectiveness of corrosion control and other methods for further reducing lead leaching from existing water systems. The R package used to automate QA/QC calculations in this work is expected to be made publicly available to assist regulators, implementers, and others in ensuring that high-quality data are obtained to facilitate the monitoring and management of lead in drinking water in small and rural LMIC systems and in other settings as applicable.

Wednesday Poster Abstracts

Assessing microbial cleanliness of high-touch surfaces in health facilities in Uganda: comparative study using locally-produced sodium hypochlorite and commercially available chlorine
Adam Drolet, PATH

Background

Healthcare associated infections (HAIs) negatively impact hundreds of millions of vulnerable populations globally including mothers and infants. In Uganda, HAIs affect an estimated 15% to 34% of patients in health care facilities (HCFs) and account for 10% of maternal deaths and 18% of neonatal deaths. Chlorine is an effective chemical disinfectant recommended for infection prevention and control (IPC) in health care settings, yet the lack of consistent availability and sufficient quantity (annual chlorine stock outs last an average of 74.3 days in Uganda) contribute to the transmission of pathogens. Electrolytic chlorine generators offer a solution to address supply chain and budget issues that lead to insufficient chorine availability and quantity and high costs.

Study design

PATH and the Uganda Ministry of Health's (MOH) Clinical Services Department have partnered to assess the effect of the Aqua Research STREAM™ Disinfectant Generator on IPC practices and outcomes in 24 health care facilities (20 intervention and 4 control) across 11 districts of the country. The study is taking place from March to August 2025 and seeks to assess: (1) microbial cleanliness levels (ATP) of high-touch surfaces in surgical theatre, labor, and postnatal wards following standard cleaning with STREAM chlorine and commercial chlorine; (2) change in chlorine availability and quality; and (3) the STREAM's total cost of ownership compared with commercial chlorine costs.

Results

A total of 511 swab samples were collected from patient bedrails, mattresses, and door handles within the 24 study health facilities at baseline. Patient mattresses reported the highest mean ATP levels prior to any cleaning intervention (3,550 mean relative light unit [RLU]), followed by bedrails (3,401 RLUs), and door handles (1,771 RLUs). Mean ATP reductions following the first surface cleaning ranged from 1,872 – 3,369 RLUs (79-97%) across the three wards in intervention sites to 1,279 – 5,128 RLUs (93-96%) in control sites. An average of 49% of surfaces met the <100 ATP cleanliness threshold in intervention sites following the initial cleaning, while 44% of surfaces in control sites reaching this threshold.

Analysis of chlorine stock availability from the 24 health facility inventory records showed that between June 2024 and February 2025, two health facilities reported chlorine stockouts lasting 3 and 156 days. Since March 2025, a total of 5,120 liters of 0.5% STREAM

chlorine has been generated. We expect to present final results on the following end-points: (1) percentage of high-touch surface samples with ATP scores of less than 100 and average ATP scores over time, by facility and ward; (2) change in average monthly chlorine volume (liters) available; (3) average concentration (mg/L) and percentage of commercial and STREAM chlorine samples that comply with their listed concentration levels; and (4) total expected STREAM capital and operational costs over five years for NOP compared to commercial chlorine products.

Discussion
The MOH has approved use of the STREAM device for Uganda's public health system. Evidence generated in this study will directly inform national scale up strategies.

Monitoring Gender in Water, Sanitation, and Hygiene: Lessons from Testing Priority Indicator Measures in Bangladesh
Bethany Caruso, Rollins School of Public Health, Emory University

While the 2030 Sustainable Development Goal Agenda prioritizes achieving gender equality across all 17 goals, SDG 6—which seeks to 'Ensure availability and sustainable management of water and sanitation for all'—has been criticized for lacking gender-specific indicators for global monitoring. In response, the WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation, and Hygiene (JMP), the global custodians of data on drinking water, sanitation, and hygiene (WASH), collaborated on a multi-phase initiative with Emory University to identify priority gender indicators. The vision is for the identified priority set to complement existing indicators for monitoring SDG targets 6.1 and 6.2 and be integrated into national and global monitoring systems. Through a multi-stakeholder process, a priority set was identified and published in March 2024. However, not all indicators have identified or tested the survey questions necessary for data collection and eventual reporting. The objectives of this session are to 1) describe the approach for testing the indicator survey questions; and 2) present lessons learned and preliminary data from testing in Bangladesh.

Approach: Testing the priority gender indicator survey questions in Bangladesh involved: 1) stakeholder meetings, 2) cognitive interviews, and 3) survey data collection. Through seven in-person stakeholder meetings (February 2025), we sought feedback on where the survey questions should be tested and solicited suggestions for additional gender indicators that could also be tested based on local priorities. Through 48 cognitive interviews with men and women in six regions of the country selected to represent environmental and social variability (February-March 2025), we sought to assess participants' understanding of proposed survey questions, enabling adaptation as needed. Through survey data collection with 600 participants (300 men, 300 women; April-May 2025) in the same regions, we aimed to identify lessons about collecting these survey questions, generate the first priority

indicator data set, and assess differences by gender and region.

Lessons Learned and Preliminary data: Stakeholder meetings were critical for determining where to carry out cognitive interviews and survey data collection. There was broad agreement on which areas should be represented, resulting in the expansion of our data collection from three regions (as planned) to six. Stakeholders supported testing the existing priority indicators, and many offered ideas for additional indicators to test that were relevant to Bangladesh, including for assessing water treatment and toilet-cleaning responsibility, sanitation decision-making, soap access, and menstrual material disposal. Cognitive interviews revealed the need for translation changes, wording specification, and the addition of survey question response options (including for existing survey questions used to monitor targets 6.1 and 6.2). Field testing has demonstrated that collecting gender-balanced, individual-level data poses challenges. Notably, women are more often available than men, making it harder to get data from men to enable disaggregated analyses. These disaggregated analyses will be presented at the conference.

Overall, our approach for testing the indicator survey questions has yielded lessons that justify testing prior to deploying surveys at scale. The approach provides an important roadmap for testing other indicator questions, particularly (but not exclusively) those that have yet to be deployed at scale.

Automated Classification of Sewage Infrastructure Vulnerabilities in Urban Salvador, Brazil
Christine Stauber, Georgia State University

Background: Urban sewage infrastructure vulnerabilities pose significant public health risks in low- and middle-income countries, with direct implications for waterborne disease transmission, environmental contamination, and community well-being. Service providers face substantial challenges in identifying and prioritizing sewage system failures across vast urban areas with limited resources. While visual inspection is critical for identifying these risks, manual classification remains resource-intensive, inconsistent, and creates delays in addressing community concerns. Automated, computer-based classification systems offer promising solutions for accelerating this process, yet their application to sewage infrastructure in resource-constrained settings remains underexplored. As part of a study on simplified sewer interventions in four neighborhoods in Salvador, photographs were collected of sewage infrastructure and infrastructure vulnerabilities. We assessed the ability to categorize these photographs using an automated classification system.
Methods and Findings: During our work, we selected and categorized 287 images of sewage infrastructure vulnerabilities previously identified and selected by the field research team across seven types: exposed plumbing (n=164), open sewage point (n=71), pipe outcropping (n=29), exposed connection (n=10), leak (n=5), damaged connection

(n=3), and other (n=5). Several significant challenges were encountered during data preparation: (1) inconsistent image quality due to variations in resolution, orientation, and inclusion of screenshots taken under different lighting conditions; (2) class imbalance was due to significant skew in the number of samples per category limited model training options; and (3) overlapping categories as identified issue types were closely related. Due to these constraints, we focused on developing a binary classification model for the two most prevalent categories using only 104 training images (52 from each category). We implemented a transfer learning approach with a modified ResNet50V2 architecture, employing image enhancement techniques (contrast and sharpness enhancement), data augmentation (rotation, zooming, flipping, brightness variation), and a three-phase progressive training methodology with gradual unfreezing of network layers. Model performance was evaluated using stratified cross-validation with standard classification metrics. Despite the limited training data, our model achieved over 90% accuracy in distinguishing between the categories of exposed plumbing and open sewage points. The progressive unfreezing approach significantly improved performance compared to conventional training methods. Visualization of model predictions revealed effective feature learning for infrastructure-specific characteristics. The model demonstrated robust generalization across different neighborhood contexts, though performance varied slightly based on image quality and environmental conditions.

Conclusion: This study demonstrates the feasibility of developing accurate deep learning models for sewage infrastructure classification even with severely constrained training data. Our findings have implications for urban infrastructure monitoring in resource-limited settings, enabling more efficient identification of potential public health hazards. For service providers, this automated classification system offers multiple operational benefits: (1) rapid triaging of reported infrastructure issues through standardized vulnerability categories; (2) improved response prioritization based on public health risk assessment; (3) optimized resource allocation for maintenance and repairs; and (4) enhanced data-driven decision making for infrastructure planning. Additionally, the classification system could integrate with existing mobile health applications (mHealth) to create a feedback loop between community reporting and institutional response, ultimately improving service delivery transparency and community trust.

Sanitation Work Without Safeguards: Institutionalising Occupational Health Protocols in Urban Tamil Nadu
Arka Sinha Roy, Indian Institute For Human Settlements

Background: Sanitation workers in Tamil Nadu (TN), India's most urbanised state (48.45%, 39 million people) , face hazardous working conditions without Occupational Health (OH) protections as mandated for other high-risk occupations under the Factories Act, 1948, or the Mines Act, 1952. Despite 53,301 members working across 649 Urban Local Bodies

(ULBs) , their risks remain unaddressed. This study established OH as a statutory right and a public health priority by developing and piloting a scalable, evidence-based protocol. Research Question: How can a scalable OH protocol be developed and integrated into public health governance to address specific occupational health risks of sanitation workers in urban Tamil Nadu?

Study Design: A mixed-methods, participatory approach included:

- Desk Review: Analysed 47 policies, research papers, and code.
- Rapid Assessment: Evaluated health screening arrangements for sanitation workers across ULBs (corporations, municipalities, and town panchayats)
- Advisory Group: Engaged 80+ stakeholders (officials and worker representatives) from Public Health, Labour, and Urban Administration departments in an advisory group.
- Field Pilots: Screened 300+ workers in 4 ULBs of Coimbatore, Tiruchirappalli, Chengalpattu, and Maraimalai Nagar.

Key Findings:

- Fragmented services that were incapable of diagnosing occupational health consequences and excluded informal workers.
- High rates of preventable conditions like high blood pressure (71%) and anaemia (40% in women) were detected at pilot screenings.
- At Maraimalai Nagar (196 workers), vision problems (nearly 50%) and hearing loss (60%), heart issues (46%), and others like substance use, body pain, and skin problems were detected, reflecting systemic neglect.
- Reactive safety measures practised, such as over-reliance on PPE.

Discussion: This study establishes OH as a core component of TN urban public health governance through a scalable protocol for sanitation workers. It integrates systematic diagnoses, digital health tracking, and interdepartmental accountability to address the systemic neglect of workers' health risks. By aligning with national missions such as SBM and AMRUT, it ensures continuous care and data-driven decision-making. A key feature is its focus on gender equity, addressing diagnostic and access gaps for female workers through targeted screenings. It mandates pre-employment and biannual OH screenings to detect preventable conditions early through digital longitudinal health monitoring tools. Additionally, it establishes clear referral pathways to primary health centres and Employees' State Insurance Corporation hospitals. By embedding OH into public health systems, this initiative sets a replicable model for rights-based, risk-informed policymaking, with the potential to transform health service delivery for high-risk sanitation work across India and beyond.

Prevalence and factors associated with different MHM products using status among the low-income women in Bangladesh
Hasin Jahan, WaterAid Bangladesh

Introduction
Globally, an estimated 1.8 billion women and girls, approximately 26% of the population, menstruate monthly. Despite being a natural physiological process, many lack access to safe and dignified menstrual hygiene management (MHM), affecting nearly 500 million individuals worldwide. Access to affordable, hygienic products is essential for health, dignity, and participation in education, work, and social life of women. However, in low- and middle-income countries like Bangladesh, menstrual health remains poorly addressed. Key barriers include high product costs, limited availability, cultural taboos, and insufficient education. Hence, this study aims to identify the factors associated with the use of different menstrual hygiene products among low-income women and adolescent girls in Bangladesh.

Methodology
A mixed-method cross-sectional study was conducted to explore the factors associated with the use of various MHM products, including old clothes, sanitary napkins, and reusable pads. The study surveyed 1,183 respondents (387 adolescent girls and 796 adult women) from low-income communities across both urban and rural areas of Dhaka, Satkhira, and Bandarban. In addition to the survey, qualitative data were collected through 22 FGDs, 35 IDIs, and 8 KIIs.

Results
The study results indicate that the median age of menstruation is 13 years among women, while adolescent girls typically begin menstruating at age 12. Regarding the first menstrual hygiene product used, 72% of respondents reported using old cloths, whereas 27.9% mentioned disposable pads. Among all respondents, 92% (n = 1059) had used sanitary pads at some point, and 71% reported using them at least once during their last three menstrual cycles. In contrast, 88% (n=1020) had used menstrual cloth at some point, with 34% currently using old cloths as their MHM product. Among the respondents 3% respondents ever used reusable sanitary pad. Comfort was the primary reason for choosing sanitary pads, cited by 93%-97% of users across groups. Other influential factors included availability (29%-43%) and ease of disposal (15%-21%), while rural participants more frequently mentioned suggestions of peer influenced them to use sanitary pad. Trusted recommendations had minimal influence (14%). In the case of menstrual cloth, affordability was the most dominant factor (81%-97%) across groups, followed by comfort (10%-38%) and peer influence (14%-22%). Additional reasons included ease of reuse, lack of alternative products, and limited awareness of other options. Among reusable pad

users, 78% cited affordability as the primary reason for their choice, followed by receiving the pads as gifts from NGOs (53%). Comfort and peer influence were each reported by 22% of users. Regression analysis showed that higher education was positively associated with sanitary pad use (OR:2.404, 95% CI:1.459-3.961, p=0.001). In contrast, factors negatively associated with sanitary pad use included rural residence (OR:0.419, 95% CI:0.263-0.669, p<0.001), limited decision-making power regarding MHM expenditure (OR:0.545, 95% CI: 0.373-0.795, p=0.002), and increasing age (OR:0.901, 95% CI:0.878-0.924, p<0.001). A separate model further indicated that rural women were 56% more likely to use cloth compared to their urban counterparts (OR:1.564, 95% CI:1.113–2.197, p=0.010).

Conclusions

The study identified affordability, education, age, residence, and decision-making autonomy as key factors influencing sanitary pad use. Improving affordability through subsidies and supporting local manufacturers for reusable products is essential. Expanding product availability in rural and low-income areas, while promoting reusable alternatives through education and awareness, can enhance access. A coordinated effort by the government, NGOs, and the private sector is necessary to ensure equitable, affordable, and sustainable menstrual hygiene management.

Scaling Urban WASH Systems in Low-Resource Settings: Integrating Infrastructure, Governance, and Community-Led Solutions in Mbale City, Uganda
Hajra Mukasa Comfort, WaterAid Uganda

Background/Introduction

Prior to the WASH for SMART Cities project (2021–2024), Mbale City, Uganda, faced severe Water, Sanitation, and Hygiene (WASH) challenges exacerbated by rapid urbanization, and inadequate infrastructure. Key issues included:
• Schools: Pupil-to-latrine ratios of 72:1 (vs. recommended 40:1), limited menstrual hygiene management (MHM) facilities, and only 63% access to basic drinking water.
• Healthcare Facilities (HCFs): 88.9% lacked basic sanitation, 72.2% had no functional handwashing stations, and 22.2% treated water before use.
• Communities: 36% used improved toilets, 19.4% of children under five had diarrhea, and 71.9% of women lacked privacy for MHM.

Project Interventions

The project, implemented by WaterAid Uganda and partners, adopted a systems-strengthening approach:

- Infrastructure: Constructed 96 inclusive latrines in 8 schools, 54 disability-friendly sanitation facilities in 9 HCFs, and installed rainwater harvesting systems (10,000–40,000L) in schools/HCFs.
- Community Empowerment: Trained 22 cesspool emptiers and 20 women's groups to manage fecal sludge and public toilets, fostering local entrepreneurship.
- Technology: Deployed solar-powered water purifiers and Mwater, a digital platform for real-time WASH monitoring.
- Governance: Supported Mbale City Council to develop a 2024–2030 WASH Investment Plan and integrated WASH into budgets.

Purpose and Research Questions
The evaluation aimed to assess:

1. How effective were integrated WASH interventions in improving health and institutional resilience?
2. What governance strategies optimized sustainability and equity?
3. How did gender-inclusive infrastructure address barriers to access?

Study Design
A mixed-methods approach included:

- Quantitative Surveys: 438 households, 8 schools, 9 HCFs (baseline vs. endline).
- Qualitative Data: 26 key informant interviews, 22 focus group discussions (FGDs), and field observations.
- Systems Analysis: Evaluated WASH "building blocks" (infrastructure, governance, financing).

Key Findings

- Health Outcomes: Diarrhea prevalence in children under five dropped 26% (19.4% to 14.4%).
- Schools: Pupil-to-latrine ratio improved to 48:1; 100% of schools provided MHM facilities, reducing female absenteeism by 27%.
- Healthcare Facilities: 100% gained basic water access; hygiene compliance at care points rose from 72.2% to 86%.
- Households: Safe water coverage reached 97.6%, improved sanitation rose from 36% to 61%, and MHM privacy improved to 98.7%.
- Economic Impact: Women-led public toilet groups generated $40–$175 monthly, reinvesting profits into community loans.

Discussion

The study validates the effectiveness of integrated WASH systems in urban settings, particularly for mitigating climate vulnerabilities (e.g., rainwater harvesting during dry spells). This gives confidence for scale. Highlights the need for life-cycle costing in WASH budgets and formalizing public-private partnerships (e.g., cesspool emptier associations), key for policy influence. Demonstrates scalability of community-led models and gender-responsive infrastructure (e.g., MHM rooms, disability-inclusive latrines).

Conclusion:
This research provides a replicable plan for achieving SDG 6 in low-resource urban contexts, emphasizing community ownership, institutional capacity building, and climate-resilient infrastructure. Its innovations in equity and hybrid financing offer critical insights for global WASH policymakers.

Reusable Sanitary Pads for Menstrual Hygiene Management: Breaking Barriers, Inspiring Change in Rwanda
Jean Baptiste Nsengiyumva, WaterAid Rwanda

Menstrual health management (MHM) remains a pressing challenge in many low- and middle-income countries, where women and girls still face limited access to safe, affordable menstrual products, resulting in profound social, educational, economic, and health consequences. In Rwanda, period poverty is linked to school and work absenteeism and broader gender inequality. The current study assessed the feasibility of promoting reusable sanitary pads (RSPs) as a sustainable, affordable, and scalable solution to improve menstrual health and hygiene outcomes in Rwanda. The study aimed to evaluate the social, economic, financial, environmental, and regulatory feasibility of RSPs and their alignment with national safety policies and development goals. Using a mixed approach, the study was conducted from December 2021 to March 2022 across seven districts in four provinces and the City of Kigali. A total of 670 respondents were engaged, comprising 455 quantitative survey participants, 16 focus group discussions and deliberative forums, 42 key informant interviews with policymakers and stakeholders, and seven interviews with RSP factory representatives. Data were analyzed using descriptive and inferential statistics, alongside thematic analysis for qualitative insights. The findings revealed that 92.1% of women and girls perceive RSPs as safe and are willing to use them. Despite growing awareness since 2016, 38.7% still rely on unsafe menstrual methods, and 72.9% reported affordability as a major barrier. Statistically, RSP usage correlates with education level ($p<0.05$), but not with age or household roles, underscoring the universal need for accessible menstrual products. Economically, RSPs offer a compelling alternative, costing an average of RWF 280 per month compared to RWF 961 for disposable pads. Rwanda's seven existing RSP factories operate below capacity, producing only 6% of the national annual demand, indicating significant market and employment potential, particularly for

women. Scaling up production could create over 700 new jobs nationwide. Environmentally, RSPs offer a crucial solution to the growing challenge of plastic waste from disposable pads, projected to reach 5.4 billion units in Rwanda alone. A national shift toward RSPs could reduce sanitary waste by 30%. However, the absence of national product standards and regulatory frameworks hinders scale-up, with only 51.7% of Rwandan-made RSPs adhering to informal standards and none officially certified. In contrast, regional peers in the East African Community have adopted and standardized RSPs. The study concludes that RSPs present a viable, impactful solution for improving menstrual health and achieving broader sustainable development outcomes. However, this requires coordinated action to address regulatory gaps, scale production, reduce raw material costs, and invest in public awareness and education. The study recommends that the Government of Rwanda waive taxes on RSP raw materials, establish clear product standards, and lead the development of a national MHM strategy in collaboration with development partners. WaterAid Rwanda is encouraged to continue advocating strategically for RSP adoption through research, policy dialogue, and community mobilization. This study generated new evidence for policymakers, practitioners, and researchers, highlighting how scaling up RSPs can promote gender equity, environmental sustainability, menstrual hygiene, as well as economic empowerment in Rwanda and other areas with similar contexts.

Evaluating Menstrual Health Pedagogical Interventions: Knowledge Acquisition, Attitudinal Shifts, and Confidence Development in Cambodian Teachers
Jess Strait, Days for Girls International

Background
Inadequate menstrual health education can negatively impact human development outcomes, including gender equality, health, and economic participation. In Cambodia, limited research has shown that inadequate menstrual health education has led to student knowledge gaps and feelings of anxiety and shame at menarche, as well as barriers to school participation. The present study seeks to assess the preparedness of Cambodian teachers to deliver student-centered menstrual health education and the efficacy of a menstrual health teacher training curriculum on improving instructor preparedness.

Methods
In partnership with the Cambodian Ministry of Education, Youth, and Sport, the Cambodia Rural Education Support Organization, Days for Girls International developed and implemented a 3-day teacher training curriculum as part of the "Menstrual Health for Gender Equality Program" within Teacher Education Colleges. The present study employed a mixed-method design to measure changes in teachers' knowledge, attitudes, and confidence on the subject of menstrual health and related instruction to students following

participation in the teacher training intervention between May and August of 2024. Quantitative results were obtained via paper-based self-completion structured questionnaires completed by instructors of grades 5, 6, and 8-10 at teacher education colleges in Ratanakiri (n=95), Phnom Penh (n=54), and Sihanouk Ville (n=59) provinces. Pre- and post-test questionnaires were administered to gauge baseline knowledge and attitudes and assess knowledge acquisition and attitudinal shifts following the teacher training. Additional qualitative results were obtained via offline face-to-face in-depth interviews with teachers in Ratanakiri (n=8).

Results
The study revealed that prior to the teacher training, teachers faced significant knowledge gaps, held negative attitudes, and lacked the resources and confidence to provide instruction on menstrual health. Pre-test knowledge scores were lowest in the subject areas of the menstrual cycle, female anatomy, and reproduction. This evidence informed the need for comprehensive menstrual health education for the teachers themselves in addition to a structured curriculum and accompanying teacher training resources. Pre-test questionnaires also revealed negative attitudes about menstruation among teachers, including beliefs that girls could not play sports or eat particular foods during menstruation.

The pre- and post-tests also assessed teacher confidence in delivering menstrual health education. In the pre-test, an average of 35% of teachers across the represented provinces indicated confidence in providing instruction on menstrual health. Following the teacher training intervention, the post-test demonstrated that 98% of teachers felt confident to teach the subject. These results highlight the underutilization of teachers in the menstrual health ecosystem, and make evident that when teachers are given accurate menstrual health education and teaching techniques, they feel more confident to equip their students and communities with the same knowledge.

Conclusion
Ensuring teachers are equipped to deliver menstrual health education effectively requires systemic changes, beginning with education for the teachers themselves. Findings from the study support recommendations to integrate menstrual health training at Teacher Education Colleges and through continued professional development, as well as to develop and disseminate comprehensive menstrual health education resources for teachers within the Cambodian context.

Assessing the psychological and physical effects of distant water sources on Tanzanian rural women
Tula Ngasala, Michigan State University

In rural Tanzania, the socioeconomic burden of collecting water lies disproportionately on women and children. When water becomes scarce, people are forced to use more distant, unprotected, and contaminated water sources, leading to many challenges that impact their quality of life. Challenges related to water scarcity affect women more than men because women are usually responsible for obtaining water used within the household. The objective is to examine the links between challenges women experience during water collection, the time spent on water collection and the water source types used. The study was conducted in rural northern Tanzania where residents experience water scarcity resulting in much time spent on water collection. Data was collected by mapping water sources and interviews with 69 married women to identify commonly used water sources, time spent on water collection, and challenges experienced during water collection. The three types of water sources identified were shallow wells, deep wells, and surface water. The challenges reported were grouped into three categories: (1) physical or emotional abuse from their intimate partners, (2) psycho-physiological stress, and (3) health problems. Multinomial logistic regression was used to predict the probability of a link between three challenge categories with 1) time spent on water collection and 2) type of water sources used. Results showed more than 60% of the women surveyed spend more than 1 hour (one-way) to collect water. Nearly 81% use surface water and shallow wells regularly, with only 19% using water from deep wells. Multinomial regression analysis results indicate that women who reported using surface water or shallow wells were likely to experience physical or emotional abuse from their partners (OR=7.8, 95%CI [3.07, 19.79]) as well as psycho-physiological stress (OR=2.43, 95%CI [1.00, 5.86]). Women who reported using domestic wells were more likely to experience health problems as compared to psycho-physiological stress or abuse from their partners (OR=3.2, 95%CI [0.94, 8.74]). Findings also showed that women who spent less than 30 minutes (one-way) were less likely to experience psycho-physiological stress (OR=0.33, 95%CI [0.12, 0.92]) but those who spent more than 1 hour (one-way) were likely to experience physical or emotional abuse from their partners (OR=9.2, 95%CI [3.66, 23.15]) as well as psycho-physiological stress (OR=12.5, 95%CI [4.9, 31.7]). In conclusion, most women preferred water sources that were more distant because they were free and accessible, but nearby water sources were not free. Findings showed that time spent collecting water influences both physical and emotional abuse and psycho-physiological stress. Health problems were also mentioned but were not statically dependent on water collection time. The government at the national and local levels should prioritize water resources management as well as implement alternative water sources i.e. rainwater harvesting to enhance the quality of life for women and ultimately decrease the likelihood of physical or emotional abuse, psycho-physiological stress, and health problems related to water scarcity. The Tanzanian Ministry of Water should establish programs that allow women to have their voices heard and be involved in all stages of planning, construction, and management of water sources.

Where is My Right? Social Security Access for Sanitation Workers in Nepal
Seema Rajouria, WaterAid Nepal

Introduction: Sanitation workers in Nepal, predominantly from marginalized 'untouchable' castes, deliver essential public health services amidst deep-rooted social stigma, inadequate compensation, and significant occupational health hazards. This study, commissioned by WaterAid, investigates the extent to which these vital workers can access existing social protection mechanisms in Nepal.

Objectives: This research aimed to: (1) assess the access of sanitation workers in Nepal to both contributory and non-contributory social protection schemes; (2) identify the key barriers hindering their access; and (3) provide evidence-based insights to inform policy and practice towards ensuring their social security.

Methods: Primary qualitative research was conducted across four urban centers in Nepal: Kathmandu Metropolitan City, Lalitpur Metropolitan City, Bhaktapur Metropolitan City, and Lahan Municipality. Data collection involved focus group discussions with 50 sanitation workers and key informant interviews with 16 municipality officials. A stakeholder meeting was also convened to gather feedback on existing policies and potential reforms.
Findings: The study revealed that while Nepal's 2018 Non-Contributory Social Protection Act offers universal allowances for certain vulnerable groups (senior citizens, single women, persons with disabilities), sanitation workers, particularly those in the largely informal sector, face significant exclusion from contributory schemes such as health and life insurance, and pensions. Key barriers identified include the increasing informalization of labor through outsourcing, a pervasive lack of awareness regarding available social security schemes (including the newly introduced Social Security Fund), and stringent citizenship documentation requirements that render many ineligible, entrenched caste-based social stigma and marginalization, often compounded by gender; and onerous and complex procedures for accessing the limited available schemes. Even formally employed sanitation workers reported facing complex administrative hurdles in accessing retirement benefits.

Recommendation: Social protection for Nepal's sanitation workers needs to be improved by formalizing employment through policy reforms, maximizing access to existing schemes via broader eligibility and better information, and initiating targeted, contributory schemes for health, safety, and pensions with shared responsibility from the state and employers.

Conclusion: Despite the existence of a national social protection framework, sanitation workers in Nepal experience severely limited social security coverage. The prevailing informality of their employment, coupled with lack of awareness and exclusionary criteria,

leaves them highly vulnerable. Urgent policy attention is required to formalize sanitation work, enhance information dissemination about social protection schemes, address citizenship-related barriers, and design targeted interventions that recognize the specific needs and risks faced by this essential yet marginalized workforce.

Estimating the Cost and Cost Savings of a WASH/IPC Program in Health Facilities in Nigeria
Stephen Sara, Save the Children

Background: Birthing mothers and newborns are among the most at-risk patients for contracting healthcare-associated infections (HAIs). An estimated 18.6% of newborn deaths and 15% of maternal deaths in Nigeria are attributed to HAIs. There is ample global evidence linking environmental cleanliness and basic IPC practices to HAI reductions. However, little evidence exists on the incidence of HAIs in LMICs, or the cost and cost-savings of WASH and IPC improvements aimed at reducing HAIs in these contexts. Findings from high-income countries suggest a very strong business case - and quality of care argument - for prioritizing investments in WASH and infection prevention.

Methods: This study estimated the cost of implementing a supplemental WASH/IPC program in eight secondary, public healthcare facilities (HCFs) in Abuja, Nigeria and weighed those costs against the potential savings from avoided treatment costs for HAIs. We hypothesized that the cost of implementing a supplemental WASH/IPC program in a secondary, public, health care setting would be less than the cost of treating maternal and newborn HAIs, thereby generating potential savings in avoided treatment costs of HAIs. The longitudinal, mixed-method study applied both quantitative and qualitative methods to collect data and answer our objectives, including the application of a contribution analysis to understand the likely contribution of the study's WASH/IPC intervention on changes in environmental cleanliness, health outcomes, and healthcare costs.

Results: The cost of implementing the supplemental WASH/IPC intervention during the study was $124,155 over one year (or approximately $15,519/HCF). The number of confirmed HAIs in participating HCFs decreased from 82 HAIs in the year preceding the intervention to 38 HAIs during the intervention period, while live births remained stable. This reduction, across eight HCFs, led to estimated cost savings of $12,237–$17,150, depending on infection severity.

Discussion: The findings show that supplemental WASH/IPC programs can reduce HAIs and partially offset program costs through savings on infection treatment. Importantly, findings show that a supplemental WASH/IPC program contributes to cleaner health care environments and reductions in HAIs, which generate potential cost savings to HCFs for

treating HAIs. However, the aggregate cost of the supplemental WASH/IPC intervention activities surpassed the cost of treating maternal and newborn HAIs. Study limitations related to scope (narrow ward and population focus), HAI surveillance and record-keeping suggest potentially higher cost-savings from WASH/IPC interventions than shown in this study.

Assessment of Faecal Sludge Management System in Emergency Rohingya Refugees Response in Cox's Bazar, Bangladesh
Md Toriqul Islam, NGO Forum for Public Health

Bangladesh is currently experiencing the world's fastest increasing Rohingya refugee settlement issue. With limited resources and available space, managing feces sludge in emergency settlements with a high population density is becoming increasingly difficult. Onsite sanitation and the removal of human waste are mainly unregulated in Bangladesh. In this study, thirty-three (33) camps with 197 Fecal Sludge Treatment Plants (FSTPs) were utilized, and around eight different faecal sludge (FS) treatment methods were used. In order to develop a clear understanding of the current faecal sludge management (FSM) practices in the target area, the study utilized a modified version of the Human Centered Design (HCD) methodology. The design of the assessment methodology has been aligned to effectively answer the research questions within the study limitations. In utilizing the HCD methodology, a mixed qualitative and quantitative assessment has been adopted. The qualitative part is used as personal interviews (in their various forms), focus group discussions, document review, and qualitative observations. By assessing the effluent quality and technical assessment at the Kutupalong Rohingya Refugee Camps, this study seeks to gauge the performance of FSTPs. Effluent quality and technical assessment from different technologies are being used to treat the fecal sludge at Rohingya camps that contain Anaerobic Baffled Reactor (ABR), Up-flow filters (UFF), Waste Stabilization Ponds (WSPs), Solid Separation Unit (SSU), Lime Stabilization Ponds (LSP), Decentralized Waste Water Treatment Plant (DEWATS), Anaerobic Lagoon (AL), Anaerobic Settling Thickening Tanks (ASTTs) and Centralized Treatment plant.

Biological Oxygen Demand (BOD) elimination efficiency through the UFF, WSP & AL were found respectively 88.89%,100% & 100% that the values were found to vary from 18 mg/L to 29 mg/L while meeting with the Department of Environment (DoE) standard (30mg/l). Chemical Oxygen Demand (COD) removed efficiency by the UFF, WSP & AL by almost 100% and values were found to be varied from 60 mg/L to 85 mg/L while the allowable limit of DoE standard is 200mg/L. Total Suspended Solid (TSS) removed efficiency best performed by UFF, WSP & AL found 100% that values were found to be varied from 2mg/L to 70 mg/L while the permissible limit of DoE standard 100 mg/L. The concentrations of nitrate (DoE, 250 mg/L) and phosphate (DoE, 35 mg/L) in treated effluent were consistently

determined to be much lower than the permitted level. Escherichia coli (E. coli) and Fecal Coliform (FC) bacteria concentrations have exceeded the allowable DoE standard of 1000 cfu/100ml. On the other hand, ABR, LSP, SSU, ASTT & DEWATS treated methods were not capable of removing the TSS, COD, and BOD refugees' camps situation according to DoE standard inland surface water bodies. Field monitoring was concentrated on a number of essential intervention issues, including adjusting water levels, maintaining uniform flow, managing vegetation, reducing odors, and maintaining slope. The FSTP has also received certain constitutive proposals that would ensure its long-term viability.

How Policy and Implementation Meet: A Regional Policy Map of Lead Monitoring and Intervention Strategies
Anna Gold, The Water Institute

Sector-wide changes to drinking water are needed to meet the challenges posed by climate change, emerging knowledge on contaminants of concern, and rapid shifts in international aid and financial systems. The actors best positioned to set the pace for these changes are national governments. Strategic planning is a cornerstone of adapting to these challenges and is best led by national governments who have the capacity to both set and enforce regulations. This is especially true for the challenge of lead (Pb) in drinking water, which spans many aspects of the drinking water sector. To enable the prevention of Pb exposure through drinking water, regulations and enforcement are needed on the types of materials installed in drinking water infrastructure, implementer actions, materials and drinking water quality monitoring, data management, and community-oriented public messaging. While a broad stakeholder network is needed to succeed, a strong policy and regulatory base is needed to establish a pathway for accelerating progress on the prevention and elimination of lead in drinking water.

This project seeks to evaluate global policies on lead to understand the pathways countries can take for accelerating progress. An initial dataset was created for 180 countries, including information about infrastructure material requirements, water quality monitoring, data management, public engagement, government ministry mandates, and other relevant laws and policies. A total of 1300 documents were collected, representing national policies around lead in drinking water. These form the basis for analyzing the existing policy landscape as well as opportunities for global advancement on this priority contaminant. Documents have been collected, translated, and systematically categorized to enable comparisons between regions and nations.

Preliminary analysis is underway and yielding useful learning for the sector. Major findings include the limited correlation between the Human Development Index and the existence of a comprehensive policy framework ($R2 = 0.05$), the global lack of 3rd party evaluation of

systems, the need for transparency on institutional WaSH investments, and the potential for regional harmonization to avoid supply chain loopholes. Further analysis is underway to understand potential pathways for accelerating the policy progress for preventing future lead contamination of drinking water.

Gopad™: Pioneering Biotransformable Menstrual Products for Sustainable Health and Waste Solutions in Low-Infrastructure Settings
Trine Angeline Sig, Real Relief ApS

Menstrual waste is an emerging yet under-addressed environmental challenge, particularly in low- and middle-income countries where waste management infrastructure is often limited or absent. Globally, 32% of all plastic waste escapes formal collection systems, contributing to the 80% of ocean plastic originating from land-based sources. In India alone, more than 12.3 billion disposable pads are discarded annually, often ending up in open environments. Cultural taboos around menstruation further complicate safe disposal, particularly in schools, leading to poor health outcomes, stress, and shame among menstruators. Despite strong links to gender equity, public health, and environmental sustainability, menstrual waste remains largely overlooked in WASH (Water, Sanitation, and Hygiene) programming.

To address this gap, Gopad™ introduces a novel approach by incorporating biotransformation technology into menstrual hygiene products. Developed in collaboration with Polymateria Limited and Real Relief, Gopad™ is the world's first biotransformable disposable menstrual pad designed to biodegrade safely in unmanaged environments without the need for industrial composting facilities. The pad consists of three layers: a topsheet and backsheet containing biotransformation technology, and an absorbent core made from biodegradable cellulose.

The biotransformation process involves three key phases: chemical transformation triggered by environmental conditions (air, sunlight, moisture, heat), conversion into a non-toxic, bioavailable wax, and complete biodegradation. Laboratory testing, following the BSI PAS 9017 protocol, and field trials in temperate, tropical, and arid climates confirmed Gopad's environmental safety and biodegradability. Specifically, results demonstrated over 90% reduction in molecular weight, validation of environmental safety across OECD 222, 211, and 202 protocols, and open-air biodegradation exceeding 90% within two years. In tropical conditions in India, field observations showed visible transformation by day 120, reinforcing the pad's real-world viability.

This foundational research establishes Gopad™ as a pioneering solution capable of addressing menstrual waste pollution where formal disposal systems are lacking. Unlike

traditional compostable products that require specific conditions, Gopad™ is suited to humanitarian, peri-urban, and rural school settings, minimizing environmental impact while preserving menstrual dignity. Importantly, the technology offers a solution that aligns with Sustainable Development Goals (SDGs) 3 (Good Health and Well-being), 5 (Gender Equality), 6 (Clean Water and Sanitation), 12 (Responsible Consumption and Production), and 13 (Climate Action).

The study highlights the urgent need for menstrual products that not only focus on access and affordability but also address environmental sustainability. Gopad™ introduces a new material category — biotransformative menstrual products — setting a new standard for innovation in menstrual health management.

Future work will focus on pilot testing, cultural acceptability studies, and field validation of disposal behaviors in real-world settings. We are actively seeking partners to support the co-development and scale-up of this solution, aiming to deliver broad-based social, health, and environmental benefits, particularly in regions where menstrual hygiene solutions are most urgently needed.

Risk, Reliability, and Cooperation: A Study of Household Water Management Decisions in Delhi
Yugasha Bakshi, Virginia Tech

Background:
Delhi, the 5th most populous city in the world with an estimated population of 33 million, is facing an increasing water crisis that includes unsafe water quality, intermittent supply, low water pressure, erratic water distribution, and systemic water loss – making it difficult for Delhi's residential water consumers to meet their daily water needs. These concerns prompted the Delhi Jal (Water) Board (DJB) to emphasize water management and rationing strategies in the Master Plan for Delhi - 2041. However, little emphasis has been given to factors shaping residents' willingness to adopt cooperative behaviors necessary for effective implementation. Field observations reveal a complex dynamic: DJB officials express frustration with what they perceive as wasteful consumer behavior, while residents feel the DJB has failed to manage infrastructure adequately. Yet both parties express desire for dialogue and improvement, with significant variation in residents' readiness to engage with DJB initiatives despite similar water challenges. This study is driven by the urgent need to understand the enabling environment for cooperation and collaboration amongst the two main stakeholders – DJB and the residents of Delhi.

Methods:

This study utilizes household surveys incorporating a discrete-choice experiment to examine the relationship between risk perception, perception of DJB, and cooperative behavior. The surveys capture water usage patterns, residents' perceived risks related to water quality and availability, and their perceptions of DJB's technical capacity and overall ability to deliver reliable services. The discrete choice experiment specifically measures how households respond to tradeoffs between various service attributes - supply hours, tariff structure, managing authority (public vs. private vs. public-private partnership), implementation of water audits, and installation of water-saving devices. Sampling strategies considered spatial inequalities, water source diversity, and challenges faced by households, aiming for a diverse representation.

Results:
The surveys are ongoing and so far, the results indicate that:

- Higher perceived risk regarding water supply negatively affects residents' willingness to cooperate with water conservation initiatives
- Residents demonstrating higher willingness to cooperate report more sustainable consumption patterns
- Higher perceptions of DJB's ability to deliver adequate services positively influence cooperation with water management initiatives
- Higher perceptions of DJB's ability to deliver adequate services mediates the relationship between perceived risk and willingness to cooperate

The surveys are expected to conclude by August 2025. Overall, the final results will consider whether/how risk perception concerning water issues and perceptions of DJB's overall ability to deliver adequate services may impact households' willingness to cooperate.

Broader Significance:
As concerns around water insecurity and scarcity are becoming more tangible, understanding behavioral dimensions of water management becomes critical. While it's well established that effective water management requires long-term cooperation and collaboration amongst stakeholders, the specific conditions that enable such cooperative behaviors remain underexplored. Identifying the specific factors that motivate household cooperation, despite service uncertainties, will inform more effective policy design, communication strategies, and stakeholder engagement approaches for water authorities in Delhi and similar urban environments facing water stress.

Association of WaSH Practices And Diarrhea Amongst Children Under 5 Years in Badin and Jacobabad, Sindh

Ahmed Bux Dayo, HANDS Welfare Foundation

Background

Diarrheal diseases remain a significant public health challenge for children under five in low- and middle-income countries, including Pakistan. In Sindh, inadequate water, sanitation, and hygiene (WASH) practices contribute substantially to diarrhea-related morbidity. This study aimed to address three key objectives: to determine the association between WASH practices and diarrheal morbidity, identify factors influencing diarrhea among children under five, and assess current WASH practices in households across Sindh.

Methodology

An analytical cross-sectional study was conducted from September to December 2024 in Badin and Jacobabad districts, Sindh encompassing 556 households with children under five. Data were collected using structured questionnaires and observational checklists to evaluate WASH practices, socio-demographic factors, and child health outcomes. Logistic regression analysis was employed to identify predictors of diarrhea, with significance set at $p < 0.05$.

Results

The study identified significant associations between WASH practices and diarrhea. Water treatment emerged as a critical factor, with households treating water showing a 74% reduction in diarrhea odds (AOR = 0.261). Poor kitchen hygiene increased the odds of diarrhea by 44% (AOR = 0.563), while reliance on unprotected water sources significantly elevated risk (AOR = 1.524). Disparities in WASH practices were observed between rural and urban areas: rural households had better access to improved water sources (41.4%) but lagged in sanitation infrastructure (25.9% vs. 47.3% in urban areas). Urban households demonstrated stronger adherence to hygiene practices, including food handling and kitchen hygiene.

Conclusion

The findings underscore the need for integrated WASH interventions that comprehensively address water safety, hygiene education, and sanitation infrastructure. Expanding access to water treatment, improving rural sanitation, and promoting behavioral change through targeted campaigns are critical for reducing diarrheal morbidity among children under five in Sindh. Policymakers must prioritize tailored, evidence-based approaches to mitigate the impact of inadequate WASH practices and improve child health outcomes.

Turning Home Water Storage from Risk into Reliability
Kevine Odira, University of Massachusetts Amherst

Home water storage systems are essential in managing intermittent water supply and frequent outages, challenges that are increasingly prevalent worldwide due to climate change, extreme weather events, and growing water scarcity. While home water storage ensures on-premises availability and access when needed, its ability to simultaneously deliver safe water and maintain supply reliability which are key components of a safely managed water supply under United Nations Sustainable Development Goal 6.1 remains uncertain. With the ever-increasing problem of water quality impairment and reliability in supply, the goal of this research is to design premise water storage systems that protect the public through water quality preservation and minimized supply interruptions. The objective here is to first assess risks associated with opportunistic and indicator pathogens upon their accumulation, persistence and release, and investigate whether biofilms act as reservoirs of opportunistic and indicator pathogens in home water storage tanks. These experiments will be carried out in a simulated manifold of water storage tanks setup we built in the lab consisting of six 10-gallon polyethylene water storage tanks, designed as scaled down 500L tanks commonly used in low-and middle-income countries such as Kenya. Primary wastewater effluent samples from our local wastewater treatment plant in Amherst, Massachusetts, United States will be used to simulate a real case-pollution intrusion event from incidents such as cross-connections contamination in premise plumbing systems. Automated water valves will be used to daily drain the tanks with weekly manual fillings to mimic daily household water usage. The experiments would involve using different water sources and temperature controllers with interventions and controls to help understand water source variation and temperature differences influence on the results. Samples would be collected from the influent and effluent before and after intrusion, taking approximately 30 days of post-intrusion sampling. Flow cytometry will be used for total and viable cell counts, and physicochemical parameters including temperature, oxidation reduction potential, turbidity, conductivity, pH will be tested to determine their influence and correlation to the bacterial counts. PVC biofilm coupons selected to match almost the same material as the polyethylene tanks will be installed within the tanks for biofilm attachment on the first day of the experiments. Biofilm sampling will occasionally be done after the intrusion event, that's after 28 days, presumably after sufficient attachment is accomplished. Viable and culture-based detection using IDEXX methods will preferably be used in assessing pathogenic risks. This will involve testing for Pseudomonas aeruginosa and Legionella pneumophila using IDEXX Pseudalert and Legiolert respectively as target opportunistic pathogens selected to matching findings in other studies in storage and premise plumbing, and Escherichia coli and total coliform indicator pathogens using IDEXX Colilert from the biofilms and bulk water. We are currently planning to start running the experiments by 12th of May, with the experiment duration taking 2.5 months, thereafter, conduct data analysis. This study will advance the understanding of water quality dynamics and the role of biofilms as a source and reservoir of pathogens in home water storage systems.

Assessing WASH infrastructure in urban hospitals in Dhaka: Risks, gaps, and policy directions
Nuhu Amin, University of Technology Sydney

Introduction: Inadequate water, sanitation, and hygiene (WASH) infrastructure in healthcare facilities (HCFs) is a persistent challenge in low- and middle-income countries (LMICs), with serious consequences for infection prevention and control (IPC). In Dhaka, Bangladesh, a densely- populated urban center, major public hospitals often operate under severe infrastructural and management constraints. Yet, systematic data on the state of WASH in these facilities is limited. This study evaluated WASH conditions in government and private hospitals in Dhaka, identified infrastructural and behavioral gaps, and explored implications for public health and healthcare delivery.

Methods: We conducted a mixed-methods, cross-sectional study between August and December 2022 in ten government and three private hospitals, which were purposively selected. The study assessed 2,875 toilets and 2,436 handwashing stations, of which 86% and 90% respectively, were directly observed using structured checklists. The evaluation focused on functionality, cleanliness, accessibility, and user-to-facility ratios. Piped water availability was recorded. For wastewater treatment, we interviewed 30 stakeholders including engineers and healthcare staff, and applied Socio-Technical Systems (STS) theory to examine systemic and operational challenges.

Results: Key findings revealed that although 89% of hospital toilets had piped water, functionality and cleanliness varied significantly between public and private facilities. In government hospitals, only 68% of toilets were functional and 33% were clean. In contrast, 92% of toilets in private hospitals were functional, though only 56% were clean. User-to-toilet ratios were also markedly different. In government hospitals, outpatient areas had an extremely high ratio of 214:1, compared to 17:1 in inpatient wards. In private hospitals, the ratio was 94:1 in outpatient areas and 19:1 in inpatient wards. Overall, only 3% of toilets had menstrual hygiene bins, and <1% were accessible for persons with disabilities. Ten of 13 hospitals had wastewater treatment systems—mainly anaerobic baffled reactors and septic tanks-but these were poorly maintained, with irregular desludging and minimal monitoring. Staff interviews revealed low awareness of wastewater risks and lack of institutional accountability for maintenance.

71% of handwashing station were functional, but soap was available at only 13% of patient-accessible handwashing station in government hospitals. In private hospitals, 86% of basins were functional, and 29% had soap available. Patient-to-basin ratios reached 45:1 in outdoor areas of public hospitals, undermining basic hygiene practices and IPC standards.

Discussion and conclusions: These findings reveal a systemic failure across the WASH continuum in urban hospitals-from toilet and handwashing access to wastewater treatment. The study demonstrates how both infrastructure inadequacies and institutional bottlenecks threaten patient safety and increase the risk of healthcare-associated infections. Addressing these issues requires a coordinated, multi-sectoral and transdisciplinary response that includes strategic budgeting and investments in infrastructure upgrades, formalized maintenance protocols, cross-sector training, and stronger regulatory oversight. These results provide evidence to inform national policy reform and investment under the Ministry of Health and Family Welfare (MoHFW), while contributing to global efforts towards achieving Sustainable Development Goal 6.2 in healthcare settings. Through this study, we advocate for a shift toward integrated and context-appropriate WASH solutions that bridge technical, institutional, and behavioral dimensions in LMIC hospitals.

Detection of Hemagglutinin H5 influenza A virus RNA and model of potential inputs in an urban California sewershed
Abby Paulos, Emory University

In 2024, highly pathogenic avian influenza A H5N1 caused outbreaks in wild birds, poultry, cows, and other mammals in the United States with 61 human cases reported by the CDC. Detection of influenza A H5 RNA in wastewater has been previously reported in sewersheds in Texas and North Carolina with nearby impacted dairy herds following the emergence of H5N1 in dairy cows.

In this project, we conducted retrospective testing of total influenza A and H5 hemagglutinin genes in wastewater as well as presenting and applying new assays for detection of H1 and H3 genes across a respiratory virus season in an urban California sewershed from September 2023 – May 2024. We developed a Monte Carlo simulation model (n=10,000 iterations) that uses the measured H5 concentrations and previously published parameters to estimate numbers of infected people, poultry, small (blue-winged teal) and large waterfowl (domestic ducks), or liters of H5-contaminated milk required to result in measured H5 concentrations in wastewater. We created a publicly available tool to apply the H5 input model in other sewersheds to estimate required inputs, available at https://abharv52.shinyapps.io/h5_input_estimates/.

Total influenza A, H1, and H3 were regularly detected, while H5 was detected March - May, 2024. In total, 13/110 total samples were positive for H5, with 13/24 samples positive between March 18 - May 10. The median H5 concentration detected was 2410 gc/dry g,

with the peak concentration detected on May 3 (19,000 gc/dry g). The lower bound (25th percentile) of contributions required to result in the median measured H5 RNA concentration were 103 liters of milk, 104 infected humans, 103 infected poultry, 103 infected ducks, or 105 infected blue-winged teal. For the peak concentration, the lower bound (25th percentile) required contributions were 104 liters of milk, 105 infected humans, 103 infected poultry, 104 infected ducks, or 106 infected blue-winged teal. The model was sensitive to the influenza A levels shed by poultry and ducks and the influenza A levels in milk.

Our findings demonstrate that in this California sewershed, contaminated milk or infected poultry were the most likely sources of H5 to wastewater. We identified a live bird market that housed up to 3,000 poultry and discharged waste to the municipal system, a viable mechanism for poultry feces to enter the system. Daily household milk waste was estimated at 22,000 L/day, and estimates for required milk inputs were within this estimate. Large waterfowl such as ducks could also be a feasible source when there is a mechanism for their waste to enter wastewater. This model and the publicly-available tool can assist public health officials in interpreting wastewater detections in their jurisdiction. Together with knowledge on wild bird patterns, live animal markets, milk contamination with H5, and whether the wastewater system is combined, public health officials can use this model to contextualize wastewater detections.

Thursday Verbal Abstracts

Water Sharing Network Position, Self-reported Stress, and Chronic Stress Cortisol by Season Among Daasanach Pastoralists in Northern, Kenya
Leslie Ford, Pennsylvania State University

Water sharing networks, or household to household transfers of water, are common as a behavioral adaptation to meet water needs in water insecure environments. In some settings these networks have been known to lead to negative health effects such as stress and elevated blood pressure (hypertension). While in other settings, water sharing is protective against elevated psychosocial stress. This research aims to understand how the lived experiences with water insecurity of Daasanach pastoralist female household heads becomes embodied as chronic stress, and how those experiences may differ by water sharing network position using the biomarker of nail cortisol, a self-report measures of stress (PSS4), and social network analysis.

Data was collected in April (long-rains), June-July (dry), and November-December (short-rains) 2023 to represent variation in water availability. This study targeted two communities, one a 10-minute walk to the market town with a solar standpipe (V2). The other is an hour walk to the market town with a manual standpipe installed in September 2023 (V1). Interviews were conducted with ~75 household per village/timepoint, nail samples were collected when possible from these participants for a total of 237 nail samples from both villages across all three time points. Random panel effects liner regression models adjusted for age, body mass index, and heat index or wet blub globe temperature will be used to test the relationship between measures of social network centrality and the two measures of stress. Centrality measures include both the in- and out- directions of degree, betweenness, closeness and eigenvector centrality.

Average nail cortisol was highest in the dry season (24.468 pg/mg: Range 133.248-6.667; N=74) compared to the long-rainy season (11.953 pg/mg: Range 44.476-0.991; N=74) and the short-rainy season (17.425 pg/mg: Range 115.556-1.954; N=89). V1, the village farthest from the market town, had higher nail cortisol during all three seasons than V2. There was almost no correlation between nail cortisol and the self-reported measure of stress (PSS4) (r=.07), this is consistent with other studies which have found that nail cortisol measures cumulative stress over time, while PSS4 measures acute stress.

No significant relationship was found between water sharing centrality measures and PSS4. Further analysis will be done with nail cortisol data and water sharing centrality measures to determine if a possible relationship exists between network position and chronic stress. This will be done for both villages at all three time points to determine if

water availability and location play a role in shaping network structure and health outcomes.

Considerations for implementing sustainable fecal sludge services in humanitarian contexts
Gabrielle String, Tufts University

Introduction
Treatment of human excreta in humanitarian contexts remains rare, which leads to environmental and public health risks. One concern, identified by the FSM Technical Working Group (TWG), is that fecal sludge treatment plants are quickly established in the first phase of response, with early design decisions made to enable rapid deployment. However, these early decisions may hinder sustainable FSTP operations during long-term operations. The objective of this mixed-method research is to identify barriers and facilitators to sustainable FSTP services, from acute to ongoing phases, in humanitarian response.

Methods
We completed a mixed-methods research protocol, including a systematic literature review, key informant interviews (KIIs) with sanitation experts, and on-site assessments of operational fecal sludge treatment plants.
For the literature review, we built upon a previous systematic review by: updating the search (six databases, 34 websites), and rescreening all identified documents with the following inclusion criteria: assessed FST implementation; in a humanitarian setting; including a sustainability criteria. Data were extracted and summarized into obstacles and enabling factors for sustainability.

For the KIIs, 40 sanitation experts at international and field level were identified for inclusion with the FSM TWG. All experts were emailed inviting them to participate in a 1-hour interview including three main sections: experiences on FSM, decision making and programmatic aspects of FSM, and overall sustainability. Nineteen interviews were conducted, transcribed, and analyzed in NVivo using thematic analysis.

Lastly, a FSTP site visit assessment form was developed, including gathering data on the emergency context, the treatment process, design considerations, construction, operation and maintenance, performances, resources and constraints and lessons learnt. FSTP visits also included interviews FSTP staff. Site visits were conducted in five contexts: Germany (3 FSTPs), Jordan (4 greywater treatment units and 2 FSTP), Cameroon (1 FSTP), Lebanon (5 FSTPs), and Tanzania (urban context, 3 FSTPs).

Results

Forty-one documents were included from the literature review, with 21 documents published between 2020-2024. Overall, 242 obstacles and 348 enabling factors to sustainable fecal sludge management were identified.

KII's were conducted with seven women and 12 men: including eight field-level and 11 international-level experts. In analysis, 10 facilitators and five barriers to sustainable fecal sludge management were identified including: 1) facilitators of modularity of technologies, robust technology, financial feasibility, technical feasibility, SAFE reuse, entire sanitation chain, ecological approach, community involvement, cultural aspect, and capacity building; and, 2) barriers of land access and quality, difficulties in operation and maintenance, lack of financial viability, institutional support or involvement, and knowledge gap in fecal sludge management.

Overall, 18 treatment plants were visited in five contexts. The site visits included technologies such as DEWATS, wetland, unplanted drying beds, activated sludge, and uniprocessor. Despite the diversity of the contexts and technologies studied, common barriers and facilitators were identified, enabling recommendations to be made for improving the sustainability of the solutions implemented.

Conclusion

The results will be triangulated to draw conclusions on improving fecal sludge treatment unit sustainability in humanitarian context, from acute implementation to protracted crisis.

"Stressed Up": Water, sanitation, and hygiene insecurity and psychological distress in South Sudan
Rochelle Frounfelker, Lehigh University

Introduction. There is a growing body of research on the relationship between water, sanitation, and hygiene (WASH) insecurity and mental health; this is particularly relevant when addressing mental health in conflict and post-conflict settings. Among war-affected populations, mental health is impacted by both war-related traumas and current daily stressors, including securing basic necessities. In conflict-affected South Sudan, water and sanitation insecurity increased from 2010 to 2020, with 41% of the population accessing basic water supply, 16% basic sanitation, with 60% practicing open defecation, and 22% accessing soap and water. In one survey, participants identified high levels of need in Juba related to access to drinking water (81.1%), toilets (76.6%), and keeping clean (33.5%) while another found individuals who reported a lack of food and/or water had poorer mental health than those who did not.

The goal of this research was to understand the relationship between WASH insecurity and psychological wellbeing in one community in Juba using a participatory approach with community members. We aimed to: 1) explore the kind of WASH insecurity experienced in South Sudan; and 2) hear how community members understood the relationship between these insecurities and their psychological wellbeing.

Methods. A total of 56 adults, grouped by gender, from the community of Rejah, South Sudan, participated in this study. We used concept mapping, an iterative, participatory mixed-methods research methodology that resulted in the development of a conceptual framework for how community members viewed the relationship between WASH insecurity and psychological well-being. Participants engaged in three rounds of data collection that included brainstorming ideas, sorting ideas into meaningful groups, and providing feedback. Locally-trained research assistants collected data and ensured the phrasing, accuracy, and clarity of statements developed for sorting. The concept map was created using hierarchical cluster analysis in groupwisdom software and focus group discussions were translated into English and analyzed using deductive coding and content analysis.

Results and Conclusion. Men generated 33 statements related to WASH insecurity and psychological well-being, and women generated 34. Men's ideas grouped into 5 clusters, with one focused on positive impacts; women's ideas grouped into 6 clusters, with two focused on fears related to gender-based violence and other dangers. Notably, the clusters of "Shame" and "Stressed Up" mapped onto culturally relevant mental health problems in Juba Arabic identified in previous qualitative research conducted in Juba. Together, participants articulated a wide variety of negative impacts of WASH insecurity, including sadness, shame, stress, worry, fear, being afraid, "thinking too much", and low self-esteem. WASH insecurity also had implications for social relationships, and could lead to isolation, lack of respect from community members, and loneliness. Overall, participants self-generated solutions to address WASH insecurity in their community, such as securing household items and constructing infrastructure. While securing household items may help to alleviate short-term stressors and shame and improve dignity and agency, many of the stressors, shames, and worries are likely to continue unless infrastructure is implemented to address long-term WASH insecurity.

What do we know about mental health and WASH Insecurity? Hearing from WASH experts
Gabrielle String, Lehigh University

Introduction
Access to adequate water, sanitation, and hygiene (WASH) services remains a major public health concern, particularly in low-resource settings. Extensive research has documented the physical health impacts of limited WASH access, however, there is limited knowledge

of how WASH access impacts mental health or how mental health impacts access to WASH. Critically, the burden of psychosocial distress and mental disorders, such as depression and anxiety, is increasingly recognized as an important contributor to loss of productivity, disability, and death. Learning how WASH practitioners understand this topic is important to implementing programs and interventions that consider WASH insecurity and mental health/psychosocial well-being.

Methods

To recruit participants for key informant interviews (KIIs), outreach was conducted through Listservs, LinkedIn groups, snowball sampling, and the personal professional networks of the research team. Recruitment materials specified that participants should be WASH experts with knowledge of mental health in low-resource contexts. Of the 63 experts contacted, 19 participated. All KIIs were conducted in English via Zoom without geographic restrictions.

Semi-structured KIIs were conducted between December 12, 2023, and February 12, 2025, each lasting approximately one hour. Topics included the types of stressors linked to WASH insecurity, subgroups disproportionately affected by the WASH-mental health connection, and common coping strategies used in response to these stressors.

Interviews were transcribed and de-identified to ensure confidentiality. The team used content analysis to identify patterns in participant responses. Transcripts were systematically coded and analyzed using MAXQDA24 to explore perceptions of WASH insecurity and mental health.

The research team independently coded the first six transcripts and met to discuss emerging codes. A codebook was developed, including definitions and examples of each code. Once consensus was reached on the initial six transcripts, two team members coded the next seven, and then the remaining six were coded by one researcher. Member checks were conducted within the team for transcript sections that were difficult to code.

Results and Conclusions

Results indicate that WASH insecurity and mental health are deeply interconnected and complex. Social, physical, and financial stressors all contribute to poor mental health outcomes. However, data analysis revealed that these stressors are rarely experienced in isolation. Similarly, water, sanitation, and hygiene are so interconnected that it is nearly impossible to examine one aspect of WASH insecurity without considering the others.

The effects of WASH insecurity and its mental health outcomes are felt across multiple layers of the social environment. Drawing on Bronfenbrenner's Ecological Systems Theory, these impacts were observed at the microsystem, mesosystem, exosystem, macrosystem, and chronosystem levels.

Across the 19 transcripts, there were 1,571 segments of text coded using 63 unique codes. The codes were clustered and analyzed to identify overlapping stressors, pathways of influence, and systemic patterns. This process informed the development of a conceptual model rooted in Bronfenbrenner's framework, illustrating how WASH insecurity operates within and across ecological levels to impact mental well-being.

These findings highlight the need for a more integrated, systems-based approach to understanding and addressing the mental health impacts of WASH insecurity.

Household Energy and Water Resource Disruptions and Coping Strategies During Floods and Droughts in Kenya
Hemali Oza, Emory University

Introduction: Floods and droughts increasingly threaten access to essential household resources, particularly in climate-vulnerable regions of Sub-Saharan Africa. This study assesses how households in Homa Bay County, Kenya experience and cope with disrupted access to (1) energy for lighting, (2) energy/fuel for cooking, and (3) drinking water during droughts and floods across both arid and non-arid regions.

Methods: A cross-sectional, population-based household survey was conducted in June–July 2024 among 378 randomly selected households across both arid and non-arid regions of Homa Bay County. The survey, administered in Dholuo using Open Data Kit, captured data on resource access during 'normal' conditions, exposure to flood and drought events in the past year, and access disruptions during those events. Survey weights were calculated using an inverse probability of selection approach and applied using the 'survey' package in R to produce Homa Bay County-level estimates. We used weighted generalized estimating equations (GEE) to compare baseline access and climate-related disruptions between arid and non-arid regions. Models were adjusted for household socioeconomic status, calculated via principal component analysis of asset ownership. Risk ratios (RRs) and 95% confidence intervals were estimated for key outcomes.

Results: In the absence of floods or droughts, we estimated 59.3%, 60.4%, and 59.7% of Homa Bay County households lacked consistent access to energy for lighting, energy/fuel for cooking, and drinking water, respectively. We estimated, in the past year, 46.2% of households experienced flooding and 70.2% experienced drought, with no significant difference between arid and non-arid regions.

Floods disrupted lighting for 71.7% of households, with one-third relying on unclean sources (e.g., kerosene, candles) or having no lighting access. Solar lighting use declined

from 70.9% to 29.9%, while candle use rose tenfold. Cooking energy disruptions affected 83.0% of households, with arid regions significantly more impacted (RR: 0.86; 95% CI: 0.75–0.99). Firewood use declined and was replaced by charcoal and kerosene. Rainwater collection for drinking increased, while use of other improved sources declined. During droughts, 24.5% of households experienced lighting disruptions, more frequently in arid regions (RR: 0.54; 95% CI: 0.38–0.79). Solar panel use dropped, and reliance on batteries, kerosene, and candles increased. We estimated nearly all households (98.3%) were using unclean sources of energy for cooking—such as biomass burning or coal. Drinking water access was disrupted for 59.1% of households, with non-arid regions significantly more affected (RR: 1.71; 95% CI: 1.17–2.49). Use of surface and unimproved sources rose, while rainwater harvesting declined.

Discussion & Conclusions: These findings underscore coping strategies—while adaptive in the short term—often carry health risks and reflect broader systemic gaps in service delivery. As climate variability intensifies, both arid and non-arid communities will require preparedness systems that go beyond emergency response and are integrated into routine infrastructure and service provision. Building resilience will require a dual approach: strengthening infrastructure for normal conditions while embedding flexibility and redundancy into systems to withstand environmental shocks.

Seasonal impact on water infrastructure: Availability, quality and source selection in Ethiopia, Ghana and Uganda
Anna Murray, The Aquaya Institute

BACKGROUND. In many parts of the world, dry seasons are becoming drier and wet seasons wetter. This is disproportionately affecting infrastructure relied upon by vulnerable populations, including water supply systems. Where seasonality influences both the quantity and quality of water, households may be forced to make difficult trade-offs between water safety, accessibility, and reliability. Evidence is limited on the impact of seasons on water infrastructure and household-level decision-making around water source selection.

OBJECTIVE. The objective of this study was to quantify the impact of seasonality on water availability and quality, and on household water source selection.

METHODS. This ongoing multi-country longitudinal study (February 2022 to October 2025) is nested in a water quality monitoring program across seven districts in Ethiopia, Ghana and Uganda. To date, the program has sampled 1,829 water points 4,794 times and 4,804 randomly-selected households at concurrent times and locations. Sampled water points include piped water, boreholes with handpumps, shallow groundwater (springs and wells),

surface water, and rainwater. We defined seasons based on periods of sustained rainfall using satellite-derived daily precipitation estimates in each district. We used generalized estimating equations to estimate the odds of water being a) available and b) free from contamination (E. coli = 0 CFU/100mL) in the dry season compared to the wet season. Further, we paired water used by households with sampled water points and implemented a decision model to identify drivers for water source selection.

RESULTS. Most sampled water points had water available (88%), although more than two-thirds of samples (69%) were contaminated with E. coli. In the dry season, water was less likely to be available (OR 0.81; 95% CI 0.67-0.97; p=0.020). Water was equally likely to be free from E. coli contamination in different seasons, although high levels of contamination (E. coli >10 CFU/100mL) were less likely in the dry season (OR 0.79; 95% CI 0.68-0.91; p=0.001). Boreholes with handpumps were the only source type where neither availability nor contamination (E. coli = 0 CFU/100mL) were affected by season. The decision model revealed that household source selection was not different by season. The strongest driver for source selection was distance, followed by reliability (defined as water available at all study visits), with perceived quality issues not a significant driver. When all source types were equally close with good reliability and quality, the probability a household chose piped water was 42%, followed by 29% for shallow groundwater, 27% for boreholes with handpumps and 2% for surface water.

CONCLUSIONS. Water availability and high levels of microbial contamination were both affected by season. While household water source choices were not different by season, they were driven by distance from the household to a water point and a preference for piped water, which is in line with Sustainable Development Goals aiming to bring piped water to people's homes. Access expansions to public water sources may consider tradeoffs between boreholes with handpumps and piped water, since boreholes appeared to be more resilient to seasonality in these settings, whereas piped water was preferred by households.

Advancing Monitoring for Carbon-Financed Water Security: Methodological Innovation and Insights from East African Projects
John Ecklu, University of Colorado Boulder

The Voluntary Carbon Market (VCM) offers growing potential to finance water security interventions that also contribute to climate mitigation and adaptation goals. While carbon credit methodologies traditionally reward direct emission reductions—such as those from renewable energy or forest protection—water-sector projects often rely on proxy indicators to quantify avoided emissions. This study identifies and evaluates critical yet underexplored monitoring parameters necessary for carbon-credit generation in water-

related subsectors, including drinking water access, microbial water quality, irrigation efficiency, and instream water quality. These indicators, while not direct measures of emissions, are central to validating climate and health impacts.

We first examine how digital monitoring, reporting, and verification (dMRV) technologies—such as remote sensors, satellite imagery, and automated sampling—can strengthen credibility and transparency in carbon methodologies. We then present empirical findings from a study evaluating microbial water quality outcomes from three carbon-financed drinking water projects in Rwanda, Kenya, and the Democratic Republic of the Congo. These projects use filtration, chlorination, and safe water delivery systems to reduce the need for boiling water, thereby avoiding emissions while improving health outcomes.

Water samples were collected and analyzed at the point of consumption pre and post-implementation. Preliminary results demonstrate significant improvements in microbial water quality in all three programs, including months after system deployment. In systems where traditional infrastructure has failed to ensure safe water at the point of consumption, these findings suggest that performance-based climate finance can incentivize continuous operation and maintenance—critical for sustained water safety. In filter-based systems, consistent water quality supports the premise that carbon financing can extend the longevity and efficacy of water treatment technologies.

These findings have broad implications for science, policy, and practice. First, they inform methodological innovation in the VCM by demonstrating how dMRV can be used to monitor non-emission parameters that are essential to impact validation. Second, they offer evidence that climate finance can fill the operational funding gap that often limits the effectiveness of traditional WASH programs.

Sustainability of Water, Sanitation, and Hygiene (WASH) Systems in Nepal: An Analysis of People's Perceptions on Climate Change and Management Perspective of WASH Systems
Resham Jung Singh, Infrastructure University Kuala Lumpur (IUKL), Malaysia

A sustainable WASH system is one that remains operational and effective for its entire intended lifespan. Climate change refers to the long-term alterations in precipitation and temperature patterns that resulted in climate-induced hazards, i.e., floods, landslides, and droughts, which ultimately affected the functionality of the WASH systems. Nepalese population has limited access to safely managed water supply systems, indicating a significant gap in providing reliable and safe water sources across Nepal, which is in a declining trend. Not only climate parameters, but the management aspect is also crucial to making the WASH systems sustainable in the long run. This research aims to evaluate the

sustainability of the WASH systems from the climate change and management perspective based on the user's perception. Three municipalities are selected for the study from different ecological zones of Nepal. Structured questionnaires prepared using the quantitative research method and a questionnaire survey done with the representatives of the Water User's and Sanitation Committees (n = 103) to assess the perception on climate change, causes, impacts, and sustainability of WASH systems. The sustainability assessment assessed five categories: financial, institutional, environmental, social, and technical. The results revealed that most of the systems are at average and low sustainable level; very few systems are observed only at a satisfactory sustainable level and not at a good level. Climate change adaptation strategies and improvements in operation and management aspects need to be considered to make systems more sustainable. This research will help to know the sustainability status and issues challenges associated with the WASH systems in Nepal, it will be beneficial to policy makers and implementing organizations.

Lead-Free Learning: The Clean Classrooms for Carolina Kids™ Approach
Laura Allen Gates, RTI International

Lead is a well-documented contaminant in drinking water, largely due to its historical use in plumbing infrastructure worldwide. Children are especially vulnerable to lead exposure, which can result in irreversible and cumulative health effects, including hearing and speech problems, damage to the brain and central nervous system, learning and behavior issues, and slowed growth and development. Despite these risks, many schools and child care facilities have not conducted comprehensive testing at all taps used for drinking or cooking.

To address this gap, the Clean Classrooms for Carolina Kids™ program was launched in 2023 as part of a legislatively mandated initiative to identify and eliminate lead in drinking and cooking water in all public schools and licensed child care facilities across North Carolina – approximately 9,000 facilities. This presentation will highlight two key components of the program: (1) results and findings on risk factors for lead in water exposure in schools and child care facilities and (2) lessons learned from risk communication with facilities and overseeing mitigation. To date, 10,800 water samples have been collected from 3,174 licensed child care facilities and 31,931 samples from 1,581 public schools. Findings indicate that 56% of facilities had at least one tap exceeding 1 part per billion (ppb)—the American Academy of Pediatrics' health-based reference level—and 14% exceeded the state's 10 ppb action level for required mitigation. Overall, 19% of all samples were at or above 1 ppb, and 2% were at or above 10 ppb. Based on the testing results, 465 facilities have been identified as requiring mitigation. Of those, 68% have requested mitigation support through the program, and 60% have completed

mitigation efforts to date.

This work contributes to one of the most comprehensive datasets on lead in drinking water in U.S. learning environments, offering critical insights into exposure patterns and risk factors. From a policy perspective, the findings support the need for more protective national standards, routine monitoring, and long-term funding for remediation— particularly in vulnerable communities. Additionally, this research demonstrates that statewide testing and mitigation programs can be implemented at scale when legislation is paired with sufficient funding, legislative backing, cross-agency coordination, and collaborative engagement with schools and child care providers.

These findings illustrate how data-driven public health programs can inform effective science-based policy and practical strategies to reduce environmental health risks globally. As other states or countries consider similar efforts, North Carolina's approach offers a replicable model for protecting children's health and ensuring access to safe drinking water in schools and child care facilities.

A Systematic Review of Global Toxic Metal Occurrence in LMIC Drinking Water
Michael Fisher, The Water Institute at UNC; UNC Chapel Hill

Toxic metals and metalloids (TMs) occur in drinking water and can cause organ damage, cardiovascular disease, cancers, and lifelong neurological and developmental impairment. However, little evidence is available on TMs in drinking water in low- and middle-income countries (LMICs). Available evidence is often highly localized, linked to particular identified sources of contamination, and/or obtained using unsuitable methods.

We conducted a systematic review and meta-analysis of peer-reviewed studies of TMs in drinking water in LMICs. The objectives of this work were to report which TMs occur in LMIC drinking water at levels of public health concern; the distribution of such occurrence with respect to source type (e.g., piped vs boreholes, etc.) and location (e.g., country, region, urban vs rural setting, etc.); where evidence gaps remain; and opportunities for prevention. A systematic review approach was used in accordance with PRISMA statement items. Inclusion criteria included peer-reviewed studies published in English since 1969 reporting concentrations of arsenic, cadmium, chromium, lead, mercury, manganese, nickel, antimony, selenium, and/or uranium in drinking water. PubMed, EBSCO Global Health, and Web of Science were searched. Risk of bias was assessed using documented methods (protocol registered with PROSPERO: CRD42024566116). Briefly, within-study risk was assessed based on study quality items defined in this work- these graded adequacy of reporting and suitability of methods. Between-study bias was evaluated based on the symmetry and continuity of the distribution of study dataset central tendencies. More than

30,000 results were prioritized using a machine learning algorithm; 14,230 studies were manually screened, of which 3,185 met inclusion criteria.

One region (Central and Southern Asia) accounted for 48% of studies, and nearly one third (31%) of LMICs were unrepresented in these data. Ten percent of studies used methods scoring high (>=6 out of a possible 10 study quality items) in suitability for detecting TMs in water at concentrations of concern. Many studies (45%) were conducted in settings selected because of known/suspected site-specific contamination; after excluding such targeted studies and focusing on studies using methods with adequate sensitivity to quantify WHO guideline exceedances for TMs, meta-regression results indicated that >10% of samples from suitable studies exceeded WHO guideline values for arsenic (30%), lead (21%), manganese (47%), mercury (10%), and uranium (14%). Occurrence results were also disaggregated by SDG region, rural/urban setting, water source type, and decade of publication; in most cases occurrence remained substantive across these categories.

While the authors speculate that TM occurrence estimates obtained in this review may be somewhat inflated by possible publication bias, methodological limitations, and other factors not fully controlled for in our analyses, the aggregate data nevertheless provide compelling evidence that increased global attention to monitoring and management of these TMs (arsenic, lead, manganese, mercury, and uranium) in drinking water in LMICs is likely warranted. Widespread inclusion of these TMs in high-quality and nationality representative monitoring efforts may be helpful in further refining estimates of occurrence beyond what is possible from a review of existing secondary data at this time.

Health Outcomes and Environmental Injustice: The Effects of Industrial Water Pollution in Cancer Alley
Shalina Shahin, Xavier University of Louisiana

Cancer Alley, a region in Louisiana with a high density of petrochemical plants and industrial facilities, represents a critical case of environmental injustice. Predominantly minority and low-income populations, including African American and Indigenous communities, endure disproportionate exposure to industrial pollutants, particularly waterborne contaminants. This environmental burden has been linked to elevated rates of cancer, waterborne diseases, respiratory illnesses, and other chronic health conditions, exacerbated by socio-economic disparities that limit access to clean water, healthcare, and necessary resources (Bullard, 2000; Brender et al., 2011; Louisiana Tumor Registry, 2023).
While the health impacts of air pollution in this region have been widely studied, significant gaps remain in understanding the pathways through which waterborne industrial pollutants affect human health. Contaminants such as heavy metals, volatile organic compounds (VOCs), and endocrine-disrupting chemicals—and their synergistic effects—pose severe risks, yet remain under-researched (Landrigan et al., 2018). To address these gaps, this

study adopts an interdisciplinary approach that integrates water quality analysis, spatial epidemiology, and community-based participatory research (CBPR). Water quality assessments will identify and quantify harmful pollutants, including benzene, chlorinated solvents, and heavy metals, all of which have carcinogenic and endocrine-disrupting effects (ATSDR, 2021). Spatial epidemiology will map the geographic correlation between exposure to these pollutants and adverse health outcomes, highlighting areas of heightened environmental injustice. Through CBPR, the research will engage affected communities, ensuring their perspectives inform actionable strategies and policy recommendations.

This study emphasizes the critical importance of equitable environmental policies and interventions. Proposed recommendations include implementing stricter regulations on industrial discharges, enhancing water treatment infrastructure, and prioritizing health screenings for vulnerable populations. Additionally, Findings from this research will provide robust evidence for addressing systemic environmental injustices and promoting public health equity. By fostering community engagement and advocating for culturally appropriate interventions, the study aims to empower local populations to co-design sustainable solutions that reduce health disparities and improve environmental health outcomes (Minkler & Wallerstein, 2011; Israel et al., 2012).

This research underscores the necessity of longitudinal epidemiological studies to track chronic exposure to contaminants and their correlation with health outcomes, revealing disease hotspots and guiding targeted interventions (Perera, 2017; Lichtveld et al., 2022). Addressing environmental racism and ensuring access to clean, safe water is vital for promoting health equity, particularly for vulnerable groups such as cancer survivors, immunocompromised individuals, and marginalized communities (Cole & Foster, 2001; Mohai et al., 2009; WHO, 2017; Bullard et al., 2008). Addressing these issues through a holistic and community-driven approach can significantly reduce health disparities in Cancer Alley and promote environmental justice for those disproportionately burdened by industrial pollution.

Surface water quality impacts from poultry operations in the Cape Fear River watershed
Ayse Ercumen, North Carolina State University

Background: Concentrated Animal Feeding Operations (CAFOs) significantly impact water quality. North Carolina (NC) ranks second nationally in food animal production, and poultry CAFOs have proliferated in the state following a swine CAFO moratorium. NC regulations for CAFO waste target liquid manure systems. Poultry CAFOs that produce dry waste are excluded from the discharge permit framework, limiting monitoring of their contributions to pollution.

Methods: To assess water quality impacts of swine and poultry CAFOs, we used Earth observation (EO) data to locate poultry CAFOs without discharge permits and obtained swine and other CAFO locations from state permit records. We used publicly available stream water quality data for the Cape Fear River Basin in southeastern NC, an area with high CAFO density. Our dataset included 12,156 monthly measurements (2016–2022) of nitrogen, phosphorus, and fecal coliform levels from 145 water quality stations throughout the basin. For each measurement, we calculated the number of CAFOs (poultry and swine, both separately and combined) in the watershed where the water quality station was located, with watershed boundaries delineated by ten-digit hydrologic unit codes (HUC10). We grouped water quality measurements into quintiles of CAFO counts per watershed and used generalized linear models with robust standard errors to identify associations between quintile groups and water quality. Models controlled for potential confounders, such as the number of landfills, wastewater treatment plants, NPDES discharges, cropland percentage, and population density per HUC10. A sensitivity analysis excluded urban HUC10s (population density>1,000/square mile) to minimize confounding from human waste.

Results: EO data revealed 3,850 poultry CAFOs while state permit records identified 1,282 swine and other CAFOs but no poultry CAFOs. HUC10-level watersheds contained an average of 114 CAFOs (range: 0–491), with a mean of 86 poultry and 27 swine operations. Streams in the highest CAFO quintile exhibited significantly elevated contaminants. After adjusting for confounders, the percentage of samples with elevated nitrate (>1 mg/L) was over seven times higher (prevalence ratio [PR]=7.36, 2.55–21.23, $p<0.005$), and the percentage with elevated fecal coliform (>200 CFU/100 mL) was over nine times higher (PR=9.25, 2.27–37.72, $p<0.005$) in HUC10s in the highest vs. lowest CAFO quintile. Poultry CAFOs were specifically associated with elevated nitrate and fecal coliform levels. The percentage of samples with elevated nitrate was over three times higher (PR=3.64, 1.32–10.05, $p=0.01$), and the percentage with elevated fecal coliform was over six times higher (PR=6.34, 2.47–16.26, $p<0.005$) in the highest vs. lowest poultry CAFO quintile. No associations were found between CAFO quintiles and phosphorus levels. Sensitivity analyses excluding urban HUCs showed similar findings.

Conclusion: This study integrated EO data with regulatory records to enhance poultry CAFO inventories, providing insights into their water quality impacts. Findings reveal a strong association between high CAFO densities and increased nitrate and fecal coliform but not phosphorus contamination. Results suggest poultry CAFOs are likely the primary contributor to elevated nitrate and fecal coliform levels. Strengthened documentation and oversight of poultry CAFOs are necessary to protect water quality and mitigate non-point source pollution.

Impact Assessment of the Greater Accra Sustainable Sanitation and Livelihoods Improvement Project on Urban Health and Education
Daniel Sarpong, Greater Accra Sustainable Sanitation And Livelihoods Improvement Project (GASSLIP)

The Greater Accra Sustainable Sanitation and Livelihoods Improvement Project (GASSLIP), which was implemented with funding support from the African Development Bank (AfDB) and the Government of Ghana, through the Ministry of Sanitation and Water Resources and Ministry of Finance (MoF). The project aimed to improve urban sanitation, hygiene, and socio-economic outcomes in low-income urban communities across the Greater Accra Metropolitan Area (GAMA). This paper would like to share with wider audience the first impact assessment, which evaluated GASSLIP's contributions to urban health and education. It focused on the period between 2020 and 2024. The assessment applied a mixed-methods approach combining household and institutional surveys (n=500), focus group discussions, health records analysis, and education performance metrics across sixty beneficiary schools.

The findings indicated a significant health gain. Open defecation, which previously affected about 15% of residents in low-income GAMA settlements, had reduced to 3.2% in project-targeted areas by 2024. This achievement could be attributed to a combination of the construction of 5000 household toilets and hygiene sensitization reaching out to approximately 70,000 leaners and 50,000 individuals respectively. The study reported 38% decline in diarrheal diseases, particularly among children under five in project areas, as reported by local health facilities, emphasizing the correlation between improved sanitation infrastructure and reduced disease burden.

In the education sector, the provision of resilient, gender-segregated WASH facilities in 60 Government assisted schools have led to a 24% reduction in absenteeism among adolescent girls, a critical step toward enhancing girl-child education. Additionally, hygiene education training introduced through school health clubs have improved WASH knowledge, with 78% of students in intervention schools demonstrating correct handwashing practices.

The project also demonstrated indirect livelihood impacts that influence health and education. Through the sanitation value chain, over 350 men and women benefited from the waste collection, toilet construction, and small business development, which invariably contributed to local economic resilience and service sustainability.
In conclusion, GASSLIP has had a measurable and multidimensional impact on urban health and educational outcomes in Greater Accra. However, a sustained gain, would depend on continued municipal investment, behavior change support, and inclusive maintenance models. These findings provided evidence for scaling similar integrated urban

sanitation interventions in other Ghanaian cities and across Sub-Saharan Africa to advance SDGs 3, 4, and 6.

Understanding pathogen dynamics in onsite sanitation systems for safer sanitation strategies in low-and middle-income countries
Musa Manga, The University of North Carolina

Globally, excreta-related diseases from exposure to fecal pathogens contribute substantially to the global burden of disease with children under the age of five being the most affected. Improved access to and quality of sanitation can significantly reduce environmental human exposure to fecal pathogens. Consequently, global initiatives prioritize achieving equitable access to sanitation for all especially through the use of onsite sanitation systems (OSS) which are more affordable for low-and middle-income countries (LMICs). However, simply building OSS isn't enough—fecal sludge is often unsafely dumped in many LMICs, posing health risks due to the discharge of viable pathogens. To prevent this, OSS must be designed and operated to promote pathogen inactivation. A key step toward this goal is understanding variation in pathogen concentration within the layers of a system as well as between different systems typically found in LMICS as this enables planners to maximize the public health impact of sanitation interventions.

We conducted a study in KampalaUganda and Lusaka Zambia to assess pathogen concentrations—using E. coli as fecal indicator—in various OSS and across different system phases. Observed OSS types included: a) fully lined tanks (FT) with overflow, b) FT without overflow, c) lined tanks with open bottoms, d) lined pits, and e) unlined pits. E. coli concentrations varied significantly across system types in both countries ($p < 0.05$), with higher levels in lined and unlined pits compared to fully lined tanks. For example, in Zambia (units in Log CFU/L): FT with overflow (8.13 ± 0.56), unlined pits (10.36 ± 0.19); in Uganda: FT with overflow (8.36 ± 0.89), unlined pits (9.33 ± 0.58). Sewer samples in both countries also showed high E. coli concentrations, comparable to pits and higher than FT (Zambia: 8.89 ± 0.08; Uganda: 9.20 ± 0.22 log CFU/L), challenging the assumption that sewers are always the safest option. Pathogen assessments within containment revealed significant differences in E. coli concentrations between the top and bottom layers of certain OSS types. In both lined and unlined pits, top-layer samples had higher E. coli levels than bottom samples (lined pits: top 10.01 ± 0.80, bottom 9.32 ± 0.90 log CFU/L, $p = 0.039$; unlined pits: top 10.35 ± 0.07, bottom 9.33 ± 1.04 log CFU/L, $p = 0.033$). This may reflect the presence of fresher sludge with viable pathogens near the top, while the bottom contains older sludge exposed to environmental stress and nutrient depletion. In contrast, FT showed no significant difference between layers ($p = 0.658$), possibly due to dilution effects in the liquid top layer and more concentrated sludge at the bottom.

Our study findings indicate that FTs may provide more effective containment of fecal pathogens compared to pits or conventional sewer systems, making them a more suitable option for reducing public health risks associated with exposure. Additionally, the lower pathogen concentrations observed at the bottom of tanks suggest that prolonged storage can lead to a decline in pathogen levels, highlighting the importance of considering retention time in the design and management of onsite sanitation systems.

Localizing vulnerability assessments: A stakeholder-driven approach to identify the most vulnerable households in Northern Haiti
Maya Lubeck-Schricker, SOIL

Background
In urban areas of developing countries, high-quality sanitation services are often unaffordable for low-income residents, limiting the societal returns associated with safe sanitation, as community-wide benefits require coverage of a large proportion of the population. Achieving such coverage typically requires subsidies, particularly for low-income households. However, there are few examples of successful pro-poor sanitation subsidy programs implemented at scale. One key question surrounding such programs is how to reliably and cost-effectively identify the poorest and most vulnerable households in urban settings to determine eligibility for a subsidy. After exploration of multiple globally validated wealth assessment tools, a container-based sanitation (CBS) provider in northern Haiti identified the EquityTool as the most appropriate measure of relative wealth to identify household eligibility for a CBS service subsidy. Despite the success of initial suitability tests, key stakeholders emphasized the importance of additionally including locally-specific measures of vulnerability that may capture experiences beyond the EquityTool. This study developed additional vulnerability questions to complement the EquityTool for identifying the most vulnerable households in Cap Haitian, Haiti.

Methods
In summer 2024, the CBS provider conducted stakeholder interviews and focus group discussions with employees, community leaders, and government authorities to develop simple, yet locally-specific, survey questions that further capture the unique socio-economic and cultural conditions in Cap Haitian's high-poverty areas. Based on the stakeholder feedback, several new survey questions were developed to accompany the EquityTool and offer a more nuanced categorization of vulnerability levels within communities where poverty is pervasive.The CBS provider has begun testing the tailored vulnerability questions alongside the EquityTool in a survey of over 600 households in order to finalize a strategy for identifying eligibility for a sanitation subsidy.

Results

Stakeholders highlighted that, in addition to traditional economic indicators, vulnerability assessments should include culturally relevant markers such as housing quality, household size, dependency on social networks, access to education, and remittances from family abroad. They also stressed the importance of involving recognized community figures in data collection to build trust, ensure transparency, and improve the accuracy of responses.

Conclusions

This engagement process serves as a model for the WASH sector, showcasing how participatory methods can generate local endorsement of vulnerability identification efforts. This research contributes to global health and development by advancing a pro-poor framework that is adaptable to specific community contexts and locally approved. It demonstrates that inclusive, context-sensitive methods are essential for effectively identifying and supporting vulnerable populations in resource-limited settings.

Assessing The Environmental Contamination Risk Of Pathogens Released By Locally Constructed Septic Tanks In Kampala

Edwin Paul Kyabaggu, Makerere University

In rapidly urbanizing cities of Low- and Middle-Income Countries (LMICs) in sub-Saharan Africa (SSA), on-site sanitation systems such as septic tanks are among the most widely used due to their relative ease of operation and maintenance. However, their construction frequently occurs without adherence to standard designs or regulatory oversight, leading to system underperformance and potential environmental contamination. Their improper operation further exacerbates the problem, as septic tanks are often emptied only when completely clogged with sludge, heightening the risk of pathogen-laden overflows that threaten environmental and public health. This study investigates how septic tank design, operation, and maintenance, together with local environmental conditions, influence the movement of pathogens into the living environment in Kampala, Uganda. Understanding these interactions is critical for developing contextual sanitation solutions, informing policy and mitigating public health risks in rapidly growing urban areas.

Focusing on two parishes Bukoto I and Mulago III, this research employed a mixed-methods approach involving field surveys, fecal sludge (FS) sampling, laboratory analysis, and spatial risk modeling. Septic tanks were typologically classified and evaluated for compliance against 13 design criteria. Pathogen release was quantified through the enumeration of bacterial indicator Escherichia coli (E. coli) and helminth eggs (Ascaris spp.) in the effluent and influent, bottom, top and composite samples from 37

containments. Environmental vulnerability was mapped using a GIS-based model, with the Analytical Hierarchical Process (AHP) used to weigh the contributing risk factors. These included soil type, slope, Topographic Wetness Index (TWI), proximity to surface water and septic tank attributes. Risk factors such as septic tank density, number of users, and effluent disposal type were derived from field data and literature.

Three main typologies were identified: (1) fully lined tanks with an effluent pipe, (2) fully lined tanks without an effluent pipe, and (3) lined tanks open at the bottom. On average, tanks met only 50% of the assessed design criteria, raising concerns about the generalized classification of such systems as "septic tanks." Mean E. coli concentrations in top, bottom and composite samples were 6.93±1.45, 6.49±2.07, and 6.46±2.42 $\log_{10}$ CFU/100 mL, respectively. These concentrations significantly exceed environmental discharge thresholds and pose serious public health risks. E. coli concentrations were significantly correlated with the number of users ($r = 0.38$, $p = 0.019$), number of connected households ($r = 0.43$, $p = 0.01$), and sludge volume ($r = 0.47$, $p = 0.03$). Tanks connected to toilets with manual flush interfaces showed higher E. coli concentrations compared to cistern flush systems ($p = 0.001$). No significant association was found between Ascaris egg concentrations and septic tank design or maintenance practices.

The spatial risk model identified TWI, soil type, and septic tank effluent discharge type as the most influential environmental contamination risk factors. Risk mapping highlighted priority zones within the study areas where the possibility of human and ecological exposure to pathogen contamination was highest. These findings underscore the urgent need for design standardization, improved regulatory oversight, and integration of localized risk mapping into urban sanitation planning. In high-risk areas, septic tanks should provide for a sewer connection or secondary treatment units, and nearby water sources must be monitored regularly to mitigate public health risks.

Sanitation Circular Economy: Co-Compost Impacts on Soil, Crop productivity, and Farmer Livelihoods in Fort Portal-Uganda.
Kabasinguzi Pamela, Caritas Fort Portal-HEWASA

Soil fertility depletion and improper faecal sludge management present significant challenges to agricultural productivity and environmental sustainability in Uganda. This study investigates the impact of co-compost derived from faecal sludge and organic waste on soil quality, crop productivity, and farmer livelihoods in Fort Portal. The research addresses critical concerns, including declining soil organic carbon (SOC) and soil acidification. To this we added, the current high costs of synthetic fertilizers and their long-term environmental impact if not applied properly. Lastly, we added the risks associated

with untreated faecal sludge and municipal solid waste disposal and the non-utilization of carbon and nutrients in this process.

A mixed-methods approach was employed, integrating field experiments, laboratory soil and compost analyses, and farmer surveys. A randomized complete block design (RCBD) with three treatments—control (no compost), co-compost (5 tons/ha), and chemical fertilizer (standard urea and NPK application)—was implemented on selected vegetable crops (carrots, beetroots, potatoes, and beans). Soil physicochemical properties, microbial diversity, heavy metal content, and economic viability were assessed using standard analytical procedures. Key findings indicate that co-compost application significantly improved soil properties, increasing pH (from 5.2 to 6.5), organic matter content (from 1.2% to 2.8%), total nitrogen (from 0.08% to 0.25%), and available phosphorus (from 8.5 mg/kg to 22.3 mg/kg). This resulted in a 20-30% yield increase across all vegetable crops (compared to control), but it is also outperforming chemical fertilizers in yield and long-term soil quality maintenance. Economic analysis revealed a 25% increase in net farm income due to reduced fertilizer costs and higher marketable yields. While heavy metal concentrations remained within permissible limits, pathogen detection highlighted the need for improved compost sanitization before field application. These findings support the integration of sanitation circular economy principles into sustainable agriculture. Policy recommendations include mandatory compost quality standards, farmer training programs, and regulatory frameworks promoting faecal sludge reuse. The study demonstrates that co-composting is a viable strategy for enhancing soil fertility, boosting food security, and mitigating environmental pollution, contributing to climate resilience and sustainable urban waste management.

Timing and Volume of Water Collection at Handpumps and Piped Water Systems in Three Rural Zambian Communities
Samantha LeValley, University of Toronto

Background
Rural piped water systems (PWSs) are proliferating where handpumps were once the norm for water provisioning. While PWSs can be beneficial, they often run intermittently (for a few hours per day) which complicates and sometimes compromises their ability to provide enough water to users. Where PWSs run intermittently, users are constrained in when they can collect water. Rural PWSs are often built alongside existing infrastructure such as handpumps. Yet little is known about the day-to-day (let alone hour-by-hour) realities of how communities rely on co-located water infrastructures.

Methods
This study installed 8 handpump sensors and 104 water meters on taps across three rural

communities in Southern Province, Zambia with between 70-250 households. Each community had a solar-powered PWS. Sensors have collected hourly water flow data since June 2024.

Results

Handpump use was concentrated in the morning: 41% of handpump withdrawals occurred before 8am. Water was rarely available from PWSs before 8am (<3% of PWS withdrawals were before 8am). PWS withdrawals were concentrated midday, but often continued into the early evening, with a quarter of withdrawals occurring after 5pm. While water was also available from handpumps in the evening, <3% of handpump withdrawals occurred after 5pm. Do early morning handpump withdrawals reflect users' desire for morning water availability, or simply the practical benefits of pumping water in the cool of the morning? Ongoing surveys in study communities promise new insights to inform future user-centered design and operation of rural PWSs.

The studied PWSs supplied water intermittently for between 2 and 8 hours/day. Intermittent operation meant that the elevated storage tanks in each system (20 m3) often drained daily – preventing them from buffering cloud-induced variations in solar insulation. Varying energy input resulted in varied average water output per community, ranging from 10 to 23 m3. PWSs supplied an average of 56 liters per capita per day (LPCD) to users, but unequally. Some received an average of only 10 LPCD while others received an average of 300 LPCD – well below and above national per capita supply standards (55 LPCD). Water withdrawals at handpumps declined substantial during the dry period (plausibly reflecting a declining water table), from an average of 4,400 L/day to 1,000 L/day.

Conclusions

Co-located water infrastructures provide unique insights into user preferences and the seasonally varying dynamics of how rural water system are used. PWSs should be designed so that 1) water is available at times when users want the water most, 2) storage capacity is used to buffer short-term variations in solar insulation, and 3) water equality is maximized, even under intermittent operation. Large variations in water availability and use (between households and between seasons) renders reported water averages misleading. System designers and regulators should focus on the range of performance in these systems. As PWSs proliferate, it is essential that their design and operation reflect user preferences and mitigate inequalities.

Randomized Controlled Trial of the PICHA7 WASH mHealth Program to Reduce Cholera in the Congo
Christine Marie George, Johns Hopkins Bloomberg School of Public Health

Background: We assessed the impact of the Preventative-Intervention-for-Cholera-for-7-Days (PICHA7) water treatment and hygiene program on serologic responses to Vibrio cholerae O1 in the Democratic Republic of the Congo (DRC).

Methods: The PICHA7 cluster-randomized controlled trial enrolled diarrhea patient households in urban Bukavu, DRC. Households were randomized into two arms: single in-person visit for the DRC government's diarrhea patient standard message on oral rehydration solution use and a basic WASH message (standard arm); or this standard message and the PICHA7 program with quarterly in-person visits and weekly voice and text mobile health messages (mHealth) (PICHA7 arm). Serum samples were analyzed for IgG and IgA antibodies to V. cholerae O1 Ogawa and Inaba O-specific polysaccharide (OSP) using enzyme-linked immunosorbent assay (ELISA). V. cholerae exposure was defined by a rise in an IgA or IgG V. cholerae O1 serological antibody from baseline to the 1-month follow-up. Generalized estimating equations were used for regression models to account for clustering at the individual and household level.

Results: Between December 2021 and December 2023, 573 participants randomly allocated to two arms were included in a sub-study of serologic responses to V. cholerae: 254 standard arm and 319 PICHA7 arm. Significantly lower V. cholerae exposure was observed in the PICHA7 arm compared to the standard arm, defined by a change in IgA V. cholerae O1 O-specific polysaccharide antibodies from baseline to the 1-month follow-up (Coefficient: -0.85 (95% CI: -1.60, -0.09).

Conclusion: The PICHA7 program which combines mHealth with quarterly in-person visits lowered V. cholerae exposure in the DRC. Clinical Trials Registration NCT05166850.

Monetary valuation of sanitation-related quality of life gains in rural Malawi – willingness to pay study
Mindy Panulo, University of Strathclyde

Introduction
While improved sanitation is widely recognized for its role in reducing disease transmission, households in low-income settings often also value sanitation's quality of life (QoL) benefits, such as privacy, safety, and dignity. These QoL outcomes are rarely incorporated into economic evaluations due to the lack of standardized methods for attributing monetary value to them. To address this gap, we built on the Quality-Adjusted Life Year approach from health economics to develop the Sanitation-Adjusted Person Year (SAPY). One SAPY is worth one year at full sanitation-related quality of life (1.0), or two years at 0.5, and so on. This study aimed to estimate the monetary value of a SAPY using a

willingness to pay (WTP) approach in rural Malawi, enabling the inclusion of sanitation QoL benefits in benefit–cost analyses.

Methods
We conducted a contingent valuation study with 300 adults in rural southern Malawi. Participants completed the SanQoL-5 Index, a five-domain instrument measuring sanitation-related quality of life, with responses aggregated into a weighted index ranging from 0.0 (worst) to 1.0 (best). Participants were presented with a hypothetical scenario involving an upgrade to an improved pit latrine from the unimproved latrine they currently used. Expected QoL improvement from the upgrade was elicited using the Sanitation Visual Analogue Scale (SanVAS). WTP was elicited using a double-bounded dichotomous choice method, followed by a maximum WTP question. We estimated average maximum WTP using linear regression, adjusting for gender and WTP for maize as a benchmark. The monetary value of a SAPY was calculated from average maximum WTP and the expected increment on the SanVAS with the upgrade, accounting for household size and a five-year toilet lifespan. Our primary analysis included 241 participants who were "quite" or "very" sure in their stated maximum WTP.

Results
Ninety-four percent of participants used unimproved sanitation facilities, with only 3% having access to latrines with full privacy (walls and doors). The mean SanQoL-5 score was 0.66 (95% CI: 0.64–0.69). The mean VAS increment participants expected from the upgrade was XX (YY-ZZ). The mean WTP for a SAPY was $6.20 (95% CI: 3.0–9.3). Sensitivity analyses to test the robustness of this estimate were conducted among all 300 participants and among 185 participants whom enumerators rated as having "carefully considered" the activity, yielding WTP estimates ranging from $4.50 to $6.64. WTP was significantly associated with WTP for maize, a benchmark commodity. We observed no differences in WTP for sanitation improvements by gender.

Conclusion
This is the first study to monetarily value sanitation-related QoL gains through the development and application of the SAPY metric. Our findings demonstrate that rural Malawians are willing to pay meaningful amounts for QoL improvements associated with improved sanitation, even in resource-constrained settings. Incorporating the SAPY into benefit–cost analyses would enable more comprehensive evaluations of sanitation interventions, capturing benefits that extend beyond disease prevention and time savings. These insights also highlight the importance of facilitating access to financial resources, such as community savings groups, to support latrine upgrades.

Domestic Water Consumption and Hygiene Behaviours in Zambian Communities

Sarah Bick, LSHTM

Access to safe and reliable water supply services is a necessary component for unlocking the health and development potential of other sanitation and hygiene interventions. Current coverage indicators obscure varying patterns of water collection and use from a variety of sources in response to changing supply, an increasingly relevant issue with the changing climate. In this analysis, we explore relationships between water supply and water use and consumption in the home environment. We completed an in-depth survey of household water collection, water storage and water use in three communities in Zambia: a rural community, a low-income peri-urban community, and a middle-income peri-urban community. Data were collected between February and March 2024. Respondents provided information on all water sources used on a regular basis and water use activities completed at source. Using a set of standard and validated tools, we measured the total volume of water stored in the home and the amount consumed in the past 24 hours for specific hygiene-related activities. The 288 respondents in our analysis relied on a variety of water sources (up to 5 different sources) routinely throughout the year. Analysis of per-capita daily water collection showed little variability by distance to primary source. Average per-capita daily water use was below minimum recommended thresholds across source types. Respondents whose primary water source was piped onto their premises used similar volumes of stored water as other households but used more water at source (without subsequent storage and transport), including more water for health protective behaviours such as hygiene. However, households with sources piped to premises were more likely to rely on secondary water sources compared to others (88% vs. 72%) and reported increased periods of discontinuity. To explore factors that influence water availability in the home, we developed structural equation models. These models suggested two unique set of factors impacting the amount of water collected or used at source among households with and without a primary source on premises, and subsequent models were refined for the two groups separately. Among respondents with off-premises source, capacity of collection containers was a significant predictor of water collection, and the effect of water discontinuity on collection was partially mitigated by increased number of trips to collect water. Among on-premises users, increased water payments reduced collection, and discontinuity had a significant positive relationship with volume collected; this finding possibly points to increased storage as a mitigating behaviour. Our data underscore the complex relationships between water sources and water consumption in the domestic context. While piped water services may more readily support domestic and personal hygiene behaviours, these services are more vulnerable to service disruptions and force households to supplement water supply from a greater variety of water sources than other services. Longitudinal measurements over time and across seasons are required to clarify associations and directionality of mitigation behaviours, and pathways should be explored in more detail through qualitative research. Future work should explore approaches to improving climate resilience to ensure sustained access to water in low-resource settings.

Measuring Water Insecurity on the Navajo Nation Using a Representative Household Survey
Natalie Exum, Johns Hopkins University

Access to safe, reliable, and affordable water is essential for health, dignity, and cultural preservation, yet many Native American communities lack basic water access. The Navajo (Diné) Nation faces unique challenges, with many families relying on costly and time-consuming water hauling due to inadequate infrastructure and concerns over water quality. However, the lack of comprehensive data on the magnitude and household-level impact of water access has hindered effective resource allocation, policymaking, and solutions. This study examines household water insecurity on the Navajo Nation using the Household Water Insecurity Experiences (HWISE) scale. The water insecurity questions were included within the Diné Household Water Survey (DHWS), a comprehensive water needs assessment of Diné households to determine a representative estimates of water access. The complete set of twelve HWISE questions, that were developed for middle- and low-income country contexts, were included to assess experiences with water use, reliability, availability, and access within the last month. The twelve questions were administered with modifications for the Diné context. Of the 985 households enrolled in DHWS in the Fort Defiance Agency, 26.7% of homes were found to lack piped water access and for those with piped water access, 16.9% reported experiencing water shutoffs. There were 964 households that completed the HWISE questions administered to the 985 households in the DHWS. For the question regarding washing clothes at home, 49.7% of homes had missing data (n=480) due to a lack of clothes washing in the household and this question was excluded from the final scoring. An additional question was added to differentiate between the use of water for drinking and water used for other household needs. For homes without piped water, 24.8% answered that they had one or more days in the last month when there had been no useable water whatsoever in the household (11.1% for all homes in the sample). Using the scoring methods defined by the HWISE scale, where a household was considered water insecure with a score ≥ 12, only 4.8% of households were classified as water insecure. This scoring system of the HWISE scale was determined to grossly underestimate the challenges with water insecurity on the Navajo Nation. The study concluded that the HWISE methodology needs modifications to be applicable for Indigenous populations in the high-income country context.

Associations between water supply intermittencies and drinking water quality, child health outcomes, and caregiver emotional stress in peri-urban Malawi
Caitlin Niven, North Carolina State University

Background

Achieving universal access to safe and affordable drinking water remains a critical global challenge, particularly in low- and middle-income countries where intermittencies in water supply are common. We aimed to examine the relationships between water intermittency and a range of outcomes, including microbial water contamination, child health, and caregiver stress.

Methods

We conducted a cross-sectional study with 237 households with a child <5 years old in a peri-urban neighborhood of Blantyre, Malawi. We conducted a structured questionnaire with primary caregivers to record water intermittencies, water handling and hygiene practices, caregiver-reported seven-day prevalence of child diarrhea and acute respiratory infection (ARI) symptoms, and stress among caregivers. We collected and analyzed drinking water samples with IDEXX Quanti-Tray/2000 for E. coli and cefotaxime-resistant E. coli. We used generalized linear models to evaluate how the occurrence, frequency and duration of water intermittencies influenced outcomes, adjusting for sociodemographic and water, sanitation, and hygiene factors.

Findings

Of 237 households, 32.5% (77) reported [3]1 water intermittency in the last 4 weeks. Households with intermittencies, compared to non-intermittent households, were more likely to be water-insecure, skip laundry and bathing and less likely to report handwashing after handling animals/animal feces or working outside. Among water samples, 65.7% (155) contained E. coli and 8.4% (19) contained cefotaxime-resistant E. coli. Intermittencies were not associated with impaired water quality. Children in households with intermittencies had higher prevalence of caregiver-defined diarrhea (prevalence ratio [PR]=1.94, 95% CI: 1.11–3.39, p=0.02) and ARI with fever (PR=2.00, 95% CI: 1.11–3.60, p=0.02). Rare/short intermittencies were more strongly associated with increased diarrhea while frequent/long intermittencies were more strongly associated with increased ARI. Caregivers in households experiencing short or frequent intermittencies reported higher stress compared to those in non-intermittent households.

Interpretation

Water intermittencies were associated with impaired hygiene, especially around animal handling, respiratory infections, diarrhea, and stress. Frequency and duration of intermittencies modified the associations, suggesting that short-vs. long-term behavioral adaptations to intermittencies may differently influence exposure to enteric vs. respiratory pathogens and stress responses. In settings experiencing water intermittencies, low-flow handwashing stations or waterless hand sanitizer may mitigate infection risks. Future research should evaluate interventions addressing water supply intermittencies.

High-resolution Analysis of Demographic and Socioeconomic Characteristics of Households with Private Wells in the USA
Caroline Sear, Virginia Tech

Introduction:
An estimated 43 million Americans rely on private wells as their primary source of drinking water. However, well users are responsible for the testing, treatment, and maintenance of their own wells, which is often neglected due to a lack of knowledge, ability, or the desire to do so. As of 1990, the US census no longer includes questions about water supply. Therefore, information about the population served by domestic wells is largely unknown. Previous investigations on demographic patterns of well users was limited to information gathered by the American Community Survey, which included data on less than 50,000 housing units. Our analysis aims to substantially expand on this to include all domestic well records (~6 million) within the US. This can then be used to inform analyses of estimated contaminant exposures or support well stewardship efforts.

Objectives:
To understand defining factors of households with private wells, we examined the dominant demographic patterns of domestic well users across the US, including race, educational attainment, and economic status. We also examine how these characteristics vary by geographic regions, sub-regions and population density.

Methods:
We use the most comprehensive national dataset available for the locations of privately owned wells across the United States, assembled by Lin et. al. (2024) and our group. This dataset includes over 6 million domestic wells. Using ArcGIS, this data is spatially linked with the most recent census data, including race, median income, and education attainment at the finest publicly available resolution. Additionally, the Regrid dataset is used to further enhance results by providing information on land and structure value and zoning information at the parcel level.

Preliminary Results:
Results show demographic patterns of households reliant on private wells that differ from that of the overall population at both county and state levels. Initial results show that well users may be more likely to be White and to have higher levels of education than the total population. Continued analysis in the coming weeks will investigate data on household income and property value, which will allow us to characterize the socioeconomic status of well owners. The analysis patterns will also be further expanded spatially to cover nearly the entire United States.

Application of Finding:

This information is intended to be further disseminated to states and counties, who are responsible for the regulation and management of domestic wells. In having a better understanding of who is reliant on domestic wells, local environmental quality and health departments can better identify possible challenges faced in well stewardship and provide services that address the needs of well users. This may be used to target outreach for well testing programs or help utilities prioritize public water supply expansion projects. Additionally, these findings may be linked to possible contaminant exposure through drinking water.

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Greywater reuse reimagined: Engineered alginate-polyethyleneimine and sludge-aluminosilicate biochar composites and models for system design.
Herbert Kaboggoza, UNC Chapel Hill

Greywater, which accounts for 75–80% of domestic wastewater, represents a significant opportunity for non-potable reuse. Biochar, a pyrogenic sorbent derived from waste biomass, offers a low-cost solution for greywater treatment. However, its practical application is constrained by limited adsorption capacity and high selectivity toward specific contaminants. This study addresses these challenges by engineering multifunctional biochar composites capable of concurrently removing pathogens, nutrients, and organic matter from complex greywater matrices.

In this research, we developed two novel alginate-polyethyleneimine (PEI) – BCALPEI – and sludge-derived aluminosilicates biochar – BCALSI – composites for effective greywater treatment in fixed-bed column systems. Aluminosilicates introduced oxygen-containing groups and metal ions (Al, Si, Mg) to boost electrostatic interactions and cation exchange capacity, while PEI—attached on calcium alginate— introduced a positive surface charge and structural stability. Both composites contribute to environmental sustainability: BCALSI provides a value-added pathway for sludge management, while BCALPEI offers a green alternative for surface functionalization. Their performance was benchmarked against biochars modified with zinc chloride, calcium alginate, and standalone PEI. Characterization via SEM-EDS, FTIR, and XPS confirmed significant changes in surface morphology and chemistry, critical for enhanced pollutant removal. Greywater samples collected from four households in Chapel Hill and Carrboro, North Carolina, exhibited high concentrations of organic matter, nutrients, and suspended solids: suspended solids (chemical oxygen demand (total suspended solids (TSS, 1871.4 ± 156.2 mg/L) COD, 1817.6 ± 40.9 mg/L, total organic carbon (TOC, 3380.0 ± 12.0 mg/L, total nitrogen (TN, 242.9 ± 8.6 mg/L), total phosphorus (TP, 6.0 ± 0.5 mg/L). It also exhibited high fecal (E. coli, $\log_{10}$ 4 ± 0.4 MPN/100 mL). Among the tested materials, $ZnCl_2$-modified biochar achieved the highest

COD removal (96.1%), PEI-biochar demonstrated superior nitrate removal (95.5%), and aluminosilicate-modified biochar exhibited the highest ammonium removal efficiency (97%). Additionally, the CatBoost machine learning algorithm accurately predicted removal efficiencies and breakthrough behaviors for key contaminants ($R^2 > 0.7$), underscoring its potential in optimizing treatment system design. By utilizing waste-derived materials and real greywater, this study advances decentralized, cost-effective greywater treatment technologies. Future work should explore pilot-scale implementation, multilayer configurations, and the removal of emerging contaminants, alongside refinement of predictive modeling approaches to enhance treatment efficiency and scalability.

Scaling financially sustainable WASH services through circuit rider supported chlorination in Central America
Wesley Meier, Cova

Background
Recent estimates indicate that globally, 2.32 billion people have contaminated drinking water that is compatible with treatment by passive chlorinators, a drinking water treatment technology that passively doses chlorine without additional end-user burden, centrally within the distribution system or storage tank. There is considerable potential for passive chlorinators to elevate existing water systems into a safely managed category by eliminating waterborne disease through disinfection. A few service delivery models have proven to be effective in implementing and sustaining support to chlorinators, including Cova's circuit rider model—which supports community water board management of chlorinators.
However, questions remain as to how these in-line chlorination service delivery models can be sustainably funded, especially in cases where community-based management is a critical aspect of service delivery. Broadly, best practices and financial mechanisms for supporting, subsidizing, and ultimately scaling both in-line chlorination, and professionally supported, community-based management of in-line chlorination remain relatively under studied and under reported on.

Methods
Here, we organized and evaluated 10 years of operational data, including local revenue from chlorine sales, operational costs, and circuit-rider collected water tariff data. Using this data, we modeled the potential for sustainable growth of Cova's circuit rider supported in-line chlorination model over the next 10 years. Next, we considered alternative revenue sources, such as volumetric benefits, results-based funding, and impact investment, to see how these funding opportunities could subsidize Cova's growth. Specifically, we identified the level of subsidy needed and the point at which a service-delivery model like

Cova's could feasibly reach a break-even point where philanthropic contributions are no longer required for operation.

Results
Our results indicate first that the majority of community water boards who receive financial capacity building support from Cova's circuit rider model have water tariffs that can sustain ongoing O&M costs, including regular repairs, purchase of chlorine, and establish a financial reserve. Further, around 30-40% of the operational costs of the circuit rider service delivery model can be subsidized through local chlorine sales—leaving a long-term subsidy need of ~60% at scale. Using this model, we project that we can cover this subsidy for service delivery of in-line chlorination, initially using philanthropic support, results-based funding, and volumetric benefits. But more critically the model indicates that by 2030 this subsidy can be covered without reliance on traditional philanthropy.

Conclusion
Our findings indicate that by leveraging local revenue, results-based funding, and volumetric benefits such as carbon credits, it is possible to sustainably fund and scale CBM supported in-line chlorination. Further, the circuit rider model for in-line chlorination service delivery has the potential to be self-sustaining, particularly at scale.

Alternatives to traditional membrane filtration for microbial water quality testing: technical performance, usability, and cost
Meseret Zerefa, The Aquaya Institute

BACKGROUND: Waterborne diseases from fecal contamination in drinking water remain a leading cause of child mortality in low- and middle-income countries. Effective interventions to improve drinking water quality rely on reliable monitoring of E. coli, a common fecal indicator. Quantifying E. coli by traditional laboratory membrane filtration methods is often impractical in resource-limited settings. While simpler methods have been developed, alternative quantitative test options remain limited. Further, methods assessments often focus on technical performance, but researchers and practitioners may select methods considering available budgets and technical capacity.

OBJECTIVE: This study evaluated three novel quantitative E. coli testing methods for use in resource-limited settings, considering technical performance, usability, and cost.

METHODS: We selected three novel methods: 1) a newly-developed molded plastic membrane filtration manifold with CompactDry E. coli-only plates, 2) Aquagenx GEL kit with incubation at 35C for 24 hours, and 3) Aquagenx GEL kit with incubation at simulated-ambient conditions for 48 hours, and evaluated them against reference methods for

technical performance, usability, and cost. For technical performance, we analyzed 282 water samples with novel methods and Reference 1: standard membrane filtration with CompactDry E. coli-only plates. We compared sensitivity and specificity (measures of true positives and negatives), risk category agreement, and correlation coefficients. For usability, twelve novice users analyzed samples with novel methods and Reference 2: Wagtech Aquasafe MSL50, a common field kit. We assessed accuracy (comparing to technician results) and ease-of-use (comparing observed errors and self-reported difficulty). For cost, we aggregated fixed, consumable, and labor costs and calculated total costs for a range of sample quantities.

RESULTS: For technical performance, all novel methods showed consistency with the reference method in identifying E. coli presence (>1 CFU/100mL); sensitivity and specificity ranged from 85%-91%. E. coli concentrations were highly correlated with the reference method (R=0.87-0.90), and risk categorizations were consistent for three-quarters of samples. The plastic manifold and GEL kit at 35C incubation performed slightly better than the GEL kit with simulated-ambient incubation, which displayed slight undercounts. Concerning usability, novice user accuracy was highest for the GEL kit (92% agreement in risk category). Novel methods performed better than Reference 2 in terms of observed errors and self-reported difficulty. Costs varied widely. At smaller sample sizes (n<100), the GEL kit with ambient incubation was most affordable, due to low fixed costs. For larger sample sizes (n=1000), the plastic manifold was most affordable, and the GEL kit at 35C incubation was significantly more expensive due to high consumable and fixed costs.

CONCLUSION: The assessed methods are suitable alternatives to traditional membrane filtration in low-resource settings. Selecting appropriate technologies requires practical consideration of study goals and limitations, including quality of results, technician experience, and available budget. In cases where few samples are needed (<100), technicians are inexperienced, and climate allows, the GEL kit with ambient incubation may be favorable, due to its ease-of-use and affordability. In cases requiring many samples (~1000), with experienced technicians and where accuracy is critical, the plastic manifold may be favorable due to its good technical performance and affordability.

Assessment of Doroudzan Storage Dam in Regulating Kor River Salinity from Saline Tributaries, Southern Iran
Maryam Tavallali, Rutgers University

Background:
In arid and semi-arid regions, the combined impacts of prolonged drought and climate change have led to noticeable declines in streamflow and water quality. Ensuring water availability, especially for drinking and agriculture, now depends on how well reservoirs are

managed. Yet rising river salinity remains a pressing challenge in these vulnerable ecosystems. The Kor River is one of the main rivers in southern Iran and serves as a lifeline for the region. To manage its flow and storage, the Doroudzan Dam was constructed in 1972 with a capacity of 993 million cubic meters (MCM). The dam supplies drinking water to Shiraz, a significant provincial capital, and irrigates farmlands across Fars province. The river is fed upstream by a large freshwater tributary and two small saline tributaries, with withdrawals intensifying salinity where the salt tributaries join the main channel. This study assesses the Doroudzan Dam's role in regulating salinity during drought-driven streamflow reduction in the Kor River. Despite its importance, limited research has assessed salinity regulation by storage dams under drought using long-term field data.

Methods:
This long-term study was conducted upstream of the Doroudzan Dam in the Kor River basin. Hydrological and water quality data (precipitation, discharge, and electrical conductivity) were obtained from the Fars Regional Water Authority for long-term trend analysis. We evaluated the dam's annual water budget by assessing outflow, inflow, evaporation, and water allocations for drinking and agriculture using 40 years of hydrological data. The efficacy of the reservoir in reducing salinity variations over time was evaluated by comparing these storage fluctuations and reservoir storage changes with long-term river salinity trends.

Results:
Over the past 14 years, a 27.8% reduction in precipitation due to severe drought beginning in 2007 and continued agricultural expansion led to a decline in streamflow from 832 to 369 MCM—a 55.6% reduction. During this period, Kor River salinity rose by 43.9% and reservoir salinity by 42.5%, indicating notable water quality degradation, showcasing the contrast between river inflow and reservoir conditions. Prior to the streamflow reduction, the mixing of low- and high-salinity inflows in the reservoir effectively regulated river salinity, reducing the fluctuation range from 230–1032 µmhos/cm upstream of the dam to 339–732 µmhos/cm at the outlet, demonstrating the reservoir's key role in mitigating salinity variability. During the streamflow reduction period, the reservoir continued to moderate salinity levels, narrowing a wider upstream fluctuation range of 442–1816 µmhos/cm to 534–1050 µmhos/cm at the outlet. These results show that the Doroudzan Dam plays a significant part in reducing salinity both during drought and in regular hydrological conditions.

Conclusion:
The findings suggest the Doroudzan Dam is essential in regulating downstream salinity and offers guidance for basins facing similar water scarcity, particularly in arid and drought-prone regions. Storage dams can be an effective approach to control salinity in rivers impacted by saline tributaries during streamflow reductions caused by prolonged

droughts, such as those that began in the mid-2000s. This research demonstrates how long-term reservoir operation can buffer salinity under prolonged drought conditions.

Physiological and Psychological Health Outcomes of Multidimensional WASH Insecurity: Evidence from the 2022 Bangladesh Demographic and Health Survey
Noor Kutubul Alam Siddiquee, Arizona State University

Despite increasing recognition of the health impacts of inadequate water, sanitation, and hygiene (WASH), a lot of hypotheses are yet to be tested to examine how multidimensional WASH insecurity (lack of access to improved water, improved sanitation facilities, and improved handwashing facilities) shapes physiological and psychological outcomes in low-resource settings like Bangladesh. This research examines the relationship between household-level WASH insecurity and health outcomes, using a nationally representative 2022 Bangladesh Demographic and Health Survey (BDHS) data.
The primary objective is to analyze how this composite WASH insecurity score predicts two sets of health outcomes: physiological stress, measured by systolic and diastolic blood pressure; and psychological distress, measured by anxiety and depression score. Drawing from the growing body of literature that WASH insecurity, created using principal component analysis (PCA), can function as a chronic stressor of health outcomes, this research applies multilevel modeling approaches to examine the association independently and also while controlling for key covariates such as gender, age, household wealth, education, marital status, BP medication, tobacco consumption, BMI score, women empowerment, and place of residence.

Initial analysis showed that higher WASH insecurity is associated with elevated blood pressure and increased symptoms of anxiety and depression. However, integrating gender aspects showed that men and women in the same household exhibit different patterns where women are more vulnerable. A higher women empowerment score reduces the severity of all physiological and psychological stressors despite living in WASH-insecure households. The analysis also found that exposure to mass media functions as a resistance mechanism to hypertension, anxiety, and depression. In addition, when WASH insecurity components were disintegrated, sanitation and hygiene insecurity independently increased the stress level, especially among women.

The findings of this research contribute to the ongoing endeavor in environmental health and medical anthropology to define WASH insecurity as a structural, infrastructural, and embodied phenomenon. It will also contribute to policy-making by highlighting the importance of considering mental health and psychological stressors in WASH intervention.

Socioeconomic and attitudinal predictors of bottled water use among lower-income households in rural Southwest Virginia
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Introduction: Bottled water consumption is rising, influenced by perceptions of taste, convenience, safety, and concerns about other sources of drinking water. However, bottled water raises quality, environmental, and economic concerns. Despite poorer economic and health outcomes in Central Appalachia, there is a severe lack of research about drinking water in the region.

Purpose: This study explores socioeconomic and attitudinal predictors of bottled water usage among 33 households in southwest Virginia.

Methods: Data were collected through in-person household surveys as part of a larger drinking water quality study. Variables considered included the following as potential predictors of primary or secondary bottled water use: income, level of education, marital status, and perception of household water quality. Analyses included descriptive statistics and logistic regression.

Results and Discussion: Results indicated that 75.8% of households use bottled water, with 14 (42.4%) reporting use of bottled water as their primary source of drinking water and 11 (33.3%) as a secondary source. Reasons for use included perceptions of taste (27.3%), convenience (24.2%), safety (12.1%), tap water is not safe (3.0%), tap water does not taste good (3%), and other reasons (6.1%). Results also indicate that socioeconomic indicators and perceived quality of households' tap water were not significant predictors of bottled water use. These findings are not consistent with other research, and recommendations include further study with increased sample size. This study adds value to existing research because there are no other studies on predictors of bottled water use in this population.

Exploring "Cleanliness" in Rural Bangladesh as Part of a Poultry Intervention to Improve Household Hygiene
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Background
Raising backyard poultry for nutrition and income is widespread in rural Bangladesh. In this setting, keeping poultry inside dwellings at night is common, which can contribute to

children's exposure to poultry feces. To address this, a 2020-21 pilot intervention supported households in building outdoor poultry sheds, alongside hand hygiene and poultry feces management components. From formative research, a frequent motivation to build a shed was to improve cleanliness inside the dwelling. As part of a follow-up evaluation (2024-25), we conducted a mixed-methods exploration of perceptions of cleanliness of self and the home environment and compared these perceptions across households following poultry housing recommendations.

Methods
75 households participated in the follow-up study. Structured questionnaires were administered to all female poultry raisers (n=75) and male household members (n=69), as well as spot checks of poultry housing and hygiene facilities. Participants completed Likert-scale questions on hygiene-related quality of life, piloted with 16 participants and subsequently optimized through cognitive interviews (n=8). Participants with a range of hygiene behaviors were selected, based on previous survey and spot check findings, to participate in in-depth, semi-structured interviews. Quantitative data were analyzed in Stata, and qualitative data were analyzed thematically.

Results
Through pre-testing and qualitative interviews, participants shared that the scope of personal cleanliness included clothing, bathing, and hand hygiene and, for some, was associated with cleaning rituals around prayer. Handwashing with soap, particularly before meals, after toilet use, and before feeding children, was highlighted. Cleanliness inside the household dwelling included the appearance of floors and furniture. Cleanliness of courtyard spaces was described in terms of the debris, animals, and waste present. The Bengali term for 'cleanliness' was commonly interpreted by participants to mean the concept of 'tidiness,' a reflection of local vernacular. For hygiene-related quality of life items, most female and male survey respondents said that it was "rarely" (F:44%; M:49%) or "sometimes" (F:44%; 45%) hard to keep the inside of the house clean. Most households (n=58;77%) had poultry housing separate from the household dwelling. However, statistical analysis revealed no association between keeping any poultry inside at night and perceived difficulty with dwelling cleanliness (Chi^2=6.30, p=0.614). In qualitative interviews, participants noted that keeping poultry outside in a shed reduced "foul" odors and "mess" inside their homes.
Quantitative analyses reflected differences in perceptions among men and women: 59% of male-female pairs had different assessments about hand hygiene difficulty, 62% about cooking space cleanliness, and 75% about courtyard cleanliness. Weighted agreement was higher (>88%), which could reflect selection of middle response options (rarely, sometimes) rather than the extremes (always, never).

Conclusion
These findings demonstrate that "cleanliness" of the self and the home environment in this

setting is associated with hygiene, organization and religion. While most households had poultry housing separate from the dwelling, there was no statistical association with perceptions of domestic hygiene, though qualitative data suggested perceived benefits. Variation in hygiene perception by gender suggests the need for gender-sensitive interventions. To inform effective policy and practice, interventions need to be grounded in local understandings of cleanliness.

Weighted Philippine Groundwater Health Index for Integrated Assessment of Groundwater Quality in Agricultural Areas
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Groundwater health assessment in the Philippines has traditionally relied on discipline-based approaches, neglecting the critical role of ecological and biophysical indicators. To address this gap, this study introduces the Weighted Philippine Groundwater Health Index (wPGHI), an assessment tool that incorporates a range of ecological and biophysical indicators such as stygofauna, fecal coliform, nitrates, phosphates, soil type, dissolved organic carbon (DOC), and environmental characteristics to assess groundwater.

The main objective is to create the PGHI to monitor groundwater in agricultural areas. Specifically, it aims to establish the standards for reference conditions for close-to-ideal and agriculture/irrigation uses, calculate the PGHI of groundwater resources in agricultural areas, and assess groundwater health based on close-to-ideal and agriculture/irrigation uses.

Groundwater samples were collected from 27 sites in 15 selected agricultural and forested areas representing the three main islands of the Philippines. These included 11 springs and 1 well in forested areas, and 12 wells and 3 springs in agricultural areas. Groundwater sites in forested areas were used to establish reference conditions and set the standard for groundwater health indicators. These established standards then served as the baseline for groundwater health assessment in agricultural areas. Stygofauna, electrical conductivity, pH, dissolved oxygen, DOC, agrochemicals, metals (antimony, arsenic, cadmium, and lead), nitrates, phosphates, and fecal coliform were collected and measured during the dry and wet seasons. Electrical conductivity, pH, and dissolved oxygen were measured in situ using a Hach HQ40d portable multi-parameter meter. Water samples for agrochemicals, metals, nitrates, phosphates, and fecal coliform were sent to accredited laboratories for analysis and measurement. The wPGHI was calculated considering the DENR standards for Class AA and Class C. Class AA standards were used to assess the deviation from reference conditions for close-to-ideal groundwater health. In contrast, Class C standards were used considering the intended irrigation/agricultural use. The ecological and biophysical characteristics of the identified reference groundwater

served as the basis for the PGHI formula in agricultural areas.

The paper showed phosphate has a powerful discriminating capacity in identifying the reference groundwater conditions in selected forested areas. Based on the computed PGHI, groundwater from 13 agricultural sites showed mild to significant deviations from reference conditions for close-to-ideal and irrigation/agricultural uses. These ecological impairments could be primarily attributed to phosphates and DOC, indicative of agricultural residues and byproducts rich in organic matter.

The PGHI offers a valuable tool for monitoring groundwater health and informing sustainable management practices, specifically for safeguarding the quality of groundwater resources on agricultural lands. This research also confirms that water quality alone cannot entirely define the health of groundwater ecosystem, underscoring the critical importance of including biotic factors for a comprehensive assessment and effective monitoring of groundwater ecosystem's health.

There should be a uniform groundwater sub-sources for stygofauna sampling. Further stygofauna research is needed to improve the groundwater biota standards and the PGHI. The PGHI could also be tested and modified accordingly in different settings. This paper could serve as a basis for formulating national standards for groundwater classification and usage and guidelines for groundwater quality and health.

How the Cost Recovery Planning tool can contribute to sustainable WASH facilities in institutions.
Om Prasad, Simavi

What:
Despite global commitments, millions of children still attend schools without or insufficient access to safe WASH services. This is not merely a gap in infrastructure—it reflects deeper systemic failures including weak planning, lack of accountability, and poor maintenance. According to the Economist Impact report (2023), inadequate toilet maintenance contributes to economic losses exceeding $1.9 billion in just four countries. The cycle of Toilet Loss where toilets fall into disrepair due to poor planning and lack of cost recovery must be broken. Simavi has been working on changing the narrative by supporting schools to be in control on their WASH facilities and in this abstract we are sharing our results.

Why:
While schools can be powerful catalysts for change, many lack the resources to maintain WASH services, resulting in wasted investments and lost learning opportunities. Simavi

has been using the Cost Recovery Planning (CRP) tool since 2017 in schools and health centres in Uganda to improve the functionality of WASH facilities in institutions. Without proper cost recovery measures, schools risk losing entire toilet blocks due to neglect or disrepair, compounding the challenges of maintaining safe and inclusive learning environments. From working in over 84 institutions, we have seen positive results in the functionality of the WASH facilities in those institutions.

How:
We looked back at the implementation of the WASH & Learn programme (2016-2023) and the WASH SDG Programme in Uganda (2017-2024), where we have implemented the CRP tool in over 74 schools and 10 health centres in four districts of Uganda. Based on qualitative data we have collected from these institutions, and from other stakeholders involved (e.g. implementing partners, community leadership structures, local WASH entrepreneurs and local government officials), we are in the process of consolidated our results in the form of a looking-back impact study.

Results:
The CRP tool have provided significant benefits for the schools and health centres involved in Simavi's WASH in Institutions Programmes. One of the primary advantages is that these tools help to create awareness of sustainability risk and empower institutions to generate their own resources to finance operation and maintenance of their WASH facilities. By utilizing available assets such as land or local grants, schools and health centres can create both short-term and long-term revenue sources, on average schools are able to generate 400 to 800 Euro's per term. As a result, the WASH infrastructure functions better and there is a higher sustainability – 90% of the institutions where the tools have been implemented demonstrated notable improvements in WASH facility functionality.

Conclusion:
The CRP tool have helped improve functionality of WASH facilities in institutions. We have seen positive results around accountability and transparency within institutions, as administrators are held responsible for managing funds effectively. The tools have also introduced innovative financing methods, encouraging schools to think creatively about potential income sources, such as agricultural projects, crafts, or local theatre productions. There is a decreased dependence on intermittent external support.

Assessment of Environmental and Social Safeguards and Climate Vulnerability, Teknaf Upazila, Bangladesh
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Bangladesh is highly vulnerable to climate change, facing challenges such as rising sea levels, droughts, floods, cyclones, and increasing temperatures. Factors like high population density, poverty, dependence on natural resources, and other environmental and social issues further exacerbate the country's susceptibility to these threats. Teknaf Upazila, situated in Cox's Bazar District, has witnessed significant population growth and environmental changes in recent years.

This study aims to assess climate vulnerability as well as environmental and social safety. Various tools and methodologies were utilized, including risk equations and metrics to analyze climate risks, an Impact Severity Index to quantify severity in a matrix, and a GIS-based model integrating climatic, geospatial, demographic, and socioeconomic variables gathered from secondary sources for risk mapping and modeling. Air quality assessments were conducted at eight selected locations using Aeroqual Series 500 machines. The Impact Severity Index employed in this study serves as an analytical tool to measure the severity of current impacts, forecast both short-term and long-term changes, and compare reversible and irreversible consequences.

Teknaf frequently experiences flash floods, landslides, storm surges, cyclones, river erosion, and water logging. Recent infrastructural developments—including increased concrete pavement and road networks—impede rainwater absorption, leading to rapid runoff into the Naf River and Bay of Bengal with minimal groundwater recharge, exacerbating flash flood occurrences. Additionally, groundwater salinity levels in the region are notably high (9.17%). The coastal plain and Saint Martin Island are particularly susceptible to permanent flooding caused by rising sea levels, which threatens local biodiversity and disrupts the ecosystem. Salinity intrusion negatively impacts agricultural productivity and inland fish farming, though it does contribute to salt production, albeit at the expense of environmental sustainability.

Increased precipitation heightens the risk of flash floods and landslides, jeopardizing lives, properties, housing, and shelters. The southeastern coastal plain frequently experiences tidal surges, and escalating storm surges will lead to sudden inundation by seawater or brackish estuarine water, extending a few kilometers inland during cyclones. Flood susceptibility in the plains intensifies pressure on hilly areas, despite their unsuitability for habitation. Anthropogenic factors further amplify vulnerabilities, affecting approximately 38% of the population, with poverty being a significant concern. Beyond environmental consequences, climate change has far-reaching socioeconomic implications, impacting rural development, migration, poverty levels, health, and food security. This study tackles these challenges through climate vulnerability assessments, disaster risk modeling and mapping, impact evaluation, and the development of sustainable mitigation frameworks. Ultimately, improved resource management strategies are crucial for minimizing the adverse effects of climate change and enhancing living conditions in Teknaf.

Integrating container cleaning practices into a Zambian Community Health Club program
Tracy Zhang, Lehigh University

Introduction. Safe water storage containers can be a reservoir for pathogens, and researchers routinely document recontamination of drinking water in household storage containers, placing a further burden on communities without reliable, safe on-demand water supply. Further recontamination can occur when containers for storing water are not properly cleaned or have developed biofilms on the interior walls. Job aids adapted from laboratory-based research provide guidance on cleaning household storage containers. However, a gap remains in understanding: 1) what container cleaning methods are actually practiced by households; and, 2) how effective these methods are at reducing biofilm growth. This pilot study aimed to understand biofilm contamination in household water storage containers and provide insight into everyday cleaning practices integrated via a community health club model.

Methods. A mixed-methods study was conducted in partnership with a local Zambian organization in four communities where WASH-promoting community health clubs (CHCs) and community health promoters (CHPs) were active. In each community, 15–20 households were randomly selected to complete a knowledge, attitudes, and practices survey and provide a water sample. Whole container biofilm samples were collected from each household's primary drinking water storage container and processed via membrane filtration to quantify heterotrophic plate counts. Four focus group discussions with CHC and CHP leaders and four key informant interviews with program staff explored how cleaning practices were promoted and taught. Descriptive statistics and statistical analysis were completed using Python and p-values <0.05 were considered statistically significant. Transcripts analyzed in MAXQDA using content analysis. Codebooks were generated and inter-rater reliability ensured consistency and validity across the codes identified.

Results and Conclusions. Our findings reveal that while awareness of container cleaning is high among households, consistent and effective practices are limited by material constraints, behavioral norms, and variability in training content across CHC and CHP platforms. From the findings, high levels of bacterial contamination were observed in 100% of storage containers, underscoring the gap between knowledge and practice, and highlighting container cleaning as a critical pathway to interrupt recontamination. The study also emphasizes the importance of contextually grounded, community-responsive approaches in WASH programming. AFMAC's program design, rooted in community participation and peer engagement, demonstrates promising strategies for behavior change. However, the lack of a standardized, standalone module on container cleaning across all training formats, the prevalent reliance on visual cues as proxies for microbial

safety, and the disproportionate responsibility placed on women to manage household water hygiene collectively underscore critical gaps in current programming that warrant targeted intervention. To address these gaps, future interventions should prioritize the design and implementation of standardized modules on container cleaning, with reliable access to essential materials such as soap and brushes/sponges, and broaden the scope of behavior change efforts to actively engage all relevant household members in the community. Further research is needed to evaluate the long-term effectiveness of these interventions across diverse sociocultural and resource-limited settings. Advancing container hygiene through integrated, adaptive, and scalable approaches is essential for reducing public health risks from unsafe water storage and improving point-of-use water quality.

Rain, Soil, and Infrastructure: Unraveling the Key Drivers of Groundwater Contamination in Coastal Georgia
Victor Obi, Institute for Water and Health, Georgia Southern University

Microbial contamination in coastal groundwater is a significant public health issue, influenced by various environmental and hydrological factors. This study investigates the impact of rainfall, soil drainage, and well infrastructure on coliform and fecal contamination in wells across Coastal Georgia. A logistic regression model was applied to assess contamination risks, revealing that the likelihood of contamination increases with rainfall, particularly in the 30 days before sampling. Each additional millimeter of rainfall raised the odds of contamination by 3.1%. The optimal threshold for predicting contamination was found to be 19.73 mm of rainfall in the 30-day period prior to sampling. We analyzed rainfall in other time windows, including the 0–7 days before sampling, 8–14 days before sampling, and post-sampling periods (0–7 days, 8–14 days, and 0–30 days after sampling). Short-term rainfall (0–7 days before sampling) triggered higher contamination rates at lower thresholds, while longer-term rainfall (0–30 days before) had a more significant impact on contamination risk. Pre-sampling rainfall consistently showed strong statistical significance (p-value < 0.005), particularly within the 0–30-day period before sampling, making it a robust predictor of fecal and combined (coliform and fecal) contamination presence.

We also explored the role of soil drainage and well infrastructure. Wells that failed to meet both proper well cover and surface water management conditions had higher contamination rates, particularly in poorly drained soils. In these soils, contamination rates were 31% for wells not meeting both conditions, compared to 18% for those that did. Fecal and combined contamination showed a stronger relationship with rainfall and soil drainage than coliform contamination alone. Wells in moderately drained soils experienced the

greatest reduction in contamination when both infrastructure conditions were met, with contamination rates reduced by nearly three-fold.

Statistical tests, including chi-square and Fisher's exact tests, identified significant findings. In well-drained soils, contamination rates were significantly higher ($p < 0.005$) when surface water conditions were not met. Similarly, in poorly drained soils, both coliform and fecal contamination were significantly more likely ($p < 0.005$) when well cover and surface water conditions were not met.

This study offers valuable perspectives into how rainfall, soil drainage, and well infrastructure influence groundwater contamination in coastal regions. The results suggest that improving well infrastructure, particularly in poorly drained soils, could substantially mitigate contamination risks. These findings are essential for shaping water quality management approaches, although further research is needed to refine the models and explore additional environmental variables.

Drinking water quality in the schools of the Gambia and health implications for school children
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Access to portable water is a basic human right and poor-quality water is a major source of diseases, especially among children. School-aged children spend a modest amount of their time at school. Consequently, they get a large portion of the water they consume daily from school water sources. The quality of water in schools has under-studied in low-income settings such as The Gambia. Therefore, this study assesses the quality and health implications of drinking water in schools in The Gambia with the aim of generating evidence that stakeholders can use to inform policies and interventions related to water sources in schools.

This study focused on water sources in schools. A region clustered simple random sampling procedure was conducted to select 168 schools using a master list of schools having an active WASH intervention program. Schools with a WASH intervention were targeted because of their involvement in the WASH project. All the seven health regions of the country were represented in the sample. Water samples were analyzed at the National water quality laboratory using DR3900 spectrophotometer and in the field with a portable incubator using membrane filtration techniques. The PH, temperature, electrical conductivity, Total Dissolve Solid (TDS), salinity (ppt), turbidity (NTU), Fecal coliform

presence, Iron (Fe), and Nitrate (NO3) concentration were the parameters analyzed. Overall, the study reported unacceptable levels of TDS (22%), nitrate presence (5.9%) of water sources, and 24.3% of water sources with fecal coliforms are from borehole. calcium (99.5%) and fluoride (100%) of water source were within the recommended quality thresholds. Regional variations were observed. Central River Region and Lower River Region were highest nitrate concentration regions, (36.3%) and (27.2%) respectively. Furthermore, Lower River Region and North Bank Region were highest in Total Dissolve Solid (34%) and (21%) respectively. Kanifing Municipal council had the overall best water quality indicators.

This study has highlighted the quality of water from school water sources in The Gambia is sub-optimal and varies across regions. While all the measured indicators require improvement, Total Dissolve Solid, fecal coliform, and Nitrate, are the worst affected. This could lead to acute respiratory tract infection, colorectal cancer, type 1 diabetes and high blood pressure in children. Stakeholders should prioritize efforts to improve the quality of drinking water sources in schools, taking into account regional variation.

Localizing vulnerability assessments: A stakeholder-driven approach to identify the most vulnerable households in Northern Haiti
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Background
In urban areas of developing countries, high-quality sanitation services are often unaffordable for low-income residents, limiting the societal returns associated with safe sanitation, as community-wide benefits require coverage of a large proportion of the population. Achieving such coverage typically requires subsidies, particularly for low-income households. However, there are few examples of successful pro-poor sanitation subsidy programs implemented at scale. One key question surrounding such programs is how to reliably and cost-effectively identify the poorest and most vulnerable households in urban settings to determine eligibility for a subsidy. After exploration of multiple globally validated wealth assessment tools, a container-based sanitation (CBS) provider in northern Haiti identified the EquityTool as the most appropriate measure of relative wealth to identify household eligibility for a CBS service subsidy. Despite the success of initial suitability tests, key stakeholders emphasized the importance of additionally including locally-specific measures of vulnerability that may capture experiences beyond the EquityTool. This study developed additional vulnerability questions to complement the EquityTool for identifying the most vulnerable households in Cap Haitian, Haiti.

Methods
In summer 2024, the CBS provider conducted stakeholder interviews and focus group

discussions with employees, community leaders, and government authorities to develop simple, yet locally-specific, survey questions that further capture the unique socio-economic and cultural conditions in Cap Haitian's high-poverty areas. Based on the stakeholder feedback, several new survey questions were developed to accompany the EquityTool and offer a more nuanced categorization of vulnerability levels within communities where poverty is pervasive.The CBS provider has begun testing the tailored vulnerability questions alongside the EquityTool in a survey of over 600 households in order to finalize a strategy for identifying eligibility for a sanitation subsidy.

Results

Stakeholders highlighted that, in addition to traditional economic indicators, vulnerability assessments should include culturally relevant markers such as housing quality, household size, dependency on social networks, access to education, and remittances from family abroad. They also stressed the importance of involving recognized community figures in data collection to build trust, ensure transparency, and improve the accuracy of responses.

Conclusions

This engagement process serves as a model for the WASH sector, showcasing how participatory methods can generate local endorsement of vulnerability identification efforts. This research contributes to global health and development by advancing a pro-poor framework that is adaptable to specific community contexts and locally approved. It demonstrates that inclusive, context-sensitive methods are essential for effectively identifying and supporting vulnerable populations in resource-limited settings.