POSTER ABSTRACTS

(Alpha Order by Title)

As of 9-24-2021

Assessing Private Well Water Stewardship Behaviors in Rural Georgia

Presenter: J. Edward Dotherow, Georgia Southern University

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In the United States, an estimated 13.5 million households rely on private well water as their primary source of drinking water. Unlike public water systems, private wells are not regulated by federal and state governments, leaving well owners responsible for ensuring the quality of their water. While there are no regulations for private well water, the USEPA recommends three behaviors (testing, treatment, maintenance) to ensure safe water.

The purpose of this study was to identify individual and social factors that influence well water stewardship in rural communities. A four-group randomized control trial was implemented to evaluate the impact of one educational intervention, one treatment intervention, and receiving both the treatment and educational intervention. Private well owners (n=64) completed a pretest measuring stewardship behaviors and psychosocial influences (using a 5-point Likert scale) before receiving the intervention. After 104 days, participants completed a posttest and were interviewed to provide context to any behavior changes.

The results of the pretest showed that only 34% of participants have ever tested their well water, with most (41%) having tested it more than ten years ago. Similarly, only 25% of participants routinely treat their well water before consumption. Of those that treat their water, most (88%) use a point-of-use treatment system. Only 16% of participants perform routine maintenance on their well, mainly (90%) pipe flushing and part updating (100%). Interestingly, the pretest showed participants were aware of the risks associated with well water (3.75/ 5) yet do not practice stewardship behaviors.

This ongoing study will inform the effectiveness of the interventions and identify the psychosocial factors associated with well stewardship behaviors. To our knowledge this study design is the first of its kind that is applied in rural USA to investigate the efficacy of well stewardship interventions. The results of this study will be instrumental to better inform policy makers and program designers to increase water quality agency.

Sewage Deaths: Law, Labor and The Politics of Difference

Presenter: Pallavi Gupta, UNC Chapel Hill

Additional Authors:

Sewage deaths: Law, Labor and the politics of difference
Even though Clean India Campaign prioritizes cleanliness, it remains deafeningly silent on the working conditions of the cleaners, who mostly hail from marginalized caste. Every year thousands of workers die trying to unclog sewages in India. In this paper, I undertake a content analysis of relevant policy documents published by government of India and by non-profits advocating the cause of sewage cleaning workers to argue that despite years of legislative and policy action, caste-based organization of cleaning related labor continues unabated.

Dalit sewage workers face imminent death, every time they enter the sewers without protective gear. The lack of adequate safety and the limited social protections offered to the workers, is connected to the workings of caste. The violence of caste manifests in not just the labor of cleaning sewers, that results in their premature death, but also in the uneven guarantee of humanity to Dalit workers.

Further, I analyze landmark judgments of the Supreme Court of India to argue that cleaning workers are denied right to a dignified and safe work environment while they are alive. Indeed, the personhood of these workers is not recognized in life, but rather in death. This paper offers a critique of the Clean India Campaign by pointing to the absence of caste from a policy which is concerned with cleanliness that is closely entangled with caste.

A Novel ESBL Colilert System for Environmental Surveillance of AMR Bacteria at Markets in LMICs

Presenter: Effita Masoamphambe, Malawi-Liverpool Wellcome Trust Clinical Research Program

Additional Authors: Derek Cocker, Nicholas Feasey, David Berendes, Amy Kirby, Tracy Morse

Background
Low-middle income countries (LMICs) face a large disease burden from antimicrobial resistant (AMR) bacteria, with extended-spectrum beta lactamase (ESBL) infections leading to high morbidity and mortality. The spread of ESBL-producing bacteria through environmental compartments needs to be quantified to better understand the drivers of resistant infections caused by ESBL bacteria in LMICs, with a particular focus on the importance of stored water and source water as possible transmission pathways. Effective methods to assess environmental contamination by ESBL-producing bacteria will be critical to test in LMIC settings, and ideally be simple, cost effective and utilise current infrastructure. We present findings from adaption of an ESBL Colilert system developed by the Centers for Disease Control and Prevention (CDC), for the identification of ESBL contamination in urban Malawian markets.

Methods
Four urban markets were visited in Blantyre, Malawi between January-February 2021. Samples were taken from stored water used by market vendors to freshen fruit and vegetable produce, and directly from the source from which they obtained the water (i.e., kiosk/borehole). Drain samples at risk points identified using environmental sampling methods and water from local rivers adjacent to the marketplace were also sampled.
Water samples were pre-processed through a 0.45µm cellulose-ester gridded membrane (VWR™) using a vacuum-based manifold and drain samples were directly incubated in enrichment media (buffered peptone water). All samples were processed via conventional culture methods using ESBL CHROMagar™ media to detect ESBL Enterobacterales. The samples were also processed in parallel using the IDEXX Colilert Quanti-tray method, in the presence of ceftriaxone (1ug/ml). The ESBL Colilert method was compared to conventional culture to determine sensitivity and specificity of ESBL identification. All positive ESBL Colilert samples were confirmed by growth of Colilert broth on ESBL CHROMagar™ media.

Results
Seventy samples were collected from urban markets, including river water (n=4), drain water (n=21), source water (n=7) and stored water (n=38). Using ESBL CHROMagar™ culture methods, 54% (n=38) of the total samples were positive for ESBL Enterobacterales, including river water (n=3; 75%), drain water (n=16; 76%), source water (n=3; 43%), and stored water samples (n=16; 42%). Using the ESBL Colilert method 80% (n=56) of the total samples were identified as positive for ESBL E. coli. There was discordance in 27 samples, with 4 out of 70 samples positive on ESBL CHROMagar™ culture alone, and 23 of 70 positive on the ESBL Colilert method that were not identified by culture.

Conclusion
The urban markets studied were heavily contaminated with ESBL Enterobacterales and may be an important location for EBSL transmission that warrants surveillance. Should future local surveillance strategies be considered, the ESBL Colilert method may be a more sensitive, simple and low-cost method for the identification of ESBL contamination compared to culture in these settings.

A Novel Water Treatment System in a Low-resource Community in Rural Benin

Presenter: Jérôme Voillat, Watalux

Additional Authors: Mr Odilon Changotadé, Ms Renata Nogueira, Mr Justin Veuthey, Ms Mami Daba Fam Thior

INTRODUCTION:
This study evaluates the performance of a novel low-cost technology in rural Benin (West Africa) that locally produces chlorine (sodium hypochlorite) then injects it into the local water system.
Often communities in low-resource areas have few options to treat their water. There is a pressing need for technologies adapted to unreliable electricity supply, that are easy to operate, and can be independent of external resources. The electrochlorinators tested produce liquid chlorine from water, simple cooking salt, and electricity.

METHODS:
31 Water tanks were selected in cooperation with local authorities to receive a novel technology using electro-chlorinator devices (WATA™) that produces liquid chlorine to be coupled into the dosing pump tank. After the implementation of the novel technology in the local water system, we administered a satisfaction survey as well as an analysis for fecal bacteria. Water samples were collected at three points: before chlorination, at the faucet nearest the point of chlorination, and finally at the most distant terminal after chlorination. To evaluate the water quality, residual chlorine control tests were performed using WataBlue™ reagent and Self-test was used for microbiology control. Water samples that tested positive for the presence of microorganisms, were taken to be analyzed at a laboratory when possible.

RESULTS:
The water tanks were distributed in 19 villages located in seven different departments. It is estimated that over 130,000 people use these facilities regularly. The water provided was not always chlorinated and 16 out of 31 tanks had a lack of access to chlorine powder. This was one of the biggest challenges in disinfecting water. Our research shows that traditionally this is mainly because of logistics (81%) but also cost issues (29%). Amongst the sites using the novel technology, 30% (9/31) of them had technical infrastructural problems like lack of water (1), faulty dosing pump (7), and lack of electricity (1) that prevented the system installed to perform. Furthermore, 60% of the water samples collected before chlorination were positive for microbiological contamination. After the installation of the WATA™ technology, all samples collected from functioning systems were negative for microbiological contamination. However, the water from six tanks presenting infrastructural problems continued to be distributed to the population despite testing positive for microbiological contamination. The average residual chlorine level analyzed at the most distant terminal fountain was 0.29 ± 0.2 mg/L which is under the country's reference level 0,1-0,8 mg/L.

CONCLUSION:
In the sites that we studied in remote communities of Benin, the major challenges to water treatment were 1) the cost and logistics of acquiring chlorine tablets and 2) infrastructure problems. The installation of water-chlorinator devices (WATA™) to produce chlorine locally to be dispensed into the system can effectively eliminate many of the traditional setbacks and produces water without microbiological contamination and with chlorine levels within the WHO's recommended values. However, the success of the technology tested depends on the infrastructure of the water facility.

A Transition for All: Equity and Community Engagement in Utility Management in Uganda's Refugee Settlements

Presenter: John Allen, Oxfam

Additional Authors: Caroline Muturi, Vincent Ogira

Water supply schemes in refugee settlements in Uganda are being transitioned from management by humanitarian actors to the country's utilities, the National Water and Sewerage Corporation (NWSC) and regional Umbrella Authorities (UAs). This effort is an emerging case where national institutions are being engaged for the sustainable delivery of services under the Comprehensive Refugee Response Framework (CRRF).

Oxfam led a study to generate insights on the 'utility transition', with three key learning objectives:
- To identify economic components needing to be addressed in the next phase of the transition;
- To identify community engagement practices, especially related to the initiation of water user tariffs;
- To explore practices and opportunities for governance and accountability under the new model.

The study consisted of literature review, key informant interviews, and focus group discussions, with transcript analysis conducted according to the three research themes. Four refugee settlements in the Midwestern and West Nile regions of Uganda were visited. Current efforts by WASH actors have focused on a range of aspects of the utility transition: Existing piped water supply systems are being upgraded in advance of their handover to utilities. This includes the extension of private connections to individuals seeking their own tapstands.

The sector is engaged in identifying volumetric-based tariffs that refugee users can afford to pay. NWSC charges refugees and host communities according to the utility's 'pro-poor' rate of 0.007 USD per 20 litre jerrycan, while UAs' water tariffs are determined on a per-system basis. Water users must also pay a fee to operators of public standposts, however, these fees have not yet been determined. In the short term, WASH agencies have introduced informal user fees, typically 0.27 USD per household/mo. Refugees in the Midwestern region, but not in the West Nile, generally, were aware of plans to establish water tariffs. Most refugees reported being willing to pay for water if services were of high quality.
Monitoring of financial information is a key part of transitioning to paid services. Limited data is available on the operational expenses of water supply systems in refugee settlements. A new development is the use of communal prepaid water dispensers, or 'water ATMs', where data from pilots can be used to inform the phased introduction of tariffs.

Community engagement is another area of focus. However, none of the communities visited in this study were aware of the utilities and their role in managing water supply. Refugees reported higher levels of satisfaction with Refuge Welfare Councils than other bodies of representation for addressing water supply matters.
The study identified opportunities to make the utility transition more equitable, participatory, and effective:
1. Enacting equitable procedures on capital investment and tapstand operations.
2. Developing sector-wide financial monitoring tools
3. Carrying out contextual understanding and risk analyses in communities where the transition is taking place.
4. Engaging communities and establishing communications plans and feedback mechanisms for social accountability.

Adapting to COVID-19: Tele-Coaching for Sanitation Entrepreneurs in Cote d'Ivoire

Presenter: Toussaint Yao Kouadio, Population Services International

Additional Authors: Marcel Etchian, Sara Owre

USAID's Sanitation Service Delivery Project (SSD) works to increase access to sanitation products and services in urban and peri-urban areas of Cote d'Ivoire. A central part of this work has been providing direct, on-site supervision and coaching to small-scale (micro) entrepreneurs to improve the quality of their service offerings and strengthen the capacity of their businesses. Travel and meeting restrictions due to the COVID-19 pandemic required a new approach. SSD therefore rolled out a new tele-coaching program to ensure continued capacity building on critical skills, such as product installation, marketing, accounting, and obtaining legal business operating status. The transition to a virtual format necessitated a more individualized approach for technical assistance, catalyzing the businesses and SSD staff to focus on addressing specific challenges and hurdles to proactively target entrepreneurs' capacities.

To launch tele-coaching, the SSD team:
- Conducted a diagnostic study to assess entrepreneurs' level of technical, managerial and accounting skills.
- Identified a set of monitoring and performance indicators from the diagnostic study results.
- Assessed each entrepreneur against the identified indicators to score and place them into one of the following groups: underachieving, achieving and overachieving.

Results from the diagnostic assessment showed poor sales turnover and financial management, and a lack of consistent organization or staffing in most enterprises. Poor production, mainly due to mismanagement of equipment and material stocks, and variable adherence to manufacturing procedures was noted across the board. Based on individual scores on the assessment and specific areas of individual improvement identified, the SSD team provided weekly tailored instructions to each entrepreneur. Entrepreneurs and the team would then communicate via voice messages in WhatsApp to troubleshoot issues as they arose in the production, sales, or management processes. To support the virtual guidance, SSD coaches also conducted quarterly field visits to validate entrepreneurs' results and speak directly with them on their personal development. These visits allowed coaches to further adapt performance indicators and individualized coaching plans.

Results:

1. 65% of micro-enterprises acquired legal registration, and an additional 5% registered with the trade register and tax administration.
2. 30% of micro-enterprises hired additional production staff and 39% hired commercial sales staff.
3. 60% of micro-enterprises have a consistent point of sale and had partnered with 111 hardware stores by June 2020, representing a 35% of SSD entrepreneurs' total sales.
4. 100% of micro-enterprises now keep a sales register, and 35% have opened bank accounts.
5. 5.Increased investment commitments from some entrepreneurs to build their businesses' capacities and market sustainability.

The tele-coaching approach ultimately proved to be even more efficient than the previous model of on-site visits, as it forced a new focus on specific weaknesses. The ability to immediately reach coaches for guidance through WhatsApp, coupled with the lower frequency and cost of in-person coaching, enabled entrepreneurs and the SSD team to work more quickly together to troubleshoot issues while effectively utilizing resources. These successes point to the long-term sustainability of the tele-coaching approach and its replicability in future sanitation market development initiatives working with micro-enterprises.

Addressing Sanitation Deficits in Underserved Communities in the Rural U.S.: Technical, Practical and Regulatory Considerations

Presenter: Kevin White, University of Alabama

Additional Authors: Mark Elliott, Jillian Maxcy-Brown, Upmanu Lall, Maura Allaire, Joe Brown

Although the Joint Monitoring Programme (JMP) estimates that 99.88% of households in the rural United States have at least basic sanitation, recent evidence from our group reveals that discharge of raw sewage from homes directly to the surface is relatively common in underserved rural communities (Maxcy-Brown et al., 2021). Additionally, emerging unpublished findings from our group have shown that other inadequate wastewater management approaches including outhouses, honey buckets and cesspools are widespread in rural areas of some states.

This presentation will focus on the suite of wastewater management solutions available for rural communities in the U.S., including technical, financial, and regulatory considerations. The typologies to be addressed include: (1) expansion of conventional sewer, (2) installation/repair of conventional septic systems and advanced onsite wastewater treatment systems (OWTS), and (3) decentralized clustered wastewater systems.

Increases in the costs and timelines of sewer and other infrastructure projects in the U.S. have been well-documented; installation of sewer main now costs roughly $1 million per mile. The cost of OWTS have also increased greatly in recent years, based on reports from a number of states. In contrast, trends in the performance, capabilities and cost of the key components of decentralized clustered wastewater treatment systems (modular treatment technology, sensors, communication technology, and control systems) have led to a substantial increase in their implementation in recent years.

As decentralized clustered systems become more widespread, potential economies of scale associated with centralized management of these cyber-physical systems provides a feasible path to robust and sustainable wastewater management in even low-income and low-density communities. However, regulators, federal funders, and some local stakeholders are understandably risk-averse with emerging approaches to wastewater management. This presentation will also cover our experience and lessons learned in working with diverse stakeholders including politicians, regulators, researchers, and community organizations to establish the Consortium for Rural Alabama Water and Wastewater.

Assessing Bacterial Synergistic Disinfection Using Silver Ions and Free Chlorine in Natural Waters

Presenter: Ana Estrella-You, University of Virginia

Additional Authors:

The World Health Organization (WHO) estimates that each year diarrheal diseases associated with unsafe drinking water, sanitation, and hand hygiene claim the lives of around 829,000 people, from which more than one third are children under the age of 5 years old. A solution to address this problem is to treat the contaminated water immediately before consumption using point-of-use (POU) technologies. Currently, there are POU technologies that use silver or free chlorine separately as the chemical disinfectant.

Several studies have evaluated the combined use of these disinfectants in synthetic water samples. To date, studies on natural waters that can exhibit significant chlorine demand and/or silver ion complexation have been limited. Herein, we evaluate the synergistic deactivation of bacterial pathogens in natural waters using silver and chlorine and assess the impact of turbidity in the disinfection effectiveness. We tested E. coli and total coliform bacteria disinfection with a combination of 10 µg/L silver ion and 100 µg/L free chlorine, and with the individual chemicals. Pond water samples and upstream samples with turbidity of 4.82 and 11.9 NTU, respectively and total organic carbon (TOC) of 1.83 and 2.59 mg/L, respectively were used. Synergy was evaluated using a previously published mathematical model.

The results of our study show the presence of a significant synergistic effect in the disinfection of E. coli and total coliform bacteria when evaluated at 3 hours of contact time for natural waters with turbidity of 4.82 and 11.9 NTU. The log10 removal of E. coli and total coliforms was 1.44 and 2.73 respectively with the lower turbidity, and 0.87 and 1.29 respectively with the higher turbidity. The synergistic effect decreased when turbidity was higher.

Additionally, the higher level of turbidity significantly reduced disinfection effectiveness by chlorine but did not affect silver disinfection effectiveness. These results indicate that silver ion with a standard redox potential of 0.80 V can be a more selective disinfectant in comparison to free chlorine which has a higher redox potential of 1.48 V for hypochlorous acid and 1.28 V for hypochlorite ion. This can be linked to the increase in chlorine demand when turbidity increases due to the high reactivity of free chlorine, e.g., chlorine reacts with particulate organic matter. Finally, to take advantage of the synergistic effect when using low concentrations of silver ion and free chlorine, the turbidity level of the water source is a key factor. For source waters that have a higher turbidity, silver disinfection alone can be more effective than chlorine disinfection, which will result in a reduction of the chemical residuals in the treated water.

Baseline Status of Safely Managed On-site Sanitation in Bangladesh

Presenter: Adnan Hakim, UNICEF, Bangladesh

Additional Authors: Rick Johnston6; Tom Slaymaker; Md. Mujibur Rahman; Amal Krishna Halder;Md. Saifur Rahman

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As part of the Global Study on “Safely Managed On-site Sanitation (SMOSS)” initiated by the Joint Monitoring Programme (JMP), Bangladesh conducted a study on SMOSS with the objective to better understand the extent to which on-site sanitation systems are safely managed with respect to the complete sanitation chain including safe containment of fecal sludge (FS), emptying, transportation, treatment and disposal/reuse.

A nationally representative survey was conducted covering varying hydro-geologic zones including remote difficult areas, the climate change impacted coastal belt, and hilly areas with different cultural beliefs. The survey included rural and urban households including low-income communities. The study adopted two stage mixed method random cluster sampling study design, in which quantitative data from 3149 households (HH) in 137 random clusters across Bangladesh were collected. Qualitative data were collected from 10 focus group discussions and 14 key informant interviews. Spot checks were conducted to verify FS containment types and level of storage, pit/septic tank effluent disposal status, means of emptying, collection and transportation of FS.

The study revealed 67% households have access to improved toilets with only 11% using shared facilities, and rural population having greater access (91%) compared to urban (61%), yet assessing population coverage with safely managed sanitation services considering the complete sanitation chain is extremely difficult to ascertain. The improved sanitation facilities include 50% pit latrines, the major part being the single off-set pit type that is advantageous for FS collection and subsequent FSM services. The study found that 16% of the population used septic tanks with adequate containment, which were counted as improved while 14% used ‘septic tanks’ directly discharging to the environment which were classified as unimproved. With only 15% access to improved sanitation, a

staggering 85% of the low-income communities in large city corporations resorts to unimproved options, including 59% with toilets that have no containment facility and are directly connected to drains/ditches/open water bodies.

While 27% out of 34% HHs requiring emptying, have actually emptied their pits/septic tanks and continued using them in the past, a significant 20% of HHs didn't have any containment facility at all, meaning direct discharge into open environment. Unhygienic, manual emptying using local tools are common (24%), and only 6% HHs did mechanical emptying mostly in urban areas using non-motorized manual pump or motorized vacuum pump. Only 2% HHs used vacuum tankers for FS transportation while others used manual transportation systems including hand carry or push cart. Reportedly, 38% of emptied FS was buried in pits within premises and 9% transported to designated locations/treatment sites which can potentially be counted as safely managed sanitation services for global monitoring. However, burying of FS in shallow pits on premises may lead to human exposure and may not be permitted under local regulations. The study revealed important challenges to be addressed to ensure effective monitoring of SMOSS systems which are currently used by 16.7 million of the population in Bangladesh. However, as sewer coverage is very low in Bangladesh, the concept of safely managed on-site sanitation systems is highly relevant and should be strengthened in future investment plans.

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Behavioural Determinants of Child Faeces Management Practices in Solomon Island Communities

Presenter: Rosie Sanderson, International WaterCentre at Griffith University

Additional Authors: Dr Adam Biran; Dr Regina Souter

The lack of safe infant and child (under 5 years old) faeces management (CFM) is a critical issue in Solomon Islands, as it is in many countries. Unsafe CFM, or the failure to separate and contain the faeces of young children, causes significant human health risks to Solomon Islanders including contributing to the diarrhoeal disease burden that causes the deaths of 1 in 4 children in the country. A confluence of situational factors influence the practice of unsafe CFM in Solomon Islands; overall poor water, sanitation, and hygiene (WASH), including low rates of access to safe sanitation facilities, varying knowledge and beliefs around the safety of the faeces of children, and the higher potential for transmission of pathogens from faeces to children because of their playing behaviours in their environment, which brings them in contact with contaminated surfaces and objects.

The Solomon Islands Government (SIG) is committed to improving sanitation across all rural areas, and is implementing demand-based approaches, in particular, Community Led Total Sanitation (CLTS), which is outlined in the National Sanitation Plan and community engagement guidelines. However, they do not currently address CFM despite young children comprising 15% of the population. There are no locally relevant communication materials for CFM.

Our research aimed to address this gap and tackle the opportunity to incorporate a CFM component or implement a subsequent intervention that complements CLTS and explicitly addresses CFM. The study was designed to understand the locally contextual behavioural determinants of CFM, and the cross-disciplinary and cross-institutional research team has now completed the formative research phase. Several purpose-built data collection tools were developed based on the Behaviour Centred Design framework and the Evo-Eco model of behaviour to qualitative analyse the perceived determinants of CFM. Field researchers from the Solomon Islands National University conducted focus group discussions and key informant interviews in five communities across two provinces in Solomon Islands, engaging with 57 households with children under 5. Infrastructure inspections and demonstrated behaviour observations were carried out and analysed semi-quantitatively.

Study participants demonstrated a reasonable understanding of the link between unsafe faeces management and disease transmission. However, the data suggests that opportunity determinants like convenience were influential barriers to safe CFM, while the desire to do the best thing for their child, (nurture) was the strongest motivational determinant amongst parents. The study reinforces the idea that water, sanitation and hygiene behaviours are less commonly influenced by lack of knowledge or information (executive behavioural control) than they are convenience and motivated behavioural control. These findings will have implications for the design of our complementary CFM activities for the national CLTS program.

Billions Anticipate Harm from Drinking Water: Findings from Nationally Representative Surveys In 142 Countries

Presenter: Joshua Miller, UNC Chapel Hill

Additional Authors: Chad Staddon, Aaron Salzberg, Julius B. Lucks, Wändi Bruine de Bruin, Sera L. Young

Water contamination due to climate change, infrastructure degradation, and destruction of critical ecosystem services present substantial threats to human health. Yet to date, surveys about experiences and perceptions of harm from drinking water have been limited to select countries and involved no worldwide comparisons. Therefore, we sought to use nationally representative data from 142 countries to 1) document the prevalence of self-reported harm from drinking water, 2) examine trends by country-level indicators, and 3) assess whether there are inequities by various individual and household demographics.

Data are drawn from the Lloyd's Register Foundation World Risk Poll, which was funded by the Foundation and implemented in 2019 by Gallup. In each country, approximately 1,000 individuals were randomly selected and interviewed by trained enumerators. Data on personal and household characteristics were collected, as well as information about risk from diverse threats. We analyzed responses to two water-related items: whether an individual personally knew someone who "experienced serious harm from drinking water in the past two years" or themselves anticipated "serious harm in the next two years" from drinking water.

To our first aim, 14.5% (95% CI: 14.1%, 15.0%) of participants globally reported knowing someone who experienced serious harm from their drinking water in the prior two years (range: 0.8% in Singapore to 54.3% in Zambia), and more than half of the world's population (54.4%; 95% CI: 53.7%, 55.1%) anticipate experiencing harm from their drinking water in the next two years (range: 8.0% in Sweden to 78.3 % in Lebanon).
To our second aim, country-level analyses showed that having experienced harm was associated with a greater proportion of annual deaths attributable to water (β: 3.1; 95% CI: 2.5, 3.7). Anticipated harm was inversely associated with per capita GDP and proportion of the population with a basic drinking water source, although there was substantial heterogeneity in the latter. For instance, 8.0% (95% CI: 6.2%, 10.2%) of individuals in Sweden compared to 39.3% (95% CI: 35.5%, 43.2%) in the United States reported likely harm from their drinking water in the next two years, although both countries have near-universal access to basic drinking water sources.

To our third aim, we found that experienced and anticipated harm differed based on individual and household characteristics. In low-income countries, a greater proportion of individuals with children in their household both experienced harm (prevalence difference: 3.6%; 95% CI: 0.9%, 6.4%) and anticipated harm from drinking water (prevalence difference: 2.4%; 95% CI: –0.8%, 5.6%) than those who did not. A greater proportion of individuals living in urban areas also reported anticipated harm from water than those living in rural settings (prevalence difference: 3.2%; 95% CI: 1.8%, 4.6%).
These findings indicate that suboptimal drinking water is a major public health concern that persists even in settings where Sustainable Development Goal targets have been met. Addressing the global water crisis will require greater investment in water purification, pollution reduction, and improvements in water governance to ensure greater equity in access to drinking water that is, and perceived as, safe.

Child Exposure to Zoonotic Enteropathogens in Coastal Ecuador

Presenter: Viviana Alban, Emory University

Additional Authors: April Ballard, Kelsey Jesser, Gabriel Trueba, Gwenyth Lee, Joseph N.S. Eisenberg, Bethany A. Caruso, Karen Levy

Background
Animals are ubiquitous in low- and middle-income settings where they are important sources of income, food, transportation, and companionship. However, insufficient separation of animals and their feces from domestic environments poses health risks for children, as persistent and recurrent exposure to zoonotic enteropathogens is associated with diarrhea, environmental enteric dysfunction, and child growth deficits. To understand zoonotic enteropathogen exposure routes among children, we carried out a mixed methods study in four rural, semi-rural, and urban communities in northwestern Ecuador.

Methods
To understand how children are exposed to animal feces, we conducted semi-structured and go-along interviews, a hybrid between observation and dialogue (n=36), from June-August 2019 with mothers of children under two who owned at least one animal. Interviews queried animal ownership, husbandry practices, and behaviors associated with child animal exposure. To identify animal-transmitted enteropathogens, animal fecal samples (n=119) were collected from and around participant households. RIDASCREEN enzyme immunoassays were used for Cryptosporidium spp. detection and real-time SYBR Green qPCR was used for Salmonella and Campylobacter spp. detection and quantification.

Results
Interviews revealed that dog, chicken, and duck feces were abundant in rural and semi-rural communities; animals roamed freely and household doors were open, allowing animals to enter. Feces were less abundant and only observed in yards in the urban community, where animals were not loose and household doors were closed. Across all sites, children were primarily exposed to animal feces by consuming soil and feces and through hand-to-mouth and object-to-mouth behaviors. Siblings also touched soil or feces and put their hands in siblings' mouths.

Laboratory results revealed that in rural communities, 15.4% of animal fecal samples tested positive for Salmonella spp. and 28.2% for Cryptosporidium spp. In the semi-rural community, 17.4% tested positive for Salmonella spp. and 8.7% for Cryptosporidium spp. No samples tested positive for Salmonella spp. in the urban community, but 11.8% were positive for Cryptosporidium spp. Most horse/donkey (71.4%) and some duck (33.3%) and chicken (12.0%) samples tested positive for Cryptosporidium spp. Cats (33.3%), dogs (28.6%), chickens (20.0%), and ducks (8.3%) tested positive for Salmonella spp. Almost all samples (95.6%) had detectable Campylobacter spp.

Conclusions
Our mixed methods approach provided insights into how human behavior and the presence of animal feces in the environment can lead to enteropathogen exposure. Children in rural and semi-rural communities are more likely to be exposed to animal feces and enteric pathogens compared to their urban counterparts due to free-range husbandry practices, community norms (e.g., open household doors), and higher prevalence of Salmonella and Cryptosporidium spp. among animals. Campylobacter spp. was ubiquitous in animal feces from all settings, and zoonotic transmission may represent a substantial contribution to childhood infections. Dogs, chickens, and ducks likely pose the highest risk to children given the prominence of their feces and enteric pathogens in their feces, though child exposure does not solely depend on one animal or on animal ownership per se. Other animals likely pose less risk regardless of enteropathogen infection, as cats bury their feces and horses/donkeys were physically separated from households.

Child Hand Contamination is Associated with Pediatric Diarrhea in Rural Democratic Republic of the Congo(REDUCE-Program)

Presenter: Patrick Mirindi, FH/WHO

Additional Authors: Christine Marie George, Lucien Bisimwa Cirhuza, Alves Birindwa, Camille Williams, Sara Beck

Objective
The Reducing Enteropathy, Undernutrition, and Contamination in the Environment (REDUCE) study focuses on identifying exposure pathways to faecal pathogens for young children in the Democratic Republic of the Congo (DRC) and on developing scalable interventions to reduce faecal contamination from these pathways.

Methods

A prospective cohort study of 690 participants was conducted to investigate the association between hand, food, and environmental faecal contamination and diarrhoeal disease prevalence among young children in Walungu Territory, South Kivu, DRC. A total of 1923 hand rinse, soil, food, object, surface, stored water and water source samples were collected during unannounced spot checks after baseline enrolment and analysed for Escherichia coli. Caregiver reports of diarrhoea were obtained from children < 5 years at a 6-month follow-up.

Results
E.coli was detected in 73% of child and caregiver hand-rinse samples, 69% of soil samples from child play spaces, 54% of child food samples, 38% of objects and surfaces children were observed putting in their mouths, 74% of stored water samples, and 40% of source water samples. Children < 5 years with E. coli on their hands had significantly higher odds of diarrhoea at the 6-month follow-up (odds ratio: 2.03 (95% confidence interval: 1.05, 3.92)).

Conclusion
The cohort study findings from the REDUCE program have shown that child hand contamination is associated with diarrhoeal disease in rural DRC, and that there is high faecal contamination in child plays spaces and food. These findings provide evidence demonstrating the urgent need to provide clean play spaces for young children and interventions targeting hand hygiene to reduce paediatric exposure to faecal pathogens.

Keywords: child health, faecal contamination, Democratic Republic of the Congo, diarrhoea,Escherichia coli

Cluster Randomized Control Trial to Evaluate Post-ODF Pro-poor Sanitation Subsidies in Rural Ghana

Presenter: Joyce Kisiangani, Aquaya Institute

Additional Authors: Caroline Delaire, John Trimmer, Jeff Albert, Ranjiv Khush, Rachel Peletz

In efforts to achieve open defecation free (ODF) communities, the Community-Led Total Sanitation (CLTS) approach shifted the focus from providing hardware subsidies to promoting sanitation behavior change through collective action. However, maintaining ODF status without financial support can be difficult, especially for poor and vulnerable community members who may be unable to afford or build durable toilets. To address the shortcomings of CLTS with respect to sustainability and equity, Ghana's national guidelines began recommending targeted pro-poor sanitation subsidies in 2018.

In partnership with UNICEF Ghana and two District Assemblies in the Northern Region, the research program USAID-WASHPaLS conducted a cluster, randomized controlled trial (cRCT) to evaluate the impact of targeted subsidies on toilet ownership and use in 109 ODF-certified communities. Baseline data collected in 2019 showed that 39% of households lacked a functional toilet and 25% practiced open defecation regularly, with higher proportions among poorer households. In 2020, District Assemblies distributed toilet vouchers to 441 vulnerable households (representing 14% of the population) identified via community consultation. This participatory approach involves a community-wide meeting to define what makes a household vulnerable and identify those who fall into this category. Follow-up surveys confirm that identified households truly meet the criteria.

All 441 (100%) beneficiary households redeemed their voucher with local artisans in the following months and received a free toilet substructure (pit lining, durable slab, and ventilation pipe). District Assemblies verified and validated 433 subsidized toilets (98%), which required that beneficiary households had built a full superstructure. Endline data collected early 2021 will help determine the extent to which this intervention increased toilet ownership and use among both poor and non-poor households. Preliminary results indicate that toilet ownership is 11% higher and open defecation 13% lower among households in treatment communities compared to control communities. The study also examined the costs of implementing targeted subsidies in rural Ghana. We found that implementation costs were on the same order as the subsidy itself, resulting in a total of approximately 270 USD per beneficiary household or 2,000 USD per community.

Overall, this study will help understand whether subsidies targeted through community consultation are a cost-effective approach to improve sanitation conditions among the rural poor. Lessons from this cRCT will also translate into practical recommendations for governments and implementers who wish to incorporate targeted subsidies in their programming.

Community Exposure Assessment to Anti-Microbial Resistance; Case Study of Malawi

Presenter: Taonga Mwapasa, University of Malawi- The polytechnic

Additional Authors: Madalitso Mphasa, Derek Cocker, Kondwani Chidziwisano, Nicholas Feasy, Tracy Morse

Background
Anti-microbial resistance (AMR) is currently one of the biggest global health concerns, however transmission pathways of AMR in public spaces, such as the wider community environment in which people and animals interact, have not been fully explored. The presence of resistant bacteria from human and animal waste in the environment has been associated with poor water, sanitation and hygiene (WASH) infrastructure and practices. Currently, low-and middle-income countries (LMICs) such as Malawi are of particular concern, as they have preexisting WASH challenges, which increase the risk of population exposure to AMR. This study examined human and animal exposure to AMR in public spaces in both urban and rural settings in Southern Malawi. Using the principles of the Sanipath tool (https://sites.google.com/view/sanipathwiki) the study focused on; (1) Identifying potential risk pathways of exposure in the environment, (2) determining the presence of resistant ESBL E. coli and K. pneumoniae in the exposure pathways and (3) understanding contributing practices to environmental contamination and exposure.

Methods
This formative research was conducted in two phases across three study sites (urban, peri-urban and rural). Firstly, we conducted interviews (n=9) with community leaders to understand the WASH practices that potentially put people and animals at risk of exposure. Secondly, we conducted transect walks within the study site's boundaries to identify potential exposure pathways to resistant bacteria. During each transect walk we collected samples from drains and standing water, soil and the environment (n=40/site, n=120/month). These samples were enriched in buffered peptone water, before plating on ESBL CHROMagar™ to determine the presence of ESBL bacteria. This study will be carried out for 12 months (October 2020-September 2021) to observe how wet and dry seasons in Malawi affect the presence of resistant bacteria in the identified exposure pathways.

Results
Based on our results to date (5 months), poor waste management and sanitation facilities such as permeable/leaking latrines have been observed to contribute to environmental contamination. Open drains, standing water, dumping sites and areas of frequent contact such as borehole handles were identified as potential exposure pathways. In the interim (Oct 2020-February 2021), 600 samples which included drain (n=270), standing water (n=186), Soil (n=84) and environmental swabs (n=60) were collected. ESBL bacteria were present in 52% of the samples with drains having the highest positivity (60%) and environmental swabs having the least positivity (5%). Furthermore, there was a higher prevalence of ESBL bacteria in the urban (66%) compared to the rural (40%) study site. Full results will be presented at the conference.

Conclusion
All sites showed significant presence of ESBL bacteria in wider public spaces, with particular concern associated with urban areas, and drainage systems. In the urban settings this was associated with areas of unplanned housing and high population density posing a great risk of AMR transmission. As such, it is crucial for communities to consider not only household but also wider WASH and environmental health in public spaces.

Comparing the Triple Bottom Line of Point-of-use or Point-of-entry (POU/POE) Water Treatment Systems to Centralized System Improvements

Presenter: Kaycie Lane, University of Massachusetts Amherst

Additional Authors: Dr. Emily Kumpel

In very small drinking water systems in the US, financing sustainable improvements requires balancing economic, public health, and environmental factors. When seeking to improve water quality and meet regulations, traditional approaches may include adding to or optimizing treatment trains, replacing assets, or seeking out new or blended water sources. However, point-of-use (POU) and point-of-entry (POE) treatment devices, installed at consumer residences, can provide an alternative option for reducing concentrations

of contaminants of health concern. While POU and POE devices can be used as a compliance option for certain contaminants, barriers to successful implementation such as device certification, 100% customer participation, and state-level permitting have made POU/POE devices a last resort option for under-performing small water systems. The purpose of this study is to capture the full range of potential costs and benefits of implementing POU/POE devices in very small water systems.

To determine which contexts POU/POE devices provide a viable alternative to upgrading centralized treatment in small community water systems, we use a Triple Bottom Line approach to evaluate public health, environmental sustainability and economic trade-offs. Four community water systems with either arsenic or nitrate Maximum Contaminant Level violations of the Safe Drinking Water Act were chosen as case studies from 4 EPA Regions. Public health impacts were evaluated using exposure assessment to determine chronic intake of a contaminant, maximum likelihoods of exposure and the estimated exposure duration possible at the current contaminant concentration. Initial exposure assessment results indicate a maximum exposure duration of 4-6 years at the current concentration of arsenic will result in the lowest observable adverse effect to the population served. These values were compared to an implementation timeline for POU/POE devices and an implementation timeline for centralized upgrades to determine which alternative can be implemented prior to see observable health impacts in a very small system. Life cycle costing and life cycle analysis were used to evaluate economic costs and environmental impacts, respectively. EPA Cost models were adapted to inform a model of cost for improving centralized treatment and POU/POE units for several different treatment technology options. Initial cost model results demonstrated adsorptive media POU/POE units are more expensive than reverse osmosis units using default cost model assumptions. Once completed, this analysis will provide three separate metrics (health, sustainability and cost) that can be used to weigh decisions for struggling small systems who are facing challenges in meeting the health-related water quality regulations.

Comparison of Trends in SARS-Cov-2 Wastewater Viral Levels and Community Reported Cases

Presenter: Aaron Best, Hope College

Additional Authors: Brent Krueger, Benjamin Kopek, Michael Pikaart, Nathan Tintle, Adam Slater

Due to the COVID-19 pandemic, higher education institutions were forced to make difficult decisions regarding the 2020-2021 academic year. Many institutions decided to have courses in an online remote format, others decided to attempt an in-person experience, while still others took a hybrid approach. Hope College (Holland, MI) decided that an in-person semester would be safer and more equitable for students. To achieve this at a residential college required broad collaboration across multiple stakeholders, using a COVID-19 mitigation strategy that included wastewater monitoring, comprehensive testing of individuals, contact tracing and isolation procedures.

We describe programmatic aspects of rapidly establishing a wastewater monitoring program that could inform individual testing of residents on campus. Required features of the wastewater monitoring approach included a low cost per sample, readily available reagents to avoid supply chain issues, same day turnaround from sample acquisition to result, scalability, and efficient communication of results to decision makers on campus. Wastewater monitoring was conducted five days per week throughout the academic year at 10 locations on campus and at wastewater treatment plants in the surrounding community. In the Fall 2020 semester, wastewater monitoring was used to initiate 29 follow up testing events of residents living in a wastewater zone leading to the identification of 41 positive, asymptomatic cases. A typical testing event took three days from observation of increasing viral wastewater signal to full testing of individuals in a residential zone and identification, isolation, and quarantine of close contacts.

Wastewater viral levels correlated to emergence of active cases, removal of active cases from residential zones, and return of individuals to residential zones after the isolation period of 10 days. Residual shedding of virus was observed in the wastewater for ~7-10 days. Likewise, community wastewater viral levels correlated with reported COVID-19 case counts in the county and the specific sewersheds, with wastewater signal rising in advance of case reporting by ~7 days. We report on the programmatic lessons learned and the association of wastewater monitoring to case counts and mitigation of COVID-19

Context-Specific WASH Guidance for Cholera Containment, Control, and Elimination

Presenter: Marine Ricau, Tufts University

Additional Authors: Travis Yates, Daniele Lantagne, Tracy Wise

Introduction

Countries with poor water, sanitation and hygiene (WASH) infrastructure are disproportionately affected by cholera outbreaks, and cholera is endemic in 47 countries. WASH interventions are implemented to reduce cholera transmission through the adoption of practices ensuring safe water and hygiene; however, implementation success varies between contexts and is not necessarily universally replicable. Countries are developing National Cholera Control Plans (NCPs) as a way to strengthening their WASH strategy; thus, guidance on context-specific WASH interventions is needed to select the most appropriate interventions for the context.

Methods
A multi-source review was used to identify cholera related evidence and policy through a systematic review of the published literature and, a review of cholera WASH guidance and existing NCPs (grey literature). Peer-reviewed publications from January 2000 to August 2020 with WASH interventions targeting prevention or control of cholera transmission were included. Guidance was reviewed and summarized, and four NCPs were reviewed.

Key informative interviews (KII) were conducted with members of the project Working Group, representing international and national NGOs, donors, and health authorities. KIIs were designed to collect: 1) qualitative information on WASH interventions related to cholera contexts, 2) decision-making approaches, and 3) understanding programmatic aspects of WASH response in cholera. Interviews were transcribed then coded and analyzed through Nvivo.

Results
Overall, 7,711 manuscripts were identified between the searches, 2,868 total titles after duplicates were removed. Ultimately, 36 manuscripts met the inclusion criteria of the systematic review, encompassing 39 contexts and 30 different interventions. A total of 15 emergency cholera interventions and 24 endemic cholera interventions were identified, covering source water treatment, HWT (Household Water Treatment), and hygiene interventions. Four NCPs were reviewed, two finalized and two in the validation process, and the recommendations of six guidance documents were summarized. The emergency and endemic interventions identified showed strong similarities, often sharing very similar activities. Results indicate that: cholera outbreaks often occur with or directly after another emergency; interventions that target cholera hot spots or individual cases are effective; strong connections with the health sector are necessary; a broad understanding of the context is important, such as previous interventions or community attitude and acceptance.

A total of 18 KIIs were completed representing various viewpoints, from health authorities to donors and program managers. Preliminary results indicate that context is often a decisive aspect of the design and implementation of WASH in cholera interventions, but there is no consensus on how to define it. Interviewees described that context is somewhat less critical in an outbreak, as WASH activities need to be implemented rapidly. They also highlighted that the cooperation with the health sector is critical and needs to be strengthened in most contexts. We expect additional and more prominent results with further analysis.

Conclusion
With this study, we aim to collaboratively develop a guidance document on context-specific WASH in cholera response to inform WASH strategy in NCPs. Early results indicate responders and writers of NCPs should focus on understanding and defining the under-lying conditions of a specific context while applying multi-sectoral projects to targeted approaches.

Delivering Transformative WASH at Scale: Nurturing Care Groups as a Vehicle for High Frequency Messaging, Norms Change, And Driving Collective Action

Presenter: Cynthia Fosuah, World Vision

Additional Authors: Ben Tidwell

Background
Delivering Transformative WASH at scale has been challenging, in part because a number of behaviors are required that contribute to “public goods,” which benefit the community more than the person doing them. Some behaviors are also affected by stigma, where individual messaging may be insufficient to shift community norms. Finally, delivering WASH promotion with the frequency and fidelity considered necessary by those promoting Transformative WASH approaches has limited these efforts. We report the results of a study of the Nurturing Care Group (NCGs) approach, a model where 10-12 women chosen by groups of 10-15 neighboring households each meet with health promoters, and then relay the messages back to their neighbors. NCGs have proven effective at reducing child mortality in more generally maternal and child health settings, including behaviors like exclusive breastfeeding and childhood

immunizations, but have to-date not been focused specifically on behaviors requiring collective action or infrastructure construction. The bi-weekly meetings and comprehensive coverage of communities with regular communications may allow for addressing collective action, stigma, and individual behavior change challenges.

Methods
We conducted a controlled before-and-after trial in two districts of Ghana from June 2019 to December 2020. The NCG program promoted a variety of key WASH behaviors, including household water treatment and storage, toilet construction and use, hand hygiene, MHM knowledge and stigma, and animal feces management. We collected data from individuals in program areas (n=324) and neighboring areas (n=430) before and after the intervention. We assessed knowledge and self-reported behavior, directly observed outcomes where possible, and tested microbiological household water quality.

Results
For habitual behaviors, detectible E. coli in drinking water decreased from 32.1% to 8% in intervention sites, compared to a 1.8% drop in control sites. Several related behaviors improved, such as storage containers covered with a lid (+28%pp), using a dipper (+26%pp) and drinking water kept beyond the reach of animals (+21%pp). Access to basic handwashing showed a 51%pp net increase, with minimal change in the control group despite the onset of COVID-19. For collective action behaviors, animal faeces management recorded a 22%pp net increase in animal enclosure during the day beyond the reach of households' drinking water. Several measures of stigma related to MHM decreased by about 75%. Finally, for more expensive product-based behaviors, a small net increase of 7%pp was recorded for basic sanitation. This is small, but not inconsequential considering the slow pace of sanitation progress in Ghana and the lack of supply-side or market-based interventions in the area.

Conclusion
Nurturing Care Groups may be an effective way to deliver high frequency behavior change messaging at scale and build social capital and intentionally leverage that into collective action. However, supplementary market-based and financing activities may be needed to drive the achievement of some key WASH SDG outcomes.

Elucidating the Impact of Locality-Specific Factors on Sanitation System Sustainability Via QSDsan

Presenter: Hannah Lohman, University of Illinois at Urbana-Champaign

Additional Authors: Victoria L. Morgan, Yalin Li, Xinyi Zhang, L. Stetson Rowles, Jeremy S. Guest

The overarching goal of this work is to explore how implementation context influences sanitation system design and sustainability, and to leverage this insight to help guide investment in sanitation technology development and deployment. In resource limited settings, conventional sanitation systems often fail to meet their goals – up to 70% of systems fail within the first two years. System failures often stem from mismatch of solutions and implementation context and a push to improve global sanitation with silver bullet solutions on opposite ends of the spectrum: conventional technologies/approaches that work in certain contexts or emerging technologies that do not work or only work for a very specific application.

This has contributed to the deployment of sanitation solutions that may not meet the constraints of a given context and contribute to a lack of perceived value by end users. Currently, there is a lack of holistic analyses of the sanitation system opportunity space that elucidate contextual factors that drive the relative sustainability of potential solutions across community populations, climates, and locations. The objectives of this work are (1) to introduce QSDsan, an open-source quantitative sustainable design (QSD) platform in Python for design, simulation, and sustainability assessment of sanitation and resource recovery systems under uncertainty, and (2) to explore the influence of context-specific input parameters on system sustainability indicators (e.g., environmental impact and user costs).

The second objective is achieved through modeling the construction, operation, and maintenance of conventional and early-stage sanitation and resource recovery technologies (e.g., non-sewered sanitation systems from household pit latrines to large-scale Omi Processors) and varying context-specific input parameters within QSDsan. Key contextual parameters include assumptions related to energy (e.g., energy source mix, electricity price), demographics (e.g., population, dietary intake), the local environment (e.g., distance to agricultural land, soil type), and economics (e.g., tax rate, discount rate). Environmental impact indicators are calculated via life cycle

assessment (LCA) and sanitation system costs (e.g., daily user cost) are calculated via techno-economic analysis (TEA). Uncertainty and sensitivity analyses are used to evaluate the contextual influence on sanitation system sustainability indicators.

Country scenarios will be assessed to understand how system selection and sustainability indicators are impacted by locality-specific assumptions. Preliminary results indicate that greenhouse gas emissions across technologies are most sensitive to a country's energy mix (e.g., fraction of energy produced by solar, wind, coal, etc.) and could influence country selection for system implementation. Demographic parameters such as dietary intake and user population impact the quantity of recoverable nutrients available for resource recovery systems and could limit economic viability of a system. Overall, this research improves the evaluation process of sanitation system selection by incorporating salient features of a community that govern the success or failure of a technology.

Embracing the Other W In WASH: Harnessing the Power of Women in Sanitation Markets

Presenter: Bernard Elegebe, Association Béninoise pour le Marketing Social et la Communication pour la Santé

Additional Authors:

Access to and use of safe sanitation in Benin is extremely low. Surveys report that between 38-53% of Benin's total population practice open defecation, 19.5% have access to limited sanitation, 16.5% have access to basic sanitation and 10.2% have access to unimproved sanitation (National Health Survey, 2018; Joint Monitoring Programme, 2017). Half of Benin's population lives in urban areas, 22% of which use basic sanitation facilities. As with many countries with poor sanitation practices, the lack of universal access to basic sanitation facilities in Benin is primarily due to the absence of affordable, high quality and accessible toilets for consumers combined with a lack of social marketing and behavior change communication.

PSI implements the USAID-funded Sanitation Service Delivery (SSD) project in Benin and Cote d'Ivoire. SSD creates a more effective, sustainable, and inclusive sanitation market for the urban poor by developing and testing scalable interventions that engage private sector service providers, and by contributing to the creation of a strong enabling environment for sanitation. The SSD project engaged about 30 entrepreneurs to construct affordable sanitation facilities for a target market of low-income households in urban and peri-urban areas. Of those, only three were women. Cultural norms in Benin usually meant that only men were involved in the manufacturing and construction of sanitation facilities. SSD supported these three women in defying the status quo.

Not only did the female entrepreneurs succeed in completing the training and constructing sanitation facilities alongside their male peers, they excelled in it. SSD observed that when female entrepreneurs were involved in the construction and behavior change communication around sanitation, women in the community were more likely to internalize the messages, purchase sanitation products, and use them on a regular basis. In intervention areas led by female entrepreneurs, adherence to latrine construction and use by female heads-of-households stood at 40%, compared to just 26% of those in male entrepreneur led areas. Over two years, the three female entrepreneurs constructed 3,058 sanitation facilities serving 1,600 people. Customers of these women reported a satisfaction rate of 96%.

The success of the women entrepreneurs involved with SSD proves that sustainable human development and meaningful progress to SDG6 cannot occur without full participation of women. Many countries and communities hold similar cultural beliefs that women should not be involved with construction or sanitation sectors, however, this experience should be a lesson that development partners must push to combat these believes and engage women in all aspects of WASH.

Emphasizing Choice in Hygiene Products Among People Experiencing Homelessness

Presenter: Alison Hoover, Emory University

Additional Authors: Ana V. Rodriguez, April M. Ballard, MPH, Bethany A. Caruso

Key learning objectives:

1. Identify the needs and preferences for personal hygiene items among people experiencing homelessness in Atlanta, Georgia during the COVID-19 pandemic.
2. Assess participant perceptions of a small-scale, crisis-oriented supply chain in Atlanta, Georgia designed to meet the acute personal hygiene, menstrual health, and sexual health needs of people experiencing homelessness.

3. Discuss the process and importance of applying research findings in real-time to center the preferences of people experiencing homelessness in outreach efforts and better meet their needs.

Background: The Dignity Pack Project is a small-scale, crisis-oriented supply chain in Atlanta, Georgia, designed to meet the acute personal hygiene, menstrual health, and sexual health needs of people experiencing homelessness (PEH). It was organized in partnership with local organizations that serve PEH to respond to conditions during the COVID-19 pandemic. The pandemic continues to illuminate and exacerbate the distinct and complex challenges PEH face when trying to meet their basic hygiene needs and maintain their health. We carried out a small-scale, survey-based study to identify the hygiene- and menstrual-related needs and preferences of PEH during the pandemic, to determine if the supply chain was meeting the basic needs of PEH, and to leverage provided insights to improve the program.

Methods: To understand the needs and preferences of PEH and gain their insights about the supply chain, we conducted interviewer-administered surveys (n=29) and unstructured observations (n=22) during supply distribution from September 2020 to March 2021. Surveys queried participant preferences, the need for and utility of the items distributed, and their general opinions about the supply chain. Informal observation of product distribution (>950 kits distributed to date) supplemented survey data in determining commonality of survey responses.

Results: Items were initially delivered in pre-packed kits, however observations and learnings from PEH early on resulted in a critical change in how hygiene items were distributed. Specifically, products—including hygiene items, period supplies, personal protective equipment, and condoms—were put out and individuals “shopped” for what they wanted. Participants expressed satisfaction with this approach, which supported agency. Soap and deodorant were identified via observation and surveys as the most wanted hygiene items. Almost every participant (93.1%) wanted body/hand hygiene products, which included soap, wipes, hand sanitizer, and washcloths. Sixty-two percent wanted other personal hygiene products (i.e., deodorant, razors) and 48.3% wanted oral hygiene products. All but one female below the age of 55 reported wanting menstrual products. Notably, men and other non-menstruators retrieved period products for menstruators in their life. Feedback from PEH led to the addition of six products, the removal of three, and the addition and then removal of two other products described as useful by some but were not popular.

Discussion: Collecting feedback from PEH, observing during distribution, and collaborating with local organizations provided critical insights and improved our approach ethically, logistically, and economically. Surveys among PEH led to the creation and implementation of an innovative outreach approach that mimics shopping at a store and emphasizes humanism, pragmatism, human rights, and autonomy. Additionally, unpacked kits were less wasteful, less labor intensive, and more cost-effective. Our findings emphasize the importance of understanding how PEH prefer to meet their hygiene and menstrual health needs and making all products available to everyone, regardless of gender.

Empowering Local Change Agents – WASH Women’s and Youth Groups in Urban Nigeria

Presenter: Amrita Mahtani, RTI International

Additional Authors: Umar Bari

Nigerian urban water corporations in Abia, Delta, and Taraba states were not supplying continuous water nor addressing city-wide sanitation issues. Customers, frustrated by the lack of services reported losing trust in the corporations. To improve WASH coverage, RTI International, through the USAID Effective WASH (E-WASH) program, supported sector-wide legislative reform, introduced customer-centric approaches, and established state level social accountability platforms. However, with many simultaneous changes, the program proposed disseminating information via multiple new platforms to ensure community engagement and participation.

RTI with local civil society organization (CSOs) piloted women and youth groups to engage directly with often marginalized members of communities. The purpose was to both inform participants and build momentum for citizen engagement for WASH reform. The CSOs established volunteer youth and women’s groups in their respective states and met with them monthly to notify them of new WASH updates, help them prioritize WASH issues in their communities, and guide them to advocate within their communities.

Sanitation was high on the priority list for the community groups in Taraba. The women and youth groups joined forces with central messaging and advocated to local government and market leaders to reactivate the monthly sanitation exercises, provide public toilets

in high-density areas, and improve environmental hygiene in marketplaces. Not only did the Ministry recruit a sanitary inspector, but it also established a sanitation working group to enforce general cleaning and reactivated market toilets in the city center and invited representatives to join the Sanitation Coalition to develop a state-wide sanitation strategy.

COVID-19 resulted in both a greater demand for water services but was met with myths about the virus' transmission. CSOs worked with youth groups in Niger to go door-to-door to elderly neighbors to explain social distancing, demonstrate proper mask use and handwashing, and answer questions. Participants reported the importance of engaging with older citizens to ease their concerns and stress preventative measures.

The Abia water corporation halted water production seven years ago, resulting in customer distrust of practical reform changes. CSOs met with women's and youth groups to highlight the corporation's commitments, introduce community scorecards, and raise awareness for WASH behavior change campaigns. These groups, made of trusted and influential community members, then cascaded these updates via house-to-house visits to 1,923 households to increase awareness.

The program found that implementing comprehensive sector reform and encouraging buy-in takes an ecological model approach. The program worked in parallel at the larger state-wide policy level to change legislation, at the WASH provider level to professionalize service delivery, and at the larger community structure level with women's and youth groups to foster connections with neighbors and individuals. The CSOs worked with the groups in unique ways in the three states. With support from CSOs, these groups were able to reach a larger audience and are currently mobilizing more people to advocate to water corporations and join citizen advocacy initiatives.

Ethnographic Fieldwork with the Rohingya Demands Both Emotional and Technical Intelligence Amongst Humanitarian Response Teams

Presenter: Jenny Lamb, Former postgraduate student at Department of Sociology and Anthropology, Society of Oriental & African Studies, University of London, UK

Additional Authors:

Background
The plight of the Rohingya in Myanmar is grave and one, which has gone on for decades with little respite, justice, and future. Their precariousness and clashes in Rakhine state led to more than 745,000 being displaced to Cox Bazar in Bangladesh in August 2017. Water, sanitation, and hygiene (WASH) are essential to reduce public health risks through the access and use of appropriate, safe, and dignified WASH infrastructure. But the failure of WASH staff to produce sanitation solutions have stripped the Rohingya of their social values, humanity and dignity. We need to get the basics right at the outset of an emergency to safeguard the wellbeing of affected populations. Through an anthropological lens, it is intended to show how critical it is for WASH staff to endure a comprehensive understanding of Rohingya life and how this should underpin the design and implementation of WASH interventions.

Methods
Ethnographic fieldwork targeted camps and host areas in Teknaf and Ukhia. Our efforts concentrated on building rapport with a small number of Rohingya to build depth and meaning, rather than a vast and shallow set of perspectives. Humanitarian response informants included WASH staff, the UN and the Government of Bangladesh. Transect walks, participant observation, unstructured and semi-structured discussions were carried out.

Results
The separation of social spaces in respect to gender roles and relations is critically important for the Rohingya. The camp environment and WASH response quashed this. Environment stressors included latrines were built too far from their shelter, on steep hillsides, with no privacy screens, locks, or lighting, nor segregated in a meaningful way. Whilst their social stressors ranged from lack of privacy, dignity, social restrictions for women and girls to move around. The environmental, and social stressors intensified sexual stressors and subsequent fear of gender-based violence, compromised privacy and dignity, and meeting unmarried men whilst at the latrine. Rohingya women and girls had to resist, substitute and invest in their own latrines inside their shelters (i.e., a bucket, a shallow hole in the ground), or carry out unhealthy regulatory behaviours by limiting their food and drink intake, visiting in groups, or during dusk and dawn.

Humanitarian WASH staff attributed their transactional nature of building latrines and lack of time dedicated for formative research in the following. Characterised by hilly terrain, lack of space and time, it was a numbers game to build as many latrines as possible, that they followed the standard designs and asked no questions, and too often engineers raced ahead leaving behind the hygiene promotion staff. Interventions suffered too much from a technical lens, community engagement being tokenistic, and staff lacked an understanding of the social construct and emotional burden in WASH.

Discussion & Conclusion
The endpoint of a purely technical lens in WASH is a compromised public health and dignified environment for the communities with which we support. The Rohingya context demonstrates WASH staff need to put themselves more often in the shoes of the community – and ask how they felt when we used the latrine in a camp for instance. We need to listen and engage with communities in a meaningful way to ensure sanitation infrastructure responds to their social and cultural norms. WASH teams need both emotional and technical intelligence to devote the time to formative research before, as it is the small tweaks that will make the difference between whether a woman or girl uses a latrine or not.

Evaluation of Design Parameters for a Biosand and Iron-Based Institutional-scale Arsenic Removal Unit

Presenter: Kit Dashwood, Samaritan's Purse and CAWST

Additional Authors: Amiah Warder, Ron Orcajada, Marcio Botto, and Ray Cantwell

Groundwater contaminated with arsenic (As) remains a prominent health issue for many low- and middle-income communities around the world. The Kanchan Arsenic Filter (KAF), one of many arsenic removal units (ARUs) promoted widely, uses 5 kg of nails to adsorb inorganic arsenic in water prior to filtration through a household BioSand Filter. Institutional- and community-scale intermittently operated slow sand filtration systems (iSSFs) are employed with increasing frequency to improve microbial water quality. However, there is a gap in arsenic removal technology comparable to the KAF at the institutional scale in rural communities. Therefore, targeting the institutional scale, and leveraging the existing iSSF design principles, a field study was undertaken to scale-up and improve the KAF design.

Four configurations of an iron contactor design were field tested in rural Cambodia. Five-hundred litres of shallow groundwater was passed through each iron contractor daily at 1.5L/min. Baseline parameters of the source water were as follows: initial arsenic concentration of 586 ± 30 ppb (95% CI, n =26), DO of 4.40 ppm, phosphate of 5 ppm, and turbidity of 21.5 NTU. The iron contactors had two levels of contact time (30 min and 3 min), two levels of nail lengths (2.2 cm and 3.1 cm), two levels of aeration (i.e. elevated and no intentional aeration), and three levels of zerovalent iron nail masses (15 kg, 30 kg and 45 kg). Effluent of each of the iron contactors was passed through a 20 cm deep roughing filter constructed of gravel and sand (d = 1 – 4 mm) before passing to an iSSF. Effluent samples were taken three times per week over a 4-month period, measuring turbidity, arsenic, iron, and phosphate concentrations.

One-way ANOVA analysis was used to assess configuration performances. The mass of nails used in the iron contactor had a significant impact on arsenic removal performance. The average arsenic removal for the 15 kg, 30 kg, and 45 kg nail mass configurations yielded an average (n=26) of 92.6% ± 1.19%, 97.3% ± 0.40%, and 97.6% ± 0.27%, respectively. The removal rate of 30 kg was not significantly different from 45 kg ($p < 0.743$). Increased aeration and nail size did not have significant impact on arsenic removal ($p < 0.526$). Additionally, the study showed evidence that the necessary media contact time for maximum arsenic removal is much shorter (~3 minutes) than the typically reported 30 mins for the KAF. The results suggest that this design is capable of reliably removing arsenic from source waters of up to 400 ppb to below the WHO defined safe levels of 10 ppb. Furthermore, the flow rate and removal performance was consistent over four months of operation without maintenance or media replacement.

This study supports the potential for a robust and low-cost institutional scale ARU based on KAF fundamentals that is appropriate for rural communities.

Evaluation of Prevalence and Changes in Antimicrobial-Resistant Fecal Organisms in Fecal Sludge and Wastewater Treatment Plants, Naivasha, Kenya

Presenter: Naomi Korir, Sanivation

Additional Authors: Amy Kirby, Jen Murphy, Emily Woods, David Berendes

Antimicrobial resistance (AMR) is a global public health threat; sanitation systems may mitigate—or exacerbate—transmission of AMR pathogens. We quantified extended-spectrum beta-lactamase-producing (ESBL) E. coli, an AMR pathogen of global concern, in influent and effluent of wastewater and fecal sludge treatment plants in Naivasha, Kenya to examine AMR in fecal waste before and after treatment. We observed prevalent ESBL E. coli (≥5 log10/100mL in influent, ≥4 log10/100mL in effluent) with higher proportions of ESBL E. coli/total E. coli than i reported from treatment plants in high-income countries. These data underscore the need to monitor AMR in sanitation systems worldwide.

Although antimicrobial resistance (AMR) is a pervasive, global threat, levels of AMR, including fecal AMR pathogens such as extended-spectrum beta-lactamase-producing (ESBL) E. coli, are not known across low- and middle-income countries (LMICs). Though improving water, sanitation, and hygiene (WASH) systems can prevent AMR- and non-AMR infections, WASH conditions remain poor and may even contribute to AMR spread in LMICs. For example, recent global estimates indicate about 25% of ESBL E. coli in feces is unsafely managed (discharged into unimproved systems or openly defecated).1 Levels of AMR pathogens and effectiveness of treatment processes before discharge should be evaluated in local sanitation systems to enumerate effective AMR mitigation strategies in communities.

In Kenya, 95% of fecal sludge is discharged into the environment without treatment. Only 17% of Kenyans have access to sewerage2, compared with goals of 40% by 2022 and 80% by 2030. In Naivasha sub-county, a fecal flow study found that 75% of the population used non-sewered sanitation.3 Following this, Sanivation, a container-based sanitation provider, partnered with Naivasha Water and Sanitation Company (NAIVAWASCO, which was designed to process sewage from 50,000 people but was serving 143,000 across both sewered and non-sewered systems) to process the non-sewered fecal sludge.

From November 2019-March 2020, we sampled the fecal sludge treatment plant (FSTP) 10 times for influent, effluent, and biosolids (final material used to make non-carbonized briquettes used as a firewood substitute) and sampled the NAIVAWASCO wastewater treatment plant (WWTP) 11 times for influent and effluent. All samples were tested for total E. coli and ESBL E. coli via IDEXX Colilert® (supplemented with cefotaxime for ESBL E. coli quantification).

In the FSTP, influent E. coli (total) and ESBL E. coli levels averaged 6.3 (95% confidence interval (CI): 6.1, 6.5) log10 most probable number (MPN) of coliform forming units/100mL and 5.0 (95% CI: 4.7, 5.3) log10 MPN/100mL, respectively. Effluent E. coli and ESBL E. coli levels averaged 5.2 (95% CI: 4.7, 5.7) log10 MPN/100mL and 4.1 (95% CI: 3.7, 4.4) log10 MPN/100mL, respectively. No biosolids samples had detectable total or ESBL E. coli (all < 4 log10 MPN/100mL). ESBL E. coli made up 6% (95% CI: 4%, 8%; range: 1-15%) of all E. coli measured in influent samples, and 7% (95% CI: 3%, 11%; range: 2-26%) of effluent samples., We observed a mean decrease of 1.0 log10 MPN/100mL in concentrations of each type of E. coli after treatment.

At the WWTP, influent E. coli and ESBL E. coli levels averaged 7.2 (95% CI: 7.0,.7.3) log10 MPN/100mL and 6.4 (95% CI: 6.2, 6.7) log10 MPN/100mL, respectively. Effluent E. coli and ESBL E. coli levels averaged 5.6 (95% CI: 5.4, 5.9) log10 MPN/100mL and 4.7 (95% CI: 4.4, 5.0) log10 MPN/100mL, respectively. ESBL E. coli comprised 23% (95% CI: 14%, 31%; range: 8-41%) of E. coli measured in influent samples and 13% (95% CI: 11%, 16%; range: 3-21%) of effluent samples., We observed a mean decrease of 1.5 log10 MPN/100mL in concentrations of total E. coli and 1.7 log10 MPN/100mL for ESBL E. coli after treatment.

ESBL E. coli, an important AMR pathogen, is readily detected at high concentrations in both influent (≥5 log10 MPN/100mL) and effluent (>4log10 MPN/100mL) from treatment plants in Naivasha, Kenya. These results suggest both frequent transmission of ESBL E. coli in local populations as well as relatively poor treatment of these and other organisms within existing sanitation plants, suggesting high levels of environmental discharge into receiving waters. In particular, ESBL E. coli entering WWTP and FSTP made up more of the overall E. coli levels than observed in high-income settings, suggesting a need for optimizing treatment to reduce AMR pathogens in addition to susceptible ones. To-date, AMR pathogens in community settings, including in sanitation systems, in LMICs have not garnered attention; however, the availability of field-practical methods, such as the WHO TriCycle or modified IDEXX methods (used here) make environmental surveillance a feasible and necessary future step in understanding AMR burden and how improving sanitation systems can reduce this burden in the environment and communities

Evaluation of Water Treatment Disinfectants for Larvicidal Effects on Aedes Aegypti

Presenter: Sydney Turner, University of Virginia

Additional Authors: Dr. James Smith

The burden of disease associated with unsafe drinking water goes beyond the risk of diarrheal disease. For communities without access to uninterrupted, piped water, the reliance on home water storage (HWS) can lead to adverse public health outcomes caused by both water degradation and proliferation of mosquito populations (WHO, 2012). Studies have been able to link poor drinking water and sanitation conditions to higher prevalence of malaria, dengue, and chikungunya fever (Yang et al, 2019; Dada et al, 2013; Vannavong et al 2017).

Mosquitoes are the most prolific species contributing to disease (Lounibos, 2002). Eighty percent of the world's population is at risk of vector-borne disease with over 700,000 deaths caused by vector-borne diseases annually (WHO, 2020). Resistance of mosquitoes to common insecticides employed in HWS containers, such as temephos, has been observed more frequently (Guedes et al, 2020; Lima et al, 2017; Legorreta-Soberanis et al, 2017); therefore, alternative vector control methods for HWS containers must be identified. To address this growing need, our research was designed to assess the larvicidal effects of juvenile (larval and pupal stages) Aedes aegypti after their aquatic growth environment was dosed with chemicals commonly incorporated as microbial disinfectants in water treatment processes.

The experiments focused on the evaluation of silver and chlorine at varying concentrations below the maximum allowable level for drinking water (as stipulated by organizations such as the WHO and EPA). The measure of success or efficacy of the water treatment disinfectant (WTD) was based on the decreased emergence of adult mosquitoes when compared to control larvae that did not come in contact with the WTD. For the larvicidal bioassays, late third instar larvae were used in accordance with protocol set forth by WHO (2005). Probit analysis was used to determine the inhibition of emergence for each WTD.

The results from these experiments demonstrate that both calcium hypochlorite (Ca(OCl)2) and silver nitrate (AgNO3) successfully inhibit the development of larvae into adult mosquitoes at concentrations below the drinking water quality standard, with silver being the most effective. We also observed differences in the morphologic changes to larvae that came in contact with silver versus chlorine, demonstrating the disinfects' mechanism of inhibiting the growth of the Ae. aegypti may differ. Our promising results led us to evaluate the larvicidal effects of the commercialized point-of-use water treatment (POUWT) technologies, the MadiDrop+ (silver nanoparticle-based technology) and the Aquatab (chlorine-based technology). These application-based experiments will help determine which POUWT technology, when used as directed, will achieve the most significant larvicidal effect, if any at all. These POUWT experiments are currently ongoing, and the results will be reported as part of this research at the conference.

The intended impact of this research is to gauge viability of using WTDs and POUWT dually as mediums for water treatment and mosquito control for HWS and lend better guidance as to what WTD will be the most effective in a given community based on relevant public health information (e.g. prevalence of water-borne and vector-borne diseases).

Evaluation Synthesis of UN System Work Towards SDG 6

Presenter: Mona Fetouh, UNICEF

Additional Authors: Travis Yates, Anna Murray

At current rates of progress, SDG 6 targets will not be achieved by 2030, and SDG 6 has the greatest capacity gap of all 17 SDGs. To address these gaps, the SDG 6 Global Acceleration Framework was launched in 2020 which intends to scale up and unify international support to achieve SDG 6 targets.

Five years into the 2030 Agenda and with increased attention on SDG 6 status, there is an opportunity to take stock of what has been achieved to date, identify facilitating factors and existing challenges, and determine a path forward with what remains to be done. A comprehensive, inter-agency evaluation synthesis offers a critical foundation to the evidence base on the achievement of SDG 6, as well as an opportunity to inform future programming and policy-making.

The overall objective of this work is to compile and summarize existing evaluations of UN and development bank work towards SDG 6. This is intended to: assess the current evaluative situation, support recommendations for future programming, and support the future evaluations related to SDG 6.

The synthesis had two phases - a mapping phase, with the initial searching and screening, as well as presentation of evidence by agency, SDG 6 target, timing and geographic coverage. The second phase, currently being finalized, presents synthesis findings by SDG 6 target and the key research questions, as well as recommendation for future programming. The research questions were broken down into primary and secondary questions.

Primary Questions

1. Based on evaluative evidence, to what extent have UN agencies contributed to progress towards the eight SDG 6 targets? When and where were interventions most effective?
2. What are the most common facilitating and hindering factors identified?
3. What lessons from these evaluations can be applied to future interventions to contribute towards reaching SDG 6 targets by 2030?

Secondary Questions

a) How well-aligned were interventions with SDG 6 targets and with key commitments?
b) How well were gender, equity and AAP integrated into interventions?
c) What did the evaluations find regarding the five SDG 6 accelerators (optimized financing, improved data and information, capacity development, innovation and governance)?
d) What does evaluative evidence say about how efficiently interventions were conducted?
e) To what extent was there evidence of UN and sister agencies coordinating and linking efforts between the SDG 6 target areas (WASH, climate, water resource management)?
f) To what extent are the evaluated interventions sustainable or likely to be sustained?

A rigorous review methodology was used to ensure a comprehensive and consistent approach to the synthesis. The methodology was based on the review process outlined by the Cochrane Handbook. The systematic review was complemented by a series of key informant interviews to validate and provide context to the findings. Data from evaluations that met inclusion criteria were extracted and coded by the Synthesis Team. Detailed methodological data were collected with Distiller SR software in conjunction with Microsoft Excel. Summarizing qualitative descriptions, such as findings and recommendations from individual evaluations, was done with Nvivo qualitative analysis software. Initial themes were outlined in the protocol with the qualitative synthesis framework, then refined as needed to represent the themes identified in the included evaluations. Data were then summarized to address the primary and secondary research questions.

The findings are intended for use by SDG 6 technical and evaluation staff in the participating agencies, as well as senior management, donors and governance entities. It is intended to provide a key source of evidence on gaps, what works well and what needs to be improved to meet the 2030 target.

Expanding Safe Fecal Sludge Management in Kisumu, Kenya: an Experimental Comparison of Latrine Pit-Emptying Services

Presenter: Rachel Peletz, The Aquaya Institute

Additional Authors: Caroline Delaire; Ranjiv Khush

Most residents of Kisumu, Kenya, use latrines constructed over basic pits or attached to more durable concrete vaults and septic tanks. Only one-third of fecal sludge generated in the city, however, is safely collected and treated. Programs for improving fecal sludge management among poor households include the development of formal manual emptying organizations that are recognized by local authorities, employ safety procedures, and transport fecal sludge to a treatment site.

In this study, we compared the financial structures of these organizations with those of vacuum trucks that primarily serve wealthier households. We also employed an incentives-based strategy to promote the expansion of safe pit-emptying services in a low-income area and compared the performance of three managing groups to coordinate these services: (1) The Association of Wastewater Managers (The Association); (2) a formal manual emptying organization; and (3) a community-based water supplier interested in coordinating emptying services.

Vacuum truck operators (VTOs) were more cost-effective than the formal manual emptying organization, and The Association was most efficient in servicing poor households. The Association also demonstrated the ability to service low income areas comprehensively by delegating a fraction of jobs (11%) to formal manual emptiers in locations not serviceable by VTOs, and overall showed the highest potential to achieve pro-poor service delivery at scale.

The key elements of this service delivery model were: (1) a competent local organization serving as a "switchboard" between households and suppliers; (2) broad flexibility given to that organization to assess pits, set prices, choose appropriate suppliers, negotiate supplier payments, coordinate timing and terms, and ensure customer satisfaction by resolving disputes; (3) holding the organization accountable by careful monitoring of high-level outcomes and customer satisfaction; (4) providing an outcome based incentive. This research was published in 2020 in the Journal of Water, Sanitation, and Hygiene for Development: https://doi.org/10.2166/washdev.2020.060, and we are applying for the research awards on Sanitation Workers.

Exploring Risk of Shared WASH Facilities on COVID-19 Transmission

Presenter: Savannah Boerger, Emory University

Additional Authors: Matthew Freeman, Joseph Eisenberg, Michael Hayashi

Background
Water, sanitation, and hygiene (WASH) practices have historically been studied in the context of enteric disease transmission, but the ongoing COVID-19 pandemic highlights an opportunity to explore the potential role of WASH in respiratory disease transmission. Shared water and sanitation facilities are widespread in resource-poor settings as an important mid-tier infrastructural step in achieving improved water and sanitation conditions, but introduce the potential for elevated exposure to infectious aerosols and fomites.

Problem Statement
Fetching drinking water and using sanitation facilities are essential activities, even in the midst of stay-at-home mandates to mitigate COVID-19 exposure. These activities create high-risk COVID-19 transmission conditions for those visiting shared WASH facilities.

Objective
Our objective was to assess the degree to which shared water and sanitation facility utilization may contribute to COVID-19 transmission and to examine various mitigation strategies that can inform policy decisions around the potential for future outbreaks.

Methods
We developed transmission models and simulated outbreaks to explore scenarios under which water and sanitation facilities may contribute to COVID-19 infections. For shared water sites, we developed deterministic Susceptible-Exposed-Infectious-Removed (SEIR) transmission models to describe COVID-19 infection dynamics in an urban setting, where multiple water sites are shared within a community, and a rural setting, where a single water site is shared among communities. We explore mitigation strategies, including social distancing and increasing water access. For shared sanitation sites, we developed a stochastic quantitative microbial risk assessment (QMRA) model incorporating COVID-19 infections from both airborne and fomite sources. We explore mitigation strategies including ventilation, single- vs. multi-stall formats, and public vs. private sharing structures.

Results
Increased water site availability and social distancing independently attenuate attack rate and peak outbreak size through density reduction. In combination, these mitigation efforts can be synergistic in reducing attack rates. When water sharing intensity is high, risks are high regardless of the degree of social distancing. When water sharing intensity is low, risks are generally low, increasing only as social distancing diminishes. In urban contexts, mitigation was more consequential than in less dense scenarios. For shared sanitation

sites, we find that aerosolized particles are the dominant mode of COVID-19 transmission within a latrine. Increasing ventilation was highly effective at mitigating simulated disease risk.

Conclusion
Shared water and sanitation activities are essential - especially for the poorest households - and therefore create a potentially important mode of transmission for respiratory diseases like COVID-19. Important trade-offs exist between infrastructural investments that are costly but provide more robust control and mandates on social distancing and cleaning water sites that are inexpensive and quick to implement. Important synergistic opportunities exist such as more modest investment in infrastructure that increases the effectiveness of social distancing and cleaning efforts.In anticipation of future respiratory and enteropathogen pathogen outbreaks — potentially novel emerging pandemics — WASH infrastructure planning should consider the health benefits associated with respiratory transmission reduction when prioritizing investments.

Exploring the Use of a Sanitation Safety Plan Framework in First Nations' Wastewater Systems

Presenter: Megan Fuller, Dalhousie University

Additional Authors: Toni Stanhope, Kaycie Lane, Amina Stoddart

First Nations communities in Canada have a documented history of sub-standard water quality, in part due to insufficient funding, lack of timely infrastructure improvement, and absence of a comprehensive federal water management strategy. The National Assessment of First Nations Water and Wastewater Systems completed in 2011 found that 21% of the 532 wastewater systems included in the study were functioning at or beyond estimated capacity and 65% of systems were medium to high risk. The report identifies wastewater effluent sampling, testing, and record keeping as areas of concern. Current regulations for wastewater effluent quality for First Nations communities only establish minimal performance standards for total suspended solids (TSS), carbonaceous biochemical oxygen demand (CBOD), and total residual chlorine (TRC) with no regulated standards for microbiological parameters. Given the predominance of moderate to high-risk systems functioning at or beyond capacity with no requirement to document microbiological treatment efficacy, there is a need to develop alternative strategies to manage environmental and health risks in First Nations wastewater systems. Sanitation safety planning (SSP) is a collaborative management methodology promoted by the World Health Organization (WHO) for the assessment and reduction of risk in sanitation systems. This research examines the potential benefits of an SSP approach to provide risk-based management for wastewater systems in First Nations communities.

This study developed a hazard identification checklist using a SSP framework to characterize potential hazards in 29 First Nations wastewater systems in Atlantic Canada. Using system assessment reports from 2013 and 2018, 52 possible hazardous events were evaluated along the sanitation chain to assess risk within systems. The results provided an understanding of hazard relationships across systems and highlighted knowledge gaps in current management practices. Overall, 69% of hazardous events had an unknown level of risk while 7% were high-risk. This was due, in large part, to lack of information for decentralized systems and communities that rely on municipal transfer agreements for wastewater treatment services. Centralized systems owned and operated by the First Nation communities were characterized by high and moderate risk levels across several key hazards, including back up power sources and incomplete record keeping.
These knowledge deficits and high-risk hazards demonstrate the interconnectivity of hazards that could result in risk propagation and accumulation along the sanitation leading to potential effluent quality concerns. This work also demonstrates how the plurality of stakeholders, such as federal regulatory agencies, chief and council on reserve, and additional government organizations, add complexity to the SSP process but are integral to the success of wastewater management and risk mitigation. This desktop study found that an SSP risk assessment approach could offer an alternative management process to compliment the regulatory approach currently in place for First Nations communities. Due the inability to visit communities, this work was done without direct involvement of First Nations wastewater operators; we recognize that any further work done to consider the implementation of SSPs in First Nations communities will need to be led by community members and First Nations water experts.

Fecal Contamination on the Household Compound and In Water Sources are Associated with Subsequent Diarrhea in Young Children in Urban Bangladesh (Chobi7 Program)

Presenter: Tahmina Parvin, International Centre for Diarrhoeal Disease Research, Bangladesh (icddr,b), Dhaka, Bangladesh.

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A prospective cohort study was conducted to investigate the environmental and individual-level risk factors for diarrheal disease among 884 children under 5 years of age in slum areas of Dhaka, Bangladesh.

Caregiver reports were collected on sociodemographic factors and hygiene behaviors. Diarrhea surveillance data was collected monthly based on caregiver-reported diarrhea for children in the past two weeks during the 12-month study period. Unannounced spot checks of the household compound were performed at 1, 3, 6, 9 and 12 months after enrollment to check for the presence of feces (animal or human), presence of animals in the child's sleeping space, assess child and caregiver hands for the presence of dirt, and to collect samples of the household's source and stored drinking water. Children with feces found on the household compound during spot checks had a significantly higher odds of diarrhea (Odds Ratio: 1.71; 95% Confidence Interval: 1.23, 2.38). Children residing in households with >100 colony forming units (CFU)/ 100 mL E. coli in source drinking water had a significantly higher odds of diarrhea (OR: 1.43; 95% CI: 1.06, 1.92).

The presence of feces on the household compound and source drinking water with >100 CFU/ 100 mL E. coli were significant risk factors for diarrheal disease for children <5 years of age in slum areas of Dhaka, Bangladesh. These findings demonstrate the urgent need for comprehensive interventions to reduce fecal contamination on the household compound to protect the health of susceptible pediatric populations.

Fetching Water, Post-Collection Contamination and Multiple Water Sources: A Prospective Cohort Study on Access to Domestic Water in Malawi

Presenter: Alexandra Cassivi, University of Victoria

Additional Authors: Elizabeth Tilley, Owen Waygood and Caetano Dorea

Introduction. Lack of access to piped water on premises remains prevalent in Malawi. Although improving water source technology and providing good quality of water at the point of collection is generally recognized to enhance access, the positive benefits may be limited by post-collection contamination and use of multiple water sources.

Objectives and methods.
The aims of this study were to better understand seasonal households' preferences and practices to access to and manage domestic water, and to evaluate water quality at different stages of water collection (i.e., point of collection, collection container, storage container, point of use) and identify critical point of water contamination. This study was conducted in the Southern Region of Malawi using a prospective cohort study design (April 2019; September 2019). Structured questionnaires along with microbial water quality testing (membrane filtration for E. coli tests) were used in households that were randomly selected households in urban and rural areas.

Results.
Multiple factors that relate to seasonality as well water source reliability (i.e., functionality, availability) and proximity (i.e., collection time) will influence households' preferences and practices in accessing drinking water, and reduce/increase the risk of post-collection contamination. Households preferred to use closer sources regardless of water quality, rather than more distant and higher quality sources. Most water sources used by households were, however, found to be initially free from contamination in the dry season; and a degradation in water quality from the point of collection to the point of consumption was more important in the rainy season.Households using a single water source were found to have greater accessibility (i.e., increased trip frequency), increased quantity of water (i.e., more reliability, less failure) and overall better quality of water. When access to a single water source was insufficient, and/or the main water source was broken or not functional, households were relying on additional water sources that were more likely to be contaminated or distant.

Conclusions.
Results from this study support the importance of focusing on promoting safe water quality at the point of consumption and highlights the importance of taking seasonal household practices, including water collection and domestic hygiene, into account in settings where

households are fetching water. The use of multiple water sources as a coping strategy needs to be considered to assess and monitor global access to water, and this is necessary to improve data interpretation, target appropriate interventions and better advice policymakers.

Functional Policies, Functional Pumps: Institutional Influences on Local Government Support for Rural Water Service Sustainability

Presenter: Caleb Cord, University of Colorado Boulder

Additional Authors: Amy Javernick-Will, Elizabeth Buhungiro, Adam Harvey, Karl Linden

Decades of capital investment without prioritizing maintenance have resulted in unreliable rural water infrastructure in sub-Saharan Africa, leading to unsafe water consumption and associated health consequences. In response, professionalized maintenance approaches are emerging and growing, featuring dedicated service providers to improve service reliability. In decentralized sub-Saharan Africa, local governments often hold service authority mandates and must support professionalized maintenance to achieve sustainable service improvements. Importantly, in 2019, Uganda released a new National Framework for the Operation and Maintenance of Rural Water Supplies, outlining professionalized maintenance arrangements through Area Service Providers (ASP) and emphasizing local government service authority roles. Given the novelty of this policy in the region, it is timely to examine its potential to motivate essential local government support.

We identified how local government roles and responsibilities shifted under this new framework and, through local government actors' perspectives, how well responsibilities align with the environments in which they make decisions. We collected, transcribed and qualitatively coded 3,380 audio minutes of data from semi-structured interviews with 93 local government actors at all hierarchical levels across 3 Ugandan districts. Interview excerpts were double coded as 1) a referenced responsibility, e.g. service monitoring or contracting, and 2) any influence cited to affect its fulfillment. Influences were uncovered through the lens of Organizational Institutional Theory, which defines institutions as frameworks which guide action through not only regulative influences, like formal policies, but also normative and cultural-cognitive influences, like pressures to act in socially appropriate ways and shared, taken-for-granted beliefs and systems of meaning, respectively.

Due to the significantly low frequency of regulative influences cited, we propose that Uganda's new framework will not alone motivate local government support. Rather, informal hierarchy structures, political and social dynamics, relationship expectations, personal identity, and deeply held beliefs about the government's role in service provision and the sanctity of water influence local government actions. Responses varied regarding whether each influence motivated actions aligned or in contradiction with the new framework, and misalignments between motivating factors and allocated responsibilities must be addressed for its successful adoption. For example, normative influences motivating unsupportive actions may be addressed through behavior change. Cultural-cognitive influences, however, are deeply engrained and difficult to change. Where possible, existing cultural-cognitive influences must be leveraged to motivate alternative, supportive actions through new incentives and coordinated messaging.

Our results additionally improve understanding of rural water political dynamics. Though political respondents often admitted performing informal and unsustainable infrastructure provision for electoral support, they also cited the burden of resultant community expectations for continued repairs. Our evidence demonstrates political actors leveraging institutional influences like their identities as leaders to support professionalized arrangements, providing sustainable solutions for their constituents and relieving personal financial burdens while maintaining electoral support. We will present these results and share local government actor experiences via pre-recorded videos from the field. The presentation will improve audience understanding of constraints on local government support and institutional influences to leverage to improve compliance with new policies as they emerge, enabling essential support for professionalized maintenance.

Hydro-Meteorological Variables and Malaria Incidence in the Brazilian Amazon

Presenter: Naziano Filizola, Pós-Graduação em Clima e Ambiente (INPA/UEA)

Additional Authors: Fernanda Fonseca, Bruna Worfarth-Couto, Andre Santos, Rogério Marinho

Malaria is a potentially fatal disease, caused by parasites of the genus Plasmodium, which are transmitted to humans by the infected female of the Anopheles mosquito. An estimated 3.3 billion people in more than 90 countries were exposed to malaria. In Brazil, approximately 99% of malaria cases are concentrated in the Amazon region. Changes in hydrological patterns, influenced by the

variation of rainfall and anthropogenic activities, modify environmental conditions, such as the level of rivers and the concentration of sediments suspended in rivers, which can change the density and longevity of the malaria vector and, consequently, can impact the incidence of malaria.

This study explored the possibility that the incidence of malaria may be influenced by fluctuations in river levels, the concentration of suspended sediments and precipitation, over the years 2005 to 2013. The four municipalities studied are located in the Brazilian Amazon on the banks of rivers with different hydrological characteristics, were: Manacapuru (Amazonas state), Beruri (Amazonas state), Santa Isabel do Rio Negro (Amazonas state), and Itaituba (Pará state), which are situated, respectively, on the banks of the Solimões River (white waters), Purus River (white waters), Negro River (black waters), and Tapajós River (clear waters). Malaria data were obtained from the Brazilian Malaria Epidemiological Surveillance System. The water level data of fluviometric stations acquired from the National Water Agency and from the database of the Observatory of Environmental Research in Hydrology and Geodynamics of the Amazon Basin. The concentration data of suspended sediments came from the same sources and fluviometric stations. However, some of these stations do not have a complete historical series for the period studied in this work. For the municipalities of Beruri and Santa Isabel do Rio Negro, we used existing data in the literature, derived from remote sensors, which used the red and near infrared bands by MODIS sensor. For the precipitation estimates, the Tropical Rainfall Measuring Mission - TRMM was used, by product “TRMM 3B43V7”.

The results suggest that the seasonal variability of rainfall and the level of rivers influences the seasonality of malaria. In addition, the disease is more intense in places and periods of low concentration of suspended sediments, showing that this may be a favorable condition for the development of the malaria cycle. Delayed effects of the incidence of malaria due to the hydro-meteorological variables were verified and the result of this lagged correlation, in up to 3 months, reflected a significant increase in the relation of the incidence of the disease and hydro-meteorological variables, confirming the influence in the increase of malaria, after periods of rain, flood and /or dispersion of suspended sediments. The seasonality of the disease has a distinct influence in each municipality studied. However, municipalities close to rivers with the same color of water characteristics (depending on the concentration of suspended sediments) have similar responses to the disease. Future work will expand the analysis in more municipalities in the Amazon region and other associated climatic and environmental factors will be tested.

Impact of Intermittent Water Supply on Bulk Water Quality and Biofilm Growth

Presenter: Mariam (Mimi) Alkattan, University of Massachusetts Amherst

Additional Authors: Emily Kumpel

One billion people globally receive piped water for less than 24 hours day in what is referred to as intermittent water supply (IWS). IWS poses a risk to public health due to the nature of intermittency which allows for contamination via bacterial regrowth, biofilm dynamics, and groundwater intrusion. There are still may gaps in our understanding of pathways of contamination in IWS, which has been a limitation in creating appropriate solutions to maintain water quality in IWS systems. To characterize these pathways, we ran a study to investigate the impact of intermittency on water quality.

For our first study of IWS, we constructed two identical model drinking water distribution system consisting of two piped recirculation system (pipeloop), one of which operated with intermittent water supply and the other a continuous water supply (CWS) as a control. The pipeloops were made of 2-inch diameter Schedule 80 PVC and were each 28-ft in total length. During the 21-week study period, the schedule for the intermittent water supply was an ‘on’ period of 6-hrs per for two days a week. Water samples were taken from the pipeloops simultaneously through the IWS supply cycle to compare microbial and physical/chemical water quality parameters. A set of water samples were taken when the IWS supply was first turned on for the day (T=0), 5 minutes after the IWS system was turn on (T=5min), and at the end of the IWS supply period (T=end).

In addition, holes were drilled in a section of each pipeloop and biofilm coupons were inserted. Biofilms act as a reservoir for pathogens and are a potential source of bacterial and pathogenic contamination, especially if they are sheared off during system startups during IWS operation. Biofilm samplers included a flat insert to be used for microscopic imaging and an outer surface for the later removal of biofilm to be used to extract DNA for genetic analysis. The biofilm samplers were removed from the CWS pipeloop, and the IWS pipeloop before and after an IWS cycle at the end of the study period to determine if biomass from the biofilms were being removed

and entering the bulk water. We also plan to present preliminary data on the results of a complimentary study using the pipeloops to model intrusion and pathogen transport via the bulk water and biofilms in IWS.

The analytical results from bulk water samples being presented as part of this research are disinfectant residual, turbidity, TOC, DO, pH, ATP, total iron, free ammonia, total nitrogen, conductivity, and temperature. In addition, results on biofilm cell spread, thickness, density, and genetic community will be presented. Key finding included a significant decrease in chlorine residual and increases in turbidity, TOC, ad microbial concentration as measured by ATP in the water that was first flushed through the IWS pipeloop (T=5min). However, IWS water quality parameters matched those is the CWS pipeloop or were better over the course of an IWS supply period. This implies the need for management of flush water in IWS systems. In addition, the biofilms in the IWS pipeloop were thinner after a supply period, indicting loss of biomass that is free to enter the water supply.

Improving Lives of Sanitation Workers: Results from Faridpur, Bangladesh

Presenter: Uttam Saha, Practical Action

Additional Authors:

Background and problem statement:
Informal sanitation workers in Bangladesh are often used as service providers in preference to the Local Authority. However, their working conditions are often very poor. In Faridpur we found they worked manually without protection, with irregular and meagre incomes. They were not connected with the Local Authority nor with safe disposal or treatment systems. Our national survey of waste and sanitation workers in 2019 found that 22% knew about the death of a fellow worker. Levels of discrimination and abuse were very high. 98% of male workers in the major cities had experienced disrespect or abuse from the public. A third of workers (36%) said they were regularly excluded in social settings, for example not being allowed to share food and drink at community events.

Objective:
Our interventions in Faridpur, and extending to 4 towns, aim to increase the proportion of households using safe pit emptying services, and improve the working conditions and social status of informal sanitation workers. We aimed reduce the financial burden on the municipality and institutionalise engagement with informal workers in large-scale programmes and policies.

Methods:
We adopted a multi-pronged, systemic approach, building capacity of informal workers and the municipality. We organised the workers, helping them to form and register two business cooperatives in Faridpur. Members were trained on running a cooperative, partnerships and contract management, and running a small business. Awareness on working conditions and labour rights was raised. We facilitated a service level agreement between the Municipality and Cooperatives giving them access to equipment, and a representatives from the co-operatives sat on a multi-stakeholder municipal steering committee. A new low-cost treatment plant ensured safe disposal. We organised extensive campaigns to showcase the contribution of these workers. We trialled a social safety net scheme including health and income insurance. We also supported the co-operatives with PPE and hygiene kits, along with training in operational health and safety.

Results:
The system has been running in Faridpur for 5 years, serves 65,000 people (40% of households), and has safely emptied 5400m3 of sludge in total. The income of the 50+ members of the cooperatives increased by BDT10,000/month (USD 115) and after 2 years their savings reached 1m BDT (USD 11,500). Relationships strengthened with the municipality and others. Co-operative leaders can independently meet with the Mayor and other officials. Socially, co-operative members can take food along with other communities for special occasions and festivals.

Uptake:
Our experiences have been regularly shared in national and global networks. The model is being incorporated into the plans of international agencies, the national UGIIP3 project in 30 towns, and is recommended in the national framework and plan for FSM. Other Government agencies have also changed their approaches, policies and tools.

Conclusion: Working with the existing informal sector can increase access to safely managed sanitation, while contributing to the social and economic empowerment of these excluded communities. For achieving scale, strong collective voices are required along with policy and regulatory support from multiple stakeholders.

Improving Management of Manually Emptied Pit Latrine Waste in Nairobi's Urban Informal Settlements

Presenter: Jordan Brands, Sanergy

Additional Authors: Leandra Rhodes-Dicker, Wali Mwalugongo, Ruthie Rosenberg, Lindsay Stradley, David Auerbach

Sanergy provides non-sewered sanitation services in Nairobi, Kenya through implementation of container-based, urine-diverting dry toilets and an accompanying collection service that provides safe emptying, transport, treatment, and reuse of waste. Sanergy has been building its network since 2011, and currently manages the full sanitation value chain for over 120,000 residents in Nairobi's informal settlements through container-based sanitation (CBS). However, the impact of this full value chain solution is limited by the high prevalence of existing pit latrines. These pits fill quickly, and with limited space to dig new ones and poor accessibility by exhauster trucks, communities rely on manual pit emptiers (MPEs) who travel to pits and manually remove the waste. MPEs coordinate with community leaders who, with no feasible alternative, unofficially condone dumping the raw waste into nearby rivers or ditches. While Sanergy continues to grow the CBS network and has developed a method for converting existing pit latrines into CBS toilets, we recognize that the majority of waste is - and will remain for the foreseeable future - in existing pits.To address the gaps in sanitation coverage that comes from poor pit latrine management, Sanergy collaborated with manual pit emptiers (MPEs) to redirect unsafely managed pit latrine waste back into the safe sanitation value chain. We employed human-centered design, with an emphasis on humility and respect for MPEs as local sanitation experts and providers of an essential service, and treated MPEs as the customers for whom a system needed to be designed and iteratively improved.

This collaboration led to the Mtaa Fresh ("Fresh Neighborhood") project in Kenya's Mukuru Kwa Njenga settlement, which provides a safe, hygienic transfer station for MPEs to dispose of fecal sludge and to protect against community exposure to untreated waste. Mtaa Fresh began with a pilot transfer station in the Riara neighborhood in 2017. Within three months, the user base grew from eight initial users to 20, and operating hours were adjusted and increased to meet demand. After one year, a full-sized transfer station was launched at the Makao Bora location with increased capacity for storing waste, and included access to cleaning supplies, showers and disinfectant as value-adds for the MPE customers. Additionally, Sanergy provided personal protective equipment and support for unionizing the community-based organization (CBO) of MPEs. Since launch at Makao Bora, trials on sludge dewatering and trash management have been conducted to further improve operational efficiency, cost-effectiveness, and customer satisfaction. Through close collaboration with MPEs and the community and an iterative design process, the project grew from a small proof-of-concept facility to a full-sized transfer station at which MPEs willingly pay to discharge waste. In the paper we discuss the steps we took to establish our transfer station, our key learnings, and our recommendations for future practitioners.

Improving Menstrual Health and Hygiene Through Workplace Interventions: Evidence from Kenya and Nepal

Presenter: Aditi Krishna, USAID/WASHPaLS

Additional Authors: D. Maneshka Eliatamby, M. Whitney Fry, Njagi, J., Muli, A., Luitel, P., Sharma, M.

People who menstruate all over the world experience challenges managing their periods, especially those who live and work in environments that do not support adequate menstrual health and hygiene (MHH). For people who menstruate working outside the home, these challenges may have critical implications for their health and well-being, as well as for economic outcomes such as work attendance, performance, and earnings. To better understand the relationship between MHH and women's opportunities for economic empowerment, the USAID Water, Sanitation, and Hygiene Partnerships and Learning for Sustainability (WASHPaLS) project is undertaking action research to assess the benefits and costs of improved MHH in the workplace, for women workers and the enterprises that employ them. The overall objective is to determine if providing adequate MHH in the workplace contributes to improved business and social outcomes, including women's economic empowerment.

Pilot interventions are being implemented in four private sector workplaces in Nepal and Kenya, increasing access to MHH products to women workers, providing education and behavior change programming, and developing MHH-friendly workplace policies over a 10-12 month period. In each workplace, the intervention design has been adapted and customized to the specific workplace setting based on findings of the formative and baseline research conducted prior to launching the interventions.

The workplace MHH interventions are evaluated using a pre- and post-test methodology with process monitoring along the intervention lifecycle. The team used a mixed-methods approach to collect data on employees' experiences in managing their periods in the workplace, health, social and economic outcomes, as well as on the costs and benefits of implementing these workplace interventions.

Across all four workplaces, baseline findings demonstrate that both women and men employees lack MHH knowledge with many pervasive misconceptions that are also informed by deeply-entrenched stigmas, taboos, and social norms regarding menstruation. Beliefs, attitudes, and norms regarding menstruation create a culture of silence that forces women to manage their periods on their own without any social support or accommodation – to avoid derision from colleagues and supervisors. Access to adequate menstrual products and facilities, and the opportunity to change products and/or clean oneself are also challenges. Process monitoring data show that both women and men are engaged and interested in intervention activities.

A comparison of baseline and endline data, which will be available in September 2021, is hypothesized to demonstrate improvements in women's abilities to manage their periods and in outcomes pertaining to health and economic wellbeing for women (e.g., absenteeism, ability to concentrate at work, job satisfaction, relationships with supervisors) as well as for the businesses that employ them (e.g. productivity, turnover, revenue, etc.). These outcomes, which will be included in financial and social cost-benefit analysis, are expected to demonstrate that implementing workplace MHH programs has net benefits for both women and employers.

These findings have important implications for a field that has largely concentrated on the MHH needs of school-age girls ignoring the unique challenges of adult, working women. A greater understanding of the challenges and how to address them is critical to encourage more women to remain in the workforce in pursuit of economic empowerment.

Improving Safety of Sanitation Workers in Wai Municipal Council, Maharashtra, India

Presenter: Arwa Bharmal, Center for Water and Sanitation, CRDF, CEPT University

Additional Authors: Aasim Mansuri, Kasturi Joshi, Bhushan Tawlare, Aditi Dwivedi, Jinal Chheda

Sanitation workers provide essential public services which underpin the functioning of cities. Although, this is often at the cost of their own health and safety. Given their difficult working conditions, it is imperative to provide them access to appropriate Personal Protective Equipments (PPEs) and monitor its usage. Importance of use of PPEs was further amplified during the COVID-19 pandemic where the sanitation workers were one of the 'frontline warriors' working relentlessly on the ground. Thus, the Center for Environmental and Planning Technology (CEPT University) through its Center for Water and Sanitation (CWAS) conducted a study focusing on access and usage of PPEs by the sanitation workers in the city of Wai in Maharashtra.

The study included a multi-dimensional and systematic approach to understand the access and usage of PPEs by the sanitation workers at WaiMunicipalcouncil (WMC). To start with, profiling of sanitation workers was done to understand the number of sanitation workers working in WMC, activities they are involved in, type of employment benefits they receive etc. WMC has also contracted some of its services to private operators. Thus, a detailed assessment of all the contracts of sanitation department was carried out with a focus on PPE. Guidelines by national government on sanitation were studied with a focus on PPE. Qualitative discussion with all sanitation workers was conducted to assess the types of PPE provided to them, its usage, issues faced in using them, etc. PPE suppliers were interviewed to identify user friendly gears, compare costs and vendor availability. The existing monitoring & replacement regime was also studied through discussions with sanitation workers as well as WMC officials to understand the systems in place and identify areas for improvement.

The sanitation department in WMC, through its own staff and private contracts, have 95 sanitation workers for provision of different services such as cleaning of community and public toilets, desludging of septic tanks, door-to-door collection of solid waste etc. The study found that overall, the use of PPEs by sanitation workers was low. WMC annually provided PPEs to its own sanitation workers but they were not work specific, user friendly and were not replaced timely. Once the PPEs were provided, its usage was not

systematically monitored. The sanitation workers appointed through private contractors did not have sufficient access to PPEs. Also, the contract documents did not have appropriate PPE related clause. Lack of awareness among the workers on health impacts of not using PPE was also observed.

To address these issues, CWAS supported WMC in drafting appropriate PPE related clauses and including them to all the contract documents of sanitation department. Based on the guidelines, list of mandatory and activity-based PPEs was prepared, procured from the market and distributed to all the workers. A monitoring system involving WMC's own staff was set up to ensure regular usage of PPEs. Paper based and digital tools were developed for their aid. To sensitize the sanitation workers about the importance of using PPEs, training workshops along with health camps and counselling sessions were conducted.

In Plain Sight: Process Description and Risk Assessment of Faecal Sludge Management in Southern Karnataka

Presenter: Anissa Mary Thomas Thattil, Father Muller Medical College

Additional Authors: Nancy Angeline Gnanaselvam, B. Ramakrishna Goud

Introduction
Faecal sludge management (FSM) includes the storage, collection, transport, treatment, and disposal of faecal sludge. Across many Indian cities, FSM is not considered a priority by local and national governments and, private companies often fill in this lacuna. Despite prohibitory legislations against manual scavenging in India, the practice still exists due to a multitude of factors that pose unique challenges. FSM possesses a high degree of occupational and environmental hazards, making it essential to have a context-specific understanding of the FSM process. This study therefore observed and documented the specific processes involved in the extraction and disposal of faecal sludge along with risk assessment, in an attempt to supplement the limited scientific literature within the south Indian context.

Methodology
This descriptive study was conducted in Bengaluru urban district, southern Karnataka, India. The snowball method of sampling was employed due to the informal and stigmatized nature of the occupation and due to the hidden character of the study population. After obtaining written informed consent from the team, the observations were video-recorded. A process flow chart was then created and the WHO semi-quantitative risk assessment matrix was employed in order to prioritize the hazards that were identified.

Key Findings
All five of the FSM operations were privately owned and each operation was manned by a team of 3-4 faecal sludge operators (FSOs). All the five observed operations used mechanical emptying methods, including the use of makeshift equipment; however there were varying degrees of dermal contact with faecal sludge. The process begins with the opening of the pit and depth assessment, odour neutralization using local materials, removal of solid waste and motorized suction of faecal sludge. Manual removal of faecal sludge was employed when technical difficulties were encountered with the motorized equipment. The use of personal protective equipment (PPE) was inadequate in all the observed operations.

Based on the WHO semi-quantitative risk assessment matrix, the high risk occupational hazards identified were: dermal contact with faecal sludge, inhalation of toxic gases, social stigma, trips and falls, injuries, substance abuse and, mental health problems. In all five observed operations, the collected raw faecal sludge was discharged directly onto empty plots of land due to the absence of designated disposal sites.

Conclusion
The study findings underscore the importance of formalizing FSM so that FSOs benefit from government health and welfare schemes; this must be accompanied by introduction of sustainable and scalable FSM technologies. Raising awareness and capacity building among local bodies and masons regarding properly constructed septic tanks along with its strict enforcement is essential for improving the safety of FSM. Provision of and training in the use of PPE by FSOs is crucial in the prevention of many of the identified hazards. Faecal sludge treatment plants must be considered for defined geographic boundaries; this will have a positive environmental impact

while also supporting safe agricultural practices. In addition, contextualized behaviour change and IEC activities will reduce stigma and discrimination and assist FSOs in successfully accessing various rehabilitation programmes.

Influencing Gender Equality Through WASH: Using the WASH-GEM to Reveal Gender Dynamics in Nepal and Cambodia

Presenter: Diana Gonzalez Botero, Institute for Sustainable Futures - University of Technology Sydney

Additional Authors: Juliet Willetts, Jess MacArthur, Naomi Carrard, Veasna Toeur, Ratan Budhathoki

Multiple established connections link safely managed water, sanitation and hygiene (WASH) and gender equality, through both social and health-related aspects. Such interconnections lead to opportunities for changes in gender equality through WASH interventions including practical and strategic changes to shift gender dynamics for individuals, in relationships and within institutions. As development actors seek to attain Sustainable Development Goals 5 (gender equality) and 6 (clean water and sanitation), the need to measure WASH programs' contributions to gender equality outcomes is increasingly pressing.

We introduce a novel measure that generates evidence on attributable impacts of WASH on gender equality: the WASH-Gender Equality Measure (WASH-GEM). The WASH-GEM has five domains of measurement – Resources, Agency, Critical Consciousness, Structures, and Wellbeing – and it explores changes in both WASH-related and beyond-WASH activities. Led by researchers at the Institute for Sustainable Futures, the measure has been tested and refined through three phases of piloting (rapid, exploratory, and validation) and engagement and collaboration with civil society partners in Nepal (SNV) and Cambodia (iDE). The measure investigates the status of both men and women and can be used within monitoring and evaluation of WASH programs.

The results from the validation pilot in Cambodia and Nepal (n=3057) were explored using both univariate and bivariate descriptive analysis. ANOVA and t-tests were also conducted for each domain and theme, across each co-variant. Lastly, correlation hypothesis testing was conducted to explore the relationship of WASH improvements and WASH program participation.

Results show that women in Cambodia have the highest perceived levels of access and use of Resources (both WASH and beyond WASH), when compared to Cambodian men and Nepali women and men. Within the Agency domain, men scored higher than women in both Cambodia and Nepal, with Nepali men having the highest levels of Agency. For example, men were more likely to say they always had the final say on large household decisions (72% Nepali men, 53% Cambodian men; 40% Cambodian women, 45% Nepali women). This shows the cultural complexity of gender dynamics, as Cambodia is often seen as more gender progressive, which was not always the case in our data.

Critical consciousness was significantly different between Cambodia and Nepal, but similar between men and women in both countries, with negatively framed questions providing stronger variance in responses. Women in Cambodia perceived social structures to be more equal than Cambodian men, with the opposite response in Nepal. For example, 34% of surveyed Nepali women believed that water collection was always women's responsibility, compared to 14% of Nepali men, 6% of Cambodian women and 2% of Cambodian men. Lastly, in both Cambodia and Nepal, men perceived higher levels of Wellbeing than women. For example, women reported higher levels of stress related to bathing (21% of women with some level of stress, compared to men at 16%).

The results highlight the geographic and gender differences of results and support the hypothesis that WASH programs can influence gender outcomes. The measure also confirms the importance of socio-economic dynamics of empowerment for both women and men.

This study introduces a validated measure and underlying theoretical framework to investigate gender outcomes in WASH programs. It provides unique insights on the expansive nature of gender outcomes associated with WASH programs in Cambodia and Nepal.

Lead Poisoning of Children in Madagascar Related to Drinking Water and Environmental Risk Factors

Presenter: Wyatt Champion, University of South Florida

Additional Authors: Lova Rakotoarisoa, Rinah Rakotondrazaka, Mahmooda Khaliq Pasha, Jeffrey Cunningham, James R. Mihelcic

Background:
An estimated one-third of children globally have blood lead levels (BLLs) exceeding the US CDC reference value of 5 µg/dL; this value may be as high as one-half for children in low- and middle-income countries (LMIC). Lead exposure occurs through a variety of routes (e.g., water, dust, air), and in LMIC specifically, informal economies (e.g., battery recycling, welding) can drive lead exposures due in part to minimal/absent regulation. Reduced awareness of the health effects, malnutrition, and other behaviors (e.g., less frequent handwashing) may compound the effects of lead exposure.

Problem Statement:
Previous work by our team identified a ubiquitous source of lead in the community of Toamasina, an urbanizing port city on the eastern coast of Madagascar. Here, decentralized, manually-operated pitcher pumps supply drinking water to much of the city's population; these pumps are typically manufactured using lead-containing components including check valves and well screens, and lead concentrations in pumped water often exceed the WHO guideline of 10 µg/L. Characterization of BLLs of children exposed to this drinking water, and identification of additional exposure routes were needed.

Objective:
To compare measured children's BLLs in this community to those measured in other LMIC, and to employ surveying to identify exposure routes in addition to the pumped water.

Methods:
BLLs were measured for 402 children (90% of whom were 6 years and under) in collaboration with local partners and health agencies. In parallel with BLL sampling, a survey was administered to parents that assessed 17 risk factors related to demographics/socioeconomics, diet, use of pitcher pumps, and parental occupations. BLL data were compared against a recent meta-review of BLLs for LMIC. Survey data were assessed in terms of statistical significance ($p<0.10$, Wilcoxon ranksum) between BLLs of subgroups (e.g., 'Yes' vs. 'No').

Results: Median childhood BLLs (7.1 and 7.0 µg/dL for 0-6 yr and 0-18 yr, respectively) are consistent with those of other Sub-Saharan African LMIC (7.7 and 6.7 µg/dL for 0-6 yr and 0-18 yr, respectively), and generally higher than LMIC in other continents. The median BLL for our 0-6 yr subgroup matched that of other low-income countries, and was higher than lower-middle and upper-middle countries; for 0-18 yr, our median BLL lies between those for low and lower-middle income countries. For both 0-6 and 0-18 yr groups, the lack of tile flooring and parental occupations involving metal work and plumbing were significant associated with elevated BLLs. Several other factors were associated with elevated BLLs (e.g., less frequent handwashing, use of pitcher pump for drinking water), but not at statistical significance. Assessment of cooking times of common foods in relation to BLLs is on-going.

Conclusions: Measured children's BLLs for Toamasina, Madagascar agree closely with literature data for similar 'background-level' populations in both Sub-Saharan Africa LMICs, and global low- and lower-middle income countries. Some factors related to lower socioeconomic status and parental occupations involving metal work and plumbing were significantly related to elevated BLLs. Our methods and findings may be appropriate in identifying and reducing lead exposures for children in other urbanizing cities.

Learning Objectives (note that I did not include this portion in the 500 word count): The audience will be able to understand potential sources of lead contamination in LMIC, how decentralized drinking water systems may serve as a source of lead, and how lead poisoning affects human health (especially in children).

Lessons From the Management of Public Handwashing Stations in Response to COVID-19 In Kenya

Presenter: Dennis Munai, Amref Health Africa

Additional Authors: Richard Gichuki; Viola Tupeiya; Judy Murithi; Jennifer Lamb; Rogers Moraro

Background
In response to the COVID-19 pandemic, the National Business Compact Coalition (NBCC) has supported the Government of Kenya's pandemic response strategy by distributing and maintaining handwashing stations (HWS) at targeted public spaces, including markets, public transport meeting points, the entrance of public buildings, restaurants, and shops/shopping centers. Between April and August 2020, over 5,000 HWS were installed across 46 counties in Kenya. HWS reflected a range of designs, from modified 20 liter buckets to larger water storage containers (100 L). HWS had both paid and unpaid caretakers who were responsible for managing and maintaining HWS during the day. While public handwashing stations have been central to COVID-19 response in many countries, there is little information about uptake of public handwashing stations, their functionality, the usability of these facilities or their sustained maintenance and operation.

Methods
This mixed-methods, observational study examined the functionality and use of HWS deployed by partners of NBCC. Systematic sampling was used to select a total of 430 HWS across 5 selected counties. HWS were observed during unannounced spot checks, HWS use was observed through 30-minute structured observation, and available caretakers and a sample of users were surveyed. Qualitative data collection comprised key informant interviews with HWS caretakers and NBCC staff and focus group discussions with members of the community (HWS users and non-users).

Results
Of the 430 HWS selected, 316 (74%) were located and present at the intended location. Among those located, 89% (265/316) were fully functional at the time of observation (water in handwashing tank, soap at the facility, tap working that provided running water to effectively lather and rinse hands of soap). In total, of the original 430 randomly selected HWS, only 62% were functional on the day of data collection. Structured observations were completed at 196 HWS and resulted in a total of 411 observed HWS users across all facilities. This translates to an average of 2.6 users per hour. 85% of observed users washed hands with soap during observations.

Among those stations that could be located, factors that influenced the uptake of HWS were found to include the height of HWS; type of taps and operating system; size of water storage container; continuous supply and availability of water and soap; type of cleansing agent (hard bar or liquid); appropriate information, education and communication materials; local drainage and social pressures on use (dependent on location and caretaker model).

Discussion and Conclusions
Effective hand hygiene is vital in the fight against COVID-19 and other diseases. Functional HWS are critically important in public settings to reduce the risk of transmission, especially where people gather and move between their home and workplace. The HWS observed in this study were found to be functional and accessible to users. However, there was lower than anticipated rates of use of the HWS distributed, therefore, robust monitoring and assessment is needed to track and ensure HWS are made available and used as intended. More than 25% of selected HWS were missing at the point of data collection, which warrants further investigation into the sustainability of the intervention.

Low-Cost Ultrasonic Sensors for Monitoring Latrine Fill Rates at Scale

Presenter: Lee E. Voth-Gaeddert, Athena Infonomics LLC

Additional Authors: Kowshik Ganesh

As per the 2011 India census, less than 33% of India was connected to a sewer system with onsite sanitation systems being the most prevalent solution in the country. Even among metropolitan cities in India, a drainage connection is available in limited parts of the city, thus leaving the burden of safe management of faecal waste with the owners of the properties. Onsite sanitation systems may include septic tanks or pits with a core mechanism to collect faecal matter within the containment system underground.

In urban areas, most onsite sanitation systems are filled once every 3-12 months; while in rural India, onsite sanitation systems are dug quite deep thus taking 3 – 10 years before desludging. Most sanitation systems are cleaned when 1) the toilet overflows / smells bad, 2) the owner accidentally inspects the system, or 3) the desludging operator conducts a free inspection. This problem becomes more acute in community / public based infrastructure such as schools, public toilets, offices, etc. Therefore, being able important to device a mechanism for properties to easily monitor their onsite sanitation systems systematically.

Design and Results: Previous attempts to develop a robust sensor for monitoring fill rates have failed to either hit a sustainable price point, provide sufficient value to its user, or provide a sufficient life for cost-effective use. We have designed a low-cost (<USD$10) ultrasonic sensor able to monitor fill rates of a wide variety of containment systems. Data can be collected locally and collected by a field worker at the site or can be transmitted to a central database. The system has been beta tested in India and is being rolled out in India and South Africa.

Discussion: The aim of this project was to attempt to hit a price point that would allow for cost-effective use at scale. If applied within a healthy data ecosystem, this sensor can aid in improving efficiencies with scheduled desludging and customer retention. Critical to this is the alignment of the digital maturity of the local context and organization utilizing this technology. Work on client management systems and vacuum truck fleet management can provide exciting opportunities for cross integration.

Mobilizing Local Volunteers to Support the Vulnerable with WASH

Presenter: Lizzy MacRae Garvin, Lifewater International

Additional Authors: Brandie Banner Shackelford, Grace Orishaba, David Azoora, Elisabeth Babb, Spera Atuhairwe

“Leave No One Behind” is one of the key principles outlined in the Sustainable Development Goals (SDGs). However, implementing WaSH organizations struggle to know whether or not they are reaching the most marginalized people in their pursuit of achieving SDG 6. In 2019, Lifewater International developed partnerships with local volunteers in three rural districts of Uganda to engage vulnerable households with WaSH activities. The volunteers included community members and church leaders. The volunteers were tasked with helping their vulnerable neighbors become “Healthy Homes”, a certification created by Lifewater that includes storing treated water safely, using an improved latrine that provides privacy, washing hands, drying dishes off the ground, and maintaining a compound clean of animal feces/rubbish.

In the three districts, Lifewater staff and community leaders identified and registered 220 vulnerable households based on the local context. At the time of registration, the community leaders provided the reason why the household was categorized as vulnerable, such as extreme poverty or being headed by a vulnerable person (e.g., a child, a widow, a disabled person, a person with a severe illness, or an elderly person). Between December 2018 and July 2019, a total of 633 community volunteers and church leaders were trained to tangibly support their vulnerable neighbors through activities like digging latrine pits, building drying racks, and supporting the purchase of household WaSH items (e.g., soap and jerry cans). These volunteers were subsequently paired with the registered vulnerable households based on their location. For an average of 21 months, Lifewater staff and volunteers visited every registered vulnerable household at least quarterly to track their progress towards becoming a Healthy Home.

By the end of March 2021, 202 vulnerable households had been registered as Healthy Homes. Ten households were removed from the program due to migration or death. Therefore, 96.2% of the remaining vulnerable households were verified by Lifewater staff as having met all of the Healthy Home criteria with the help of their neighbors. In comparison, 95.1% of the 9,953 total households in the three targeted districts had met all of the Healthy Home criteria during that time. We conclude that organizations can effectively target and support vulnerable people with WaSH through a process of: a) identifying marginalized households in conjunction with community leaders, b) mobilizing community volunteers and local leaders to aid them, and c) conducting regular monitoring visits to assess progress and to offer hope and encouragement. The learnings from this strategy will impact future WaSH programming for 153,435 people in four countries currently served by Lifewater International.

Modelling Localized Ascaris Spp. Transport from Stools to Soils

Presenter: Drew Capone, UNC Chapel Hill

Additional Authors: Aaron Bivins, Joe Brown

Ascaris spp. is a soil-transmitted helminth (STH) effecting an estimated 800 million people worldwide. Chronic childhood infection by Ascaris spp. can have a range of effects on children, including growth faltering, anemia, and gastrointestinal effects and adverse longer-term developmental outcomes. Recent cluster-randomized trials of sanitation interventions have found mixed effects on STHs, including Ascaris spp. A potential reason for the null effect observed in some trials may be because interventions did not effectively

contain child fecal wastes, which may not be well controlled via latrine interventions alone. Our research aim was to estimate the daily quantity of fresh child feces that is transported to domestic soil within the localized area of a low-income urban informal settlement. This approach could be used to prioritize between different interventions, including improvements to latrine construction, child feces management, or upgrades to the built environment.

In May 2018 we collected soil at four locations from a subset of compounds enrolled in the Maputo Sanitation (MapSan) trial: household entrances, dishwashing areas, solid waste storage areas, and latrine entrances. We recovered presumptively viable Ascaris spp. ova from 62% of 84 soils with a mean density of 0.25 log10 (sd = 0.71) ova per gram soil. During the 24-month phase of the MapSan trial stool from 25% of children (n=134/454) were positive for Ascaris spp. ova. The mean ova density per gram stool was 3.7 log10 (sd = 0.88) among these children.

We fit a lognormal distribution to the density of Ascaris spp. ova in soils and stools using maximum likelihood estimation. Then, we used a stochastic mass balance approach to model the number of Ascaris spp. ova transported to soils each day in a pre-defined localized area. We solved for the input to the system – the mass of child feces transported to soil – from the initial number of ova in soil, which we estimated stochastically, and the first-order decay of Ascaris spp. ova in soil. The US EPA requirement for Class A Biosolids, which are applied to fields as fertilizer, is <0.25 viable helminth ova per gram solids. We found a mean density of 1.8 Ascaris spp. ova per gram domestic soil, which is 7.1 times greater than the EPA standard for biosolids, and suggests children in this setting are at high risk of infection from Ascaris spp.

We estimate the 10th percentile of fresh child feces transported to soil per day in the localized area was 81 grams, the 50th percentile was 3.2 grams, and the 90th percentile was 0.09 grams. During the 24-month phase of the MapSan trial only 29% of children reported defecating directly into the latrine. This suggests a substantial amount of the Ascaris spp. ova enumerated in soils could plausibly have been transported because of the unsafe management of a small quantity of child feces each day. Sanitation stakeholders may be able to apply this approach to estimate the magnitude of the transport of feces from various sources to the environment to better design and prioritize interventions.

Moving Toward Tailored Solutions to Improve Kenyan Pastoralists' Sanitation

Presenter: Jessica Tribbe, The Aquaya Institute

Additional Authors: John Trimmer, Edinah Samuel, Brian Mwangi, Rachel Peletx

Community-Led Total Sanitation (CLTS) has been widely used and adapted as a strategy for reducing open defecation. Kenya has adopted CLTS as a core strategy, but standard methods have achieved limited success among pastoralist groups in low-density, water-scarce regions. Pastoralists' lives often involve movement to find water and pasture for livestock, potentially decreasing the value of stationary sanitation infrastructure, while other contextual constraints (e.g., soil conditions and durability of local materials in arid regions) may also hinder sanitation implementation. Therefore, this research examined the underlying factors and constraints affecting sanitation adoption among pastoralists, and identified strategies to achieve greater levels of improved sanitation coverage.

Across three counties (Samburu, Turkana, Kitui) in Kenya with varying contexts of sanitation and pastoralism, we conducted qualitative research in 17 pastoral communities. In total, we completed 34 focus groups and 154 interviews with households, community leaders, government officials, and implementing partners, which we analyzed via the Integrated Behavior Model for WASH. We found several common challenges across all counties (e.g., water scarcity, access to affordable and appropriate materials), but we also noted distinct constraints affecting sanitation success in specific contexts. In particular, existing latrines among partially mobile communities do not meet cultural requirements, while basic needs (e.g., food, water) take priority in Turkana, where remoteness and high levels of nomadism can also hinder engagement.

Additionally, in both Samburu and Turkana, local government structures for CLTS implementation and reporting seem to be particularly complex and somewhat unclear, which may lead to tracking errors or reporting inconsistencies. CLTS has been more successful in Kitui, where communities are less mobile; however, challenges still exist in harder-to-reach areas containing newly-formed or relocated communities, with low household density and difficult soil conditions.

Strong enabling environments and tailored implementation strategies are needed to address these general and context-specific constraints. For example, consolidating local government roles and reporting structures (as has been done in Kitui) may improve CLTS progress tracking. In contexts such as Turkana, with environmental challenges, limited local materials, and high poverty, it may be appropriate to explore targeted subsidies to support more durable latrine construction. As cultural beliefs among pastoralists evolve, sensitization efforts might emphasize protection of livestock (seen as having high symbolic value) or pride in having a latrine for visitors to use.

Generally, we built upon the Integrated Behavior Model to develop a simple and systematic context analysis tool that can be used prior to sanitation interventions in pastoralist communities. This tool encompasses targeted questions about key sanitation drivers related to topics such as environmental conditions, culture, economics, and community leadership, to suggest tailored strategies for implementation. Moving forward, such knowledge can inform rural sanitation programs that are equitable, sensitive to local considerations, and effective in reducing open defecation among pastoralists.

Learning objectives:
1. Explain how characteristics of pastoral communities can impact sanitation interventions.
2. Classify distinct constraints affecting pastoralist groups.
3. Identify possible adaptations for improving pastoralists' sanitation.
4. Introduce a novel, simple, and systematic context analysis tool for assessing pastoralist communities prior to sanitation interventions.

Non-sewered Sanitation Systems Greenhouse Gas Emissions: Trade-offs Amongst Sustainable Development Goals to End Open Defecation

Presenter: Kelsey Shaw, University of Victoria

Additional Authors: Dr. Caetano Dorea

Sanitation systems are a fundamental human right that provide an essential health-related service and can promote sustainable development; however, limited focus has been placed on their contributions to climate mitigation and adaptation. Sustainable development goals (SDGs) can be used to provide a multidimensional perspective on development, and it has also highlighted that there are synergies and trade-offs in the interactions among different SDGs. Currently, there is a conflict between SDG 6, specifically SDG 6.2, and SDG 13. The former relates to achieving universal sanitation and ending open defecation. The latter relates to taking urgent action to combat climate change.

Decentralized (on-site) sanitation technologies were the focus of this assessment as they are generally the most scalable, effective and equitable adaptation measure within the sanitation sector. They have a lower economic burden on the household user, some forms have been proven to be effective in reducing negative climate impacts, and most importantly, they can provide access to improved sanitation for the most vulnerable populations. Specifically, this assessment focused on the three different service levels of sanitation (i.e. improved, unimproved and no service) as defined by the Joint Monitoring Programme (JMP) as they pertain to three Shared Socioeconomic Pathways (SSPs), as described in the framework presented in 2014 by O'Neill et al.. The current Intergovernmental Panel on Climate Change (IPCC) GHG estimation methodology was used as the basis for calculations in this analysis. However, due to the limitations this methodology has, especially among decentralized sanitation, this analysis made provisions for refinement and comparison of the current IPCC model with improved and experimentally verified emission factors (EFs). Specific objectives included:

1. A model and comparison of scenarios for global future GHG emissions that would allow SDG 6.2 to be met in 2030 from household decentralized sanitation infrastructure given differences in demography, urbanization and economic growth as represented by three different SSPs (i.e. SSP1, SSP2 and SSP3).
2. A sensitivity analysis to determine the relative impact of each individual on-site sanitation system (e.g. septic tanks, pit latrines, composting toilets, etc.), as they relate to the service level in the sanitation management ladder (i.e. improved, unimproved and no service) defined by the JMP, had on climate change mitigation in the form of GHG emissions.
3. An expansion upon the existing IPCC GHG estimation methodology using improved emission factors for each non-sewered sanitation form through augmentation with published measured data sets.

This analysis considered the 100-year global warming potential (GWP) values of all three GHGs: methane (CH4), nitrous oxide (N2O) and carbon dioxide (CO2) that can be emitted; in carbon dioxide equivalents (CO2 eq.) for each scenario and decentralized sanitation

technology. Ultimately six (6) scenarios (i.e. 1a, 1b, 2a, 2b, 3a and 3b) were developed for various combinations of pathways and sanitation technologies, including a comparison between IPCC and improved EFs for the specified on-site sanitation technologies assessed.

There was significant variability between the scenarios, with results ranging from 68 Tg CO2eq/year (SSP1 – Scenario 1a) to 7 TgCO2eq/year (SSP3 – Scenario 3b) as expressed in 100-year GWP CO2eq in the year 2030. The main contributors of GHG emissions in each scenario were demonstrated to be septic tank systems and pit latrines. Although in scenarios that utilized improved EF's these emissions were significantly reduced compared to those using only standard IPCC EFs. This analysis demonstrated that using field-based experimental EF's reduced estimated GHG emissions within each SSP scenario on average by 53%.

This model has helped to analyze the interaction between SDG 6 and SDG 13 and analyze the GHG emissions of meeting sanitation targets using common forms of decentralized sanitation technologies through the lens of sustainable development. An increase in the understanding of sanitation and climate change linkages among stakeholders can ultimately lead to a better inclusion of sanitation, and other basic human rights, in climate action goals.

Orientative Inspection of Sanitation Services in Rural Areas in Peru

Presenter: Ana Vergara, Sunass

Additional Authors:

The National Superintendency of Sanitation Services (SUNASS), Peru's regulatory body, since 2017 SUNASS has the obligation to regulate the provision of sanitation services in rural areas. In rural areas, sanitation services are provided in more than 95% of the cases by non-profit community organizations in town centers with less than 2,000 inhabitants.

As a consequence, the regulatory function cannot be applied as if it were provided by wáter utilities. As context information it is mentioned that the provision of services in rural areas is deficient, less than 3% of the population receives properly disinfected water and a high percentage of the infrastructure is in poor conditions. Faced with this situation, the regulator has chosen to apply supervision with an orientation and preventive approach, which through incentives such as the recognition of good management practices in the formalization of the community organization and in the adequate disinfection of water through benchmarking of community organizations that is carried out at the national level in the 24 regions of the country.

The monitoring actions began at the end of 2017 and have continued to be formalized t in 2020, through the approval of the Quality Regulation for the provision of services in community organizations and the Regulation for the supervision of community organizations. Orientative supervision consists of verifying the provision of services by guiding and teaching the provider (the community organization) during the supervision, in order to contribute to the improvement of services. Likewise, the recognition of good practices through benchmarking workshops in the 24 regions of the country of community organizations with good practices in the 24 national benchmarking workshops, contribute to the improvement in the provision of sanitation services and to the change in the behavior of the community organizations through this incentive.

It has been identified that supervision, when it is orientative, is accepted by the community organizations and is not rejected despite the absence of any economic incentive to receive and attend the regulator, because in the rural world, the providers are used to receive economic incentives from the government, On the other hand, the recognition of good practices at the regional level with benchmarking contributes to incentivize other community organizations to improve their work practices (behavioral change) and at the same time, this will contribute to an improvement in the provision of services in rural areas.
Something new in the provision of sanitation services in rural areas is the obligation that a woman must be on the board of directors of the communal organization. There is also a considerable participation of women in benchmarking workshops and in community organizations with good practice.

Pathways Enabling the Reliability and Scale of Rural Water Infrastructure Maintenance Interventions

Presenter: Caleb Cord, University of Colorado Boulder

Additional Authors: Amy Javernick-Will, Elizabeth Buhungiro, Adam Harvey, Harold Lockwood, Karl Linden

Maintaining existing rural water infrastructure is imperative to achieving SDG 6.1: "availability and sustainable management of drinking water and sanitation for all." Historically, informal and unsystematic maintenance of rural water infrastructure in sub-Saharan Africa has been the norm, hindering progress toward SDG 6.1 and negatively impacting human health. Today, professionalized maintenance approaches are emerging and growing to ensure infrastructure functionality and service continuity, implemented by a variety of public and private actors in diverse contexts with unique enabling/hindering system conditions. There is a dearth of research, however, on what combinations of these conditions enable successful professionalized maintenance implementation.

Drawing on quantitative and qualitative data from 6 years of implementation and detailed case knowledge from 12 months of fieldwork in Uganda, we constructed case studies and are employing a rigorous method of cross-case comparison - fuzzy-set Qualitative Comparative Analysis (fsQCA) - to investigate combinations of system conditions leading to 2 outcomes of success: scale and reliability of professionalized maintenance services. We systematically analyzed twenty-two cases, service areas within lower local government units, based on 33 conditions hypothesized to influence scale and reliability. Examined conditions span multiple domains: procedural (e.g. field staffing), political (e.g. local government participation), social (e.g. sector coordination), natural (e.g. groundwater levels), and physical (e.g. access to urban centers).

We collected data through focus group discussions with technicians and utility field staff, semi-structured interviews with utility managers, and semi-structured interviews with service authorities for procedural, political and social conditions. We conducted spatial calculations in ArcGIS and multilevel statistical modeling with quantitative data from service providers and government databases for natural and physical conditions. Each condition was calibrated for each case to compare within fsQCA, using set theory to describe the extent to which each service area falls within the set of each condition and outcome. Conditions that varied across cases and emerged from intermediate analyses as important for success include development partner/sector aid coordination, local government participation, political advocacy, prior consumer exposure to service providers, urbanicity, spare parts access, groundwater depth, seasonality, and utility field office resources. While fsQCA is currently underway, we will present in detail the identified combinations of these conditions which led to cases with successful levels of scale and reliability.

This presentation will provide evidence of relationships between diverse system conditions and important outcomes for professionalized maintenance services. Specific case studies achieving contrasting levels of scale and reliability will be highlighted for contextualization of the results. The presentation will specifically feature field-based perspectives of service providers and authorities working to professionalize rural water maintenance every day. Our presentation will provide practitioners, policymakers, donors and researchers with improved understanding of the interconnections between the political, social, natural, and physical environments within which service providers operate and will encourage audience participation to share additional perspectives and experiences from other contexts.

Perceptions of Latrine Safety and Mental Well-Being in Kampala, Uganda

Presenter: Ajile Owens, Emory University

Additional Authors: Sheela Sinharoy, Amelia Conrad, Madeleine Patrick, Bethany Caruso

Background:
In Uganda, 60% of Kampala residents live in slums, and this percentage is increasing by 10% each year. Because of the growing population, shared sanitation facilities are increasingly common. Latrine users often report that their facilities are overused, dirty, and lacking adequate doors or proper lighting. Latrine conditions and perceptions of harm when using these facilities may influence women's mental well-being. This study aimed to understand the relationship between latrine attributes, perceptions of safety, and anxiety in Kampala, Uganda.

Methods:
Between December 2019 and February 2020, surveys were conducted with 1,024 women in ten neighborhoods in Kampala, as part of a cross-sectional study of sanitation-related empowerment. Latrine attributes assessed by the survey included perceived privacy, lockability, lighting, latrine sharing, and distance from the home. Outcomes included perceived lack of safety when using the latrine at night and anxiety, using a two-question sub-scale of the PHQ-4. Multiple regression models determined associations between latrine

attributes, perceived lack of safety, and anxiety. Regression models also included variables for age, marital status, and an asset-based wealth indicator.

Results:
Only 13% of women owned a private toilet; women who shared latrines did so with an average of eleven households. Most nighttime sanitation locations were private in structure (71%), with a few private in location (7%) or private in both location and structure (11%). Latrines were generally well-lit on the way to and inside the latrine (60%) and possessed a working lock inside (84%). Women usually had a latrine in their yard (73%), resulting in a mean travel time of three minutes. Approximately half (52%) of women reported never feeling unsafe using their latrine at night, and 33% of participants scored above the clinically relevant anxiety threshold. Women who reported more frequently perceived lack of safety had higher anxiety scores (OR: 1.32, $p<0.001$). A latrine's private location (OR: 1.75) and ability to lock (OR: 1.22) were associated with frequent perceived lack of safety. The privacy of a latrine's location was also significantly associated with a higher anxiety score among women who never perceived a lack of safety (OR: 4.99, $p=0.003$). Conversely, women who used latrines with sufficient lighting inside and on the way to the latrine reported both more frequent perceived safety and lower anxiety scores. No demographic variables were significantly associated with perceived lack of safety; however, the age group 35-44 years old ($p=0.03$) and lower asset-based wealth ($p=0.003$) were associated with a higher anxiety score.

Conclusion:
This study demonstrates that latrine attributes—including those beyond the structure itself, like placement and path lighting—play a role in how safe women feel using their latrines at night. However, these relationships can be highly nuanced. In this setting, the private location of latrines made women feel less safe, suggesting that latrines situated in private areas may place women at greater risk of harm. Stakeholders can use evidence like this and feedback from users to reassess and improve upon latrine characteristics to enhance sanitation experiences and related outcomes.

Performance of a Novel AI-based Proxy-Means Test to Target Pro-poor Water Subsidies in Rural Ghana

Presenter: Chloé Poulin, The Aquaya Institute

Additional Authors: John Trimmer, Jessie Press-Williams, Ranjiv Khush, Rachel Peletz, Caroline Delaire

Despite increased access to improved drinking water in the last two decades, water service providers and governments in sub-Saharan Africa struggle to ensure that poor households benefit from these services. In Ghana, the Joint Monitoring Programme (JMP) estimates that only 54% of households amongst the poorest quintile have access to basic water services, compared to 94% amongst the wealthiest quintile. Subsidizing access to safe water services is one option for reaching the poorest households, but the history of subsidies in the water sector shows that they are often poorly targeted and fail to support the most vulnerable.

In Ghana, several approaches may help target water tariff subsidies for the poor. These include three survey-based methods (the Livelihood Empowerment Against Poverty (LEAP) program, the Poverty Probability Index (PPI), the Demographic and Health Survey's (DHS) wealth index) and a participatory approach relying on community consultation. In this research, we compare these four approaches with a novel Artificial Intelligence (AI)-based methodology with respect to effectiveness, costs, and stakeholder preferences.

To develop the AI-based methodology, we applied machine learning techniques to the 2017 Ghana Living Standard Survey (GLSS) dataset (n=8464) to derive a model predicting household poverty based on 43 key household characteristics. Applying our model to a "test set" (2539 households from the GLSS dataset), we found that predictions had an accuracy (i.e., correct predictions of the poor and non-poor), a sensitivity (i.e., correct predictions of the truly poor) and a specificity (i.e., correct predictions of the truly non-poor) of 84% each, which was an improvement compared to existing models.

We then evaluated our AI-based methodology in the field against the four other approaches mentioned above. We surveyed approximately 800 households in small towns of the Ahafo and Ashanti regions. The survey included questions capturing the 43 household characteristics required for our AI-based model as well as questions required to compute the PPI and DHS wealth index. We also asked respondents whether they were beneficiaries of the government LEAP program. Parallel to the survey, we led community consultations to identify households recognized as particularly vulnerable by their peers. We documented implementation costs both for

the survey and for community consultations. Finally, we conducted qualitative interviews with community members and local government to assess stakeholder perceptions and ease of implementation.

Preliminary results suggest that our AI-based model and community consultations identified fewer households as “poor” than the other three methods. These households were also more socio-economically vulnerable than the households identified by other methods, indicating lower risks of false positives (i.e., non-poor households predicted as poor). Further, we find that survey-based methods are more expensive to administer than community consultations, though stakeholders tend to prefer survey-based methods, which they perceive as presenting fewer risks of false negatives (i.e., poor households predicted as non-poor).

Overall, this study will help water suppliers and decision-makers understand trade-offs between different poverty targeting methods with respect to effectiveness, stakeholder perceptions, and costs. More broadly, it will contribute to consolidating methodologies for implementing pro-poor water subsidies.

Quantifying Factors Associated with Personal Hygiene as Measured by the qPHAT Methodology: Andilaye Trial, Ethiopia

Presenter: Rebecca Kann, Rollins School of Public Health, Emory University

Additional Authors: Matthew Freeman, Maryann Delea, Jedidiah Snyder

Background:
Many water, sanitation and hygiene (WASH) interventions target improvements to personal hygiene behaviors to reduce the transmission of infectious diseases. Health and development programs implementing WASH interventions confront many behavioral, contextual, and technological factors that serve as barriers to the uptake of improved WASH behaviors. In addition, accurate and objective measurement of hygiene behaviors remains a challenge for monitoring and evaluation of WASH programs and interventions.

Methods:
This analysis was conducted as a sub-study of the Andilaye Trial, an impact evaluation of a community-based WASH behavior change intervention implemented in Amhara, Ethiopia. The outcomes of interest were facial and hand cleanliness of the youngest child (aged 1-11 years) residing in the study household. These outcomes were measured using the Quantitative Personal Hygiene Assessment Tool (qPHAT), a novel metric that generates reliable quantitative measures of facial and hand cleanliness. For our primary research question, we employed multivariable models to evaluate the associations between quantitative measures of facial and hand cleanliness and (1) household WASH conditions (i.e., contextual and technological factors), (2) psychosocial behavioral factors and (3) reported personal hygiene practices. Our secondary research question assessed the direct impact of the Andilaye intervention on hygiene outcomes. Models employed a generalized linear regression framework with generalized estimating equations and robust standard errors to account for clustering at the community level.

Results:
We analyzed data from 1,010 index children (hand and facial cleanliness data generated via qPHAT methodology) and their caretakers (reported or observed intermediate behavioral factors). Measures of cleanliness indicated that most children had at least some dirt on their hands and faces. Higher perceived water insecurity, a measure of household WASH conditions reported by the caretaker, was associated with dirtier faces (β=-0.08 95% CI [-0.12,-0.04]). Several psychosocial factors were associated with cleanliness outcomes. Caretaker-reported commitment to washing was associated with dirtier faces (β=-0.61 95% CI [-0.99,-0.13]), signaling the intent to adopt improved hygiene practices among households with poor cleanliness. Perceptions regarding the cleanliness of others in one’s social group (i.e., empirical expectations) was associated with cleaner faces (β=0.41 95% CI [0.15,0.67]). The belief that washing takes too much water was associated with both cleaner faces and cleaner hands (β=0.26 95% CI [0.10,0.57] and β=-0.26 95% CI [-0.19,0.43], respectively). Reported hygiene practices were not significantly associated with measures of hand or facial cleanliness. The intervention did not result in meaningful differences in either facial or hand cleanliness (β=0.12, 95% CI [-0.23,-0.47] and β=0.05, 95% CI [-0.37,0.46], respectively).

Conclusions:
This research highlights the role of intermediate behavioral factors, including water insecurity and psychosocial factors, in influencing hygiene practices. While several hygiene metrics exist, they often rely on reported practices or observations of cleanliness, both of

which are prone to bias. We demonstrate the value of using quantifiable and objective proxy indicators of personal hygiene practices. The qPHAT metric may be valuable in future research and evaluations of WASH interventions to provide a nuanced measure of hygiene outcomes and understand factors that serve as barriers to the uptake of improved WASH behaviors.

Quantifying the Health Impacts of Floods

Presenter: Sebastian Rowan, U.S. Army Corps of Engineers

Additional Authors: Elissa Yeates; Emily Wells

Flooding is the leading cause of disasters worldwide, and these events significantly impact affected communities. Floods can harm the environment and affect the physical and mental health of residents; however, flood risk management decision making is often driven by assessments of potential damage to property and infrastructure. Engineers and planners lack tools and methods to consider the potential health impacts of floods in risk assessments, and this can lead to over-investment in flood risk management in areas with high property values, and under-investment in areas with vulnerability to adverse health outcomes from floods.

The purposes of this study are to identify physical and mental health impacts commonly associated with flood events and to develop quantitative relationships between flood intensity, population characteristics, and incidence of these outcomes that can be incorporated into flood risk models used in flood risk management.

To this end we conduct a systematic review of natural hazards and epidemiology literature which empirically assess various health outcomes following flooding events. We conducted a search in the Web of Science and Engineering Village index citation databases which yielded 3962 unique potentially relevant studies for the review. After screening for eligibility based on titles and abstracts, 231 articles were kept for full text analysis and final eligibility determination. Final eligibility criteria include: study includes subjects age 18+ affected by a flood, and study quantitatively assesses incidence of at least one of the following health outcomes in relation to the flood event: PTSD, anxiety, depression, physical injury, infectious disease, exacerbation of chronic illness.

Full text analysis is ongoing and on track to be complete by July 2021. Once complete, we will conduct a meta analysis of eligible studies and calculate pooled odds ratio estimates for each outcome of interest. We will also extract available information related to flood magnitude (depth, duration, velocity, extent, etc.) that will allow us to control for this factor in our analysis and begin to develop basic predictive models of health impacts from floods of varying magnitudes.

The results of this study will inform efforts by the U.S. Army Corps of Engineers to improve quantification of the benefits of flood risk management project alternatives. Quantitative relationships between flood magnitude and health outcomes will be incorporated into computational flood risk models, and gaps identified through this study will inform future research projects to better understand the full range of flood impacts.

Sanitation Workers' Safety and Dignity: Policy Formulation in Odisha

Presenter: G. Mathi Vathanan, Housing & Urban Development Department, Government of Odisha

Additional Authors: Manvita Baradi, Meghna Malhotra, Prerana Somani

Key learning objectives

1. Understanding the systemic and societal obstacles resulting in poor socio-economic conditions of sanitation workers in urban India
2. Developing policy level solutions to ensure holistic development of sanitation workers
3. Formulating protocols to ensure enforcement of legislations and regulations for safety and dignity of sanitation workers

Introduction

In India, sanitation workers suffer from centuries of social ostracization and their contribution towards keeping cities clean remain largely unacknowledged. Despite having legislations and regulations since past three decades to protect their basic human rights, the reality remains bleak due to lack of planning, implementation and convergence amongst stakeholders. Odisha state recognised the need of overhauling the current system and creating an enabling environment for the safety and dignity of sanitation workers involved in operation & maintenance and cleaning of community/ public toilets, wastewater treatment plants, drain, septic tanks and sewer

cleaning. The scheme Garima (meaning, dignity) was launched to provide a comprehensive solution by institutionalizing and regulating sanitation services and providing service level, financial and social benefits to sanitation workers.

Systemic issues in India
Sanitation workers battle systemic hurdles to access support, even through dedicated schemes like the Self Employment Scheme for Rehabilitation of Manual Scavenger. Policymakers adopt a myopic strategy of providing cheap loans to them for starting a business without focusing on building their capacities to successfully run an entrepreneurial start-up. Lack of sanitation workers' database is a hurdle in identifying them and providing welfare and rehabilitative assistance. They are mostly intergenerational workers, with little understanding of the impact of unsafe work environment on their health and life expectancy.

Developing a holistic solution
An inclusive policy is imperative to ensure enforcement of statutory provisions under various legislations and free sanitation workers from the shackles of social stigma and poverty. Through Garima, Odisha is enumerating formal and informal sanitation workers. The state will counsel them to undertake an informed decision of continuing in sanitation sector or adopting an alternate livelihoods and train them to build their skillset. The scheme has successfully established convergence between departments of Labour and Housing & Urban Development (HUD) to recognize sanitation work as 'skilled' and 'highly skilled' and raise the minimum wages. Odisha is advocating to issue codes for personal protective equipment (PPE) suiting the needs of sanitation workers in India and to develop user-centric and gender sensitive PPE prototypes. With support of Urban Management Centre, Odisha is establishing standard operating protocols and enhancing mechanization of sanitation work. To ensure social security of sanitation workers, various departments have collaborated to provide free treatment, illness allowance and scholarship for education of their children. Additionally, Garima will provide grants for motorised two-wheelers to enable effortless travel easily despite lack of public transportation owing to Covid-19 pandemic restrictions.

Conclusion
Odisha aims to establish sanitation work as a respectful occupation by uprooting the disgust ingrained in the society for ages. The state is facilitating continuous deliberation and engagement of stakeholders informing them about relevant legislations and their roles as employers and service seekers.
Garima is the first-of-its-kind initiative in India to envision sustainable development and empowerment of sanitation workers. Involvement of stakeholders including central government, private and non-governmental organizations, activists and health & safety experts shall lead to augmented efforts and facilitate changes that have been long-due for the safety and dignity of sanitation workers.

Sustainable Sanitation Jobs: Prospects for Enhancing the Livelihoods of Pit-Emptiers in Bangladesh

Presenter: Mariam Zaqout, University of Leeds

Additional Authors: Sally Cawood, Barbara Evans and Dani Barrington

Manual pit-emptying – the removal of faecal sludge from pits and tanks using hands or basic tools – is a widespread practice in Bangladesh, and in other low- and middle-income countries. Despite this, little is known about the livelihoods of pit-emptiers.

This paper analyses data from six cases of pit-emptying in three cities in Bangladesh, across three different operational modes: private cooperatives, government employees and self-employed workers. These cases describe the experiences of emptiers from diverse socio-economic, religious and ethnic backgrounds, operating across a formal–informal spectrum.

We find that government employees and self-employed groups are deprived of basic rights, fear a loss of income brought about by mechanisation and cannot access alternative livelihoods. While the status of emptiers in private cooperatives has improved recently due to the support of governmental organisations (GOs) and non-governmental organisations (NGOs), the extent to which these cooperatives are sustainable, without the ongoing support of NGOs or GOs, remains unclear.

In all modes, sustainable livelihoods are hindered by deep-rooted social and financial barriers. Organisations can support pit-emptiers by designing sanitation interventions that prioritise the human right to decent work, focusing not only on the beneficiaries of universal sanitation, but also on those who work to implement this ambitious goal.

The Role of Social Capital in The Pathway from Participatory Community Engagement to Water Insecurity

Presenter: Allison Salinger, Emory University

Additional Authors: Dr. Sheela Sinharoy, Dr. Becky Batagol, Dr. Naomi Francis, Dr. Sudirman Nasir

Social constructs, such as social capital (i.e., networks, social trust, cohesion that facilitate cooperation for mutual benefit), are key facilitators/mediators of the relationship between community-based interventions and desired outcomes. However, these constructs have been under-studied in WASH. The purpose of this study (funded by DFAT/Water for Women) was to determine whether socially inclusive, participatory intervention activities influenced cognitive social capital (CSC) in urban informal settlements enrolled in the RISE (Revitalizing Informal Settlement and their Environments) trial in Indonesia. We hypothesized that the participatory approach of RISE would increase residents' CSC, which would be associated with reduced household water insecurity. Literature suggests that social capital can operate differently by gender; therefore, we assessed gendered differences in this pathway.

RISE is a cluster-randomized controlled trial of a water-sensitive infrastructure intervention, conducted from 2017-2022. Phone surveys, which included the Short Adapted Social Capital Assessment Tool (SASCAT) and the Household Water Insecurity Experiences Scale, were administered in Makassar, Indonesia in 2020. We targeted 2 respondents (1 male; 1 female) in all households enrolled in RISE. We performed a confirmatory factor analysis (CFA) using SASCAT responses, then built a latent variable structural equation model to assess whether CSC mediated the relationship between intervention and water insecurity. We performed the same analysis using only female respondents. Models were adjusted for settlement-level clustering.

Of the 771 surveys completed with 451 households, 428 (56%) were with women. The CFA confirmed that 5 items (trust in neighbors, residents you don't know well, and leaders; social harmony; sense of belonging) loaded onto a factor representing CSC with loadings 0.36-0.77. Both the unadjusted and adjusted models demonstrated good fit (unadjusted: RMSEA=0.043, CFI=0.938, TLI=0.900, SRMR=0.033; adjusted: SRMR=0.033). The intervention had a strong positive effect on CSC in the unadjusted model (β=0.20, $p<0.001$) and a somewhat weaker positive effect in the adjusted model (β=0.20, $p=0.068$). Cognitive social capital had a weak, inverse association with water insecurity in the unadjusted (β=-0.062, $p=0.194$) and adjusted (β=-0.062, $p=0.430$) models. The indirect effect of the intervention on water insecurity through CSC was not significant (unadjusted: β=-0.06, $p=0.215$; adjusted: β=-0.06, $p=0.520$). The women-only models were similar to the full sample models in regard to fit, directionality, and effect size.

This study is among the first to demonstrate that participatory and socially inclusive intervention activities can be effective in increasing trust, social harmony, and sense of belonging amongst residents. Many studies have shown that higher baseline social capital can enhance the outcomes of community-based interventions and cite the need for initiatives to strengthen community social capital prior to intervention roll-out. Our study makes an important contribution to this body of literature by demonstrating that participatory community engagement activities prior to implementation can be effective in building the intra-community trust and cohesion that may be necessary for sustained uptake and maintenance.

Time and Motion Assessment of Pit Emptying Operations

Presenter: Bruce Rutayisire, Pit Vidura

Additional Authors: Dennis Wolter , Nicholas Kuria , Rachel Sklar

Introduction:
The demand for fecal sludge collection and transportation is expanding in low-income urban areas with no sewer connections. Consequently, many researchers are focusing on developing suitable technologies for those areas. On the other hand, the gap between low-income households' willingness to pay and the cost of delivering emptying services in low-income areas is a significant barrier to the business viability of this sector. Our study aimed to better understand the processes and bottlenecks associated with emptying on-site facilities to optimize the processes. Thus, lowering overall service costs, and driving affordability for low-income households.

Methods:

In this research, Pit Vidura, a sanitation service provider for households and institutions in Kigali - Rwanda, was used as a case study. We conducted a time and motion study to track and record the duration of tasks involved in every single job for 13 months. The tasks monitored were pre-pumping preparation, trash fishing, pumping, cleaning, and repairing. Also, factors like types of the pit and emptying methods were analyzed to identify their impact on the total process time.

Results:
In 925 jobs assessed, the two most time-consuming tasks regardless of emptying method are trash fishing and pumping with more than 60% of the total process time. However, less mechanized tasks like preparation, cleaning, and repair showed a high coefficient of variation (CV > 100%) compared to more mechanized tasks like pumping (CV < 70%). This study also revealed that the emptying method is a significant factor in the duration of tasks. The semi-mechanized method took 56% longer than the mechanized method (Vacuum trucks). Despite that, the semi-mechanized method served two-thirds of the serviced pit latrines during the study period mainly because of road accessibility and the quantity of trash inside the pit. This research showed that the emptying process of pit latrines is 30% to 50 % longer than soak pits and septic tanks emptying on average. Between-group analysis of variance (ANOVA) was calculated on average emptying time for different types of pits. The analysis was statistically significant, $F(2, 873) = 143.97$, $p < .05$. Lastly, trash fishing was found to increase the processing time by 30%. However, during the study period, 48% of the job performed required trash fishing.
Conclusion:
To increase affordability and sanitation service provider profitability, interventions related to the most-time consuming activities should be prioritized. As efficient and affordable emptying technologies are not available, simple interventions like clearly defined standards operating procedure, use of toilet addition that prevents the trash from entering (SaTo toilet pans) can help streamline and optimize the process. As pit latrines are the common form of sanitation in developing countries, improving trash fishing and optimizing semi-mechanized methods can increase the profitability of pit emptying companies.

Understanding Barriers to Inclusion of Older People with Incontinence in Humanitarian WASH Programming – Findings from Research in Ethiopia and Malawi

Presenter: Michelle Farrington, Oxfam and HelpAge International

Additional Authors: Marion Staunton, Diana Hiscock, Amita Bhakta, Jamie Myers

Introduction
Incontinence is a complex health, protection, social and dignity issue where a person cannot control the flow of their urine or faeces. It is a highly stigmatising condition that can cause emotional, social, practical and economic challenges for the person who is living with it and their families. People with incontinence need more privacy, soap and water and time to manage their hygiene and daily activities, but older people in particular may find it difficult to manage incontinence due to a lack of consultation on their needs for WASH services in the community and in the home.

Methods
A joint team from Oxfam, HelpAge and IDS, supported by independent consultants Amita Bhakta and Sarah House, and national partners MANEPO, St. John of God Hospitalier and the Federal Ministry of Health, Ethiopia, are currently undertaking a research project to address the lack of experience and evidence available on the scope of the problem of incontinence and its implications for older people. An initial landscape review – drawing on information from HelpAge's needs assessments - highlighted major gaps for further research, and ongoing landscape scanning has revealed that COVID-19 has exacerbated issues for many older people in humanitarian contexts. Field research is currently being undertaken in Gambella Ethiopia, with research also planned to take place in Malawi later in 2021. This initial research aims to engage with stakeholders across sectors – including WASH, Health, Protection and with Older Person's Organisations - to understand their current understanding of and engagement in supporting older people with incontinence and investigate possible opportunities for strengthening such support in the future. The priority during this research will be to speak to and listen to older people themselves on their experiences of living with incontinence or caring for people with incontinence and understanding the ways that they address the challenges on a daily basis.

The methodology will be mainly qualitative, with particular focus on participatory approaches. These will be implemented with the support by HelpAge's network members, including older people associations and organisations of older people with disability, and Oxfam field staff. We will also build on HelpAge's existing quantitative data collection processes to adapt them to pick up issues related to incontinence in general surveys – using direct/indirect questions. We will test methods to encourage older people to be confident to

speak on this sensitive issue and will put emphasis on alternative communication needs of people, such as people who have difficulty in speaking, or who are deaf or have intellectual or cognitive impairments – to find alternative ways to get their viewpoints. A second round of research will take place in June/July in Malawi, to utilise the tools tested to gather feedback on the issue of incontinence from older people themselves. The eventual output of the research will be a practical and sensitive methodology to understand the scope and scale of incontinence and how it affects older people living with it and their caregivers in humanitarian contexts.

The final outputs for the research – planned to be ready for dissemination in October/November 2021 - will include a report of the findings and a briefing note, which will include recommendations on good practices for learning about this issue going forward, and guidance and tools for WASH actors to incorporate into their assessments and programmes activities to sensitively find out more about incontinence in their current contexts. The findings will be fed back to the people involved in the research and disseminated widely using accessible formats, and the tools and guidance will be made widely available through the IDS's Sanitation Learning Hub and Oxfam's WASH Website.

Results
This themed presentation aims to give an overview of the WASH sector's current understanding of the issue of incontinence in older people, and their current coping mechanisms, from the landscape scans and research visits. As part of this presentation we would like to invite WASH practitioners to discuss the findings and recommendations generated by the research to determine how the WASH sector can better engage with and support people with incontinence with linkages across sectors, such as health, protection, age, disability and gender. We see this presentation as a catalyst to bring a focus on the needs and priorities of people with incontinence and the importance of engaging with them within the WASH sector.

Understanding Rural Women's Domestic Work Experiences: Development of a DWE Measurement Tool Using Confirmatory Factor Analysis

Presenter: Abisola Osinuga, University of Iowa

Additional Authors: Brandi Janssen; Nathan B. Fethke; William T. Story; John A. Imaledo; Kelly K. Baker

Gender norms prescribe domestic labor as primarily a female's responsibility in developing countries. Many domestic tasks depend on access to water so the physical, emotional, and time demands of domestic labor may be exacerbated for women living in water-insecure environments. However, the effects of domestic labor and water insecurity have mostly been studied separately with respect to women's health. As a result, evidence is lacking on how water insecurity could contribute to women's domestic work experiences (DWE). Previous studies have mostly used time spent on work as a measure of exposure. However, time-use measures may be limited in helping us understanding the lived experiences (physical, social, and psychosocial conditions) of women. This paper documented the development of DWE measures tailored to the context of rural areas in developing countries, assessed rural Nigerian women's DWE, and examined relationships among the measures.

Survey questions were developed using constructs from the transactional model of stress and the demand-control model theories. Interviewer-administered survey data were collected from 365 women in four rural communities of Ibadan, Nigeria. Latent factors of DWE were identified by analyzing survey items grouped into domains (physical, psychosocial, and social) using confirmatory factor analysis (CFA). Reliability including convergent and discriminant validity of the latent factors were all examined. Raw and regression-based factor scores were estimated. Pearson's correlation was used to examine relationships among latent factor scores of DWE (within and across domains) and t-tests were used to determine if factor scores significantly differed across socio-demographic characteristics.

Reliability was satisfactory (Cronbach alpha > 0.7). The DWE measures consisted of latent factors of the physical (frequency of common domestic tasks, water sourcing and carriage, experience of water scarcity); psychosocial (stress appraisal and demand-control) and social domains (social support). The CFA model had good fit indices including strong convergent and discriminant validity. There were significant correlations among the latent factors within and across domains. High frequency of domestic work scores was significantly correlated ($r = 0.31$; $p < 0.01$) with increased experience of water scarcity, increased stress appraisal ($r = 0.36$; $p < 0.01$) and decreased social support ($r = -0.25$; $p < 0.01$). Increased water sourcing and carriage scores were associated with increased experience of water scarcity ($r = 0.20$; $p < 0.01$). Women in younger reproductive age groups (18-25; 26-30 years) had significantly higher demand-control and higher water sourcing/carriage scores. Women who were pregnant had significantly higher demand-control scores but lower frequency of domestic tasks scores. The DWE measures were valid and reliable. Multiple inter-related factors contribute to women's DWE and some measures of DWE vary across age categories and pregnancy status. Water collection

labor was linked to increased work demands, lack of social support and decision authority over task completion. This study revealed the importance of taking a multi-factorial approach when measuring rural women's DWE, rather than relying solely on frequency/time measures. Future research in other culturally diverse and rural settings are needed to further refine these measures which could be useful in measuring progress towards SDG goals for gender equality and women's health.

WASH and Health Risk Factors and the Gut Microbiome of Young Children in Maputo, Mozambique

Presenter: Jackie Knee, LSHTM

Additional Authors: Minjae Kim, Joe Brown, Kostas Konstantinidis

Frequent exposure to enteric pathogens during early childhood may result in changes to the gut microbiome. Risk of exposure to enteric pathogens is often higher in settings where water, sanitation, and hygiene (WASH) infrastructure is lacking and sanitary conditions are poor. We aimed to assess whether access to an advanced onsite sanitation intervention was associated with differences in the microbiome of children <4 years old living in low-income neighborhoods of Maputo, Mozambique compared with control children. Additionally, we aimed to identify demographic, environmental, WASH-related, and health-related risk factors associated with differences in the gut microbiome.

This study is nested within the Maputo Sanitation trial, a controlled before-and-after evaluation of a shared onsite sanitation intervention in urban Mozambique. We used shotgun metagenomic sequencing to measure the abundance and diversity of bacterial populations, antimicrobial resistance genes (ARG), and virulence factors (VF) in stool samples collected from 70 intervention children and 80 control children. All samples were collected 12 or 24 months after the intervention was implemented. We compared outcomes between intervention and control and identified risk factors using generalized estimating equations to fit Poisson regression models with robust standard errors and a false discovery rate of 0.25.

Access to the intervention was not associated with species diversity (adjusted PR 1.00 [95% confidence interval 0.99-1.01]). Few species were differentially abundant between intervention and control children, including Faecalibacterium prausnitzii which was enriched in intervention children. The intervention was not associated with ARG abundance, ARG diversity, or VF abundance. Increasing age was associated with a small increase in overall species diversity (aPR 1.03 [1.01-1.04]) and a decrease in ARG abundance (aPR 0.61 [0.46-0.80]) and ARG diversity (aPR 0.81 [0.75-0.88]) when comparing children aged 2-4 years to children <1-year-old. Detection of Shigella and Trichuris in stool was associated with a decrease in both ARG abundance (Shigella aPR 0.66 [0.51-0.84]; Trichuris aPR 0.72 [0.55 – 0.93]) and VF abundance (Shigella aPR 0.52 [0.33-0.82]; Trichuris aPR 0.53 [0.31-0.90], while Ascaris infection was associated with an increase in ARG abundance (aPR 1.37 [1.06-1.76]). Reported diarrhea was associated with an increase in ARG (aPR 1.43 [1.12-1.82]) and VF (aPR 1.76 [1.22-2.53]) abundance. No environmental or WASH-related risk factors were associated with changes to the microbiome.

This study is one of the first to assess associations between WASH conditions, enteric infection, and the gut microbiome in young children living in a low-resource setting. While access to the intervention was associated with few differences in the gut microbiome composition, we did observe enrichment of F. prasunitzii, a bacterium that has been identified as potentially important in maintaining a healthy gut, among intervention children. While few other WASH or environmental factors were associated with microbiome measures, detection of several key pathogens, including Shigella and Trichuris, was associated with decreased abundance of ARGs and VF. This finding warrants further investigation as Shigella and Trichuris were the only two pathogens impacted by the intervention in a sub-group analysis of the main MapSan trial.

Water, Sanitation, and Hygiene Interventions to Prevent Soil-Transmitted Helminth Infection: A Systematic Review and Meta-Analysis

Presenter: Joshua Garn, University of Nevada, Reno

Additional Authors: Matthew Freeman, Rubina Imtiaz, Lisa Pfadenhauer, Jacob Burns

Worldwide it is estimated that 1.5 billion people are infected with soil transmitted helminths. Reinfection occurs rapidly following deworming, and interruption of transmission is unlikely without complementary control efforts, such as improvements in water, sanitation, and hygiene (WASH) access and behaviors. We review the effectiveness of WASH interventions to prevent soil-transmitted

helminth infection among trials. While previous reviews have assessed WASH and STH infection, those studies were primarily observational, and the number of rigorous intervention studies has more than doubled since the most recent systematic review by Strunz et al. in 2014.

All randomized controlled trials (RCTs) and non-randomized trials (non-RCTs) that assessed WASH access or practices on soil-transmitted helminths (STHs) were included in this review. The primary outcome of this study was prevalence of any STH infection. Prevalence of individual worms was a secondary outcome, including for A. lumbricoides, T. trichiura, hookworm (A. duodenale or N. americanus), or S. stercoralis. Intensity of infection, measured as a count of eggs per gram of feces for each species, was also a secondary outcome. Two review authors independently reviewed titles and abstracts, performed data extraction, and assessed the risk of bias using the Cochrane 'Risk of Bias' assessment tool. Random effects meta-analysis was used to pool study estimates. Moran's I^2 statistic was used to assess heterogeneity and subgroup analyses were conducted to explore sources of heterogeneity. The quality of evidence was assessed using the GRADE Guideline Development Tool.

There were 30 studies that met the inclusion criterion; 18 were RCTs and 12 were non-RCTs. The overall pooled effect estimate among RCTs showed that WASH interventions were protective against any STH infection (OR 0.86, 95% CI: 0.75 to 0.98). Among RCTs assessing this primary outcome, the risk of bias for individual studies was generally low, and the GRADE quality of evidence was high. All of the meta-analyses assessing individual worm infection among both RCTs and non-RCTs had effect estimates in the preventive direction, although wide confidence intervals for some of the estimates leave the possibility of the null or even harmful effects and the quality of the evidence ranged from very low to moderate. Our review found 16 studies assessing intensity of infection, and individual studies showed mixed evidence supporting WASH. Previous reviews had noted a paucity of studies reporting on intensity of infection, and while we found 16 studies, measures of variability and measures of effect were often not reported, and varied reporting of measures of effect made meta-analysis infeasible.

Policymakers can take note of evidence in several areas supporting WASH in the reduction of STH infections. Our a priori primary outcome, prevalence of infection with at least one STH species, showed 14% lower odds of infection of any STH among RCTs, and all of the meta-analyses we did on individual worms showed effect estimates in the preventive direction. While this evidence suggests that WASH interventions may protect from STH infection, WASH also serves as a broad preventive measure for many other diseases that have fecal oral transmission routes.