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Abstracts Book

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Welcome to the 2023 UNC Water and Health Conference. The following abstracts

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★   Top 20 Abstracts

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VERBAL ABSTRACTS

★ **Barriers to safe sanitation access among housed populations in the United States: A systematic review**

Amy Kryston, University of North Carolina
Additional Authors: Drs. Musa Manga and Courtney Woods

Background:
Nearly six million people residing in the United States do not have access to safely managed sanitation. Housed populations may lack access to centralized wastewater treatment systems or functioning onsite wastewater treatment systems, which may place them at higher risk for adverse health outcomes associated with unsafe sanitation.

Objectives:
We sought to identify and understand the various social barriers that impact access to safe sanitation in the United States.

Methods:
We included peer-reviewed studies published between January 2000 and March 2023. The publication search was conducted using Scopus, ProQuest Social Science Database, and HeinOnline. We extracted data on social barriers and physical factors associated with access to sanitation.

Results:
Twenty publications met the inclusion criteria, and data relating to 11 social barriers and two physical factors were extracted. The social barriers to safe sanitation access mentioned most frequently were found to be socioeconomic status and race-based discrimination. Studies discussed sanitation in communities in five states. Specific communities included in the publications were predominantly unincorporated.

Discussion:
Barriers pertained to lack of access to centralized wastewater treatment system, inadequate repair or replacement of septic systems, and lack of safely managed onsite sanitation systems. We discuss the intersectionality of the barriers, the underlying policy and history that leads to them, and make recommendations to address inequitable access to safe sanitation. These findings may help inform policy and future research. Legislation and policy should be critically reviewed at national, state, and local levels to limit or eliminate ability for utilities to be extended on the basis of a community's income and property values or racial makeup. Policy recommendations also include additional community engagement, onsite sanitation system monitoring, and knowledge dissemination and education of septic system users. More geographically-diverse research and research on sanitation in specific communities such as those of migrant farmworkers, undocumented persons, and tenants are recommended.

★ **Probable direction of bacterial movement from pit latrines in coastal Bangladesh**
Mahbubur Rahman, icddr,b
Additional Authors: Solaiman Doza, Mohammed Ilias Mahmud, Kazi Matin Ahmed, Stephen P. Luby, Thomas F Clasen, Leanne Unicomb, Abu Mohd Naser

In many low-income countries, pit latrines are the most commonly used methods of removing human excreta. Usually in rural locations, community groundwater sources utilized for drinking and domestic tasks are located adjacent to pit latrines. This may lead to groundwater contamination and can spread of diseases and illnesses. Leachate from pit latrines is more prevalent when the groundwater table is shallow, so it's essential to manage and maintain pit latrines properly to reduce their adverse impact on water quality. Evidence suggested that geological and hydrological processes regulate groundwater flow direction, which influence bacterial leaching from pit latrines in shallow groundwater. Coastal Bangladesh is predominantly formed from the sediment deposits of river Ganges, which flows south and southeastwards. We evaluated the direction of fecal indicator bacteria [FIB: E. coli (EC) and fecal coliforms (FC)] leaching in a coastal sub-district of Bangladesh. We constructed 68 offset pour-flush pit latrines in the eligible households. We implemented block randomization to assign 34 latrines to get a 50-

cm thick sand barrier under and around the pit, and 34 had no sand barrier among the geographically clustered households to reduce confounding from regional geological factors. Six meters deep monitoring wells (MWs) were installed in northeast, northwest, southeast and southwest directions around each pit at 1m distance. We collected water samples from MWs in months 1 through 5, 12, 15, 18 and 24. Samples were analyzed using IDEXX most probable number method with Colilert-18 media. We calculated mean log10MPN of FIB counts; used multi-level models with random effects for each latrine and MW to determine whether MW direction affects FIB contamination when adjusting for latrine type. We used northeast wells as reference group for comparison. We found highest fecal contamination in southeast monitoring wells (1.45 mean log10MPN EC and 1.65 mean log10MPN FC). Southeast wells had 0.17 higher mean log10MPN EC (95% CI: 0.05, 0.29) and mean log10MPN FC (95% CI: 0.04, 0.28) than northeast wells. The odds of water contamination classified as very high WHO risk versus combined low, intermediate, and high risks were 1.4 (95% CI: 1.1, 1.6) times higher in southeast wells for EC and 1.4 (95% CI: 1.1, 1.7) times for FC compared to northeast wells. The finding revealed that bacterial leaching from latrine pits occurred to a greater degree in the southeast direction, which coincided with groundwater flow direction. Therefore, it may be crucial to take this into account when installing a shallow tubewell next to a pit latrine to prevent contamination and ensure proper sanitation. To meet the SDG goals, additional longitudinal study may aid improve our understanding of how pit latrine leaching affects community fecal exposure and consequent health effects.

Inclusive sanitation: Challenges in service delivery to urban poor
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Additional Authors: Monissha Manivannan

Background:
Tiruchirappalli (Trichy), the fourth largest corporation in Tamil Nadu, India, with a population of 0.91 million, faces challenges in providing adequate sanitation facilities, especially for the urban poor. The city has a total of 294 urban poor settlements, both notified and non-notified. To address this issue, the City-Wide Inclusive Sanitation (CWIS) programme is being implemented in Trichy to achieve equitable and sustainable sanitation services. This paper highlights the challenges faced in sanitation service provisioning in Trichy.

Methods:
To identify the challenges in accessing sanitation facilities, focused group discussions were held with residents from 26 urban poor settlements. Interactions were also held with 25 urban local body (ULB) officers regarding the constraints in implementing sanitation services programmes.

Key Findings Land Issues:
Swachh Bharat Mission (SBM), launched in 2014, delinks land rights from sanitation access, but several challenges remain in effecting this provision. Urban poor households are required to show property tax payment receipt as proof of land rights and as an eligibility criterion to apply for sewer connection, which they do not have because of lack of land ownership. Additionally, in settlements located in central government land (railways or airport), ULBs are unable to build community toilets, despite mission provisions.

Space and Cost Issues:
Inadequate space for construction of toilets and standard containment structures is a major challenge. Containment tanks are constructed in basements, smaller than standard, sometimes even without a soak pit, leading to frequent filling, increasing the need for de-sludging, whose costs affect urban poor. Narrow streets in urban poor settlements also increase de-sludging costs. The subsidy from SBM for household toilet construction is not comparable to market cost, and additional costs towards sewer connection and related household modification create barriers to sanitation access. Trichy's network of 400+ community toilets require periodic maintenance. Lack of designated funds for fecal sludge management is a challenge.

Technical and Technological issues:
Untrained masons lack adequate technical know-how to address field-level challenges such as space constraints or poor households dependent on masons for construction of on-site sanitation structures (OSS), who connect wastewater to open drains. Urban poor settlements in low lying areas find it difficult to make the last mile sewer connection as their basement levels are lower than the sewer system. This calls for micro-level planning of UGSS.

Governance issues:
The approval process merely checks the provision of OSS rather than OSS specifications. Households with built-up area less than 750 sq.m do not require completion certificate as per TNCDBR . Inadequate staffing and unclear role definition by ULB are other challenges in ensuring safe sanitation.

Conclusion:
The study highlights the need for micro-planning and localized problem-solving to address the technical, operational, governance and funding challenges in Trichy. The findings underscore the need for improved national policy responses to support safe sanitation.

★ **Evidence from 48 Brazilian Cities on Climate-Induced Sanitation Risk**
Gabrielle Marega, University of Toronto
Additional Authors: Jennifer Drake and David Meyer

Background:
Safely managing human waste is critical to the health and well-being of humans, especially in cities. In urban settings, sanitary sewers are the most common infrastructure implemented to provide safe sanitation. They are designed to accommodate sanitary flows, groundwater infiltration, and some rainfall-derived inflow and infiltration (I&I). Excess I&I can lead to Sanitary Sewer Overflows (SSOs), compromising the safe collection of sewage and causing harmful health consequences. Due to climate change, rainfall events are expected to increase in intensity and frequency, directly magnifying the impacts of I&I on sanitary networks. Yet, little is known about I&I in networks in low- and middle-income countries. In this research, we quantified the average I&I collected in different operational networks in Brazil and, thereby, its vulnerability to climate change.

Methods:
We analyzed data from 48 wastewater treatment plants (WWTPs) in Brazil provided by the Brazilian National Water and Sanitation Agency. The data set includes quarterly data over two decades on the flow rate and biological oxygen demand (BOD) at each WWTP's inlet. We used two distinct methods to quantify the percentage of the total flow corresponding to I&I in each sewer network: the water balance and the dilution method. The water balance method correlates the population served and the water consumption per capita with the WWTP's total flow rate. The dilution method correlates the expected BOD produced with the total BOD at the inlet of the WWTP. Additional data sets were merged to provide water consumption per capita, population served by the WWTP, and historical precipitation data.

Results:
Analyzed WWTPs served 3,738 to 754,920 inhabitants located in six states in Brazil. Both methods produced similar estimates of average I&I, approximately 30%, which aligns with assumptions used in many jurisdictions globally. However, at some WWTPs, I&I was a concerningly large fraction (e.g., > 70%) of the flows received. Higher values of I&I indicate a higher climate-induced sanitation risk: an increase in rainfall due to climate change will increase I&I in the system, increasing the frequency and severity of SSOs. Therefore, WWTP with a higher percentage of I&I are more vulnerable to climate change impacts and should be prioritized for upgrades. Furthermore, preliminary results showed a seasonal pattern for I&I: drier quarters have lower I&I than wetter quarters.

Conclusions:
Quantifying I&I in operational networks is the first step towards strategically improving the climate resilience of sanitary sewers. In Brazil, average I&I values are similar to those reported in studies in North

America, Europe, and China. Yet, we also found WWTPs with I&I that were above average. We recommend incorporating I&I studies when designing new sanitary sewers for safer sewage collection. Concerningly, we found strong evidence that some sanitary networks are extremely vulnerable to climate-induced risks because of high I&I values. Therefore, we recommend that regulators incentivize utilities with vulnerable networks to plan adaptations and mitigation strategies to decrease the network's vulnerability, enhancing future health and well-being amidst a changing climate.

★ **Testing a behavioural-science informed intervention to improve hand hygiene during childbirth in Cambodia: results from the CHAMP Plus Study**
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Additional Authors: Naisim Sum, Senghort Ret, Channara Thea, Bernice Sarpong

Hand hygiene is a critical component of infection prevention and control strategies to reduce the burden of maternal and neonatal infections. Building on previous work to improve hand hygiene along the continuum of care, we adapted and tested a behavioural-science informed intervention to improve hand hygiene among midwives, new mothers, and other caregivers – the CHAMP Plus intervention. First, the CHAMP Plus intervention specifically targeted improved midwife adherence to hand hygiene for aseptic procedures during childbirth and included color-coded environmental cutes and nudges, covert systems where midwives could provide real-time feedback and support when they observed other midwives non-compliance with hygiene protocols, and structured group reflections on hygiene performance. This was supported through a hybrid training program based on low-dose/high frequency training modules which consisted of short online and in-person training sessions completed at the facility that used participatory and problem-based training. Midwives were also responsible for introducing the second component of the intervention to mothers and family members designed to improve hand hygiene in post-natal care facilities that included multiple behavioural-science informed intervention components. The intervention was tested in a controlled before-and-after study in six referral hospitals in peri-urban areas using direct observation of midwife and caregiver hand hygiene. For childbirth, hand hygiene at start of critical moments was classified into three categories: adequate (hands washed with soap, clean gloves worn), inadequate (gloves changed or outer gloves removed without hand washing with soap), or invalided (hands potentially recontaminated). For childbirth, midwives participating in the CHAMP Plus intervention had four times higher odds of adequate hand hygiene prior to the start of key events requiring aseptic procedures (OR: 4.12 (1.47 – 11.56), p=0.007). In contrast, there was no evidence of an improvement in the odds of a midwife starting a procedure with fully invalided hand hygiene. There was no observed change in hand hygiene in post-natal care areas. Semi-structured interviews with mid-wives indicate that there was high levels of participation and engagement with the training modules and midwives had overall positive response to all other intervention components. However, data also suggest that intervention component for post-natal care areas was inconsistently delivered and had poor fidelity. Overall, findings suggest that the CHAMP Plus intervention was successful in reducing partial or incomplete adherence to hygiene protocol but had limited effect on the highest risk events. While responsible for post-natal care, the capacity of midwives to deliver additional behaviour change interventions in post-natal care environments should be reviewed.

★ **Sustaining behavior change through learning in preventive health: an experiment in Pakistan**
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Additional Authors: Gabriella Fleischman, Reshma Hussam, Akib Khan

What motivates sustained technology adoption? We design an experiment in the context of water chlorination in Pakistani slums to test the impact of an intervention that helps individuals learn about the health returns to chlorinating their water over time. This intervention enables caregivers to compare their children's diarrheal incidence with the average diarrheal incidence in households that do not use chlorine tablets, both before and after chlorine provision. Crucially, we embed a parallel experimental arm to rule out habit formation as a driving mechanism, as both learning and habit formation imply that the more one engages in the past, the more one will engage in the future - but the two have distinct policy implications. We randomize participants into four groups: control, free chlorine tablets (active control), free chlorine

with learning about health returns (learning through noticing), and free chlorine with temporary financial incentives (habit formation). We halt behavioral interventions after three months, preserving free provision of chlorine, and track chlorine use and health for another three months. We find that the learning tool leads to a sustained increase in chlorine in the three months after we halt interventions. Increases are largest among those households who are predicted (using baseline variables in the control sample) to experience improvements in their diarrhea rates, meaning those households who are most likely to learn from the tool. Effects are amplified among those predicted to experience health improvements to the community benchmark, suggesting the social comparison was an important component of learning. We also document sustained health impacts among info-tool participants, in contrast to those in the incentives arm, who exhibit neither sustained health nor behavioral changes. Finally, we document evidence of spillovers, wherein control households with more neighboring treated households exhibiting larger improvements in chlorination and health.

Sanitation Interventions and Women's Empowerment: A Comparative Assessment of Two Cities in Bangladesh
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Background:
Inadequate access to safely managed sanitation services is prevalent in developing countries, disproportionately affecting women. Moreover, limited evidence exists on how WASH circumstances impact women's empowerment and, in turn, how women's empowerment affects WASH. Sanitation interventions in cities are progressing, including in Bangladesh, to address the issue of access to safe sanitation and reach SDG targets. This study examined aspects of women's empowerment in Saidpur and Meherpur municipalities of Bangladesh, where interventions focusing on safely managed sanitation services have been underway since 2013 and 2017, respectively.

Methodology:
The Measuring Urban Sanitation and Empowerment (MUSE) study surveyed 1449 adult women in low-income neighborhoods of Saidpur and Meherpur, Bangladesh, from March-April 2022. The survey included scales to measure 16 subdomains of empowerment related to urban sanitation within the three larger domains of Resources, Agency, and Institutional Structures. In addition, the survey collected information on population demographics, WASH facility access and practices, menstruation and relevant experiences related to the COVID-19 pandemic and lockdown. We used standard descriptive statistics to compare subdomain scores between women in Saidpur and Meherpur.

Results:
A much higher percentage (90%) of the low-income community (LIC) population in Saidpur had access to safe toilets, compared to Meherpur, where only 40% had such access. Only 1% (95% CI: 0.002, 0.016) of women in Saidpur reported that they feel unsafe while using sanitation facilities compared to 9% in Meherpur (95% CI: 0.069, 0.112) (Safety and Security subdomain of the Resources domain). In both Saidpur and Meherpur, 40% of survey respondents said they hold decision-making positions in committees or forums within the city. However, women in Saidpur displayed a 9% higher positive belief than women in Meherpur regarding their potential to hold similar positions as men (Agency domain). Within the Institutional Structures domain, women in Saidpur reported a higher frequency of conflict-free interactions with local leaders or authorities regarding sanitation-related issues (94.4%, 95% CI: 0.924, 0.959) than women in Meherpur (87.6%, 95% CI:0.856, 0.896). Although both cities practice gender-equal pay, women experience obstacles in economic activities due to insufficient menstrual hygiene management, as 2% (95% CI: .005, .063) of women in Saidpur and 7% (95% CI: 0.039, 0.122) of women in Mehrepur avoid income-generating activities during menstruation. In comparison to Meherpur, data from women in Saidpur also indicated higher levels of empowerment related to menstrual hygiene management (OR: 3.50), confidence in leadership (OR: 2.5), relationships with local leaders (OR: 2.36), and safety and security of women (OR: 14.13).

Conclusion:

The positive findings of empowerment domains in women of Saidpur compared to Meherpur may be related to longer sanitation interventions in the city. For the same reason, the barriers women face in sanitation-related issues, including safety and security, are less pronounced in Saidpur. The collective action of local government and stakeholders is crucial in identifying the root causes of the less successful factors and implementing measures to improve them to ensure the sustained progress of women's empowerment in safe sanitation.

Addressing and Measuring Change in Structural Barriers to Gender Equality within the Federal Ministry of Water and Energy in Ethiopia
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Background:
Women are disproportionately impacted by WASH but make up a minority of leadership in WASH decision making at all levels. When women are engaged in WASH decision making, services are more sustainable, more equitable, and are perceived as having higher service quality (citations). And yet, globally, women are under-represented at all levels; they lead fewer than 12% of the water and environment related ministries and make up fewer than 18% of workers at water utilities (World Bank). To ensure gender-equitable WASH services, there is a need to strengthen women's participation and leadership and awareness of gender equality, not only at the community level, but at structural levels, including national and local governments that influence the policies, investments, scale and regulation of services for all.

Objective and Methods:
As part of the Seizing the Moment WASH initiative in Ethiopia, CARE has supported the Federal Ministry of Water and Energy and the Ministry of Women and Social Affairs to jointly conduct over a 1-year period to identify and examine the gender norms and structures within the Ministries that result in internal gender inequities. The Ministry of Water and Energy evaluated itself with the Gender Levelling Tool (GLT), which comprises 17 indicators of gender equality. The Ministries then jointly identified weaknesses that perpetuate gender inequalities and identified priority actions to address these weaknesses. CARE will support the Ministries to conduct a follow-up assessment using the Gender Levelling Tool in July 2023 to examine where progress has been made in the initial year of implementation. This study describes results of the Gender Levelling Tool assessment at baseline and mid-line of the Seizing the Moment WASH program in Ethiopia, how the Ministry identified and addressed internal barriers to gender equity, and how it measures progress towards greater structural gender equity.

Results:
In its initial assessment, the Ministry of Water and Energy scored 68/100 on the Gender Levelling Tool, which represents a "gender sensitive score." However, the Ministry identified specific areas of weakness, including limited budget for gender activities and analysis, limited operationalization of articulated commitments to gender action plans, and poor hiring and retention of women, particularly in leadership positions within the Ministry. Fewer than 10% of leadership positions within the Ministry are held by women. CARE and the Ministry of Women and Social Affairs then supported the Ministry to more deeply assess and address these weaknesses, through actions such as Social Analysis and Action (critical dialogue), re-evaluating job descriptions and advertisements to better attract and retain women candidates, and strengthening the Ministry of Women and Social Affairs' capacity and tool-kit to monitor and demand accountability from other line Ministries, including the Ministry of Water and Energy. The Ministry of Women and Social Affairs and the Ministry of Water will re-evaluate its scores on the GLT, 9-months after initial analysis (in June 2023) to determine magnitude of change within the 17 indicators/domains of change.

Discussion as to how this informs policy and practice:
To our knowledge, this is the first intervention directed specifically at the Federal Ministry level to identify and address structural gender inequalities that impact WASH services. As the development sector

identifies the need for gender-transformative WASH, there is a need to better understand how to address gender norms at a structural level, and how these transformative approaches are resulting in measured change. The findings of the Seizing the Moment assessments help sector actors – including government, researchers, and NGOs – to better understand which interventions comprise a truly gender-transformative approach.

Changes in the menstrual hygiene management facilities and usage among Bangladeshi school girls and its effect on school absenteeism from 2013 to 2018
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Additional Authors: Mahbub ul Alam, Noshin Sayiara Suchi, Abul Kasham Shoab, Hasin Jahan, Mahadi Hasan, Mahbubur Rahman

Background:
Like other low- and middle-income countries, Bangladeshi school girls often find themselves unable to meet their menstrual needs at school due to a lack of menstrual hygiene management (MHM) facilities which includes separate toilet facilities for girls to change and dispose of their menstrual absorbents, lack of privacy, and prevalent stigma. National hygiene baseline survey conducted in 2013 showed that around 41% girls missed schools on average of 2.8 days due to menstruation. This paper aims to investigate changes in MHM facilities in school and its effect on school absenteeism between 2013 and 2018.

Methods:
Two nationally representative survey was conducted from March to June 2013 and March to May 2018. In 2013, from 100 clusters and 700 schools a total of 2,333 schoolgirls were interviewed and in 2018, from 176 clusters, 704 schools, a total 2,816 randomly selected girls were interviewed along with spot checks for menstrual health facilities. We used proportion difference to determine the changes in MHM facilities in schools and school absenteeism from 2013 to 2018, and adjusted proportion difference using generalized estimating equation (GEE) to identify the factors that contributed to the changes.
Results:
School absenteeism during menstruation among adolescent school girls decreased from 41% to 30% (PD: -11; CI -17 to -4.9). Availability of separate facility at school for changing menstrual absorbents (3.3% vs 8.3%; PD: 4.8; CI 2.0 to 7.5) and bins in girls' toilet for disposing menstrual absorbents (3.6% vs 23%; PD: 19; CI 15 to 24) also increased from 2013 to 2018. Usage of separate facility for changing menstrual materials increased significantly from 2013 to 2018 (PD 17; CI 3.4 to 38). The usage of sanitary pads significantly increased among school girls (10% vs 57%; PD: 38; CI 36 to 41). School attendance was 8.7% higher among girls (P value: .001; CI: 3.4 to 14) when the school had separate toilet for girls. Use of the separate toilet facility was 43% higher when the facility was safe with lock, clean and private (CI: 16 to 69). Students who had restrictions from parents in going out during menstruation are 5 times less likely to attend schools during menstruation (CI: -9.6 to -1.5). School girls who believed menstrual problems interfered with their school performance were 23% less likely to attend schools during menstruation (CI: -26 to -19).

Conclusion:
With the improving MHM facilities in schools and its usage among school girls in Bangladesh the absenteeism has reduced significantly from 2013 to 2018. Provision along with maintenance of MHM facilities and counseling of students on MHM are crucial to reduce absenteeism due to menstruation among school girls.
The acceptability of reusable menstrual pads from the perspective of menstrual hygiene management in Bolivia
Mina Lee, United Nations Population Fund

Reusable menstrual pads have emerged as a sustainable and cost-effective alternative to disposable pads in recent years. However, their adoption among women in Bolivia is still limited by cultural attitudes towards menstruation and insufficient access to education and resources on menstrual hygiene

management (MHM). Bolivia women still resort to using non-hygienic methods, such as old cloths, to manage their menstrual flow. Unlike other countries, Bolivia has not made progress in ensuring free access to sanitary products, and a 13% Value Added Tax is applied. Evidence on reusable menstrual pads is limited, especially in the Bolivian context. This study examined Bolivian women's acceptability of reusable menstrual pads and how they can improve their MHM. A three-month pilot study was carried out from December 2022 to February 2023 using donated Hannah pads, a brand of certified organic cotton pads known for their absorbency and comfort that are not yet available in Bolivia. We used convenience sampling to recruit 69 Bolivian women of reproductive age from three health facilities in La Paz. In December, our team's midwives conducted the first structured questionnaire to collect information on the participants' menstrual experiences, knowledge, and product usage. Additionally, education was provided on menstruation management, and instructions on using and cleaning the pads were given. Participants were also provided with a kit containing small, medium, and overnight sizes of Hannah pads, laundry soap, a pouch, and an instruction leaflet. In February, we conducted a second survey using Google Survey to assess satisfaction after two months of use; responses were collected through WhatsApp and phone calls. The study revealed that reusable menstrual pads were generally acceptable and beneficial alternatives to disposable pads. More than 80% of the participants expressed satisfaction with non-blood leakage (90%) and cost-effectiveness (87%). Particularly, participants reported reduced menstrual pain (28%) and improved overall health (70%). Furthermore, 76% of participants expressed a willingness to continue using the reusable pads, and 90% of them would recommend them to their friends or acquaintances. However, washing barriers remain; 12% expressed dissatisfaction with washing the pads, and 66% found the washing process time-consuming. The study also emphasized the need for better information and education on MHM in Bolivia, as over 50% of the participants had misconceptions about several topics, such as pregnancy, bathing, and body weakness during menstruation. Furthermore, cost was the main criterion considered when choosing a menstrual product and they suggested that the appropriate price of a single reusable menstrual pad can range from 1.6 to 2.9 USD. This highlights the importance of making reusable pads more accessible to and affordable for more Bolivian women. Overall, this study contributes to the general understanding of the potential of reusable menstrual products for urban Bolivian women of reproductive age. However, the results do not represent women in other parts of Bolivia or with different socioeconomic backgrounds. Continued research and advocacy efforts are needed to improve menstrual education and access to alternative and affordable menstrual products in Bolivia.

Multi-City Menstrual Friendly Public Toilet (MFPT) Study: Policy, Practice, and Advocacy
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Background:
Public toilets in urban centers are a necessary sanitation resource for anyone menstruating while in public domains. Evidence attests to the paucity and poor quality of these resources globally, yet little research has used standardized metrics of adequacy nor addressed how political and social support might be mobilized to correct deficiencies found. This study, conducted in six cities (Barcelona, Kampala, Manila, New York City, Osaka, Rio de Janeiro), documents local public toilet supply, condition, and menstrual health and hygiene (MHH) adequacy. It also makes preliminary inquiry into sources of social and governmental support for providing and maintaining menstrual-friendly facilities. This work aims to answer the following questions: 1) How well do these cities provide MHH resources in public toilets? 2) Are there differences between cities and neighborhood types? 3) What mechanisms and systems can provide and/or support MHM resources?

Methods:
This mixed-methods study includes: 1) public toilet audits in six cities and 2) key informant interviews with toilet or menstruation advocates, and government officials (n=8/city; total n=48, interviews ongoing

through June 2023). In each city, four comparable areas were selected: business, tourist, transit, and residential. Field researchers used a novel instrument to audit each accessible public toilet within 500m of the area's central point. RStudio (R Core Team, 2022) and ArcGIS Pro (ESRI, version 3.0) were used to generate descriptive statistics and geographic visualizations to allow comparisons among cities and among neighborhood types. We identified key informants involved in ensuring access to menstrual-friendly public toilets through the professional networks of researchers in each city, snowball sampling and cold-contacting identified stakeholders. In each city, key informant interviews explore the policies and practical implementation realities of providing and up-keeping public toilets that include MHH components.

Results:
Local audits reveal that managing menstrual hygiene with confidence, privacy and safety regularly presents problems, but these varied in type and degree of severity among and within cities. Thematic analysis (July 2023) will mine interview transcripts with key informants to create local histories of public toilet provision and maintenance. Analysis will seek to identify the barriers and enablers to improving social equity in access to menstruation-friendly public toilets. Sub-group analyses will compare results across site by salient urban features (income level, economy, tourism, population, etc.).

Conclusion:
Despite the growth of attention to MHH, distribution deficits exist in available facilities and adequacy of menstrual support. Variation is also seen in formal and informal political commitment to address provision of and gendered inequities in public toilets. Further research is needed to understand the range of barriers to and enablers of improving quality toilet provision. These findings can inform and motivate governments and other stakeholders to address this gap in public toilet provision through policy, practice, and advocacy.

The Menstrual Practice Needs Scale Short Form (MPNS-SF): Development and validation in Bangladesh and Uganda
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Background and purpose:
Menstrual health is vital to the wellbeing of women, girls and all people who menstruate. Research to understand menstrual health needs and evaluate interventions has been limited by a lack of high-quality measures for core concepts. The Menstrual Practice Needs Scale (MPNS) addressed part of this gap and provided a validated way to measure respondents' menstrual hygiene experience. The 36-item MPNS has seen rapid uptake in research and practice. A shorter form can enable greater uptake in NGO monitoring and multi-component surveys where the full item set is not feasible. This study responds to stakeholder requests for a validated short form.

Methods:
MPNS-SF development drew on multiple methods. Use of items in past research, stakeholder feedback and item factor loadings across studies to date informed item selection. Cognitive interviews with 20 adolescent schoolgirls in Khulna, Bangladesh informed item interpretability and included participatory activities to rank the importance of items to girls in this setting. A survey of 360 adolescent schoolgirls in Khulna, Bangladesh was undertaken. Exploratory and confirmatory factor analysis tested the shortform factor structure and validity evaluated. Validity and factor structure were further tested through re-analysis of MPNS data from past research, including a sample of 538 schoolgirls in Soroti, Uganda and 525 women working in Mukono, Uganda. We assessed internal consistency and compared the validity of the measure between the full and short form versions. Results. The final short form retained items across domains capturing respondent experiences of satisfactory quantity and comfort of menstrual materials, acceptability of locations for changing and disposing of menstrual materials, privacy, and safety. One item was revised to ensure applicability to all respondents and one new item was added to capture

experiences of those travelling home from school or work to change materials. The final short form includes 18 items, 12 applicable to all respondents, 2 for those disposing of materials and 4 those who wash and reuse absorbents. Items reflect the 6 original subscales, with the four core subscales demonstrating good fit among adolescents in Khulna, Bangladesh (RMSEA=0.064 95%CI 0.043-0.084, CFI=.94, TLI=.92), in Soroti, Uganda (RMSEA=0.039 95%CI 0.028-0.050, CFI=.95, TLI=.94). Hypothesised associations between the MPNS scores were comparable between the full and short form measures. Internal consistency remained acceptable despite small numbers of sub-scale items with total score Cronbach's α of 0.77.

Conclusions and implications:
The MPNS-SF offers a reliable and valid tool to assess the menstrual hygiene experience of women and adolescent girls in research and practice. It responds to stakeholder feedback, reduces participant burden, and offers improvements to scoring calibration for those who do and do not attend school or work during menstruation. The MPNS-SF will enable uptake of the measure and integration into a broader range of research and monitoring activities to improve comparability across studies. Improved measurement will enable a strengthened evidence base for menstrual health and hygiene.

Improving the Functionality of Rural Community Water Points Through service Contracts: A Case of Chiradzulu District, Malawi
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Chiradzulu is a district in the southern region of Malawi with a population of 365,875 (National Statistics Office of Malawi, 2018). In Malawi,92.1% of the households have access to an improved water source and 90.1% of the improved water points are handpumps which are managed through a community-based approach. Low functionality rates (around 60 to 70% in sub-Saharan Africa) and low service levels are the visible symptoms of the widespread failure of community-based management and in Chiradzulu functionality is at 71% (Annual Monitoring Report,2021). Therefore, this study followed the results of a pilot research on engagement of trained Area and Pump Mechanics for handpumps adapting an insurance model for regular maintenance of community water handpumps to improve on functionality of community water points. The study followed the functionality of handpumps and level of service in Chiradzulu district for 2 years. Water point functionality in the district improved by 23% (from 59% to 84%) and water points down time significantly reduced by 20% (56% to 76%). There is a significant correlation between increased number of service contracts in a district and improved functionality of community handpumps. This also translates into improved community water level of service.

Water quality and economic implications related to bottled water reliance in rural West Virginia
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Background:
An increasing number of Americans are opting for more expensive and less regulated commercial water sources. In 2020, over 15 billion gallons of bottled water was purchased in the US, costing approximately $36.3 billion. Perceptions of poor water quality and/or distrust in public water authorities often drive bottled water purchase and consumption. For some communities, these perceptions are valid: a recent examination of Safe Drinking Water Act (SDWA) violation data demonstrates that rural low-income and minority communities are significantly more likely to be burdened with unavailable and/or unsafe in-home drinking water. There is therefore increasing concern that traditionally disadvantaged populations are bearing greater and poorly characterized economic and health impacts associated with bottled water reliance.

Objectives:
This study aims to 1) quantify traditional markers of water quality (fecal indicator bacteria, nutrients, metals) and emerging contaminants (PFAS species) present in in-home sources, roadside springs, and locally purchased bottled water in an Appalachian county; 2) compare drinking water quality to SDWA standards and guidelines; 3) characterize typical water usage patterns between sources; and 4) assess water affordability by creating models that consider the direct consumer costs (e.g. purchase, transportation) and indirect costs (e.g. environmental, health) associated with different sources. Methods: Fifteen households were recruited via community partnerships in McDowell County, WV, where nearly one-third of households live below the poverty line. All participants completed a survey detailing use, perceptions, motivations, and expenditures (both time and money) related to in-home piped, bottled water, and roadside spring use, if applicable. Fourteen in-home, eighteen bottled water (six brands), and four roadside spring samples were analyzed for the aforementioned contaminants via Standard Methods.

Results:
Nearly 75% of survey respondents rely exclusively on bottled water as their primary drinking water source. Unsurprisingly, in-home sample water quality was poor: 79% of point-of-use samples were coliform positive, 36% were E. coli positive, 29% exceeded aesthetic guidelines for iron, and 50% exceeded the health guideline for sodium. PFAS species were detected in 86% of home samples (maximum total PFAS concentration of 7.32 ppt). All roadside spring samples were coliform positive, and one spring contained detectable PFAS. Bottled water samples did not exceed any EPA MCLs, SMCLs, Health Reference Levels, or Health Advisories other than pH (83% of samples below 6.5). However, households that primarily drink bottled water are spending, on average, 8% of their median household income on bottled water purchases alone. Further, for those who rely on multiple sources (e.g. springs, municipal, bottled), the associated economic burden comprises approximately 25% of their median household income, which greatly exceeds the EPA's water affordability standard of 2%.

Conclusion:
Although bottled water reliance is associated with very large direct economic and time costs in McDowell County, it is not surprising that residents do not consume in-home water, given very high rates of health-related and aesthetic contaminants. Similar data collection efforts, including household surveys and paired water quality analysis, are planned for Charles City County, Virginia and eastern Kentucky in summer 2023.

Water quality and economic implications related to bottled water reliance in rural West Virginia
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Background:
 Global policies, driven by UN Sustainable Development Goals, have led to an increased focus on implementation of piped water systems in rural communities. Currently, India is one such country that is rapidly implementing piped-to-premise water supplies at a staggering rate of 55,000 new connections per day to meet a national goal of providing every household with a tap by 2024. The Government of India seeks to improve access to water by providing equitable water supply that sustainably provides long-term drinking water security [1]. However, we do not yet understand if implementing a piped system will increase availability of water in all communities, especially those with intermittent water supplies (networks which provide water for less than 24 hours per day). Given the significant ongoing and proposed financial and political investments in piped systems in India and across the Global South, it is critical that we advance our understanding of the implications for water access and availability to facilitate informed and equitable decision-making.

Methods:
The Indian government tracks the number of household water taps installed, but we have found this data is inaccurate and insufficient for ensuring equitable access to water has increased. To more fully understand how piped-to-premise interventions result in increased access and equity in water supply and

the subsequent impacts on water security, it is imperative to learn from the lived experiences of water drawers. Therefore, the objective of this research centers on water user's experiences and interactions with water supplies and ultimately seeks to understand how piped water systems actually affect user's access to water. As such, semi-structured interviews and focus group discussions were conducted in six hamlets in eastern Gujarat, India, which are at different stages of the transition from non-piped to piped water systems. Within these six hamlets, approximately one hundred water users participated in the interviews and focus groups.

Results:
Thematic analysis of interview and focus group discussions showed that relying on a single water source is insufficient, even if that source is a new piped water system. All users reported that local piped systems operated intermittently, and all users reported using household storage containers to mitigate water availability issues. In addition, water supply intermittency is exacerbated by poor connections to the electrical grid, reducing the run time of well pumps. Frequent power outages resulted in continued reliance on non-piped water sources, which undermined the success of new piped water systems.

Conclusion:
Our findings emphasize understanding user's experiences as a key element to ensuring new piped water systems meet the goals of global and national policies driving piped water infrastructure. Global goals uphold piped systems as ideal (the top rung of the service ladder) – yet the world's most dramatic expansion of piped systems to date has left users severely wanting. More work is needed to understand where and how rural piped systems can be relied upon to benefit users. [1] Government of India. "Operational Guidelines for the Implementation of Jal Jeevan Mission," December 2019.

The impact of the Mini-PASS system on water security, sanitation, and health in unpiped rural Alaskan homes
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Background:
Over 3,000 households in Alaska lack piped water and wastewater systems, primarily within remote Alaska Native (AN) communities. Residents experience a higher incidence of acute respiratory illnesses and skin infections, likely due to inadequate access to water and sanitation services. Households often self-haul limited quantities of water, leading many to reuse water in handwash basins. Many households use 5-gallon buckets as toilets ("honey buckets") and self-haul sewage to the dump, likely exposing themselves to fecal-borne pathogens. The development of the Mini-PASS system was spurred by the need for better hygiene during the COVID-19 pandemic. A collaboration between tribal health organizations, community representatives, ANTHC, Centers for Disease Control and Prevention (CDC), CDC Foundation and Silverline led to 100 systems being installed by November 2021. The system includes two components: a handwashing station (HWS), which includes a gravity fed sink that allows users to wash their hands in clean, flowing water, and a vented honey bucket (VHB), which works to pull odors out of the home.

Methods:
To investigate the effectiveness and acceptability of the Mini-PASS system, we performed pre- and post-semi-structured interviews with households. The first data collection phase included baseline data gathered prior to installation, and at intervals (3, 6-9 and 12+ months) post installation. 145 interviews were conducted in 2021 and 2022, representing all communities in which the system was installed. A second data collection phase occurred with the same communities and four additional communities in Spring 2023. Interview questions explored the topics of water quantity and source, hand washing, behavior change, childhood health symptoms, household acceptability and user assessment.

Results:

The following represents preliminary results from the first out of two data collection phases: A majority of households reported that the HWS increased feelings of health and cleanliness. Households described health-related behavioral changes (reduced use of wash basins and an increase in handwashing with running water, personal hygiene and household cleaning). Some households believed that the HWS led to reduced illness, and less worry about hauling or running out of water. A majority of households reported the VHB feeling healthier and cleaner than their previous toilet due to a reduction in odor. Households reported feelings of increased safety especially among children and elders, comfort, convenience and mental health. Some households utilized the VHB fan to clear smoke from the house and improve indoor air quality.

Conclusion:
Initial analysis indicates that the Mini-PASS unit appears to be accepted and valued by a large majority of households interviewed and seems to be contributing to improved quality of life. The analysis of data from the second phase of data collection (114 household interviews) is underway and will be completed by August 2023. This data will provide insights about the appropriateness, acceptability, sustainability, and health and quality of life impacts of the Mini-PASS system. The results of this study will inform the broader community about the potential benefits of an affordable, responsive, transitional solution for communities that lack piped water and sewer. Key Learning Objectives 1). Describe how the Mini-PASS has affected individual and community health 2). Explain the impact of Mini-PASS on overall quality of life 3). Identify issues with the Mini-PASS system design 4.) Describe the impact the Mini-PASS had on water security

Optimizing sample collection and data interpretation for effective wastewater-based epidemiology in combined sewer systems
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COVID-19 has spurred growth in the science surrounding wastewater-based epidemiology (WBE) pertaining to the detection of severe acute respiratory virus 2 (SARS-CoV-2) in waste streams as an early warning signal for public health. However, the highly variable wastewater environment has made it difficult to standardize an approach for sampling and analysis, especially in locations using combined sewer infrastructure. This study addresses knowledge gaps of WBE via three specific aims: (1) to compare diurnal fluctuations of SARS-CoV-2 and the human fecal indicator, pepper mild mottle virus (PMMoV) in wastewater treatment plant (WWTP) influent samples collected during dry versus wet weather conditions; (2) to assess accuracy of grab versus 24-hour composite samples collected under variable flow conditions; and (3) to examine changes in wastewater influent composition associated with rainfall derived inflow and infiltration (RDII) and impacts to SARS-CoV-2 and PMMoV abundance. Using droplet digital polymerase chain reaction (ddPCR), both SARS-CoV-2 and PMMoV were quantified hourly at two WWTPs in West Virginia during three wet and three dry weather events. A parallel configuration of two automated samplers was deployed at each WWTP to collect: (a) 24 grab samples, collected hourly, and (b) an equivalent 24-hour composite. Wastewater physiochemistry metadata (chemical oxygen demand, ammonia, conductivity, total suspended solids, turbidity, pH, temperature, and influent flow) was also collected. Results provided evidence of the influence of site-specific factors on viral abundance, including the potential role of septage haulers in skewed viral RNA abundance and RDII as a driver of overall viral concentrations. Significantly lower concentrations of SARS-CoV-2 were observed during wet weather days at both WWTPs (Mann Whitney U, $p<0.001$). On dry days, composite concentrations of SARS-CoV-2 ranged from 81% less than to 190% greater than the median hourly concentration, while results from wet weather days were more variable, ranging from 29% less than to 1,372% greater than the median hourly concentration, indicating potential flushing of viral RNA and dilution of grab samples to a point of near non-detection. Several physiochemical parameters showed significant positive correlations to viral RNA concentration regardless of dry or wet weather (Spearman's rank, $p<0.01$), but consistency of observations was not preserved between both WWTPs, suggesting site-specific factors such as infiltration rate and community infection prevalence play a crucial role in determining viral presence and abundance in combined sewer WBE samples. Collectively, this study identifies crucial determinants for WBE sample collection and data validation within combined sewer systems to enhance accuracy in

reporting, inform local public health intervention, and mitigate the spread of infectious disease across communities.

Human Fecal Contamination of Household Drinking Water and Soil and Enteric Pathogens in Child Stool

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Recent household water, sanitation, and hygiene (WASH) interventions have shown inconsistent effects on child health and modest impacts on fecal contamination, suggesting the household WASH interventions did not prevent environmental exposure to enteric pathogens. Environmental exposure is often assessed using indicator organisms but relationships between fecal indicators and exposure to specific pathogens remain poorly characterized. We investigated whether E. coli and two human fecal markers (HF183 and Mnif) measured by quantitative polymerase chain reaction (qPCR) in urban Mozambican household soil and drinking water were associated with detection in child stool of eight bacteria, three viruses, and three protozoa measured by multiplex reverse-transcription PCR and soil transmitted helminths (STH) assessed by microscopy. For each sample matrix and indicator, we used Bayesian multilevel logistic regression with pathogen-varying intercepts and slopes to obtain a pooled estimate of the overall indicator-pathogen relationship while simultaneously estimating pathogen-specific associations with adaptive shrinkage. At least one pathogen was detected in 86% (173/201) of child stools, most frequently Shigella (51%), Giardia (50%), and Trichuris (43%); norovirus GI/GII was the most common virus (14%). Increasing E. coli concentrations in drinking water were associated with elevated stool pathogen prevalence (pooled OR: 1.32, 95% CI: 0.99, 1.73), though significant only for Ascaris (OR: 1.7; 95% CI: 1.1, 3.1). The odds of detecting Shigella (OR: 0.46; 95% CI: 0.16, 0.91) or Giardia (OR: 0.53; 95% CI: 0.21, 0.99) in stool were lower when human marker HF183 was detected in drinking water. No fecal indicator in soil was clearly associated with any pathogen, although the odds of Campylobacter were suggestively elevated for soils with detectable HF183 (OR: 2.1; 95% CI: 0.96, 4.1). We did not find evidence to support human markers as reliable indicators of enteric pathogen carriage in a high-prevalence domestic setting. Future efforts to characterize environmental exposure pathways should prioritize direct pathogen assessment, which may offer richer, more relevant insights and be more responsive to WASH conditions.

Key learning objectives for this presentation include introducing a novel statistical approach that enables joint analysis of multiple study outcomes, an increasingly common situation as multi-target molecular panels are more widely adopted, and examining the potential and challenges of microbial source tracking for environmental exposure assessment, particularly in domestic contexts.

Strategies to control antimicrobial resistance in WWTPs effluent from municipal, hospital, and domestic wastewater: systematic review

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Background:
The increasing prevalence of antimicrobial resistance (AMR) in the environment has become a significant global public health threat. Untreated wastewater is an important reservoir of antibiotic-resistant bacteria (ARB), antibiotic resistance genes (ARGs) and antibiotic residues since it contains various inputs from different sources such as humans, animals and environments. The wastewater treatment plants (WWTP) plays a crucial role in disseminating ARB, ARG and antibiotic residues before releasing treated wastewater into the environment. There has been an increase in AMR research in WWTPs in recent years; however, there has been a lack of synthesis of evidence on the effective treatment methods for removing antibiotics residues, ARGs, and ARB from the effluent of WWTPs receiving municipal, domestic and hospital (MDH) discharge. Therefore, our systematic review aimed to compare the effectiveness of different conventional and new wastewater treatment methods by determining their removal rate of ARGs

and ARB in the treated effluent and to evaluate the concentration, prevalence and kinds of antibiotics residues removed in effluent from WWTPs receiving wastewater from various sources. Additionally, we aimed to determine if wastewater treatment processes in WWTPs facilitate the selection of ARB despite a significant decrease in the total number of bacteria.

Method:
We systematically searched Ovid Medline, Ovid Embase, Web of Science, World Health Organization Global Index Medicus (WHO GIM), ProQuest Environmental Science collection and Trove databases for peer-reviewed English articles published between January 1, 2000, and December 15, 2020. Two reviewers individually screened the titles and abstracts, conducted data extraction and evaluated the risk of bias. Corresponding authors were contacted when additional data were required. The meta-analysis of the removal rate was performed using R software. A random-effect model was used to calculate the pooled removal rate with 95% confidence intervals due to the significant heterogeneity. Our review protocol has been previously published.

Result:
The search resulted in 6925 articles. After duplication was removed, 124 full-text articles were assessed for eligibility, with 34 articles meeting our inclusion criteria. Most WWTPs were conventional, and eight conventional WWTPs had added new methods. Despite the heterogeneity in published results, the pooled removal rate of ARB and ARG from conventional WWTP using secondary treatment-activated sludge (STAS) was 66.09% and 26.13%, respectively. The removal rates of ARB and ARG increased significantly (87.49 and 93.90%, accordingly) in WWTPs using the tertiary treatment and secondary treatment with anaerobic digestion compared to WWTP using only STAS. Moreover, conventional treatment with the new method (e.g. ultraviolet radiation) showed better removal of ARB and ARGS; however, the result is mixed for antibiotic residues. Regarding the selection of ARB, only three studies mentioned selective pressure. WWTPs treat processes and cell carrying resistance genes may cause selective pressure rise.

Conclusion:
ARGs were poorly removed by the conventional treatment method while adding a new treatment method with conventional treatment showed a better removal rate of ARB, ARGs and antibiotics. However, none of the treatment methods was shown to completely remove ARB, ARGs and antibiotic residues from wastewater.

Exploring the use of Next-Generation-Sequencing for Characterizing Environmental Transmission of Antimicrobial Resistance
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The emergence of antimicrobial resistant (AMR) bacteria has been identified as one of the principal public health threats of the 21st century, with the environment being identified as a potential pathway for transmission to humans, though the extent of this is still unknown. Escherichia coli has a high rate of resistance, with Extended-Spectrum Beta-Lactamase (ESBL)-producing E. coli classified by the World Health Organization (WHO) as a public health threat requiring action. Environmental surveillance is considered essential to combat the rise of antibiotic resistance, requiring new tools to detect and characterize antibiotic resistant pathogens, including ESBL-producing E. coli.

Whole genome sequencing (WGS) is useful for epidemiological surveillance, but its application depends on the type of sample being analyzed. Sequencing a single isolate yields deep coverage but limited genomic information on the environment sampled, while metagenomic sequencing can provide a more comprehensive view of an environmental sample's resistome but requires standardization and validation. Additionally, metagenomic sequencing may lead to high representation of irrelevant pathogens and is rarely able to provide strain-level detail. An alternative to these two methods is to sequence a culture that contains various microorganisms. In this study, we developed a new approach for sequencing a mixed culture. This method provides more context than single isolate sequencing and more relevant details than

metagenomic sequencing.

We collected wastewater influent from two municipalities located in Wake County, North Carolina and used the modified-IDEXX assay to culture presumptive ESBL-producing E. coli and total coliforms. We subsequently extracted DNA from a sample of the culture and performed whole genome sequencing on the Oxford Nanopore Technology (ONT) MinION device.

Our objective is to analyze the data generated from these experiments to investigate the characteristics of ESBL-producing E. coli in wastewater influent. Specifically, we aim to determine the strain type, virulence type, plasmid types, resistance mechanisms, and ascertain whether novel resistant genes are acquired within the environment. Preliminary findings indicate that this methodology enables the identification of various bacterial species present in a sample and the detection of antibiotic resistance genes and their associated hosts. Taxonomic analysis revealed that the most prominent specie present was E. coli, followed by various Pseudomonas species, Klebsiella Pneumoniae, and more. Through antibiotic resistance profiling, we were able to detect numerous clinically relevant antibiotic resistant genes. For example, the CTX-M-15 gene and CMY-59 genes were detected on various E. coli strains and TEM-4 was detected on Klebsiella Pneumoniae. This data serves as proof of concept of this novel approach. Additionally, this method exhibits promise for use in low- and middle- income countries, enabling rapid identification and characterization of ESBL-producing E. coli in real-time. The modified IDEXX assay requires minimal equipment, and the nanopore is exceedingly portable and easily powered via laptop connectivity. We intend to apply this method in Tanzania soon to investigate the transmission pathway of ESBL-producing E. coli.

Effects of weather extremes on fecal contamination along pathogen transmission pathways in rural Bangladeshi households.
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Background:
Climate change is predicted to influence human exposure to pathogens but the effects of increasing rainfall and temperature on fecal-oral transmission through specific pathways has not been well investigated.

Methods:
We evaluated the effect of extreme rain, extreme temperature, and heatwaves during different antecedent periods (0-14 days) on *E. coli* measured along various fecal transmission pathways in rural Bangladeshi households. *E. coli* was enumerated in samples of mother and child hand rinses, food, stored drinking water, tubewell water, flies, ponds, and courtyard soil using IDEXX Quanti-Tray/2000 in nine rounds over 3.5 years (n=26,659 samples). Daily rainfall and temperature data were obtained from the National Oceanic and Atmospheric Administration (NOAA) and National Aeronautics and Space Administration (NASA) and spatiotemporally matched to the *E. coli* data. Extreme rain was defined as >90th percentile of daily rainfall values, extreme temperature as >90th percentile of daily temperature values and a heatwave as three consecutive days >95th percentile of daily temperature values during the study period. We used generalized linear models (GLM) with a negative binomial error distribution and robust standard errors to estimate *E. coli* count ratios (ECRs) associated with these weather variables for each sample type.

Results:
In analyses controlling for temperature, extreme rain on the day of sampling was associated with 2 to 4-fold higher *E. coli* counts in ponds (ECR=4.01 (2.59, 6.23), p<0.0005), stored water (ECR=1.94 (1.34, 2.80), p<0.0005) and food (ECR=3.20 (1.68, 6.08), p<0.0005) and lower *E. coli* counts in soil (ECR=0.36 (0.25, 0.53), p<0.0005) and flies (ECR=0.06 (0.02, 0.18), p<0.0005) compared to no rain. Effects were

similar when rainfall occurred 1-2 and 7 days before sampling and slightly attenuated when it occurred 14 days before sampling. Controlling for rainfall, extreme temperature on the day of sampling was associated with 1.5 to 3-fold higher *E. coli* counts in stored water (ECR=1.48 (1.05, 2.10), p=0.024) and food (ECR=2.91 (1.46, 5.80), p<0.0005) and lower *E. coli* counts in ponds (ECR=0.29 (0.11, 0.79), p=0.016), source water (ECR=0.04 (0.01, 0.10), p<0.0005) and flies (ECR=0.14 (0.03, 0.79), p=0.026) compared to days with no extreme temperature. Heatwaves in the 7 or 14 days before sampling were associated with lower *E. coli* counts in soil. There was no consistent association between rainfall or temperature and *E. coli* on hands.

Conclusion:
In rural Bangladesh, stored drinking water, food, tubewell water, soil, ponds, and flies were the fecal transmission pathways most affected by weather-related factors. As rainfall intensity and temperatures increase with global climate change, measures to control enteric infections in this setting should focus on reducing contamination of drinking water and food stored at home and reducing exposure to contaminated surface waters following weather extremes.

Financing climate adaptation of urban sanitation and equity
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Additional Authors: Zhe Zhan, Katy Roelich, Anna Mdee, Barbara Evans

Background:
Rendering urban sanitation systems resilient to changing climate conditions will require substantial investments. Many cities in high- While many high-income countries have century-old dilapidated sewerage infrastructure, low- and middle-income countries often struggle with substantial gaps in sanitation access, service quality, and funding. Initial optimism that climate finance through the multilateral climate funds would partially close the funding gap for sanitation in LMICs has been disappointed so far.

To date, research has paid little attention to analysing potential financing approaches for adapting sanitation systems, and there is growing concern that resilience measures may reinforce existing sanitation inequalities within cities. Drawing on work on financing and financialisation of urban (wastewater) infrastructure adaptation, our research examines the funding realities of past and ongoing projects for adapting urban sanitation systems to climate change aiming to answer the question: How equitable are past and ongoing investments aiming at adapting urban sanitation systems to climate change?

Method:
We used a combination of cross-case document analysis and seven key informant interviews with ten representatives of funding agencies, utilities, and municipalities to assess sanitation adaptation funding arrangements in eight cities and investigate their consideration of social and intergenerational equity. The document review and analysis of interview transcripts were based on deductive and inductive thematic analysis. Our iterative approach to selecting the case studies aimed to cover a breadth of adaptation measures from different geographic and socio-economic contexts, covering all components of the sanitation chain, sewered and non-sewered, and showcasing diverse approaches to financing sanitation adaptation investments.

Results:
Investing in sanitation systems always serves multiple purposes and results in multi-faceted benefits. Climate-resilient sanitation is paid for by the traditional sources of sanitation funding: tariffs, taxes, transfers and household investments. Debt-financing of sanitation adaptation often relies on repayment through customer bills with only opaque considerations of the affordability for different socio-economic customer groups. The lack of appropriate accounting for the lifecycle costs of resilient infrastructure threatens to mortgage future generations. Current approaches to 'greening' of adaptation financing neither shift nor redistribute the financial risk more equitably, nor do they make the repayment of the investments substantially cheaper for customers.

Conclusion:
The selected cases illustrate how climate change adaptation adds another layer of complexity and uncertainty to sustainable urban sanitation planning, adding to the costs of ensuring effective system operation. While establishing the marginal costs of adaptation of urban sanitation is challenging, we believe it could result in misinterpreting communities' right to have effective sanitation systems as a 'negotiable add-on.' Privately funded initiatives for equitable climate adaptation seem inappropriate, and public funds (taxes and transfers) are the most appropriate funding source to account for the social and intergenerational equity within climate-resilient sanitation systems

An ex-post evaluation examining sustainability of outcomes in the Chivi WASH program Zimbabwe
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Purpose:
The goal of ex-post evaluation was to understand community and household sanitation characteristics that were maintained 4 years after completion of the Chivi WASH project (CHW) in Zimbabwe. Many projects conduct baseline and endline analysis. This project additionally collected data in the intervention and control areas 4 years after the close of the intervention. One of the main reasons for this ex-post analysis is that the CWP achieved great levels of open defecation free (ODF) communities before closing in 2017. The ex-post was conducted to see if these ODF rates were maintained and reasons why they were or were not.

Study Design & Research Questions:
Data used in this analysis were collected in February and March 2021. The Chivi WASH Project (CWP) was implemented in Chivi North district, a rural area of Zimbabwe, between 2014 and 2017 with the goal of increasing equitable and sustainable access to safe water and use of sanitation. 2021 data collection took place within ten wards of the Chivi district and encompassed 49 stakeholder interviews and 315 household questionnaires. Households were randomly selected from the intervention communities. Analysis firstly looked at sustained ODF status and household latrine coverage (and reported used). Secondly analysis looked at the effects of perception of gender (a score of how the survey respondent answered certain questions on women and girls), community factors, toilet safety and distance, materials and latrine-construction funding source. Additionally, we evaluated associated community and household level factors on handwashing practices at critical times.

Key Findings:
In 2021 93% of HHs surveyed had a latrine – down from 97% at endline in 2017. However, according to records of the local government 26% of communities that were ODF in 2017 were still ODF in 2021. A household's wealth index was significantly associated with whether or not they had a latrine. A household head who is male was also significantly associated with having a latrine. Survey participants with a latrine (improved toilet facility or pit latrine) were more likely to practice good hand hygiene than those without. Regardless of materials used, latrines with an exterior structure prove to have a stronger effect on sustaining ODF status. Latrines with earth/sand floors and thatch roofs show to have the highest odds of ODF status being sustained. Although not statistically significant, houses with latrines within 10 meters of the household were more likely to have and use their latrine. There was also a significant association between HH latrine use and perceptions of safety. The odds of HH latrine use were 9.44 times higher among respondents reporting "feeling safe" when toileting at night compared to respondents who do not feel safe. HHs that reported having a gender-separate area for toileting 68 had 20.72 times higher odds of HH latrine use than HHs without. Lastly, there was a positive association between HH latrine use and access to an improved water source.

Discussion of findings inform policy or practice:
We recommend having toilets located within 10 meters of the household which our results indicate will increase the sustainability of ODF status. Additionally, expanding access to latrine-related loans or

increasing households access to additional funding through Village Savings and Loans groups – can help with latrine purchase. While these findings are not necessarily new to the sector, it is important to note that ODF can be maintained in communities when the program advances gender equality, increases the labor-pool for latrine masons and has a reliable water source.

★ **Understanding the cost of improved manual pit-latrine emptying and transport services**
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Additional Authors: Yvonne Lugali, Jullita Chinseu, Carlos Batarda, Jamie Bartram and Barbara Evans

Globally 1.3 billion people in cities use on-site sanitation systems and in Sub-Saharan Africa 62% are using pit-latrines. Emptying is generally done by informal businesses who dangerously dispose of sludge nearby. Improving services so they are safely-managed, hygienic and licensed is required for household, worker, community and environmental health and dignity. But this increases costs making services unaffordable to many households using these systems. Sanitation is a public service, and city authorities need better cost information to inform budgeting and planning.

Several studies have analysed improved manual pit-latrine emptying costs based on data from single businesses, whilst others have analysed mechanical emptying, informal manual emptying or used the tariff as an approximation of cost. No studies have analysed service cost using data from multiple businesses.

The study objective is to increase understanding of improved manual pit-latrine emptying and transport service delivery cost for low-income households in informal settlements. We use the concept of Total Annualised Cost per Household (TACH) to support city budgetary planning and reports costs using 2018 international dollars (Int$) to improve cross-country comparison. TACH is modelled using secondary data shared by Water For People from Kampala, Uganda and Blantyre, Malawi from 23 businesses. Recognising the limitations of self-reported operational and financial estimates provided by businesses: qualitative analysis is used to review cost data and determine model inputs, TACH is modelled analytically, and sensitivity analysis is used to evaluate the influence of model inputs and structure. TACH is calculated based on a business completing 700 emptying jobs per year.

Businesses report diversity in both operating variables and unit costs: scale, emptying volumes, labour wage and structure, vehicle type and ownership, referral payment, advertising, and management. The basic model TACH is 51 Int$ where emptying labour (44%), transport (17%) and fuel (10%), referrals (8%) and management salaries (8%) are the largest costs. Sensitivity analysis on the basic model finds that TACH is minimised more by efficiently using resources than by increasing the number of teams and jobs, mostly because unit labour costs do not reduce with scale. Household emptying volume and frequency strongly influence TACH: doubling volume reduces TACH 23%, and doubling frequency increases TACH 56%. Financing vehicle purchase is more cost effective than renting vehicles during the loan repayment period if businesses are doing more than four jobs per week.

Results are consistent with other studies after accounting for differences in the modelling approach. Results are also consistent with finding manual emptying to be more costly than mechanical emptying. Three variables drive cost: emptying frequency, emptying labour and operating efficiency. Labour is linked to the nature of manual emptying and more efficient emptying equipment could reduce costs and also improve emptying hygiene. But no technological breakthroughs have been achieved despite prolonged efforts. Investing in household systems that can be more easily accessed and emptied can reduce TACH.

This study can improve understanding and increase confidence for city authorities. Market-based service systems promote different operating models but this limits citywide cost efficiency. Further research is required to determine if city authorities should encourage a competitive market of small businesses or larger scale cost-efficient businesses.

Process Evaluation for the Delivery of a Water, Sanitation and Hygiene Mobile Health Program in the Democratic Republic of the Congo: Preventive Intervention for Cholera for 7 days (PICHA7) Program

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In the Democratic Republic of the Congo (DRC) there are estimated to be 85 million diarrhea episodes annually. Effective and scalable water, sanitation, and hygiene (WASH) interventions are needed to reduce diarrheal diseases globally. Phone-based reminders of public health information have been shown to reduce disease morbidity and increase health-protective behaviors. The objective of the Preventive Intervention for Cholera for 7 Days (PICHA7) program is to develop evidence-based WASH interventions to reduce cholera and other severe diarrheal diseases in DRC. The PICHA7 mobile health (mHealth) program delivers weekly voice, text, and interactive voice response (IVR) messages to diarrhea patient households promoting handwashing with soap and water treatment and safe water storage. The randomized pilot of the PICHA7 program demonstrated this intervention was effective in increasing handwashing with soap and water treatment behaviors during the three-month program period compared to the standard message given in DRC on the use of oral rehydration solution for rehydration. The objective of this study was to assess the implementation of the PICHA7 mHealth program during this randomized pilot to determine the feasibility of delivering this program in urban eastern DRC. This study was conducted in Bukavu in South Kivu province in eastern DRC. Three hundred fifty-six participants were in households that received weekly text, voice and IVR messages from the PICHA7 mHealth program over the 3-month program pilot. Outcome indicators included unique text, voice, and IVR messages received (fidelity) and % of unique messages fully listened to (dose). Eighty three percent of text messages were received by program households. Eighty seven percent of voice and 88% of IVR messages sent were answered by at least one household member. Ninety percent of voice messages were fully listened to, and 62% of IVR messages. These findings have shown high fidelity and dose of mobile messages delivered for the PICHA7 mHealth program, demonstrating the feasibility of delivering the PICHA7 mHealth program in our study setting in eastern DRC.

Can WASH/Nutritional Interventions Reduce Antibiotic Use: Evidence from Cluster-Randomized Controlled Trials in Bangladesh and Kenya

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Background:
Children in low- and middle-income countries experience a high burden of diarrheal and respiratory infections and frequently use antibiotics, which can lead to antimicrobial resistance. Improving water, sanitation and hygiene conditions and children's nutritional status can potentially reduce infections and antibiotic use by reducing children's exposure to pathogens and improving their immunity, respectively.

Methods:
We utilized data from two cluster-randomized controlled trials of water, sanitation, handwashing (WSH) and nutrition interventions in rural Bangladesh (Gazipur, Mymensingh, Tangail, Kishoreganj districts) and Kenya (Kakamega, Bungoma, Vihiga counties) to assess intervention effects on antibiotic use in a birth cohort. The interventions reduced diarrhea and respiratory infections in Bangladesh but not in Kenya. We recorded caregiver-reported antibiotic use in longitudinal household visits when the birth cohort was on

average 3, 14 and 28 months old in Bangladesh (n=4158 child observations) and 6, 17 and 22 months old in Kenya (n=4280 child observations). In each country, we compared children receiving WSH, nutrition and nutrition plus WSH (N+WSH) interventions to control children receiving no intervention using pooled data from all three timepoints, with subgroup analyses by child age and sex.

Results: In Bangladesh, 63% of children in the control group had used antibiotics at least once and 25% multiple times in the last 90 days. In Kenya, 53% of children in the control group had used antibiotics at least once and 13% multiple times in the last 90 days. All interventions reduced antibiotic use in Bangladesh. Compared to controls, the percent of children who used antibiotics at least once was 10-14% (6-9 percentage points) lower among children in the intervention arms (WSH arm prevalence ratio [PR]=0.90, 95% CI: 0.82-0.99, p=0.03, nutrition arm PR=0.84, 95% CI: 0.76-0.92, p<0.001, N+WSH arm PR=0.86, 95% CI: 0.78-0.93, p<0.001). The percent of children who used antibiotics multiple times was 26-35% (6-9 percentage points) lower in all intervention arms than controls. Intervention effects appeared strongest among the youngest age group and similar for girls and boys. In Kenya, none of the interventions reduced antibiotic use.

Discussion: The observed intervention effects on antibiotic use are internally consistent with previously reported effects (or lack thereof) on diarrhea and respiratory infections in the WASH Benefits Bangladesh and Kenya trials, supporting a causal mechanism. Our findings suggest that interventions to improve water, sanitation and hygiene conditions and/or children's nutritional status can reduce pediatric antibiotic use in some settings in low- and middle-income countries and augment antibiotic stewardship strategies. Studies should assess whether any such reductions translate to reduced community carriage of antimicrobial resistance

★ **Improved child feces management mediates reductions in childhood diarrhea from an on-site sanitation intervention: causal mediation analysis of a cluster-randomized trial in rural Bangladesh**
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Background:
The WASH Benefits Bangladesh trial implemented a multi-component sanitation intervention that led to a sustained reduction in the prevalence of diarrheal disease among children under five. Intervention components included latrine construction or upgrades, provision of potties and sani-scoops for managing child and animal feces, and frequent in-home behavioral promotion led by local promoters. It remains unclear which of these components contributed to reduced diarrheal disease.

Methods:
We conducted a causal mediation analysis to assess the specific mechanisms for the intervention's effects on diarrhea within a subset of participating households (n = 720) that were visited eight times over 2.5 years for mediator and outcome assessment. Potential mediator variables were selected from three categories: i) latrine quality indicators, ii) latrine use practices, and iii) feces management practices. Potential mediators were analyzed using a counterfactual-based framework for causal mediation analysis. Mediation effects were assessed separately during monsoon and dry seasons. We estimated the average causal mediation effect (ACME) for each mediator, defined as the intervention's effect on diarrheal disease that was caused by the intervention's effect on the mediator of interest and the mediator's subsequent effect on diarrheal disease. Mediators were assessed individually in separate models, except for latrine use practices, which were modeled as causally dependent on latrine quality indicators.

Results:
In total, we recorded 3,850 observations of children under five in monsoon seasons and 2,626 in dry seasons. During both monsoon and dry seasons, we found statistically significant mediation effects within two categories: latrine use practices and feces management practices. During dry seasons, effects were

also mediated through one latrine quality indicator: access to a flush/pour-flush latrine. The strongest specific mediators during monsoon seasons (overall intervention effect: prevalence difference (PD) = -4.5%) were reduced open defecation among children under three years old (ACME (PD) = -1.7%, 95% CI -4.4%, -0.3%), increased disposal of child feces into latrines (ACME = -1.5%, 95% CI -2.1%, -0.9%), and reduced open defecation among children aged 3-8 (ACME = -1.4%, 95% CI -2.5%, -0.5%). The strongest mediators during dry seasons (overall intervention effect: PD = -2.3%) were increased access to a flush/pour-flush latrine (ACME = 1.8%, 95% CI -2.9%, -0.8%), reduced open defecation among children aged 3-8 (ACME = -1.4%, 95% CI -2.7%, -0.2%), and increased disposal of child feces into latrines (ACME = -1.4%, 95% CI -2.1%, -0.6%). Collinearity between mediators due to their common influence by the intervention resulted in ACMEs that sum to values greater than overall effects.

Discussion:
The effect of the WASH Benefits Bangladesh sanitation intervention on diarrheal disease was mediated primarily through improved child feces management practices and reduced open defecation among children. Access to a flush or pour-flush facility was a significant mediator during the dry season only, suggesting seasonal differences in sanitation benefits. Although the intervention significantly improved latrine quality compared to controls, relatively high latrine quality at baseline may have limited the benefits of additional latrine improvements. Targeting safe child feces management may increase the health benefits of rural sanitation interventions.

Progress and opportunities: A review of menstrual health policy, service delivery and evidence in the East Asia and Pacific region
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Despite progress in the East Asia and Pacific (EAP) region, the menstrual health needs of millions of girls and women continue to go unmet. Those who menstruate face restrictions on their mobility, choices, and participation in school and community life.

To assess the progress in menstrual health-related policies, service delivery, and evidence base between 2016 and 2022, UNICEF, Burnet Institute and WaterAid carried out a review across 19 EAP countries. The review was the first to use the 2021 definition of menstrual health as a framework for comprehensive review, including the five defined needs: (1) access to information and education; (2) access to materials, facilities and services; (3) access to care for discomforts and disorders; (4) access to a supportive social environment; (5) non-discrimination and participation. Further, we leveraged the five 'building blocks' of the Sanitation and Water for All partnership as a novel approach to assess the enabling environment for menstrual health: policies and plans; institutional arrangements; financing; capacity; and planning, monitoring and review.

Methods included a desk review of health, gender equality, education, WASH, environment, and disaster-risk reduction policies from 19 countries. Stakeholders from 15 countries participated in an informant survey to document policy and programming, while over 50 key informant interviews provided perspectives on progress, enablers and barriers. Simultaneously, a systematic review of academic and grey literature detailed extant evidence for the effectiveness of interventions to support menstrual health. A regional advisory group provided feedback and input throughout the process and a workshop on key findings was a forum to reflect and share lessons.

We found that the most progress had been made in addressing two of the requirements for menstrual health: access to information and education on menstruation; and access to materials, facilities and services such as water, sanitation and hygiene. Significantly less progress was found for the other three requirements. In the enabling environment, most progress had been made on including menstrual health in WASH, education and health policies, strategies and guidelines. Lack of clear roles and responsibilities across different sectors and levels of government was a key bottleneck to policy implementation, and impeded the allocation of resources. The review suggests that policymakers and practitioners should give

greater attention to neglected menstrual health needs. Policies require clearer institutional arrangements, funding, and capacity building efforts to translate to better services for girls and women.

We identified limited monitoring and evaluation evidence. Eighteen eligible studies were included in the systematic review, with most evaluating the knowledge gains achieved by education interventions but failing to assess broader outcomes. Studies exhibited a high risk of bias without adequate controls, limitations in intervention allocation, adherence, and participant retention. There is insufficient evidence to establish the effectiveness of any menstrual health interventions in EAP. Rigorous evidence is urgently needed to understand the effects of menstrual health interventions, to refine policy and service delivery and to secure sustained funding for scaling up.

Effectiveness of the MEGAMBO intervention to improve menstrual health, and school-attendance among rural Gambian girls
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Introduction:
Menstrual health and hygiene is a recognised global public health challenge, and there is a lack of evidence to inform cost-effective and sustainable interventions to mitigate adverse effects on education. The MEGAMBO trial aims to assess whether a multi-component intervention addressing physical and emotional aspects of menstrual health improves school attendance, urogenital health, and other wellbeing outcomes among girls in secondary school in The Gambia.

Methods:
A cluster-randomised trial was conducted in 50 schools of the Lower River and North Bank regions of The Gambia to evaluate the effectiveness of a multicomponent menstrual health intervention, on education, health and wellbeing outcomes. The study was conducted between October 2019 and December 2020. Half the schools (25) were randomised to receive the intervention which comprised the following components: i) Peer education camps and menstrual hygiene laboratories in schools, ii) Mother's outreach sessions, iii) Community meetings and iv) improving school Water Sanitation and Hygiene (WASH) facilities. The other 25 schools did not receive any intervention and acted as controls. Primary outcome was prevalence of girls with at least one-day school absence during their last period; secondary outcomes included: Urinary Tract Infections (UTI) symptoms, biochemical markers of UTI in urine, Reproductive Tract Infection (RTI) symptoms, scales measuring menstruation-associated wellbeing, social support and knowledge, attitudes and practices towards menstruation and menstrual hygiene in target schoolgirls.

Results:
The outcome was assessed in 3556 schoolgirls (1724 control and 1832 intervention). Self-reported school absenteeism of at least one day during the last period was only slightly lower in the intervention arm than the control arm (15.6% vs 17.1%,95%CI=-4.6%-1.9%). Symptoms of RTI and UTI were high among all the girls (65% and 60%, respectively) but not statistical difference between control and intervention arms. Prevalence of UTI was slightly lower in the intervention than the control arm (12.4% vs 14.0%,95%CI=-7.0%-0.5%). The intervention had broad positive effects on self-reported menstrual knowledge, attitudes and practices. The mean number of correct responses to knowledge-based questions were 5.0 vs 5.9 (95%CI=0.6-1.1); mean number of positive attitudes were 3.2 vs 3.8 (95%CI=0.4-0.7) and mean number of positive practices were 1.6 vs 2.0 (95%CI=0.2-0.5). Menstrual-associated wellbeing factor score had almost 12 percentage points increase between control and intervention 27.1% vs 40.96% (95%CI=5.9%-17.4%). Similarly, a 10 percentage points increase between control and intervention was seen in the social support score 26.6% vs 37.5% (95%CI=6.3%-14.1%). Some moderate changes on WASH situation were observed in the intervention schools. Effect size for knowledge, attitudes and practices seemed to be larger in Arabic schools vs English schools. None of the other outcome measures were affected by school type, school size or village development rank.

Conclusion:
The multicomponent intervention package was associated with improved menstrual knowledge, attitudes and practices, and menstrual-related wellbeing and social support, but there was no association with reduced school absenteeism and urogenital health. Better methods to record school attendance need to be sought and future work is needed to optimise the intervention package so as to see a change in absenteeism.

Knowledge, attitudes, and support of women's menstrual experiences among men in Kampala, Uganda

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Background:
In low- and middle-income countries, women and girls frequently face barriers to adequate menstrual health and hygiene that are exacerbated by restrictive social norms. Research examining knowledge and attitudes toward menstruation has primarily targeted girls in school, with a growing focus on adult women. Limited information exists on the knowledge and attitudes of boys and men. However, men often make decisions for their households regarding healthcare access and expenditures such as purchasing menstrual materials or investing in making sanitation locations more menstruation-friendly. The objective of this research is to examine men's knowledge, attitudes, and support related to menstruation. During this session, we will present information on men's perspectives of menstruation, including attitudes about women discussing menstruation, participation in discussions about menstruation, and willingness to purchase or provide funding for menstrual materials for household members.

Methods:
We collected survey data from 344 men in Kampala, Uganda in April-May 2022 in neighborhoods purposively selected by Kampala Capital City Authority. Adult males were randomly sampled within neighborhoods. Survey questions captured demographics and attitudes related to menstruation-related speech. Men who reported living with a menstruating woman or girl were asked additional questions about their knowledge and attitudes towards the menstrual experiences of menstruators in their household and their support during menstruation. Descriptive statistics were calculated, and additional analyses will test associations between participant demographics and their levels of knowledge, attitudes, and support related to menstruation.

Results:
Out of the 344 men surveyed, 51.5% agreed that it is acceptable for women to discuss menstruation in front of men; fewer (31.2%) agreed that it is acceptable for women to discuss menstruation publicly. Among the 195 (56.7%) men who reported living with a woman or girl who menstruates, 81.0% reported providing money for women in their household to meet menstrual needs, and 71.8% felt comfortable expressing their opinions on menstruation-related sanitation issues. 40.1% of these men reported that they (the man) could have the final say on decisions related to making toilets female-friendly. In this session, we will present results of ongoing analyses.

Discussion:
This research contributes new evidence related to men's knowledge and attitudes on menstruation. Given gendered social norms and power structures, men's knowledge of menstrual issues faced by women, and their receptiveness to conversations about menstruation, can play an important role in women and girls' ability to communicate and meet their menstrual needs. Engaging with men may help to destigmatize and normalize discussions about menstruation. This presentation will identify potential levers or entry points through which programs could aim to engage men to build a supportive environment for menstrual health and hygiene in their communities and households.

Learning objectives:
Participants will gain an understanding of how men's attitudes toward menstruation can affect women's ability to manage menstruation and be able to identify specific knowledge or practices they can explore

for targeting men in their own contexts. This information can be utilized in programming to improve menstrual health outcomes for women, which should engage men and boys as actors in creating a supportive environment.

Menstrual Practice Needs Scale for the Workplace (MPNS-W): Validation and associations with key well-being outcomes

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Background:
Unmet menstruation-related needs are common among women in low- and middle-income settings, negatively affect physical and mental health, and reduced ability to participate in education and employment. While research on menstrual health (MH) has increased in recent years, the primary focus has been adolescent girls. Menstrual experiences of adult women, especially in the workplace, are understudied. The Menstrual Practice Needs Scale (MPNS) was originally validated among schoolgirls, then adapted and revalidated among adult women in Uganda. We further adapted the MPNS to focus on the workplace and refined items based on cognitive interviews. This study aimed to validate the adapted tool (MPNS-W) for measuring menstrual experiences in the workplace in two new country contexts and assess relationships between MPNS-W scores and well-being outcomes.

Methods:
Trained enumerators surveyed women from randomly sampled households in Nairobi, Kenya and Kathmandu, Nepal in September-October, 2021. The analytic sample (N=892; Kenya=565, Nepal=327) included women who reported changing and disposing of menstrual materials while working outside the home during their last menstrual period. We used exploratory and confirmatory factor analyses (EFA and CFA) to test validity and dimensionality of the MPNS-W and measurement invariance modeling to determine whether the tool performed equivalently across countries. Binary logistic regression and Pearson's correlation coefficients were used to assess hypothesized relationships of MPNS-W scores with psychological well-being (as measured by the WHO-5 Well-Being Scale), perceived self-efficacy to manage menstruation in the workplace, and work absenteeism.

Results:
The final EFA yielded a solution with good model fit and four factors: menstrual material satisfaction & access, disposal & changing environment, transport & storage, and menstrual material reliability. The CFA confirmed that the four-factor solution fit the data well (RMSEA=0.077; CFI=0.963; TLI=0.956); all items had strong (>0.6) and significant factor loadings. Tests of measurement invariance demonstrated that factor structures, factor loadings, and indicator intercepts were equivalent between countries. Total MPNS-W scores and subscale scores for menstrual material satisfaction & access and disposal & changing environment significantly predicted psychological well-being, menstruation-related self-efficacy, and work absenteeism.

Conclusions:
This study validates the MPNS-W and provides a revised factor structure consistent across Kenya and Nepal. The differences in factor structure between the MPNS and MPNS-W illuminate the unique experiences of menstruators in the workplace. Identified relationships demonstrate how workplace menstrual experiences impact well-being. This tool fills an important gap for research and practice: MPNS-W scores can be used to assess determinants (e.g., workplace social environment) and outcomes (e.g., economic empowerment) of MH and to inform, evaluate, and advocate for workplace interventions and policies.

Learning objectives:
Participants will be able to (1) describe how to utilize the easy-to-implement tool in their work, (2) understand the importance of measuring menstrual experiences in the workplace both for generating empirical evidence on this understudied population and for broadening the scope of outcomes evaluated

in existing MH programming, and (3) generate ideas for how psychometric methodologies can be used to facilitate more rigorous development of self-reported metrics in the WASH sector.

Effect of a Water, Sanitation, and Hygiene Program on Handwashing with Soap among Diarrhea Patients and Caregivers in Healthcare Facilities in The Democratic Republic of the Congo:A Randomized Pilot of the PICHA7 program

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Healthcare-acquired infections are a major problem in healthcare facility settings globally. The Democratic Republic of the Congo (DRC) has over 2 million diarrhea patients admitted to health facilities annually. Health facilities can be a high-risk environment for transmission of diarrheal diseases. The objective of the Preventive Intervention for Cholera for 7 Days (PICHA7) program is to develop evidence-based water, sanitation, and hygiene (WASH) interventions to reduce cholera and other severe diarrheal diseases in DRC. This study evaluated the effectiveness of PICHA7 program delivery in increasing handwashing with soap at stool/vomit and food related events in a healthcare facility setting among diarrhea patients and their attendants. A randomized pilot of the PICHA7 program was conducted among 284 participants from 27 health facilities from March 2020 to November 2021 in urban Bukavu in South Kivu Province of DRC. The 'Standard Message' Arm received the standard message given in DRC to diarrhea patients on the use of oral rehydration solution. The PICHA7 arm received the PICHA7 WASH pictorial communication module bedside to the diarrhea patient, and a soapy water bottle in the healthcare facility. Within 24 hours of intervention delivery, three-hour structured observation of handwashing practices at stool/vomit- and food-related events (key events) was conducted in healthcare facilities of diarrhea patients and their attendants. Compared to the Standard Message Arm, there was significantly more handwashing with soap at key events in the PICHA7 Arm (39% vs. 12 %) (Odds Ratio: 5.32; (95% Confidence Interval (CI): 2.00, 14.10). These findings demonstrate that delivery of the PICHA7 WASH pictorial communication module and provision of a soapy water bottle to diarrhea patients and their attendants presents a promising approach to increase handwashing with soap among this high-risk population in healthcare facilities in eastern DRC.

Adapting WASH Interventions for Primary Healthcare Facilities in Uganda: A Participatory Design Approach

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Over the past five years, primary healthcare facilities (PHCFs) in Kabarole district, Uganda, have increased their coverage of water, sanitation and hygiene (WASH) infrastructure and materials. To sustain these improvements, and protect patients and staff, systems are needed to promote proper management and maintenance of WASH infrastructure and corresponding WASH-related infection prevention and control (IPC) practices. We used a multi-step participatory process to design interventions for a pilot project, which intends to improve the management of environmental cleaning (EC), hand hygiene (HH) practices and operation and maintenance (O&M) of waterpoints at PHCFs in Uganda.

In December 2022, Infectious Diseases Institute convened a two-day intervention co-design workshop with representatives from the Kabarole District Health Office and the five pilot PHCFs. Participants shared experiences within project domains, reviewed approaches implemented elsewhere and came to a consensus on proposed interventions: 1) developing standard operating procedures (SOPs) and accompanying job aids for environmental cleaning and waterpoint O&M and, 2) implementing an interfacility hand hygiene competition.

Following the co-design workshop, a mixed-methods baseline assessment was conducted at the five facilities. This assessment included a survey with the HCF in-charge (director) and IPC focal person; observations of WASH infrastructure; in-depth interviews (clinical staff n=5, cleaning staff n=5), knowledge, attitude and practice surveys with cleaners and staff; focus groups discussions (FGDs) with patients and caregivers (n=5); and observations of clinical staff (n=11) HH and EC practices (n=10). Descriptive data analysis was conducted on quantitative and qualitative data to establish baseline conditions, measure the acceptability of the proposed interventions before participation (prospective acceptability) and inform proposed interventions.

At baseline, no facilities had EC SOPs that included 1) step-by-step techniques for specific tasks and 2) a schedule indicating task frequency. In-depth interviews with cleaners and healthcare workers (HCWs) with EC responsibilities found they supported utilizing job aids as reminders of best practices and thought this approach would be effective in improving cleaning practices, but also requested increased personal protective equipment.

During direct observation, HCWs performed appropriate HH (washing hands with water and soap or using alcohol-based handrub) at 54% (45/84) of observed opportunities. While 4 out of 5 facilities reported some form of HH monitoring, in interviews, few HCWs were aware of these activities. In interviews, HCWs shared that they believed the proposed competition would be effective and were eager to participate, the latter indicative of a positive affective attitude, an important component of acceptability.

In-depth interviews and FGDs revealed that piped water systems were well-managed, but there were concerns about the quality of water from rainwater harvesting tanks, which are secondary sources used widely for laundry processing, environmental cleaning and bathing. Consequently, the focus of the O&M intervention shifted to rainwater harvesting tanks.

This participatory design process generated intervention approaches with high prospective acceptability, particularly in perceived effectiveness and affective attitude. During the coming intervention phase, three and six-month follow up assessments will be conducted to measure changes in each domain and continued acceptability. Results will be used to refine interventions before being scaled up to additional facilities.

Assessment of infrastructure, behaviours and user satisfaction of Guardian Waiting Shelters at Southern Malawi hospitals
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Background:
In Malawi, Guardian Waiting Shelters (GWS) serve as temporary residential homes at healthcare facilities for essential caregivers (guardians) whose relatives have been admitted to hospital. Patient guardians can be short or long-term residents at GWS and use these facilities for sleeping, preparing meals for family members, and play an essential role in health service provision in low-resource contexts. Crowded and unsanitary conditions at the GWS may present significant risks for communicable disease transmission between guardians, patients, and the community. Our study explored environmental conditions and their consequences for guardians in healthcare facilities in Southern Malawi.

Methods:
A rapid assessment was conducted in 12 GWS at ten public and two private hospitals. The assessment examined GWS management structures, available infrastructure and services, and the behaviours and perceptions of stakeholders and guardians. A checklist (n=12) captured the general infrastructure of the GWS (e.g., latrines, water and handwashing facilities, cooking and sleeping areas). Key Informant Interviews were conducted with caretakers, hospital staff and Hospital Advisory Committee members (n=28). In-depth Interviews (n=72) and Focus Group Discussions (n=23) with guardians, explored issues of management, access and use of infrastructure and associated behaviours, plus general life at the GWS. Qualitative and quantitative methods were used to analyse the data.

Results:

GWS supported on average 100 patient guardians per day, the majority of whom were predominantly female. Of the 12 GWS assessed, four also served as maternity waiting shelters and four charged user fees for guardians to buy cleaning and lighting materials. Stakeholders described perspectives on who owns and manages GWS. Guardians assumed that GWS belonged to the health care facilities they served, while hospital management typically viewed the GWS as a district or community service that should be managed by those stakeholders. In the absence of clear management and ownership, environmental conditions at GWS were poor. Guardians complained of congested sleeping rooms, lack of electricity, and no facilities to store belongings. Guardians reported intermittent and sporadic access to water (n=5), which limited guardians ability to cook and care for their own hygiene. Nine of the GWS had unusable and or unhygienic toilets which were either full or contained exposed faeces, disregarded used nappies and menstrual hygiene materials. Guardians alternatively used hospital ward latrines, bathing shelters as toilets or openly defecated. Handwashing facilities were only observed in privately owned GWS (n=2) and soap was unavailable. Consequently, GWS users feel their safety and well-being were compromised and were at risk of disease transmission when staying within GWS, such as cholera and COVID.

Conclusion:

GWS are an essential yet much-neglected component of the health service system in Malawi and a much-needed resource for those who attend to their relatives in the hospital. However, their place in the local government systems for management and maintenance is currently unclear, and this has led to long-term neglect. Thus, a coherent and accountable structure is important, which will provide the necessary infrastructure to ensure access and use of GWS is a safe, healthy and dignified environment for guardians and their families.

Household and community risks from informal industrialized bat guano farming facilities in Cambodia
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Additional Authors: Sarin Neang, Tristan Burgess, and Jonathon Gass

Introduction:

The STOP Spillover project is a multi-country consortium of partners funded by USAID to identify emerging infectious disease risks, and then design interventions to mitigate and prevent spillover. In Cambodia, the consortium has identified informal industrialized bat guano farming in households as high risk of spillover.

Methods:

To characterize household and community risk for informal industrialized bat guano farming, two concurrent studies were conducted in April 2023: bat ecology; and, food, water, and surfaces. In the bat ecology study, bat guano farming households were visited and completed a survey on: artificial bat roost construction, installation, and maintenance; guano collection practices; knowledge of bats; PPE practices; and, economics of guano sale. Surveillance equipment was left overnight to capture dusk and dawn movements to estimate bat population size; at dawn samples of bat guano and urine were collected and stored in RNAShield. In the food, water, and surfaces study, bat guano farming households and non-bat guano neighbor households were visited. Surveys on demographics, water practices, food practices, hygiene practices, and bat exposures were conducted. Swab samples were collected from high-touch household areas and from food stored uncovered, and stored in RNAShield; drinking water and vegetable gardening water samples were also collected. Tufts and Cambodian institutional review boards approved both studies, and all samples were stored on ice and transported to the laboratory in Phnom Penh within 12 hours of collection. Samples are currently stored at -80C, with PCR and sequencing for bat DNA (as a surrogate for contamination) and alpha- and beta-coronaviruses (as priority pathogen sampling) pending.

Results:

In April 2023, 14 farming households were enrolled in the bat ecology study, with all completing surveys and 11 completing surveillance; in total 178 samples were collected. Additionally, 10 bat-guano farming

and 10 non-bat guano neighbor households were visited; all completed the survey, with 77 water samples and 408 surface and food samples collected. Preliminary analysis indicates that households invest relatively large sums (thousands of USD) in constructing large artificial bat roosts on their property that return a large value to the household (30 USD per bag of guano). Household members have good knowledge of bats, and women are primarily responsible for collecting guano, often with inadequate PPE. Bat guano was visibly present on food and surfaces of both farming and neighbor households. Of note is neighbor households had strikingly lower SES than farming households. Data analysis is currently ongoing, and laboratory results will be available June 2023. Subsequent analysis triangulating survey and laboratory results will identify hotspots of risk for development of targeting mitigation measures.

Discussion:
Informal industrialized bat guano farming in Cambodian households is a highly lucrative business that leads to spillover risk to farmers, farming households, and the surrounding community. These risks may be disproportionately born. Community and household hygiene interventions are needed to reduce spillover risks. Full results from these studies, with recommended interventions to reduce risk, will be fully available by October 2023.

Sanitary inspection characteristics, precipitation, and microbial water quality - A three-country study of rural boreholes in Sub-Saharan Africa
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Sanitary Inspection (SI) is a low-cost on-site risk assessment tool for water supply systems that evaluates conditions, sources of fecal contamination, and common practices that may impact microbial water safety. Research suggests that these scores estimate the vulnerability of water systems to contamination that may be transported or exacerbated by rainfall events. Our research characterizes associations between microbial water safety in boreholes and sanitary inspection data when rainfall and other data are incorporated. This work also characterizes the relative importance of common sanitary inspection items in the case study context.

Data analysis was performed using SI data and microbial water safety (E. coli CFU (colony forming unit)/100 mL) data collected from 1200 rural boreholes in Ethiopia, Ghana and Burkina Faso. Composite SI risk scores were calculated for overall sanitary risks as well as for sub-categories (source, transport, and barrier) risks as previously described by Kelly et al. Daily rainfall data were extracted from the Climate Hazards Center InfraRed Precipitation with Station (CHIRPS) dataset. Associations between microbial water quality and either composite or disaggregated sanitary risk scores were evaluated using binary logistic regression (E. coli MPN [most probable number] detection/non-detection) and ordered logistic regression (WHO microbial risk category).

Ordered logistic regression indicated that sanitary risk is significantly associated with WHO ordered risk category for microbial contamination when accounting for rainfall, with an odds ratio of 4.15 (95% CI:1.2-13.6). When risk categories were disaggregated, only barrier risk had a significant association with microbial contamination when accounting for rainfall (OR 2.49 [95% CI:1.11- 5.56]) for barrier risk. Binary logistic regression results were qualitatively similar. Seven individual sanitary inspection questions were significant in our analyses: Sewer within 10 meters from water source; cracked/broken drainage channel; stagnant water at/around drainage channel; fencing around water source; presence of cement floor/slab protecting water source; visible cracks in cement floor/slab; presence of wall around cement floor/slab extending below the surface of the ground.

This work suggests that barrier risk scores are particularly relevant for assessing borehole vulnerability to microbial contamination during rainfall events in the study area. Further work may expand on these results to explore weighting and other approaches to improve the surveillance value of SI methods for boreholes and other water systems.

Development of a protocol for using geo-trackers to identify enteric pathogens transmission pathways in urban health research: Opportunities, challenges and lessons learnt from a pilot study in Kenya

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Background:
The high frequency of interaction between humans and domestic animals like chickens, dogs, cats, and goats could play an important role in transmitting enteric pathogens and infections in humans. Evidence on how often and where human-animal interactions occur could improve the effectiveness of public health programs for the prevention of zoonotic disease transmission and rapid response to disease outbreaks. This study aimed to develop methods for using geo-trackers to measure the spatial-temporal movement of and interaction between animals and children between households and public areas in urban settings for use in the PATHOME study of enteric disease transmission in urban neighbourhoods of Kenya. We also evaluated the lessons learnt to identify the opportunities and challenges for scale-up of these methods in our study and recommendations for adopting these methods for others.

Methods:
We first conducted a search to identify a list of commercially available geo-tracker devices that met pre-defined criteria for our study context. We then pilot-tested a subset of these devices to identify one device with the best technological performance and usability. Then, we conducted stakeholder meetings with community members to gather their input on the study design. Afterwards, we ran the exercise in ten households with ten infants (six in Kibera and three in Jericho). Out of the ten households, seven had animals. We tracked infants and animals in seven households and only infants in the remaining three households over two consecutive days and iteratively adapted our protocol to improve data quality and participant comfort with protocols. We evaluated the effectiveness of the geo-tracking exercise by analyzing insights from in-depth interviews with the stakeholders, Community Health Volunteers (CHVs), and infant caregivers. We also observed the animal and infant behaviour during the exercise, measured the reliability of the geo-trackers, including battery life, devised a protocol for scale-up, and observed opportunities and challenges based upon some of the lessons learnt.

Results:
There was a good reception of the geo-tracking exercise by the stakeholders, with few concerns about the safety of the infants and animals, the challenge in convincing the caregivers to allow their animals/infants to be tracked, concerns on tracking infants below three months who have limited movements, change of behaviour, especially from animals when the tracker is placed on them and the curiosity of the people around which might scare the animals away.
In general, there was no change of behaviour from all the infants tracked as the trackers were either placed in the pockets or inside their clothes. For all the animals tracked (n=7), cases of discomfort were observed (up to 30 minutes after the placement). Insights from caregivers and CHVs interviewed revealed that a few caregivers were concerned about their privacy and whether the trackers recorded personal information. About 55% of the caregivers preferred the tracker to be placed inside the child's clothing, with the rest choosing to be placed inside the pockets or socks. All the trackers used had a good battery life that lasted for the entire tracking period (24 hours).

Conclusions:
The use of geo-trackers plays an important role in monitoring infants' movements, which sheds more light on various disease transmission pathways. In addition, animal tracking provides a clear picture of the multiple locations of the animals and their interaction with the infants. This pilot provides clear guidance on using geo-trackers in monitoring disease transmission and provides challenges and some lessons learnt during the implementation for scale-up purposes.
Keywords: Geo-tracking, Tractive, Public health surveillance

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Wealthy households drink safer water: socioeconomic inequities in household microbial water quality in sub-Saharan Africa

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BACKGROUND:
Poor microbial drinking water quality adversely affects health, particularly among children. Prior studies have documented inequities in access to piped water and other improved sources between urban and rural settings and across wealth quintiles. Fewer studies have assessed inequities in household microbial drinking water quality. As the United Nations' Sustainable Development Goals strive to "leave no one behind," more evidence is needed to identify and address persisting inequities in low- and middle-income countries. This study contributes to this effort with new evidence from Ethiopia, Ghana, and Uganda.

METHODS:
Cross-sectional household data were collected in two districts per country in 2022. In each, 24 enumeration areas (EAs) were selected by probability-proportional-to-size random sampling and their populations categorized into wealth quintiles using Demographic and Health Survey methods. Households were randomly selected with equal representation from wealth quintiles. Enumerators interviewed households (n=1437) about drinking water sources and water handling, and collected stored water samples as respondents would drink. We analyzed E. coli concentration using membrane filtration with CompactDry© plates. We assessed socioeconomic differences in household water quality using 1) a concentration index with Erreygers correction, a measure of inequity; and 2) multivariate logistic regression on E. coli concentration (<=10 CFU/100mL) and wealth quintile, controlling for source type, safe storage, reported treatment, time since collection, urban/rural, precipitation amount, population density, and adjusting for EA-level clustering with random effects. To limit potential confounders, we ran a second model with households using improved, public sources equally distributed among wealth quintiles.

RESULTS:
Overall, 68% of households collected drinking water from improved sources (33-89% by country). Household water treatment was low (2%), and 39% stored water safely in a covered container with narrow opening (11-85% by country). Ten percent of samples had <1 CFU/100mL E. coli, 13% had 1-10 CFU/100mL, 29% had 11-100 CFU/100mL, and 47% had >100 CFU/100mL. Households with lower socioeconomic status disproportionately relied on unimproved drinking water sources (concentration index: -0.24; 95% CI: -0.28, -0.20) and had higher levels of microbial contamination (>10 CFU/100mL) in drinking water (concentration index: -0.17; 95% CI: -0.19, -0.15). When controlling for covariates (n=1374), the wealthiest quintile was more likely to have better water quality (<=10 CFU/100mL) than the lowest wealth quintile (OR=1.87, p=0.01). Compared to boreholes with hand pumps, bottled/sachet water was more likely to have better microbial quality (OR=20.3, p<0.001), and unprotected springs less likely (OR=0.29, p<0.001). Safe storage was not associated with microbial quality. Limiting to improved sources (n=558), disparities persisted; the wealthiest quintile was more likely to have E. coli <=100 CFU/100mL than the lowest wealth quintile (OR=2.48, p=0.008).

DISCUSSION:
Microbial contamination is widespread in household drinking water within these settings in sub-Saharan Africa, as three-quarters had microbial contamination considered high risk (>10 CFU/100mL). Our findings suggest water contamination disproportionately affects the poor for reasons other than source type and storage practices. Future research should aim to elucidate the factors underlying these inequities. Water supply, water quality, and sanitation interventions should explicitly target the poor to address these inequities and leave no one behind.

A novel index for assessing the resilience of sanitation infrastructure to extreme rainfall and flooding

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Enhancing the resilience of urban sanitation against climate-related extreme events is critical to long-term infrastructure planning. Sanitation infrastructure in informal urban settlements is susceptible to failure during extreme rainfall and flooding, resulting in excreta release into the environment and increasing risks to public health. There are few indices available that can be used to assess the resilience of sanitation infrastructure in informal settlements to extreme rainfall and flooding. The purpose of this study was to develop and apply a novel sanitation resilience index for assessing and ranking the resilience of sanitation infrastructure in informal communities. We collected data from 200 sanitation facilities in Kibera, Kenya, through community transect walks, field observations, semi-structured interviews, and sanitary risk inspections. Exploratory graph analysis and confirmatory factor analysis were conducted to determine the data structure and evaluate scale dimensionality. Scale development analysis yielded a novel, 19-item resilience index supported by a four-factor structure: physical infrastructure design (5 items), functionality of infrastructure (8 items), routine operations and management (4 items), and hydrogeological factors (2 items). We applied the index to estimate composite scores for different sanitation infrastructure types and ran a linear regression to determine if there was a difference between the mean composite scores for different types of infrastructure. Results showed that the level of resilience was significantly associated with the type of sanitation infrastructure. Among the assessed infrastructure types, resilience index scores ranged between 1.03 and 2.37 out of a possible range of 0 to 4. Toilets connected to a piped sewer (r = 1.345, 95% CI: 1.19—1.50) and toilets connected to a septic system (r = 1.014, 95% CI: 0.78—1.25) were found to be more resilient compared to latrines (r = 0.663, 95% CI: 0.36—0.97) and hanging toilets (r = 0.014, 95% CI: -0.30—0.33). The three most sensitive predictors of sanitation resilience were siting new infrastructure outside of floodplains (r =1.866, p < 0.001), maintenance of the structural integrity of existing infrastructure (r = 1.146, p < 0.001) and sealing all outlets leading to open storm drains (r = 1.111, p < 0.001) as the three most sensitive predictors of sanitation resilience. These findings suggest that proper infrastructure siting, regular superstructure repairs, and discontinuing the practice of discharging effluent into open storm drains may have the highest potential for enhancing sanitation resilience. The results of this study can improve practice by providing insights that inform the development of guidelines for the siting, design, and management of more resilient sanitation infrastructure. In addition, input from this study may contribute to the development of national policies and legislation that will spur investment in sewer and septic systems, which are deemed to be more robust and resilient sanitation infrastructure options.

★ **Prior knowledge of supply interruptions mitigates the emotional and behavioural impacts of water supply intermittency**
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Background:
Intermittent water supplies are a common feature of life for many people, particularly those in the Global South. The JMP's SDG definition for "safely managed water" includes a criterion for water access that accepts supply intermittency: Water is regarded as available when needed if it is available most of the time. Some outages are planned and managed, and others may not be predictable. In either case users may not know of these in advance.
The impact of the unpredictability of water supply outages, as distinct from the effects of intermittency, is less-well theorised and under-researched. This study examines associations between unpredictability of intermittency on psychosocial and behavioural outcomes. We hypothesise that unpredictability will be associated with poorer psychosocial and behavioral outcomes, independent of frequency of interruptions in supply.

Methods:
This study analyses responses to eight questions posed as part of a Household Water Insecurity

Experiences (HWISE) survey from data gathered from ten sites in eight countries (n=1,797). We created a score for adverse psychosocial/emotional impacts and adverse behavioural responses related to household water insecurity. Using structural equation modelling to handle missing data, we estimate the association between water supply interruption and these outcomes. Then we included predictability of interruptions as an independent variable in the same model .

Results & Implications:
We found significantly higher negative psychosocial and behavioural responses in households that had reported water supply interruptions. However, these negative effects were, respectively, approximately 25% and 50% lower for households who knew of the interruption in advance. These results demonstrate that unpredictability of supply—over and above intermittency alone—is correlated with substantial negative outcomes for households' lived experience of water insecurity. These findings underscore the undesirability of unreliable intermittent water supply and that we should continue to strive for reliable water supply as our long-term goal.

In the short to medium term, these findings can help inform policy and practice in a number of ways:
1. The negative effects on users of intermittency and unpredictability are substantial. Anger over poor service levels may undermine trust in service providers and impact customers' willingness to pay for services.
2. For systems currently unable to meet demand, where intermittency is unavoidable in the short to the medium term, modest operational improvements that can reduce the unpredictability of outages may mitigate some adverse effects of intermittency.
3. Information systems, such as those based on SMS messaging of service interruptions to users should be reconsidered. While the difficulty of making these work successfully should not be underestimated, better information provision has the potential to mitigate negative impacts on users as service provides work towards providing reliable and/or continuous services.

Water Portfolio Diversification as a Strategy to Catalyze Urban Water Security in Cities
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Demand for freshwater in cities continues to increase as industry grows, diets change, and populations expand, with climate change exacerbating these challenges. These challenges coincide with aging water infrastructure, leading to serious risks to water access. Although these risks to water supply are widely recognized, there has been limited research on the potential of water supply diversification to tackle growing demands and stressors, particularly in low-resource settings. This study aims to shed light on how water supply diversification can increase resilience in water supply in urban contexts.

Methods:
The study undertook a literature review of more than 170 references spanning over 42 countries on topics related to the improvement of urban water security through diversification. In addition, the study conducted seven in-depth case studies, each focused on a city that used water supply diversification in its water planning approach - Amman, Cape Town, Manila, Addis Ababa, Lusaka, Quito, and São Paulo. Each city was selected based on a set of quantitative and qualitative indicators to offer a diverse set of examples in low-resource settings. Case study research was based on a targeted document review and key informant interviews.

Results:
Although diversification as an explicit strategy is relatively new and has often focused primarily on identifying new sources of water, cities have used a variety of diversification activities as a strategy to increase resilience. However, it often required a crisis or shock to get the political will, finance, and wider stakeholder support for diversification to be prioritized.
Successful water supply diversification strategies require planning frameworks to organize concepts, tools, and individuals to develop solutions. This study identified and assessed frameworks that have had attention and uptake. However, cities in low resource settings faced challenges in implementing these

frameworks, as their planning systems are not prepared to handle uncertainties, monitoring and data tools are underfunded, and technical capacity is lacking. Water supply diversification options are also affected by multi-sector institutional mechanisms for water allocation. This study found that to effectively negotiate for diversification, cities used incentives, trusted intermediaries, and worked to gain public buy-in. However, cities faced challenges related to unequal power dynamics, intersectoral and transboundary conflicts, and policy fragmentation. Finally, financing is a serious challenge to the realization of many diversification options. While the "best" set of financing alternatives for a particular city will depend on its income level, the type of diversification approach, and the local context, there are successful examples of cities combining funding sources and financing mechanisms to fund water supply diversification projects.

Conclusion:
Despite the challenges, many cities in LMICs have successfully implemented water supply diversification. This study uncovered strategies, tools, and enabling factors that have fostered success across contexts. For example, the inclusion of stakeholders throughout the planning, negotiation and financing phases generally leads to more successful implementation. The impact of water supply diversification as a strategy to increase urban water security has led these cities to continue to prioritize diversification.

Water Security in cities: A case of Anjar and Gandhidham
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Cities, across the globe are running out of water and are encountering their "day zero." The situation is further aggravated by changing climate and resultant uncertain weather patterns. Currently around, 2.3 billion people live in water-stressed countries, of which 733 million live in high and critically water-stressed countries [1].

The Sustainable Development Goal (SDG) six, identifies the cruciality around water and hence aims to 'Ensure availability and sustainable management of water and sanitation for all' [2]. Indian cities are no different, a 2018 NITI Aayog report titled "Composite water Index (CWI)' highlighted that 21 major cities are racing to reach zero groundwater levels by 2020, affecting access for 100 million people [3]. Understanding the severity, Government of India (GoI) has launched AMRUT 2.0 (Atal Mission for Rejuvenation and Urban Transformation) which focuses on making cities water-secure and self-sufficient through circular economy of water [4].

In this context, CWAS-CEPT university is developing a water security action plan along with action-oriented pilot projects on rain water harvesting, ground water recharge, used water reuse, urban flood recharging etc., for Anjar and Gandhidham cities, situated in the arid region of Kachchh (Gujarat) in India. The two cities are characterized as water stressed, drought-prone areas with erratic rainfall pattern.
In order to plan a water secure city, detailed assessment and in-depth understanding of existing water situation is crucial. For the same, an assessment framework has been developed. The framework, assess the water resources and water services across quantity, quality, reliability, and affordability.
Considering the vital role which stakeholder perspective and institutional and regulatory frameworks plays in achieving water security across the water supply service chain, the same has been included in the framework to understand the water dynamics within the cities. Further, the assessment helps to identify the key challenges, issues, and opportunities across the service chain. Based on the findings, the water security action plan envisages initiatives which can make the city's water systems sustainable and resilient.

The water security action plan initiatives would help the cities to over come water scarcity through augmenting own water resources, strengthening service delivery with optimum utilization of existing infrastructure; institutional accountability and transparency can bring in accord between citizens and the governing body; awareness programs would help in achieving behavioral changes in citizens on judicious use of water which can be clubbed with community participation to bring in sense of ownership and responsibility.

The session will throw light on above mentioned topics and discuss the procedure that needs to be followed to make cities water secure.

Shared sanitation in informal settlements: a systematic review, meta-analysis, and primer for global monitoring standards
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Additional Authors: Sarah Lebu, Chimdi Moughalu, Musa Manga

Globally, about one-quarter of the urban population lives in urban informal settlements and lack adequate access to improved sanitation services. The high population density in informal settlements makes it impractical to have individual household-level toilets due to limited physical space and high costs that low-income households cannot afford. Thus, most households in informal settlements share sanitation facilities with other households, facilitating access which would otherwise be unavailable to them. This review aimed to synthesize existing research on shared sanitation practices, their coverage, use, as well as their impacts on public health and the environment. We systematically searched eight databases: PubMed, Scopus, Embase, Global Health, Web of Science, Virtual Health Library, Cochrane, and Google Scholar for studies published from Jan 1, 2000, to May 1, 2023. Grey literature databases were also searched. Original research articles of observational studies that reported on shared sanitation practices were included. Screening, data extraction and quality assessment were conducted by at least two independent researchers. We used the Cochrane risk of bias tool to assess study bias. A meta-analysis was performed using a random effects model through the Cochrane Collaboration, Review Manager version 5.4.1. Fifty-one papers that matched all criteria were included in the final review. The evidence on shared sanitation practices was limited. Preliminary results showed that sanitation facilities were shared by an average of eight households and often poorly maintained and unclean. Moreover, the quality of these facilities deteriorated as the number of households sharing them increased. In future analysis, we hypothesize that even at varying levels of shared sanitation, reported health outcomes such as diarrheal diseases, gastrointestinal illnesses, and sanitation related sexual assault will be higher for shared sanitation compared to no coverage. However, households with access to shared sanitation are likely to report limited health benefits compared to those with household-level toilets. Further analysis will be carried out on the meta-analytic estimates of both direct and indirect outcomes linked to the use of shared sanitation facilities. The pooled estimates will offer valuable insights into the prevalence rates of diarrhea, gastrointestinal illnesses, and physical safety concerns associated with using shared sanitation facilities. Furthermore, the study will provide insights into the recommended minimum standards that shared sanitation facilities should adhere to, in order to ensure the provision of sustainable access to sanitation. Our study concludes that shared sanitation facilities can be a practical solution in areas where individual household sanitation is not feasible and can provide comparable health benefits to having no facilities. We propose a new framework for evaluating the quality of shared sanitation, which could lead to reclassification of such facilities as improved sanitation under the global Joint Monitoring Programme. Additionally, our results may encourage increased investment in shared sanitation programs.

Animal ownership and waste management strategy coverage in communities and associations with human health
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In Nepal, household biodigester systems have been scaled in rural subsistence farming communities as a means to promote the installation of improved latrines, which empty into the biodigester to contain and anaerobically digest human waste. Many households also have backyard animals, which is also associated with increased fecal contamination of the domestic environment and poses health risks for children. Previous work has found that high levels of community latrine coverage reduces household contamination and diarrhea. It is not well understood how community density of animal ownership may increase or decrease fecal contamination in the household environment and subsequently affect household health.

We conducted a cross-sectional survey in 30 villages in Kavrepalanchowk, Nepal in March 2023. Community health workers went to each household to ask household members about animal ownership, animal waste management practices, and household illness. We created village-level indicators by calculating the proportion of households with cows, buffalo, goats, and chickens as well as biodigesters. We also totaled the number of animals by village, by type and overall. We used random effects models to test the association between village-level indicators and illness outcomes (diarrhea or respiratory illness in the past 7 days) among all household members and among children less than five. We used random intercepts for village (and household in models with all household members) and adjusted for age, sex, female head of household education, and land size.

We collected data on 1,722 households and 6,526 household members. Out of 325 children less than five years old, 6.6% had diarrhea and 8.8% had respiratory illness in the past 7 days. Of all households, 1,495 (87%) owned at least one backyard animal. Animal types included goats (59% of households owned), cows (58%), buffalo (30%), chicken (26%), dogs (4%), cats (2%), rabbits (<1%), and pigs (<1%). We found no associations between proportions of households owning cows, buffalo, chicken, goats, or dogs or the number of animals in the village and diarrhea or respiratory illness. We did find an association between biodigester ownership and diarrhea however; an increase of 10% of households with a biodigester in a given village was associated with a 2.9% lower probability of diarrhea among children less than 5 (95% CI: -4.6%, -1.3%). There was also a lower probability of diarrhea for all household members but this was not statistically significant.

Higher biodigester ownership at the village level was correlated with lower prevalence of diarrhea, which may be due to the higher levels of containment of human waste. While we did not find relationships between village-level animal ownership and health outcomes, we weren't able to assess specific waste management strategies. Our subsequent exposure pathways study in households with children less than 5 years old will look more closely at heterogeneity in animal confinement, care, and waste management practices, environmental contamination, and health outcomes.

Biodigesters may contain human waste at the community level and reduce child diarrhea
Community-level animal ownership is not associated with child diarrhea
More research is needed to understand heterogeneity in animal waste management and environmental and health outcomes, which our future research plans to address

Black soldier fly larvae for treatment of faecal sludge from pit latrines in informal settlements
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Background and overall purpose:
Faecal sludge management (FSM) in urban areas of low-and middle-income countries (LMICs) is not properly implemented due to inaccessibility of sanitation facilities and high faecal sludge (FS) emptying costs, amongst others. Application of decentralized (onsite) FS treatment facilities/systems such as treatment with black soldier fly larvae (BSFL) allows FS to be emptied, treated, and used at and/or near the point of generation leading to reduced transportation costs. However, unlike in solid waste and fresh human excreta, use of BSFL in the treatment of FS from pit latrines - which are the most common sanitation facilities in urban areas of LMICs - has not yet been explored. Moreover, the optimal conditions for efficient FS degradation, such as moisture content, feeding rate and larval density are not yet well known. Against this backdrop, the overarching aim of this study was to determine the effectiveness of BSFL in treating FS under different conditions of moisture content, feeding rate and larval density.

Methods:
FS samples collected from lined and unlined pit latrines in Bwaise I parish in Kampala, Uganda and experiments were set up to be fed by 10-day old larvae. The influence of the BSFL treatment on FS were assessed using total solids (TS), chemical oxygen demand (COD), total nitrogen (TN), phosphates,

helminth eggs as well as heavy metals such as copper (Cu), zinc (Zn), manganese (Mn), chromium (Cr), lead (Pb) and mercury (Hg). Also, the quality of residue left after treatment was assessed.

Key results and discussion:
The optimal feeding rate, larval density and moisture content were found to be 50 mg/larvae/day, 1.33 larvae/cm2 and 60%, respectively. The average contaminant reduction efficiency at optimum conditions were observed to be 72% and 66% for FS from lined and unlined pit latrines, respectively. It was noted that BSFL can reduce FS volume from both lined and unlined pit latrines by about 60–72% under optimal conditions. This implies that BSFL can be used in effectively treating FS from pit latrines irrespective of lining conditions. It was further noted that under optimal conditions, FS from pit latrine with moisture content as high as 90% can be effectively treated with BSFL with volume reduction efficiency of about 50%. This shows that BSFL can feed on FS from pit latrines without dewatering, thus eliminating the need for a dewatering unit. The properties of the residue left after treatment were within the allowable limit for use as compost except for helminth egg concentration.

Conclusions:
The results of the study show that BSFL can be applied for effective treatment of FS from pit latrines in informal urban settlements while generating good quality residue thereby providing an additional value chain in FSM. Areas of future research noted from the study include the need for studies on the effect of BSFL age on FS decomposition, odour control methods for resulting residue, and effect the dosage of BSFL residue has on the quality of the soil. Addressing these research gaps will help in designing and implementing scalable and sustainable decentralized systems using BSFL within informal settlements

Biochar: A Novel Technology for Onsite Domestic Wastewater Treatment - A Critical Review
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Globally, about 2.7 billion people depend on onsite sanitation systems (OSS) (e.g., septic tanks) for their sanitation needs. Although onsite sanitation systems help in providing primary treatment for domestic wastewater, they don't effectively remove nutrients, pathogens, and other inorganic contaminants. Previous studies have posited that the use of post treatment systems which incorporate biochar - solid carbonaceous residue produced from pyrolysis of biomass -leads to improved contaminant removal efficiency. However, the mechanism through which contaminants are removed and factors potentially affecting their removal are still understudied. To fill this knowledge gaps, this review discusses factors which affect efficiency of biochar in removing contaminants found in onsite domestic wastewater, modifications applied to improve the efficiency of biochar in removing contaminants, mechanisms through which different contaminants are removed and constraints in the use of biochar for onsite wastewater treatment.

The results from the studies show that biochar has high removal efficiencies for contaminants; 36.9 - 99.98% for pathogens, >70% for phosphorus and nitrogen, >60% for chemical oxygen demand and 10-82% for emerging contaminants. The major factors which affect the efficiency of biochar in removing contaminants from domestic wastewater and their optimal conditions include feedstock type, specific surface area/porosity, temperature, adsorbent dose, resident time, solution pH, heating rate. The modification methods include physical and chemical modification and impregnation methods. It was noted that the use of biochar for the removal of contaminants from domestic wastewater involves a combination of mechanisms which include adsorption, filtration, biodegradation, ion exchange and pore entrapment. The combination of these mechanisms is brought about by the synergy between the properties of biochar and micro-organisms trapped in the biofilm on the surface of the biochar. In addition, after treatment, spent biochar can be recycled and used as soil conditioner, re-used in wastewater treatment, or used as energy source. Future areas of research in the use of biochar for the treatment of wastewater include the modification of biochar, use of biochar in the removal of antibiotic resistant genes (ARGs), application of wet carbonization methods for biochar production and resistance of biochar to physical disintegration. The results of this study provide useful information that can be applied in the use of biochar for the

treatment of wastewater and guide future design of treatment systems for optimized treatment performance.

Leveraging and Strengthening Market Systems to Professionalize Water Service Delivery in Eastern DRC
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USAID's Sustainable Water and Sanitation Systems Activity (SWASSA) is supporting the establishment of formalized, legal service providers to manage water supply infrastructure in peri-urban sites across the North and South Kivu Provinces of the Democratic Republic of the Congo (DRC). While professionalized WASH service provision is becoming more common across sub-Saharan Africa, there is limited evidence of successful approaches implemented in contexts like eastern DRC, where armed conflict, community resistance to foreign aid, and weak governance and institutional structures are commonplace. Though these factors are unique to North and South Kivu, one factor is not unique here: informal community management has failed to ensure sustainable water service delivery. Additionally, early findings from SWASSA's work indicate that resistance to changing institutional arrangements is strong. This presentation will highlight emerging findings from SWASSA's Market Systems Development (MSD) activities, including a public-private-partnership (PPP) analysis and detailed financial modeling, in four sites in North and South Kivu. Through these MSD activities, we are supporting local community organizations called ASUREPs to become legally-recognized entities, identifying private sector actors that ASUREPs can contract to manage their infrastructure, and supporting local authorities to leverage and strengthen their capacity to oversee these arrangements and regulate service provision. Given the complex nature of the possible contracting arrangements at hand, this presentation will explore the contextually-sensitive benefits and risks of multiple contracting options for these actors to work together alongside financial modeling results that uncover the long-term financial sustainability of various options in these challenging sites. A success story from one long-standing service provider in the region with whom SWASSA closely works, Yme Jibu, will be highlighted during the presentation.

Long-Term Impacts of an Urban Sanitation Intervention on Child Growth in Maputo, Mozambique
Erin Kowalsky, University of North Carolina
Additional Authors: Drew Capone, Márcia Chiluvane, Victória Cumbane, Oliver Cumming, David Holcomb, Yarrow Linden, Elly Mataveia, Vanessa Monteiro, Amanda Lai, Gouthami Rao, Edna Viegas, Joe Brown

Safe water, sanitation, and hygiene (WASH) can interrupt enteric pathogen transmission and may improve growth outcomes in children. Growth deficits manifest as children age, with early childhood the critical window for interventions. We conducted a cross-sectional assessment of growth outcomes in a cohort of children exposed from birth to either an existing shared sanitation intervention or unimproved shared latrines in poor condition in Maputo, Mozambique. The sanitation intervention, implemented at compounds (household clusters) in 2015-2018 by the non-profit organization Water and Sanitation for the Urban Poor (WSUP), consisted of shared, on-site, pour-flush toilets with septic tanks and soak away pits. We enrolled 1070 children aged 1 – 60 months who had been born into and continuously resided in either a control compound with unimproved shared sanitation facilities (552 children from 303 compounds) or an intervention compound that had received the WSUP intervention at least five years prior (520 children from 286 compounds). We assessed child length, height, and weight following standardized World Health Organization (WHO) protocols and calculated height/length-for-age (HAZ), weight-for-age (WAZ), and weight-for-height (WHZ) z-scores using the 2010 WHO Child Growth Standards and the R package z-scorer. We used linear regression to estimate the mean difference in HAZ, WAZ, and WHZ between treatment arms and modified Poisson regression to estimate prevalence ratios (PR) of stunting (HAZ < -2), wasting (WHZ < -2), and underweight (WAZ < -2) for children born into intervention clusters compared with control clusters. Estimates were obtained using generalized estimating equations (GEE) with robust standard errors to account for clustering by compound and were adjusted for age, sex, household wealth, and caregiver education. Approximately 28% (95% CI: 25%, 32%), 4.9% (95% CI: 3.4%, 7.0%), and 8.0%

(95% CI: 6.0%, 11%) of control children were stunted, wasted, and underweight, respectively, compared with 20% (95% CI: 17%, 24%), 4.0% (95% CI: 2.7%, 6.1%), and 4.8% (95% CI: 3.3%, 7.9%) of children in the intervention arm. Children in intervention households were significantly taller (mean HAZ difference 0.35; 95% CI: 0.11, 0.59) and heavier (mean WAZ difference 0.23; 95% CI: 0.05, 0.41) on average than control household children, although we did not observe a meaningful difference in WHZ (-0.001; 95% CI: -0.25, 0.25). Likewise, we observed significantly lower prevalence of stunting (PR: 0.68; 95% CI: 0.51, 0.91) and underweight (PR: 0.53; 95% CI: 0.23, 1.0), but not wasting (PR: 0.76; 95% CI: 0.38, 1.5), in intervention children relative to control children. Age group (<24 months, 24 – 60 months) did not modify growth status associations on the ratio scale. Although unmeasured confounding cannot be ruled out in observational studies of this kind, our preliminary results suggest that children born into better, well-established sanitation conditions have meaningfully improved growth. Health impacts can be observed over time necessitating longer term follow-up when evaluating WASH interventions.

Assessing the status of private sector participation in water service provision in arid Northern Kenya
Jason Lopez, Millennium Water Alliance
Additional Authors: Emmanuel Olela, Styvers Kathuni

Background:
Participation of the private sector in water provision is believed to be integral to supplementing efforts by governments and development bodies in improving water supply. It is also viewed as one of the means for plugging the funding gap required to achieve universal water access. While private sector participation in water supply is not novel, it is particularly difficult to attract or augment private sector participation in hard to reach and marginalized areas. This is the case for the marginalized Arid and Semi-Arid Lands (ASALs) of Northern Kenya, where minimal information exists on the status of private sector participation in water provision.

Objectives:
To address this data gap in the ASALs of Northern Kenya, the Millennium Water Alliance (MWA) conducted an assessment to i) establish the barriers to private sector participation in water provision Northern Kenya, ii) evaluate the roles of existing private sector players in water supply markets in the region and iii) propose strategies to augment participation of private entities in water supply provision.

Methods:
This assessment employed a non-experimental research study methodology that collected qualitative data through 183 Key Informant Interviews (KIIs) and 39 Focus Group Discussions (FGDs). The KIIs were conducted with local government officials in the water sector, local private sector entities operating in Northern Kenya, national and international private sector players, and development organizations. FGDs were conducted with community groups in the region to triangulate data on private sector activities in water supply. A thematic data analysis approach was used to analyse the data. This involved coding and clustering interview reports into concepts, from which themes such as barriers to private sector entry and existing and potential private sector opportunities emerged.

Results:
The assessment determined 3 key barriers to private sector participation in water supply in the ASALs of Northern Kenya. These include the lack of adequate incentives to promote private sector participation in underdeveloped markets such as those in Northern Kenya, minimal water sector data which the private sector can use to make investment decisions and, inadequate regulatory frameworks around private sector participation in water service delivery. We established that there are already local, national, and international private sector players operating in the region who are performing various water provision roles. The more common private sector roles include provision of equipment like pumps, pipes, solar panels etc. largely to non-governmental organizations, water conveyance through trucking by private trucks, and water research and consulting. Emerging private sector roles in water provision include operation and maintenance of rural water supply systems, water supply services financing and provision

of data collection software systems.

Implications:
Considering these findings, the key strategy devised to increase private sector participation in water supply in the ASALs of Northern Kenya is to expand their emerging roles, specifically the operation and maintenance of water systems and financing of water supply services. This can be achieved through provision of risk guarantees by development partners and supporting intensive data acquisition to inform investment and the development of suitable business models for the region.

Expanding Community-Led Total Sanitation to include animal management: a pilot randomized-controlled trial in Mali
Laura Kwong, University of California, Berkeley
Additional Authors: Ahmadou N Sow, Moussa Malle, Hazara Ouedraogo, Natalie De La Cruz, Jacques Hlaibi, Mahfuza Islam, Delia Randolph, Kirk Dearden, Elizabeth D. Thomas

Background:
Despite its focus on preventing fecal matter from entering the environment, Community-Led Total Sanitation (CLTS) places little emphasis on animal management. Integrating safe management of animal feces into an existing community-level program to safely manage human feces may substantially reduce overall exposure to feces and improve both human and animal health. We evaluated the impact of a modified CLTS program on the presence of feces in rural Segou, Mali, where CLTS is the national approach to rural sanitation and households typically keep goats, chickens, and cows.

Methods:
We piloted an innovative intervention that integrated animal feces management into CLTS either simultaneously (A–CLTS) (n=10 villages) or as a supplementary component after CLTS had been delivered (CLTS+A) (n=10). We compared the programs to each other and to villages that had CLTS with no animal component (CLTS) (n = 5). During year-long Phase 1, we conducted formative research to inform the development of an animal-inclusive CLTS intervention through a literature review, focus group discussions, key informant interviews, and stakeholder consultations. In Phase 2, following a baseline assessment of 335 randomly selected households, the village-level intervention was implemented in Feb 2022 with endline data collected Nov-Dec 2022. The primary outcome was the observed presence of chicken feces in areas outdoors where the child plays. We also analyzed the presence of chicken, sheep/goat, cattle, and human feces in/on the child's sleeping room, where children play inside the house, the porch, the shade behind the house, the kitchen, outside the kitchen's entrance, around the latrine, the drinking water collection location, the area animals are fed outside their confinement structure, and other locations.

Results:
Our animal-inclusive CLTS intervention included development and promotion of animal confinement structures (with separate locations for sick animals); training on improved composting, safe manure application, hygienic milking, and hygienic birthing; and education on zoonotic diseases, animal disease management (vaccination and deworming), and the risks posed to children by close contact with animals and animal feces. In the CLTS+A arm, compared to the A-CLTS arm, sheep/goat feces were slightly less common in the area outside where the child plays (unadjusted RR=0.85 [95% CI: 0.72, 1.00]); chicken feces were slightly less commonly present on the porch (unadjusted RR=0.61 [0.47, 0.81]); outside the kitchen (RR=0.82 [0.68, 0.98]); at the drinking water collection location (RR=1.73 [0.57, 0.94]); and the shade behind the house (R=0.71 [0.57, 0.90]). Households in the CLTS+A arm also reported cleaning up feces in the house more frequently than households in the A-CLTS arm.

Conclusion:
Preliminary analyses show that animal feces managment recommendations added to CLTS implemented previously was slightly more effective at reducing the presence of animal feces in the environment compared to simultaneous integration of animal feces management and CLTS. Further analysis will be conducted prior to developing recommendation on supporting households in managing both human and

animal feces.

★ **Identifying and Interrupting Fecal-Oral Pathways in Children Under Two Years in Southeastern Madagascar**
Tinotenda Muvuti, ADRA

Background:
In Madagascar, approximately 50% of children under the age of five are stunted. Hand-to-mouth contact, drinking water, food, dirt, flies and fomites are all pathways that expose them to fecal pathogens and increase their risk of poor health and stunting. Understanding the extent to which each pathway contributes to infection could enhance targeted interventions to improve child health and support multi-sectoral resilience programming, which aims to sustainably improve food and nutrition security in southeastern Madagascar.

Objectives:
This study identifies the predominant routes of exposure to fecal pathogens among children under two in three regions of southeastern Madagascar as a basis for proposing interventions to interrupt these transmission routes.

Methods:
Fieldwork was divided into two phases. Phase 1 involved 35 structured child observations and caregiver surveys to identify four key exposure routes: child hand-to-mouth contact, drinking water, soil, and food ingestion. Phase 2 included 185 caregiver surveys and spot observations of households. Environmental samples were analyzed for Escherichia Coli (E. coli) and six different pathogens (Campylobacter, Shigella, Salmonella, Entamoeba Histolytica, Giardia Intestinalis, and Adenovirus). A Quantitative Microbial Risk Assessment was performed to quantify risks associated with each pathway by age category.

Results:
220 households were surveyed, and 835 E. coli samples were analyzed. Soil and drinking water were the most contaminated environmental compartments, with more than 80% of soil samples and more 60% of drinking water samples being in the highest contamination category (i.e., >100 MPN [Most Probable Number] per gram and per 100 mL). Pathogen analysis showed slightly different results: the most contaminated environmental compartments were children's handrinse (46% of samples contaminated), soil (31%), and drinking water (26%). Pathogens were more often detected in animal feces (67%) than in children's feces (26%).

The total estimated daily amount of E. coli ingested increased with a child's age: 10 MPN/day at 0-6 months; 188 MPN/day at 7-12 months; 213 MPN/day at 13-24 months. The results of the 1,000 Monte-Carlo simulations revealed wide-ranging exposure estimates especially for the hand-to-mouth contact. The main pathway for E. coli intake also varied across age groups: for 0-6 months, the main pathway was hand-to-mouth contact (70% of total ingestion), while for the 7-12 months group, hand-to-mouth contact and drinking water represented 68% of the total ingestion. For 13-24 months, cooked food, drinking water and hand-to-mouth contact were the main pathways, representing 90% of the total ingestion.

Conclusion:
Our findings highlighted the need to test for pathogens beyond E.coli. Based on these results, we proposed a set of recommendations, focused on the 7-24 month age category, to reduce pathogen ingestion. Nutrition-sensitive interventions are currently being piloted by the project. For example, the use of "balotoms", a small piece of easy-to-wash fabric to reduce children's contact with soil, is being promoted. Community-level behaviour change sessions and Family Scorecards are also used to reinforce improved practices, in addition to traditional WASH interventions. The project will collect data to monitor and measure the impact of these interventions.

Who participates in 'participatory' design of WASH infrastructure: a mixed-methods process evaluation
Thea Mink, Emory University
Additional Authors: Allison Salinger, Naomi Francis, Sudirman Nasir, Becky Batagol, Sheela Sinharoy

Background:
Inclusive participation is essential for community-based water and sanitation (WASH) interventions, especially in complex environments such as urban informal settlements. Process evaluations are a method to learn whether interventions have been implemented as intended, but remain relatively rare in the WASH sector. This mixed-methods, theory-driven process evaluation aimed to generate evidence on the participation (reach) and participant-reported satisfaction (dose received) of the Revitalizing Informal Settlements and their Environments (RISE) trial's participatory design phase in Makassar, Indonesia and Suva, Fiji.

Methodology:
RISE conducted participatory activities including household visits and community-level workshops in six settlements each in Makassar and Suva between 2019-2020, to co-design WASH infrastructure. Following the completion of participatory design workshops, household surveys were conducted, targeting all households in intervention settlements; quantitative data on reach and dose received were collected from 320 respondents in Makassar and 503 respondents in Suva. We used multivariable models to assess socio-demographic predictors of reach and perceived influence (dose received) in participatory design activities. Qualitative data on reach and satisfaction (dose received) were collected from nine RISE staff and 29 resident in-depth interviews and six resident focus group discussions, which were analyzed thematically.

Results:
Most target audiences participated in community-level design workshops and household visits, with a notable exception for residents living with disabilities in Suva (OR: 0.08, 95% CI: 0.01, 0.66). Barriers to participation that emerged from the qualitative analyses included those related to program delivery, such as the activities conflicting with other responsibilities, and barriers related to identity and social dynamics, such as individuals' gender and disability. Desired level of influence varied among participants; for example, in Suva, women wanted more influence over participatory design decision-making compared to men (OR: 3.33, 95% CI: 1.28, 8.55), while religious minorities wanted less influence compared to Christian respondents (OR: 2.38, 95% CI: 1.14, 4.95). Qualitative data showed that most participants felt satisfied by RISE's inclusive and participatory design, although some residents, including youth, reported feeling excluded from activities by community representatives.

Conclusion:
This study found that RISE participatory design workshops and household visits achieved good reach and dose received. Household visits were an important activity to reach women and people living with disabilities, and most respondents were satisfied with their level of influence over RISE design. The study also identified gender and social inequities in design participation and influence over decision-making. We recommend that WASH interventions reflect on the quality of their engagement with communities and local organizations in order to identify and appropriately include groups of interest, such as partnering with local women's, religious, and disabled persons' organizations to train enumeration teams. Process evaluations are also encouraged to assess participant-reported influence and satisfaction (as measures of dose received) to further understand and promote community engagement.

Learning objectives:
By the end of this presentation, participants will be able to describe how WASH process evaluations can be used to assess reach and dose received with a gender and social inclusion focus.

Increasing blue-green algae exposure calls to animal poison control – North America, 2010-2022. Novel environmental sentinels?
Rebecca Bloch, North Carolina State University

Additional Authors: Grace Faulkner, Elizabeth D. Hilborn, Tina Wismer, Nicole Martin, Sarah Rhea

Background:
Harmful algal blooms resulting from overgrowth of toxin producing organisms are symptomatic of a changing environment and are increasing worldwide as usage and nutrient contamination of freshwater sources increase. Harmful blue-green algae (HGBA) are frequent causes of freshwater harmful algal blooms that can also occur in saltwater or estuaries, causing illness and death in humans and animals. Although the National Centers for Coastal Ocean Science monitors large coastal and lake regions for HGBA, and the Centers for Disease Control and Prevention's One Health Harmful Algal Bloom System collects national data on human and animal HBGA-related illness, these efforts are limited to certain areas resulting in a need to supplement current US monitoring of HBGA. Data from the American Society for Prevention of Cruelty to Animals (ASPCA) Animal Poison Control Centers (APCC) has not been explored for HBGA exposures and could facilitate recognition of contaminated aquatic areas to inform protection of human and animal health.

Objectives:
Thirteen years of companion animal (dog and cat) HBGA exposure calls made to ASPCA APCC were characterized, including HBGA call frequency, over time and by geographic region, and annual percentages of HBGA calls; compared to a measure of public awareness of harmful algal blooms; and evaluated for suitability as a public health information source.

Methods:
HBGA exposure calls made during January 1, 2010-December 31, 2022 from the US or Canada to ASPCA APCC were analyzed for trends in occurrence, seasonality, exposure routes, and certainty of HBGA as the causative agent. Public interest in and awareness of HBGAs were evaluated by examining annual totals from a Nexis Uni®-indexed search of news publications in the US by the term "harmful algal bloom".

Results:
Of 999 HBGA calls, 99.4% (N=993) were dog exposures. Annual percentage of HBGA calls out of total APCC calls increased 0.005% (2010) to 0.070% (2022). Over 65% (655/999) of HBGA calls occurred in July-September, largely from the New England (N=154 (15.4%)) and Pacific (N=129 (12.9.%)) regions. Similar to humans, companion animal HBGA exposure routes were predominantly dermal and oral (N=956 (95.7%)). Certainty of HBGA as the agent of illness was high; in just over 60% (N=603) of calls HBGA was observed or there was strong evidence of HBGA. "Harmful algal bloom" Nexis Uni® publications increased from 2010 to 2022, peaking in 2019 (N=1834).

Conclusions:
Increases in ASPCA APCC companion animal HBGA exposure calls during 2010-2022 were largely driven by increased HBGA call volume in the summer and in the New England and Pacific regions. HBGA call increases could have been influenced by public awareness, as news publication quantity increased around the same times. Dogs may accompany humans to HBGA-contaminated locations, and their HBGA exposure routes are similar to humans. HBGA may not always be visibly apparent, dog illness may be the first sign of HGBA presence, making them an important indicator of potential human health risk. If evaluated in a timely manner, ASPCA APCC HGBA call data could contribute to early warning of HBGA events.
This abstract does not necessarily reflect EPA policy.

Prioritizing Indicators for National and Global Monitoring of Gender in Water, Sanitation, and Hygiene
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The 2030 Sustainable Development Goal Agenda prioritizes achieving gender equality across all 17 goals. However, some SDGs lack gender-specific indicators for monitoring and are considered gender-blind, including SDG 6, which seeks to 'Ensure availability and sustainable management of water and sanitation for all.' The UN-Water Integrated Monitoring Initiative for SDG 6 has embarked upon a 'gender contextualisation' of all SDG 6 global indicators. Aligned with that effort, the WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation, and Hygiene (JMP) and the UN Water Global Analysis and Assessment of Sanitation and Drinking Water (GLAAS)—the global custodians of data on drinking water, sanitation, and hygiene (WASH)—are committed to improving how gender is monitored for SDG targets 6.1, 6.2, 6.a and 6.b. In 2020, the JMP, GLAAS, and Emory University initiated a multi-year initiative to review opportunities for enhanced monitoring of gender in relation to these targets and to identify a set of priority indicators for integration into national and global monitoring. The objectives of this session are 1) to describe the multi-phase approach for identifying priority indicators; and 2) to present the priority indicators identified.

Specifically, during Phase 1 (2020-2021), the 'review phase', Emory University conducted a literature review and create a conceptual framework of gender equality related to WASH, which underwent external review; collated and sorted tools and data sources by dimensions of the created framework; and held a series of expert consultations to assess the utility of available tools and data for monitoring. During Phase 2 (2022-2023), the 'prioritization phase', Emory recruited and led a core team of eight gender, measurement, and/or WASH experts to support prioritization activities, including: ranking dimensions of the gender equality and WASH framework to identify those appropriate for monitoring; compiling potential indicators for monitoring the identified dimensions; deploying a survey to over 100 gender, measurement, and/or WASH experts to assess support for potential indicators; assessing quantitative and qualitative data from 70+ survey respondents representing various geographies and sectors; making final recommendations to the JMP and GLAAS. During the session we will share the final list of priority indicators. These priority indicators have measures in use and data available for immediate analysis and reporting. We will also share which indicators were identified as relevant, but in need of further development before they can be adopted (i.e., conceptually valuable but in need of measure validation and/or data collection at scale) and which were rejected.

The session includes learning objectives for both the presenters and session participants: Members of the JMP, GLAAS, Emory, and core teams will benefit from gaining feedback from session participants on how to further develop the indicators deemed important, but in need of validation or scaled data collection. Session participants will benefit by learning what the final priority indicators are and understanding the rigorous processes involved in selecting the priority indicators, which typically are not transparent or well-documented. The process could be used for similar initiatives related to WASH in other settings.

Using wastewater sampling to investigate community-level differences in the burden of antibacterial resistance in a major urban center, USA
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Additional Authors: Marlene K. Wolfe, Oluwatosin Olojo, Caroline H. Sheikhzadeh

Background:
Although at least 2.8 million Americans suffer from antibacterial-resistant (AR) infections each year, whether minority populations in the United States are disproportionately at risk remains poorly understood. Studies using the electronic medical record (EMR) have reported differences in community-acquired AR infection risk by race and ethnicity, insurance status, and socioeconomic deprivation. However, EMR-based studies are not representative of the American population due to inequitable healthcare access. Wastewater monitoring can be used to test entire populations for markers of disease. Because colonized or infected persons shed AR bacteria in their feces, urine, and other secretions, wastewater can provide a community composite biological sample that is not biased by healthcare access. The goal of this study was to quantify AR bacteria in wastewater across a socioeconomically diverse US city and to investigate potential relationships with community characteristics.

Methods:

We tested samples of raw influent wastewater from 7 wastewater treatment plants in the greater Atlanta, USA area in December 2022 and in March and May 2023. Wastewater was directly plated on antibiotic-supplemented media to quantify fluoroquinolone-resistant, third-generation cephalosporin-resistant, and carbapenem-resistant Enterobacteriaceae. The sociodemographic characteristics of the sewer shed areas contributing to each sample were tabulated by aggregating data from the U.S. Census Bureau's 2020 American Community Survey (ACS) for the census tracts covered by the sewer network leading to the sampling point. Linear regression was used to assess the relationship between ACS variables and the concentrations of AR bacteria in wastewater.

Results:
Each target of interest was detected in Atlanta wastewater with concentrations ranging from the lower limit of detection (~ 3 log10 CFU/100 ml) to 5.7 log10 CFU/100 ml, with significant differences observed between sampling rounds. May 2023 results are yet to be obtained. Sewer sheds across Atlanta varied widely in terms of racial composition (range: 5-79% White, 8-89% Black), insurance access (range: 5-15% uninsured), percent speaking English as a second language (range: 0.4-10%), and percent living in crowded households (range: 0.3-2.7%). Concentrations of fluoroquinolone-resistant Enterobacteriaceae were higher in wastewater from sewer sheds where a greater percentage of persons lived in crowded households ($\beta = 0.48 \pm 0.16$, p=0.01). Concentrations of both third-generation cephalosporin-resistant and carbapenem-resistant Enterobacteriaceae were higher in sewer sheds where a greater percent of persons spoke English as a second language ($\beta=0.09 \pm 0.04$, p=0.02 and $\beta=0.11 \pm 0.05$, p=0.05, respectively). Concentrations of third-generation cephalosporin-resistant Enterobacteriaceae were lower in sewer sheds where a higher percentage of persons relied on public insurance ($\beta=-0.04 \pm 0.01$, p=0.02); conversely, concentrations were higher in sewer sheds with a higher use of private insurance ($\beta=0.03 \pm 0.01$, p=0.02).

Discussion:
Patterns of AR resistance across sewer sheds in the greater Atlanta area are associated with sociodemographic characteristics including language, living conditions, and healthcare access. Wastewater surveillance may be a valuable tool for identifying communities at heightened risk of AR infections.

Enteric Pathogen Flows at Citywide Scales
Drew Capone, Indiana University
Additional Authors: Vanessa Monteiro, Victoria Cumbane, Edna Viegas, Joe Brown

Understanding the performance of extant sanitation infrastructure is a challenge for governments and development agencies in low-resource settings. A variety of tools have been developed to simplify the decision-making process. One tool that is being deployed widely is the "shit-flow diagram" (SFD), which pictorializes how safe and unsafe fecal flows occur throughout a city. However, the public health hazards of fecal wastes streams are often not equal. Fecal wastes may vary substantially based on the localized disease burden and by the persistence of different pathogens. Our research aim was to overlay pathogen data onto the SFD to advance our understanding of how pathogens flow at citywide scales. First, we identified sampling locations across Maputo, Mozambique corresponding to the nodes on the city's SFD using satellite imagery and input from local government officials. Next, we collected 85 soil samples and 110 high-volume water samples. Sample collection locations included wastewater treatment plant influent and effluent, wastewater outfalls, surface waters, open drains, fecal sludges, and soils at solid waste disposal sites. We cultured samples for fecal indicator bacteria, concentrated water samples, extracted nucleic acids, and quantified genes corresponding to 27 enteric pathogens using multi-parallel real-time PCR. We observed substantial variation in the pathogen profiles and concentrations between sampling locations. For example, median Giardia concentrations (gene copies per liter) were highest in fecal sludges ($10^{8.1}$), followed by wastewater influent ($10^{6.7}$), wastewater effluent ($10^{5.8}$), wastewater outfalls ($10^{5.5}$), flood waters ($10^{1.8}$), open drains ($10^{1.7}$), and surface water ($10^{1.3}$). We combined these quantitative data with the data from Maputo's SFD to generate novel pathogen flow tables, which visualize how pathogens move through the city. This approach may help prioritize investments in sanitation infrastructure to interrupt enteric pathogen transmission at citywide scales.

Unmet water and sanitation needs of marginalized and vulnerable populations
Ivy Chumo, APHRC
Additional Authors: Blessing Mberu & Caroline Kabaria

Introduction:
Promoting sustainable water and sanitation in informal settlements and its residents requires an understanding of unmet water and sanitation needs and adaptation among marginalized and vulnerable groups (MVGs). This is because water and sanitation needs identified on behalf of MVGs as "unmet" are sometimes not perceived as unmet, or even 'meetable', and the adaptation strategies from above are often perceived as unsuitable by the MVGs. To the best of our knowledge no study has used governance diaries to identify unmet water and sanitation needs and adaptation strategies of MVGs from their perspectives.

Methods:
We conducted an ethnography using governance diaries with 24 participants in Korogocho and Viwandani informal settlements in Nairobi, Kenya. The governance diaries approach involved conducting bi-weekly governance in-depth interviews (IDIs) with study participants for 4 months, complemented with observations, reflections, participant diaries and informal discussions. We used Maslow's hierarchy of needs for the framework analysis.

Results:
We identified unmet water and sanitation needs related to primary, secondary and tertiary needs in order of hierarchy. MVGs did not need a full satisfaction of a lower need to yearn for a higher one, and continue living despite the unmet water and sanitation needs. The urban paradox reminds us that cities are not always beneficial for all. There is a continued need for holistic approaches to uncover the often hidden adaptation strategies for achieving unmet needs. Our study identified behavioural and cognitive adaptation strategies.

Conclusion:
Water and sanitation actors need to embrace and build on local adaptation strategies in efforts to address unmet water and sanitation needs of MVGs in pursuit of inclusive urbanization in Africa. The identification of unmet needs and adaptation strategies adds to the literature, policy and practice on how and why residents and MVGs continue working and living in informal settlements despite the lack of or inadequate basic amenities. Our study findings implies that actors in informal settlements need to build and re-build on local adaptation strategies, as unmet water and sanitation needs tend to increase with worsened marginality and vulnerability status. Beyond adaptation strategies adopted by MVGs, Government, service providers and caregivers should take more useful actions to prevent or reduce the unmet needs.

A Randomized Controlled Trial of the Community-Led Strong-Heart-Water-Study Program to Reduce Arsenic Exposure in American Indian Communities
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Additional Authors: Tracy Zacher, Kelly Endres, Francine Richards, Lisa Bear Robe, David Harvey, Lyle G. Best, Reno Red Cloud, Annabelle Black Bear, Steve Ristau, Dean Aurand, Leslie Skinner, Christa Cuny, Marie Gross, Elizabeth D. Thomas, Ana Rule, Kellogg Schwab, Lawrence H. Moulton, Marcia O'Leary, Ana Navas-Acien

Chronic arsenic exposure has been associated with an increased risk of cardiovascular disease, diabetes, cancers of the lung, pancreas and prostate, and all-cause mortality in American Indian communities in the Strong Heart Study. The Strong Heart Water Study (SHWS) designed and evaluated a multi-level, participatory community-led intervention to reduce arsenic exposure among private well users in partnership with Northern Great Plains American Indian Nations. A cluster randomized controlled trial (cRCT) was conducted to evaluate the effectiveness of the SHWS program over a two-year period on: (1) urinary arsenic; and (2) reported use of arsenic safe water for drinking and cooking. The cRCT

compared the installation of a point-of-use arsenic filter and a mobile health (mHealth) program (3 phone calls; SHWS mHealth & filter arm) to a more intensive program, which included this same program plus 3 home visits (3 phone calls and 3 home visits; SHWS intensive arm). A 48% significant reduction in urinary arsenic (geometric mean 13.2 to 7.0 µg/g creatinine) was observed from baseline to the final 2-year follow-up when both study arms were combined (change in urinary arsenic (µg) per gram creatinine from baseline to final follow-up: 0.52 (95% Confidence Interval (CI): 0.39, 0.69)). By treatment arm, the reduction in urinary arsenic from baseline to the final follow-up visit was 57% in the mHealth & filter arm and 29% in the intensive arm. There was no significant difference in urinary arsenic levels by treatment arm at the final follow-up visit (comparing the intensive vs. mHealth & filter arms: 1.21 (95% CI: 0.77, 1.90). In both arms combined, exclusive use of arsenic-safe water from baseline to the final follow-up visit significantly increased for water used for cooking (17% to 50%) and drinking (12% to 43%). Delivery of the community-led SHWS program, including the installation of a point-of-use arsenic filter and an mHealth program on the use of arsenic-safe water without home visits, resulted in a significant reduction in urinary arsenic and significant increases in reported use of arsenic-safe water for drinking and cooking during the two-year study period. The SHWS presents a model that can be used for the design, implementation, and evaluation of arsenic mitigation program globally.

Modified Biosand Filtration Using Aluminum Hydroxide Filter Media to Enhance Fluoride Removal
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There are over 20 countries whose citizens consume groundwater containing high levels of fluoride, including Nigeria, Mexico, India, China, and Ghana. The World Health Organization (WHO) sets the maximum contaminant limit (MCL) for fluoride consumption at 1.5 mg/L. Chronic exposure to drinking water with elevated fluoride levels can cause dental and skeletal fluorosis. The aim of this study was to modify and improve the design of conventional biosand filters (BSFs) using aluminum hydroxide coated media materials (pumice and biochar) to maximize BSF's removal of fluoride, turbidity, organic matter and fecal indicator bacteria (FIB), while maintaining an adequate filtration rate. Batch adsorption studies were initially performed to assess fluoride removal capacity of sand and aluminum hydroxide coated pumice and biochar. Bench-scale column studies were conducted using three BSF columns: 1) uncoated sand as a control, 2) aluminum hydroxide coated pumice, and 3) a mixture of coated biochar with an uncoated sand layer at the top. The efficacy of multiple contaminant removal from the feed water (fluoride, E. coli, turbidity, UV254), pH and filtration rate were evaluated every other day for > one year. Aluminum concentrations and alkalinity were measured weekly. After fluoride breakthrough, biochar and pumice were recoated and the re-coated media fluoride adsorption capacity was assessed. The results showed that both aluminum hydroxide coated biochar and pumice removed fluoride to below the WHO MCL for > a year without recoating. The coated pumice BSF achieved ³ 98% fluoride removal for 418 days. The coated biochar BSF achieved ³ 90% fluoride removal for 313 days. Filtered water from the coated pumice BSF was low but was successfully adjusted by post treatment with oyster shells. Recoated biochar effectively removed fluoride, demonstrating that biochar could be reused to provide safe drinking water for a longer period; however, recoating did not restore pumice's adsorption capacity. The study also showed that the BSFs containing coated biochar and pumice were effective at removing E. coli (>98%), turbidity (>98%), and UV254 (>80%) from contaminated surface water. Filtration rate was impacted, due to clogging of the filter. After it was cleaned, the filtration rate improved adequately. This study shows that BSFs containing natural materials coated with aluminum hydroxide coating can provide people in developing countries with safe drinking water and help reduce the spread of dental and skeletal fluorosis as well as other waterborne diseases.

★ **Occurrence of per- and polyfluoroalkyl substances (PFAS) in private drinking water supplies in Southwest Virginia**
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Background:
Per- and polyfluoroalkyl substances (PFAS) are of increasing human health concern due to their resistance to degradation, widespread occurrence in the environment, bioaccumulation in human and

animal organ tissue, and potential negative health impacts. Drinking water is suspected to be a primary source of human PFAS exposure, and the regulatory landscape for municipal waters is rapidly evolving, with Safe Drinking Water Act (SDWA) maximum contaminant levels (MCLs) and goals (MCLGs) proposed in March 2022. However, private drinking water supplies (e.g. household wells) may be uniquely vulnerable to PFAS contamination, as these systems are not subject to SDWA and often include limited treatment prior to use for drinking or cooking.

Objectives:
This study characterized occurrence of PFAS compound detection in private drinking water supplies in two counties in Southwest Virginia (Floyd and Roanoke), and examined the potential for reliance on citizen-science based strategies for sample collection in future broader sampling efforts.
Methods: Twenty total previous participants in a Virginia Cooperative Extension well water testing program were recruited for participation. Multiple samples were collected on separate occasions by homeowners and experts at the home drinking water point of use (POU) for comparison; all samples were analyzed for inorganic ions, indicator bacteria, and 31 PFAS chemicals, including PFOA, PFOS, PFNA, PFHxS, GenX, and PFBS, via US EPA Standard Methods 533 and 537.1. Homeowners completed surveys detailing system maintenance, perceived POU water quality, and typical household use of products containing PFAS.

Results:
At least one PFAS chemical was detected in 76% of POU samples collected (n=60), with an average total PFAS concentration of 23.5 parts per trillion (ppt). PFOA and PFOS were detected in 13% and 22% of POU samples, respectively (proposed MCLGs = zero). Of the 31 PFAS compounds targeted, 15 were detected in at least one sample. On average, a single POU sample contained approximately 3.3 PFAS; a maximum of 8 PFAS compounds per sample detected in a single sample. Although concentrations in samples collected by experts and homeowners differed significantly (Wilcoxon, alpha = 0.05), this bias was inconsistent and may be partially attributable to differences in sampling time (i.e. morning vs. afternoon). There was no significant difference in the number of PFAS compounds in samples collected by homeowners and experts. Cosmetics and nonstick cookware were the most commonly reported potential PFAS products used by homeowners.

Conclusions:
The detection of PFAS in southwest Virginian private drinking water systems is not uncommon. Further, this work supports the newly released USEPA regulatory strategy given frequent detections of PFAS in complex mixtures (≥ 3 compounds) in drinking water. The considerable variation in PFAS detection patterns between homes and inconsistent evidence of bias suggests future studies reliant on homeowner collection of samples is possible given proper training and instruction to collect at the same time of day (i.e. first thing in the morning). Education and outreach materials are necessary to support homeowners dependent on private wells in managing potential treatment and risk, particularly as PFAS regulatory targets continue to rapidly evolve.

Assessment of water quality in non-household settings in two urban counties in Kenya
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Background:
Unsafe water is the leading risk factor for waterborne infectious diseases and contributes globally to 1.2 million deaths annually. Water safety in non-household settings, such as schools and healthcare facilities (HCFs) is important, as these settings have populations more vulnerable to the effects of consuming contaminated water. Although it is not a standard requirement to chlorinate water for handwashing, this water is often used for other purposes, such as drinking. We investigated the quality of water used for drinking and handwashing in schools, community locations, and HCFs in Nairobi and Kisumu counties.

Methods:
We surveyed 11 schools, 30 HCFs, and 20 community locations (e.g., markets, police stations) between November 2021 and February 2022 and collected data on site characteristics using a structured survey tool. Water samples were collected from randomly selected handwashing stations (HWS) in the survey locations, while drinking and source water samples were collected if accessible. Free chlorine residual (FCR) testing was measured onsite using a chlorine test kit. If the FCR was <0.2 mg/L, the World Health Organization (WHO) recommendation for drinking water, a sample was collected and tested, using IDEXX® Colilert-18, for the presence of total coliforms and E. coli, both indicators of microbiological contamination. Logistic regression was used to identify site characteristics associated with E. coli and total coliforms.

Results:
Most samples (177/192; 92%) had FCR levels of <0.2 mg/L. In schools, 50/60 (83%) samples had an FCR of <0.2 mg/L; of these, 46 (92%) were positive for total coliforms, and 23 (46%) were positive for E. coli. In HCFs, 68/76 (89%) samples had an FCR of <0.2 mg/L. Due to resource limitations, 32 of these 68 samples we tested for microbiological indicators, of which 27 (94%) were positive for total coliforms and 18 (56%) were positive for E. coli. In community locations, 59/60 (98%) samples had an FCR of <0.2 mg/L. Again, due to resource limitations, 54 of these were tested for microbiological indicators, of which 49 (91%) were positive for total coliforms and 30 (61%) were positive for E. coli. HWS water (odds ratio (OR): 8.9; 95% CI: 1.9-41.8) and source water (OR; 18.5; 95% CI:2.5-134.8) had higher odds of contamination with total coliforms compared with drinking water. HWS and drinking water points where the distance from the water source was >500 meters had higher odds of E. coli contamination (OR: 3.0; 95% CI:1.2-7.5) compared with settings whose water source location was within the institution. Distance from the water source and intended water use were associated with microbial water quality.

Conclusion:
Most water samples tested were unfit for human consumption as defined by both chlorine and microbiological standards. Consistent and sufficient chlorination is key in ensuring that water is free from contamination and in reducing disease burden, especially in non-household shared settings with vulnerable populations, such as schools and HCFs. These findings were disseminated and discussed with school principals and community leaders, alerting them to the need to chlorinate water and allowing chlorination intervention efforts to be implemented.

THE TAB KIT / A Radically Accessible Rainwater Harvesting System that Improves Household Access to Resilient Water Supply
Tom De Blasis, (tbd) collective

WHAT / (tbd) collective has developed a novel, simple, effective, and easy to maintain household rainwater harvesting system called the TAB KIT (tarp and barrel). Assembled from materials readily available within countries across the globe, the TAB KIT can be rapidly sourced, deployed and installed, instantly generating a sustainable water source for individuals and households. The kit includes a standard 4x4 meter tarp, a 200L barrel, and 10-meter rope.

WHY / Across the globe, 2B people lack access to safely managed drinking water, though the right to safe drinking water was codified by the UN General Assembly in 2010. The world is unlikely to reach the SDG 6.1 Target of "universal and equitable access to safe and affordable drinking water for all" without new approaches. Current efforts must make progress 4x faster with 4x the investment, as given the status quo only 37% of sub-Saharan Africa's population will be using safely managed drinking water by 2030.

Rainwater harvesting is a necessary resource and tool to meet increasing water demand, and to create water security and resilience during an accelerating climate crisis. RWH offers a complementary approach to increasing household access to safely managed drinking water for households, as rain harvesting systems are considered an improved drinking water source by the WHO. The challenge is that standard RWH systems are expensive and difficult to source, install and maintain, limiting their adoption.

HOW / Starting in 2022, (tbd) collective has deployed and monitored 45 TAB systems in 44 households and 1 community facility across Nepal, Mexico, and Bolivia. The systems were distributed during the rainy season, with baseline data being collected via one-to-one hour-long interviews with each household. We then returned two months later to interview each household again about the usefulness and impact of the TAB, using the same one-to-one hour-long interview format. Being that these deployments were for human-centered design research and prototyping, the information collected was qualitative and focused on self-reporting. We also took TDS measurements of all sources to understand water quality.

RESULTS / Before receiving the TAB system households were not accessing enough water everyday – only 21% of the UN Right to Water on average – and now households report that they have more than enough water to meet all of their needs on a daily basis.

Furthermore, the TAB significantly reduced time, risk, and energy required for water fetching, through an 88% reduction in number of trips per day fetching water, saving 4.5 hours per day on average.

For those that were buying water we found that they were spending on average 22% of their household income on water, and 67% of households that were buying water reported a reduction on spending on water.

100% of the 44 households found it useful and gave the TAB an average rating of 5.25 on a scale of 0 – 5 for usefulness

The rainwater that was collected was on average 20x better than the water that was previously being collected by households.

CONCLUSION / The results indicate that The TAB KIT is a viable and essential tool to improve access to safely managed water for households in communities of highest need around the world.

Is WASH insecurity related to happiness or life satisfaction? Evidence from MICS5 surveys
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Additional Authors: Shashank Vankadari, Rochelle Frounfelker, John Hughes

Introduction:
There is a well-established body of research on the relationship between water, sanitation, and hygiene (WASH) insecurity and physical health, with the impact of WASH interventions typically focused on measures of infectious disease. This neglects the importance of WASH security and noncommunicable diseases, such as mental health. Globally, the burden of psychosocial distress and mental disorders, such as depression and anxiety, is increasingly recognized as an important contributor to lost productivity, disability, and death. Unfortunately, research on the intersection of WASH and mental health is still nascent. To date, there is some evidence for an association between water insecurity, sanitation, and psychological distress. Additional research has focused on identifying associations between mental health and uptake/utilization of WASH practices, leading to pilot interventions that address both. Although there is a strong theoretical rationale and growing empirical evidence on the link between WASH insecurity and psychosocial wellbeing, there are gaps that need to be addressed. Wholistic investigations into how, and in what ways, WASH insecurity is linked to and interacts with other social determinants of health (such as poverty and education) relevant to mental wellness is needed. This is relevant for designing and implementing interventions that directly target factors that mediate the relationship. Phase One of our investigation on this topic is analysis of publicly-available data.

Methods:
The Multiple Indicator Cluster Surveys program (MICS), carried out by UNICEF, is the largest source of statistically sound and internationally comparable data on children and women, with 351 surveys carried out in 118 countries over a 28-year period. The 5th wave of the MICS, conducted between 2013 and 2017, includes household-level questions related to WASH security and individual-level questions related to psychosocial wellbeing and life satisfaction of adults aged 15-24. Previous MICS-based studies have

investigated the relationship between life satisfaction and demographic variables (wealth index, gender, age, education level), but not WASH security.

Specifically, we are investigating 1) the relationship between WASH insecurity and psychosocial wellbeing, and 2) significant contextual differences between geographical regions. To do this, we define two outcome variables, self-reported happiness and self-reported life satisfaction, and six independent variables: water source type, access, availability, and quality; sanitation facility type; and, handwashing facility type. Our three hypotheses are that WASH insecurity will be negatively associated with psychosocial wellbeing, gender will be an effect modifier in this relationship, and geographical context will be an associated variable. Our statistical analyses employs generalized linear models, including ordinal and linear regression models.

Results and Conclusions:
Participants include 18,524 adults in Nigeria and 6500 adults in Cote d'Ivoire who participated in the MICS5 Survey. Data analysis is ongoing and will be completed and summarized August 2023. The results collected herein will inform the design of Key Informant Interviews to be conducted with WASH sector actors to understand field experiences linking WASH insecurity and mental health and wellbeing. This will build to the last phase of the project, conducting community-mapping exercises with participants living in two low-resource communities served by partner NGOs to understand experiences with WASH insecurity.

Groundwater extraction modeling to supporting program planning in resource-limited contexts, example from Kenya.
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Additional Authors: Allison Lee, Humphrey Buradi, Allison Fechter Gregory, Emma Kelly, Aaron Salzberg

Background:
The Water Project (TWP) engages with local communities in Western Kenya to provide reliable and safe water services. Due to precipitation variability, TWP is interested in prioritizing groundwater systems over rainwater harvesting. However, concerns about groundwater sustainability have arisen due to the increased rate of drilling and extraction in the area and uncertainty caused by climate change. This project aims to investigate groundwater characteristics in the region, identify gaps in primary data collection, and provide steps to explore the sustainability of implementing additional boreholes, despite limitations in field data availability.

Objectives:
We utilize a combination of available field data, remote sensing data, and justified assumptions to assess the groundwater situation using the free ModelMuse graphical user interface (GUI) and MODFLOW 6 software. Using the developed groundwater model, we simulate borehole implementation scenarios for decision-making, identify opportunities to improve model accuracy, and build modeling capacity for TWP and partner staff.

Methods:
We define the study area with the hydrological boundaries of catchment areas with well-distributed field data. We use field-collected extraction yield, well depth, and static water level, and we use publicly available watershed boundaries, digital elevation models, river shapefiles, precipitation rasters, and evapotranspiration rasters. From shared hydrogeological surveys, we estimate hydraulic conductivity based on soil types, and we calculate runoff and recharge using the Rational Method and the Soil Water Balance Equation. Due to data limitations, we assume the provided well yield data are representative of abstraction in the study area, and we use steady-state simulation. After calibrating simulated piezometric head results against observed static water level, we use the calibrated groundwater model to assess how new wells impact groundwater levels.

Results:
To evaluate the sustainability of potential locations for new wells, we compare simulated piezometric head at these locations under two scenarios: before and after the addition of an expected 200 m3/day of

extraction. If the additional well produces a drawdown of more than 2 meters, extraction at this location should be reduced and reconsidered.

We also identify data gaps and areas for improvement in data collection and modeling strategies. We recommend incorporating data from pumping tests, local rain gauges, borehole log data, more observation wells, and river field observations to further improve model accuracy. Transient modeling will better account for wet and dry seasons, and incorporating the Stream Package with associated river data will better represent the relationship between groundwater and river. With better model accuracy, the groundwater modeling process can be applied to a number of decision-support scenarios, including additional well locations or extraction amounts; impacts from climate change, development, or population growth; and changes in groundwater levels or budget over time.

Conclusion:
Groundwater modeling is essential for sustainable groundwater management. This project investigates groundwater characteristics in a resource-limited context and provides steps for exploring the feasibility and sustainability of implementing additional boreholes in the region. We identified data gaps and opportunities for improvement in data collection and modeling strategies, which may provide valuable insights for practitioners in other developing countries facing similar challenges.

Extending a groundwater demand model with groundwater level estimates and climate financing toward drought management
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Water scarcity and security in the drylands of East Africa is projected to worsen due to the impacts of climate change. As a result, livelihoods of pastoral communities that inhabit these regions are threatened and losses are expected to rise. Groundwater resources remain relatively underutilized and where abstraction is present, little is known about the available water quantity and quality. We have been tracking groundwater use in northern Kenya and Ethiopia using satellite-connected in-situ sensors. We have established a strong link between abstraction and rainfall. From these associations, we developed and deployed an operational machine-learning driven forecasting model providing estimates of groundwater demand to support borehole operations and maintenance, and other drought early actions related to water access. We will describe an extension of this model through the integration of sensor-based groundwater level data combined with satellite estimates of storage volumes for key aquifers in Kenya. We will also describe a framework that leverages climate financing based on carbon credits generated from a borehole water treatment model to enable sustainable borehole operations and maintenance. These new extensions will improve pro-active drought responses and are directly tied to a regional multi-disciplinary anticipatory actions program across the Horn of Africa.

Informal, Invisible and Illegal work: A Case Study of Manual and Mechanized Pit Emptiers in a Small Town in India
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The sanitation sector has witnessed significant transformations in recent decades, with a global emphasis on expanding access to sanitation facilities, particularly in off-grid sanitation towns of the global South. The major focus has been on constructing water-seal toilets and On-Site Sanitation systems (OSS) to achieve sustainable sanitation practices. This shift has not only influenced how sanitation work is carried out but has also impacted the labour force engaged in this sector. In off-grid sanitation towns, particularly those located along the coast, where the absence of sewered sanitation systems and geographical conditions pose sanitation challenges, sanitation infrastructures are often inadequate. Consequently, there arises a consistent demand for sanitation workers. This study seeks to delve into the contemporary dynamics of fecal waste management, with a specific focus on the distinct challenges faced by manual and mechanized pit emptiers (septic tank cleaners) in Alleppey, a coastal town in Kerala, India. The study

aims to elucidate differences in the nature of work, working conditions, benefits, and the various marginal positions occupied by manual and mechanized pit emptiers. Additionally, it seeks to frame manual and mechanized pit emptying as an essential, yet largely unregulated, service. In India, sanitation work remains stigmatized, often performed by lower-caste individuals, leading to precarious employment conditions and societal perceptions of "dirty" work. While sanitation workers play a pivotal role in achieving Sustainable Development Goal 6.2 (ensuring equitable sanitation access), urgent attention is warranted for Goal 8.8 (protecting labour rights and ensuring safe working environments, especially for those in precarious employment).

The study employs a qualitative research approach, employing Key Informant Interviews, Focus Group Discussions, and participant observations with different actors, including pit emptiers, residents, government officials, and elected representatives. The research adhered to an informed consent process, with interviews recorded, transcribed, translated, and thematically analyzed. The findings of this study underscore that all forms of pit-emptying activities in Alleppey town operate within the informal sector and there is no female participation in the work. Also, substantial disparities exist in terms of the nature of work, social backgrounds, tools and technologies employed, wages, societal interactions, and government involvement. Notably, while both manual and mechanized pit-emptying activities exist informally, mechanized pit-emptying leans towards illegality, as the collected waste is often disposed of in water bodies or open spaces, leading to penalties and arrests for the workers involved. This illegality forces these workers to operate at night, rendering them "invisible." Manual pit emptiers, on the other hand, are Dalit migrants from the neighbouring state of Tamil Nadu, who experience invisibility due to the social marginality associated with their work and their socio-spatial isolation. The study also highlights the impact of climate change and geographical factors, such as the depth of the water table and water-logging issues, that have a role in the households' decisions to opt for mechanized or manual pit-emptying services. Mechanized services are favored in densely populated urban areas and households with limited space for manual emptying and septage transfer to the new pit next to the septic tank.

How risky is the work of sanitation workers? A quantitative and qualitative assessment of the health and safety risks among latrine operators and emptiers in the Kumasi Metropolis, Ghana

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Background and study objectives:
Sanitation workers play a crucial role in the sanitation service chain. Without them, heaps of vermin-infested waste and overflowing septic tanks will be common sights in cities, causing disease outbreaks. Although these workers bear huge risks in their line of work, they are frequently stigmatized, discriminated against and least protected. Many studies have assessed the health and safety risks faced by these workers, but none has quantified the risks associated with their work, especially for toilet operators - pit emptiers, janitors, public toilet attendants, and container-based sanitation operators, especially during the COVID-19 outbreak.

This study therefore quantifies the health and safety risks faced by these workers by examining the common illnesses, job-specific risks, protective measures, incentives, and disincentives among this occupational group. This would enable decision-makers effectively prioritise and reduce high risks to their barest minimum to safeguard the well-being of these workers.

Methods:
Overall, 219 sanitation workers comprising 185 public toilet operators, 17 container-based sanitation operators, and 17 vacuum truck drivers were interviewed using a semi-structured questionnaire in Kumasi, Ghana. This was complemented by 4 Key Informant Interviews with sanitation service regulators, 4 Focus Group Discussions, and validated through a stakeholder workshop. A 5x5 risk scoring matrix was used to compute the job-specific risks (RAv) ranked on a scale of low (1-4) to extreme risk (20-25).

Binomial logistic regression was used to assess predictors of common illnesses among the latrine operators and emptiers.

Results:
The highest risk faced by vacuum truck drivers was infection from contact with faeces (RAv=17; Very High risk) while infection from inhalation of foul odours (RAv=13; High risk) was the topmost risk faced by container-based sanitation operators. Among public toilet attendants, back pain from prolonged sitting periods (RAv=10; High risk) was the highest risk, while janitors reported of stigmatization as the highest risk. Janitors commonly experienced body aches while vacuum truck drivers and public toilet attendants suffered mostly from headaches and lower back pains respectively. Older sanitation workers were more likely to have Musculoskeletal disorders (95% CI: 1.01-1.05; β=0.03; cOR=1.03). Just about a tenth (14%; n=31) of the workers had sufficient PPEs while only one-fifth (21%; n=47) had health insurance. Almost all (97%) the workers were aware of COVID-19 and although none reported being infected with COVID-19, they all agreed that the disease made their work riskier. For about half (44%; N=148) of them, COVID-19 has highly influenced their safety consciousness at the workplace.

Conclusion and policy implications:
The study underscores the urgent need to safeguard the wellbeing of sanitation workers in the Metropolis. Most importantly, the local authority should develop a robust database on sanitation workers, provide health and safety training and institute mandatory medical checkups for the sanitary workers to be financed by employers. Health and safety of sanitation workers should be incorporated into local sanitation byelaws and a monitoring and enforcement taskforce instituted to ensure provision and use of adequate protective equipment and working logistics. Further research is recommended to examine practical measures that can be adopted to improve recognition and reduce stigmatization of sanitation workers.

Work-related musculoskeletal disorders among desludging operators in Uganda
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Background:
Work-related musculoskeletal disorders (WRMSDs) are a significant cause of disability, absenteeism, and low productivity among workers. Desludging operators who are responsible for the crucial task of safe emptying, transportation, and disposal of faecal sludge from the septic tank/pits to desludging sites, are at a heightened risk of suffering from WRMSDs. Existing evidence indicates that this risk is aggravated by several factors, including inadequate awareness of occupational hazards, inadequate measures to control such hazards, poorly designed workstations, and other related factors. Despite this enormous exposure of desludging operators to WRMSDs, there is limited evidence regarding the prevalence and risk factors of WRMSDs among this group in Uganda.

Objective:
This study aimed to assess the prevalence of WRMSDs and associated factors among desludging operators in Uganda. Study findings will be crucial in informing the design of effective interventions to address WRMSDs among desludging operators.

Methods:
A cross-sectional study utilizing quantitative data collection methods was conducted among 303 desludging operators in Uganda. A structured questionnaire pre-loaded on the Kobo Collect mobile data collection application was used to obtain information on the socio-demographic characteristics, self-reported musculoskeletal disorders, and ergonomic and psychosocial risk factors. Data was analyzed using STATA version 15 and Modified Poisson Regression was used to measure the strength of association between the independent variables and WRMSD.

Results:
Out of the 303 respondents, 43.2% (131/303) were aged between 18-30 years, and 50.2% (152/303) reported having had trouble (ache, pain, numbness, injury) in any of their body parts within the last 12 months before the study. The prevalence of WRMSDs among desludging operators was 29.7%. Socio-demographic factors such as having attended safety training in the last 12 months (APR= 0.55, 95% CI: 0.31-0.98), and undertaking regular health check-ups (APR= 1.68, 95% CI: 1.16-2.44) were significantly associated with WRMSDs. Ergonomics factors such as working with hand above the head (APR=0.40, 95% CI: 0.26-0.62), working with a bent wrist (APR=2.64, 95%CI: 1.54-4.52), and pinching unsupported objects (APR=0.87, 95% CI: 0.59-1.29) were significantly associated with WRMSD. Psychosocial factors such as neither agreeing nor disagreeing about being able to influence the availability of equipment needed to do their work (APR=0.43, 95% CI: 0.20-0.94), having much influence over the amount of work done (APR=1.75, 95% CI: 1.05-2.91) and sometimes feeling felt that everything done was an effort (APR=1.71, 95% CI: 1.01-2.89) were significantly associated with WRMSDs.

Conclusions:
WRMSDs were highly prevalent, 29.7%, among desludging operators in Uganda. We recommend providing ergonomic training and education regarding WRMSD prevention and mitigation to desludging operators. Furthermore, interventions such as modifying workstations, implementing multifaceted ergonomic interventions, providing regular exercise programs at the workplace, and considering work pace and rest and recovery opportunities should be implemented to reduce the risk of WRMSDs in this group.

Awareness of Occupational Biohazards, and Utilization of Personal Protective Equipment among Sanitation Workers in Fecal-Waste Management Plants in Uganda.
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Addiitonal Authors: Lesley Rose Ninsiima, Filimin Niyongabo, Bridget Nagawa Tamale, Baguma James Natweeta, Lydia Namakula Nabawanuka, Rawlance Ndejjo, and David Musoke

Introduction:
Urbanization in Uganda has exerted pressure on the existing sanitation facilities including sewer systems and fecal waste treatment plants increasing health risks, environmental risks and socioeconomic differential risks to sanitation workers and the public. Sanitation workers are also exposed to biohazards such as bacteria, endotoxins, allergens and particulate matter while working along the sanitation chain. This poses a threat to their health hence the need for occupational health and safety promotion. This study aimed at establishing awareness of occupational biohazard risks and utilization of personal protective equipment among fecal waste management plant workers in nine regional cities of Uganda.

Methods: The was a cross sectional study that utilized both qualitative and quantitative data methods. Quantitative data was collected using a pre-tested structured questionnaire among sanitation workers at fecal management plants. Also, key informant interviews were conducted among stakeholders using probe detailed guides. Quantitative data was captured using phone-based Kobo collect software and analyzed in Stata 14 while qualitative data was audio recorded, and thematically analyzed using Nvivo version 12 software.

Results:
Out of the 417 respondents, 95.0% (396/417) were males, 46.5% (194/417) were aged thirty years and below, 91.1% (380/417) had dependents and 44.8% (187/417) had attained secondary level education. Over 89.2% of the sanitation workers utilized PPE in the past 30 days. There was also high awareness of PPE as 99.5% were aware of at least one PPE and 95.7% highlighted durable gloves as the most known PPE in the fecal sludge establishment.

Utilization of PPE was significantly associated with; working for more than 8 hours (APR=1.09, 95% CI:1.03-1.15); average monthly income above 264 USD (APR=1.08, 955 CI:1.00-1.17); presence of occupational health and safety officer or personnel at the fecal waste management plant (APR=1.10, 95% CI: 1.03-1.16); reporting that PPE can reduce the risk of exposure to biohazards (APR=1.89, 95%

CI:1.02-3.49); PPE use being mandatory at the workplace (APR=1.14, 95%CI:1.02-1.27); and PPE being available at the plants (APR=1.48, 95% CI:1.25-1.75). In addition, five themes were developed from the 17 key informant interviews conducted in 9 regions of Uganda. These were occupational hazards such as sharp objects, slips and poisonous gases; protection against occupational hazards for instance use of PPE and administrative control strategies; facilitators to use of PPE include existence of policies and safety personnel; barriers to PPE use such as unaffordability and unavailability of PPE, inadequate knowledge; and recommendations for improved use of PPE include amending the existing regulations and creating more awareness.

Conclusion:
Majority of the sanitation workers at fecal management plants were aware of biohazards and utilized PPE at fecal waste management plants. Utilization of PPE was associated with working for more than 8 hours, high income levels, having a safety officer at the fecal waste management plant, availability of PPE and mandatory use of PPE at fecal waste management plants. Therefore, continuous sensitization, hiring of safety officers, providing PPE at workplaces, and enforcement of regulations on mandatory use of PPE should be conducted at fecal waste management plants to ensure safety of sanitation workers.

Three-arm experimental trial comparing operations and maintenance models for WASH in Schools in Addis Ababa
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Additional Authors: Fiker Abebe, Samuel Ayele, Abel Kebede, Tsege Afrassa

In 2019, Splash set out to reach every government school in Addis Ababa with full water, sanitation, hygiene (WASH), and menstrual health coverage. We know from experience and from sector research that having a robust O&M (Operations & Maintenance) strategy is key to the sustainability of WASH infrastructure. At the same time, a strong local supply chain is essential to enable schools to access spare parts after the project's implementation phase.
Splash is refining and further developing our infrastructure O&M strategies to help schools and the Addis Ababa Bureau of Education (BoE) sustain our interventions long after the project is complete. To do so, Splash conducted a three-arm experimental trial comparing different O&M models for WASH infrastructure at 24 sampled schools. The models that were compared include:

1) Model 1 - O&M technicians hired by the government who were permanent employees at the school.
2) Model 2 - O&M technicians trained by TVET colleges who were permanent employees of their respective vocational colleges.
3) Model 3 - Independent O&M technicians who fix and maintain infrastructure in their community hired by the school.

The main objective of the study was to determine which of the three O&M models performs the best across several performance criteria, including: labor and materials costs, downtime, and ease of communication and scheduling. Moreover, Splash aims to develop a city-wide O&M solution to reduce system downtime, ensure services remain functional, and strengthen our current implementation modality in schools.

The study found School technicians (Model 1) fixed more issues than TVETs (Model 2) and local artisans (Model 3), but they were simpler issues to fix. Additionally, School technicians are less expensive than TVETs and local artisans. The median cost per issue for school technicians is 444 ETB, compared to 3,054 ETB and 1,944 ETB for TVETs and local artisans, respectively. Regarding downtime, School technicians can respond more quickly to issues, resulting in less downtime, so long as spare parts and tools are readily available. It is clear from the logbook analysis, as well as from the focus group discussions, that school technicians were able to address issues in a much timelier manner compared to TVET technicians and local artisan. The median number of days it took to fix an issue is less than one day for school technicians, compared to two and four days for TVETs and local artisan, respectively. Lastly, There is a local supply of most spare parts and materials, but acquiring high-quality parts in a timely manner will pose a challenge for many schools. Across all three models, there were challenges

with timely delivery of parts and materials for fixing issues. While most parts and materials needed are readily available in the local market, most schools face limited budgets for WASH-related O&M and may not be able to quickly find high-quality materials in a timely manner. Using this research, Splash will be developing a full-scale O&M implementation strategy in the coming months, with plans to scale up a city-wide O&M strategy.

Strengthening WASH in Schools (WinS) through massive open course – capacity building at scale shows measurable results
Kh Shafiur Rahaman, London School of Hygiene and Tropical Medicine
Additional Authors: Marvin Marquez, Bella Elisabeth Monse, Robert Dreribelbis

Background:
The Department of Education (DepEd) of the Philippines, supported by GIZ and UNICEF, runs the national WASH in Schools (WinS) program based on the GIZ/UNICEF3-star approach, which promotes a stepwise approach to reach national WinS Standards and foster the institutionalization of WASH in the education sector.   In 2019, the Department of Education (DepEd), in collaboration with GIZ Regional Fit for School program and SEAMEO Innotech, developed a digital learning platform for WASH in Schools (WinS) through a Massive Open Online Course (MOOC). This platform provides an alternative model for capacity development among teachers and other school personnel to ensure uniform implementation guidance of WinS in the schools across the country. Using national monitoring data, we assess the relationship between MOOC participation with school-level changes in WinS status.

Methodology:
Annual WinS monitoring data from the 2017/2018 (baseline) and 2021/2022 (endline) school years were used for this analysis. We classified schools according to their star ranking, a standardize composite measure of school WinS services adopted by DepEd. Scores range from 0-star (not meeting JMP basic service level) to 3 stars (where any star level complies with JMP basic service levels and 3 stars comply with national standards). Star Ranking was calculated both at baseline and endline for the school's overall WASH status and for water, sanitation, and hygiene domains. Changes in star ranking between baseline and endline were calculated in two ways, the absolute change (ordinal) and any improvement in star status (binary). Regression models assessed the relationship between teacher enrolment in the MOOC and the school-specific change in Star Status between baseline and endline.

Results:
Baseline and endline data were available for 28,779 schools. Of those, 5,980 schools had at least one teacher enrolled in the MOOC. At baseline, approximately 90% schools had 'zero star' ranking declining to 54% at endline. Schools with at least one teacher enrolled in the MOOC increased their overall star ranking between baseline and endline by an average of 0.59 points (95% CI: 0.56 – 0.63). Positive changes were observed in schools with MOOC participation for water ($\beta = 0.21$ ($0.18 - 0.33$)); sanitation ($\beta = 0.27$ ($0.25 - 0.30$)); and hygiene ($\beta = 0.55$ ($0.52 - 0.58$)). The odds that schools would improve their Star Ranking between baseline and endline were 3 times higher in schools with at least one teacher enrolled in the MOOC compared to schools with no teachers enrolled (OR: 2.99, 95% CI: 2.82 – 3.18). Among schools with zero stars at baseline, schools with at least one teacher enrolled in the MOOC had 3.40 times higher odds of improving star ranking between baseline and endline compared to schools that did not have a teacher enrolled in the MOOC (95 CI: 3.19 – 3.63).

Conclusion:
The results demonstrate that schools with teachers enrolled in the DepED MOOC showed significant improvements in their overall WinS status and individual WinS domains, MOOCs, as part of the education sector's continued professional development for teachers' workforce, offer significant potential for scalable and cost-effective capacity building to support WinS implementation and institutionalization.

Impact of WinS on Child Health and School Attendance in Addis Ababa, Ethiopia: a Cluster-Randomised trial

Sarah Bick, London School of Hygiene and Tropical Medicine
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Water, sanitation and hygiene (WASH) interventions in schools (WinS) have been proposed to reduce morbidity in schoolchildren, including gastrointestinal and respiratory infection, and improve school attendance, particularly among post-menarcheal girls. However, evidence of the impact of WinS interventions on pupil health and educational outcomes has been mixed. We evaluated the WASH in Schools for Everyone (WISE) programme implemented by US-based NGO Splash in partnership with the Government of Ethiopia, which aims to achieve universal WASH coverage in schools in Addis Ababa, Ethiopia over a five-year period.

We conducted a cluster-randomised trial among 60 randomly selected primary schools and randomly assigned them 1:1 to receive the intervention during the 2021/22 academic year or the following year (waitlist control). The intervention comprised WASH infrastructure improvements, including water storage and filtration, drinking water / handwashing stations and upgraded sanitation facilities, and behaviour change promotion. Within each participating school, we enrolled between 2 and 4 randomly selected classes in to reach a total school enrolment of approximately 100 pupils. Individual pupils (ages 7 - 16) were enrolled in November 2021. At four follow-up visits between March and July 2022, enumerators recorded roll-call absence, pupil-reported illness (diarrhoea, respiratory infection) and pupil-reported absence in past week among pupils present. Secondary outcomes including wellbeing and menstrual hygiene self-efficacy were recorded at the final follow-up.

We found a 17% reduction in odds of pupil-reported respiratory infection in the past week during the follow-up period among pupils in intervention vs. control schools (OR: 0.83, 95% CI: 0.70, 0.99), notable in the context of the COVID-19 pandemic. No impacts on diarrhoea or absence were observed. There was evidence of greater intervention effects among boys vs. girls. The Splash intervention was delivered with high fidelity. Further analyses will explore the heterogeneity in effects and the link between compliance and observed outcomes.

Supporting student knowledge AND practice: The effect of combined WASH education and infrastructure maintenance
Gracie Hornsby, Stanford University
Additional Authors: Jenna Davis, Gary Darmstadt, Christine Pu, Swati Agnihotri

The school environment has often been utilized for delivering WASH behavior change programming since school programs can be a cost-efficient alternative to delivering programming at the household level, especially in sparsely populated areas. Schools are also often targeted for infrastructure investments to improve WASH access since children spend a significant portion of their day at schools and are more vulnerable to infections than adults. While schools present unique opportunities for improving access to WASH infrastructure, challenges with post-construction maintenance of infrastructure prevent students from reaping long-term benefits from these infrastructure investments and developing healthy habits. Maintenance of WASH infrastructure is thus imperative for cultivating lasting behavior change in the school context.

In partnership with World Vision and Oxford Policy Management-India, we tested the effect of individual and combined WASH education and infrastructure maintenance interventions on primary students' learning and behavior. The 4-arm, cluster randomized controlled trial was conducted in 200 government primary schools in rural Uttar Pradesh, India. Each treatment arm included 50 schools that received (1) a 12-session WASH curricular program, (2) an enhanced WASH infrastructure maintenance service, or (3) both the WASH curriculum and the maintenance service. Outcomes from each treatment arm will be compared to those of a 50-school control arm. Within each school, a random sample of 20 Grade 1 and 20 Grade 4 students was drawn, for a total of 8,000 students.

The study design includes structured surveys of students and teachers at baseline, halfway through the curriculum delivery (after all key concepts have been introduced), and after conclusion of the full curricular program. In addition, each phase of the study includes up to 5 unannounced infrastructure

observations and 3 unannounced student handwashing behavior observations per school. A midline qualitative process assessment, along with a qualitative endline assessment, will also be conducted. Analysis of the first 2 rounds of survey and observational data will be complete by August 2023, which will allow us to estimate the impact of the first-stage curriculum and the infrastructure maintenance interventions. Primary outcomes include student knowledge of key ideas such as identifying safe water sources, and the frequency of student handwashing with soap and toilet use. Following our hypothesized impact pathways, we will also explore the influence of mediators such as student age and gender on key outcomes.

To a literature on WASH in schools characterized by great variation in research designs, data-collection and -analysis approaches, and evidence of effective approaches, this study will contribute rigorous evidence on the individual and combined impacts of targeted education and infrastructure maintenance efforts on student knowledge and behavior in the Indian context. Strategic engagement activities are planned to ensure the Government of India's Swachh Bharat: Swachh Vidyalaya (Clean India: Clean Schools) Campaign, which seeks to ensure that every school in the country has functional and well-maintained WASH facilities, can benefit from the learning and insights generated in this work.

The Agency, Resources, and Institutional Structures for Sanitation-Related Empowerment (ARISE) scales: Five-country validation study
Sheela Sinharoy, Emory University
Additional Authors: Madeleine Patrick, Malini Reddy, Thea Mink, Bethany Caruso

Objectives:
Sustainable Development Goal 6 aims to ensure access to water and sanitation for all, and target 6.2 emphasizes "paying special attention to the needs of women and girls." Research examining linkages between water, sanitation and hygiene (WASH) and gender, including aspects of women's empowerment, is growing. However, measurement of abstract concepts such as empowerment has been an ongoing challenge that has limited the ability of researchers, implementers, and policymakers to examine the impacts of WASH programs and policies on women's empowerment and vice versa. Survey instruments exist for measuring empowerment within other sectors, but similar tools have been lacking in WASH. The objective of this presentation will be to share our process for the development and validation of survey instruments to measure empowerment in relation to sanitation in urban areas of low- and middle-income countries.

Methods:
We followed a multi-phased, theory-informed approach to develop, test, refine, and validate our survey instruments. Phase 1 (2018-2019) included item development (informed by a systematic review and landscape analysis), cognitive interviews, key informant interviews, and expert review. Phase 2 (2019-2021) involved survey implementation with 2,020 women across two cities (Tiruchirappalli, India and Kampala, Uganda) followed by statistical analyses including exploratory, confirmatory, and multiple-group confirmatory factor analysis and item response theory methods, along with reliability and validity testing. Phase 3 (2021-2023) involved survey implementation with 5,569 women across eight cities (Meherpur and Saidpur, Bangladesh; Warangal, Narsapur, and Tiruchirappalli, India; Dakar, Senegal; Kampala, Uganda; Lusaka, Zambia) followed by statistical analyses using the same methods as Phase 2.

Results:
Our rigorous scale development and validation process resulted in the Agency, Resources, and Institutional Structures for Sanitation-related Empowerment (ARISE) scales, each of which represents one of 16 sub-domains of sanitation-related empowerment and can be used alone or in combination with others, as needed. The ARISE scales are the only set of psychometrically validated metrics for the measurement of women's empowerment in the WASH sector. The 16 scales have between 5-21 questions (items) each. In addition to the scales, we validated optional add-on measures of empowerment related to menstruation.

Conclusion:

The ARISE scales provide researchers and implementers with practical, user-friendly, and fit-for-purpose tools to measure sub-domains of empowerment in a valid and reliable way. The scales were developed and validated in coordination with city governments and other key stakeholders to generate data for better targeting, design, implementation, and evaluation of strategies to improve women's empowerment in the context of urban sanitation at program and policy levels. We will discuss next steps, including the validation of short forms for the five scales with more than 10 items, and will also introduce a set of guidance documents to support the use of the tools in the field, from implementation to data analysis and interpretation by city officials, development organizations, and other end-users.

Learning Objectives:
By the end of the presentation, attendees will understand the scale validation process and be able to explain and provide examples of how and for what purpose the ARISE scales could be utilized in their work.

Sensor-based monitoring for improved circuit rider management of chlorinated, piped schemes in Central America
Megan Lindmark, EOS International
Additional Authors: Wesley Meier, Brayan Lopez, Diana Calix, Keishanique Moton-Tyler, Craig Just

Background:
Passive chlorinators are a simple and affordable drinking water treatment technology which automatically dose chlorine into community level piped schemes without burdening the end user. However, manual monitoring and evaluation of these requires significant labor and consumable input.
Simultaneously, sensor-based monitoring of water point functionality has grown and improved real time O&M decision making. However, remotely monitoring chlorination requires prohibitively expensive sensors. Therefore, the objective of our work is to use affordable surrogate sensors coupled with classification algorithms to improve real time operations of passive chlorination, and to evaluate financial viability and community perception of sensor-based monitoring.

Methods:
We designed and installed sensor-based monitoring systems including oxidation reduction potential (ORP), pH, and water level sensors in 6 community water tanks with passive chlorinators in Nicaragua and Honduras. Using sensor data coupled with manually collected chlorine grab samples we designed classification models to classify low and adequate chlorine events, below or above 0.5 mg/L respectively based on ORP and pH alone.
In this work we merge two concepts, free chlorine residual dosing consistency and uptime into a new metric for passive chlorination effectiveness: free chlorine residual uptime, measured as the proportion of time in which a chlorination system is delivering adequate concentrations of chlorine for disinfection. Further, using the classification model established here, we rolled out real time WhatsApp low chlorine alerts in the first pilot community. We then used sensor data to calculate the frequency and duration of low chlorine events pre and post implementation of real time alerts. Finally, we interviewed key community, waterboard, and NGO stakeholders to evaluate the perceived benefit and potential willingness to pay for sensor-based monitoring services.

Results:
Our results suggest that it is possible to use ORP and pH to classify low chlorine events with up to 89% accuracy. Accuracy, along with sensitivity and specificity were site specific. We predict that a hypothetical classification triggered alert system could improve free chlorine residual uptime from 50% to up to 99%. In comparison, preliminary results from our ongoing evaluation of real time alerts suggest that 99% hypothetical uptime will require a combined effort between real time alert triggered community response, and ad hoc technician assistance following real time alerts.
Finally, we note that the cost of sensor-based monitoring is still prohibitively expensive for at-cost purchase by communities. However, we present both the potential and perceived benefit and willingness to pay, alongside several innovative funding strategies that could make sensor-monitored chlorinators

feasible at scale.

Conclusion:
This work represents an important and novel method for the estimation and classification of chlorination system functionality. Further, we present preliminary results that sensor-based monitoring of passive chlorinators can not only improve monitoring granularity, but also outcome free chlorine residual, and in turn can play a critical role in improving health outcomes associated with waterborne illness. Finally, we address critical financial roadblocks to scalability, through community-based willingness to pay and innovative financial strategies.

Subsewershed Wastewater Surveillance in Rural Appalachia Reveals Influence of Inflow and Infiltration on Enteropathogen Signal
Amanda Darling, Virginia Tech University
Additional Authors: Peter Vikesland, Amy Pruden, Leigh Anne Krometis, Mami Taniuchi, Alasdair Cohen

BACKGROUND:
Despite the advantages of wastewater-based surveillance (WBS) for monitoring community health, in the U.S. it has been used primarily in densely populated urban and peri-urban communities with relatively well-maintained and resourced sewer infrastructure. There is currently a lack of knowledge with regard to how WBS may be responsibly and productively implemented in rural communities, and the potential of wastewater-based epidemiology to better understand health outcomes and disparities in lower-income rural settings.

METHODS:
In September, 2022, in collaboration with a local utility and others, we initiated a year-long monthly wastewater sampling and monitoring campaign in a small, rural town and sewershed in Southwest Virginia. At the project onset, it was known that this system had a number of infrastructural challenges, including sewer main leaks and groundwater and surface water infiltration and inflow (I&I). In addition to collecting wastewater treatment plant (WWTP) influent, we sampled 12 sewershed nodes (collecting samples at manholes and pump stations) at each branch line to the sewer conveyance system to assess pathogen signal, and potential signal loss due to I&I and sewer system design characteristics. TaqMan Array Card (TAC) qPCR was performed for simultaneous quantification of 26 enteric pathogen targets.

RESULTS:
After six months of data collection, Rotavirus, SARS-CoV-2, Norovirus GI, and Adenovirus were present in 25%, 50 %, 25%, and 75% of WWTP influent samples respectively. Across all pathogen targets, the detection rate in the wastewater treatment plant influent was 21% lower than that of a location immediately downstream of a large residential facility. Physicochemical parameters (Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Total Phosphorus (TP)) varied across sites due to differences in I&I. When normalized to COD and TP, pathogens levels (gene copies per liter) exhibited less variability along the sewer conveyance system. Grab samples collected at times of peak flow had more variable COD and TSS between collection months than composite sampling sites.

BROADER SIGNIFICANCE:
Our preliminary results indicate that in smaller rural systems such as this with persistent I&I, there is a substantial risk of underestimating pathogen circulation when sampling only WWTP influent, as is the current standard practice for most WBS programs. Results from our study are shared with our utility collaborator and the WWTP staff and we will be working with the Virginia Department of Health to understand how findings from this project may be used to inform the improved use of WBS in other rural areas in Virginia and elsewhere.

Multiple Water Source Use in Western Kenya Schools
Harnoor Kaur, The Water Project
Additional Authors: Allison Gregory, Humphrey Buradi Zadok, Joan Were, Mwandije Victor Daniel, and Esther Murungi

Introduction:
The Joint Monitoring Program (JMP) ladder for drinking water in schools defines basic access as "water from an improved source that is available at the school." However, this classification can mask the complex reality of schools that use multiple water sources. This is particularly true when a school's main source of water is rainwater harvesting since water availability can fluctuate with seasonal rainfall. We visited 15 schools with rainwater harvesting systems in Western Kenya, a commonly used source type in the region, with the aim of better understanding multiple source use as a coping mechanism for seasonal water shortages.

Methodology:
A mixed-method study was conducted at fifteen schools with rainwater tanks (volumes of 50K or 75K liters). Focus group discussions, interviews, and surveys were conducted with water point managers, school staff, and teachers to identify multiple water sources and their use in school. The interviews were recorded, transcribed, translated, and then thematically analyzed using ATLAS.ti. Quantitative data were analyzed using STATA.

Findings:
The study's findings indicate that schools in the Western Kenya region are using multiple sources to meet their water demands. On average, each school used eight sources, with a minimum of six and a maximum of ten sources. Focus group participants from the 15 schools identified a total of 116 water sources that were used across the year, with 61 (53%) of the sources being unprotected. Most of the protected sources on school grounds are also rain-fed sources (70%), which makes them vulnerable to precipitation changes.
The study found that schools employ various coping mechanisms to deal with limited access to drinking water, particularly during the dry season. One such mechanism is to allocate different water sources to different uses, with unprotected sources used more for cleaning, gardening, and irrigation. Moreover, we found that schools rely heavily on unimproved and off-campus sources (rivers and unprotected springs) during the dry season, as most improved sources on school grounds are rain-fed. When schools identified sources used only in the dry season, 80% were unprotected, compared to 30% of sources used only in the rainy season. This further requires schools to ask students to bring water from home. Ten (67%) of the schools required students to bring water from home in the dry season (two additional schools required it year-round).

Conclusion:
Our data suggest that schools using multiple sources may fluctuate between different rungs of the JMP ladder throughout the year due to the seasonality and reliability of rain-fed water sources. Therefore, it is important to complement the use of the JMP ladder with more detailed data that accounts for the local context.

Leveraging small, local service providers for citywide drinking water and fecal sludge management services
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Additional Authors: Rishi Agarwal, Meher Abrao, Niharika Mukerji

Purpose:
Public water and sanitation service providers and authorities across low- and middle-income countries (LMICs) often lack the financial resources and/or capabilities to provide citywide water and fecal sludge management (FSM) coverage, especially to marginalized households living in low-income/ informal/ peri-urban settlements on the fringes of cities. Small, local service providers (SLPs) often fill this service gap but are not officially recognized or regulated, leading to expensive, poor quality services.

Method:
This research aimed to understand possible approaches to formally leverage SLPs for citywide water and FSM service provision in LMICs. The study used a two-phased methodology:

- Phase 1 involved a literature review of 127 documents spanning 48 countries and 18 key informant interviews (KIIs) to understand the broad characteristics of SLP service provision.
- Phase 2 involved in-depth case studies of seven cities engaging SLPs for service provision, shortlisted from a dataset of 1,397 WASH projects across ~50 funders. The cities included Lusaka (Zambia), Kampala (Uganda), Khulna (Bangladesh), and Sinnar (India) for FSM, and Maputo (Mozambique), Kisumu (Kenya), and Manila (Philippines) for water. 30 key informants were interviewed, including government actors, implementers, and SLPs.

Findings:
Where markets are unregulated, cities can formally leverage SLPs by recognizing SLPs and facilitating their participation, or by actively managing the market through influencing SLPs' service offering, such as by setting prices or taking on marketing roles.

Several enabling factors are important for cities to successfully leverage SLPs for expanding services. In the case studies, regulatory directives to expand coverage, economic incentives for reducing the financial burden of service delivery, and social conditions like disease outbreaks and low customer affordability triggered these interventions. Buy-in and involvement of multiple governmental and non-governmental stakeholders also enabled implementation.

Implementing these interventions requires stakeholders to take three types of actions: (1) managing the engagement with SLPs (e.g., partnerships), (2) establishing rules for the engagement (e.g., tariffs), and/or (3) creating infrastructure (e.g., disposal facilities) that supports SLPs to deliver services. However, this can take time as these actions are often piloted in small areas and scaled up gradually; for example, this process took ~14 years from pilot to scale-up in Kisumu.

Discussion:
Cities that successfully leverage SLPs can improve service delivery outcomes. Across case studies, formal service coverage expanded significantly, especially for previously underserved populations. Increased regulation and involvement of public institutions also improved customer service, reliability, and affordability. However, implementation of these interventions faces challenges. For example, ensuring compliance with safety regulations or establishing prices that balance affordability for households and cost-recovery for SLPs is hard. Moreover, marginalized SLPs are often unable to participate in more heavily regulated or managed markets. For example, manual pit emptiers rarely win formal partnership bids and face the risk of displacement as cities put management contracts in place.

While the study serves as a starting point, the topic is still nascent and requires further research to validate the challenges, success factors, and impact of interventions leveraging SLPs.

Water chlorination mitigates increased risk of weather-related water intermittency impacts in an urban, climate-vulnerable setting
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Additional Authors: Dr. Arumugam Kalimuthu and Dr. N. Manikandan

In India, over 1.2 billion people generates nearly 1.75 million tonnes of excreta daily, which when properly used can serve as a potential source of energy. Faecal sludge generally has high calorific value which can be attributed to the organic constituents present in it. The organic matter in human excreta consist of a mixture of undigested fats, fatty acids bacterial biomass, polysaccharides (sugars), protein, completely undigested cellulose, dead cells gut secretions and other secondary organic matter derivatives etc. making it a rich source of biomass and nutrients However, it is treated as waste and generally not reused.

To address the issue, WASH Institute initiated a research to develop briquettes from faecal sludge (FS) that can serve as a replacement for charcoal obtained from wood and can be used in industrial applications. The project was piloted in Dindigul District of Tamil Nadu, India which has a Sewage Treatment plant (STP) with a capacity of handling 13.65 MLD of sewage, generating 4.5 tonnes of dewatered biosolids per day.

The methodology involved obtaining FS from the STP, drying it in a briquette-making shed for few days until it is 90% moisture free. A wooden stand with post was used for breaking down the dry sludge to fine particles and then sieving it. The FS was then mixed with biomass materials such as Cow Dung, Saw Dust, Coir dust, Ground nut husk in a 50:50 ratio. Standard size pellets were made by using a manual hand pelleting machine and dried for 3 days. The dried pellets were then carbonized, and the final product was tested for efficiency by burning it and measuring the amount of heat generated along with time taken by the briquettes to been completely.

The preliminary research showed that FS mixed with biomass showed promising results as it is rich in carbon and hence can be very well used as a replacement for conventional wood charcoal. In addition to this, reusing FS as a fuel can help in mitigating the environment pollution caused by unsafe disposal of FS. The potential uses and market places for the briquette have been identified and the use of briquette making is going to be adopted as a new approach in India, serving as a model for the entire section both domestically and globally.

Benefits of connecting to piped water: Evidence from a quasi-experimental impact evaluation in Lusaka Zambia
Dadirai Fundira, Mathematica Policy Research Inc
Additional Authors: Adriana Gonzales, Doreen Goma-Tembo, Rodgers Musonda, Muleya Sonde, Grace Mschili, Gelson Tembo, Jeremy Page, Clair Null

Background:
In the context of rapid urbanization, Lusaka Water Supply and Sanitation Company (LWSC) has been unable to expand its piped water network into every unplanned, densely-populated, low-income neighborhood in the city. Where the network is available, not all residential properties are connected, and those connected often receive limited service and poor-quality water. Between 2013-2020, the Government of Zambia's compact with the Millennium Challenge Corporation (MCC) included expanding LWSC's piped water network. Among the compact's many beneficiaries, close to 8000 households across 4 unplanned, densely-populated, low-income neighborhoods in Lusaka got connected to the new network. This study of their experience contributes to the sparse literature on rigorous estimates of the impacts of piped water in urban settings.

Objectives:
This study aimed to
(1) Assess whether newly connected households could be considered to have "safely managed" water according to the Joint Monitoring Program definition (accessible, available, and free from contamination)
(2) Quantify the benefits of having a piped network among connected households using a valid comparison group.

Methods:
We surveyed 1,999 households in 4 low-income neighborhoods of Lusaka between February and June 2022 after the piped water network extension. We compared outcomes between matched connected and unconnected households. Two neighborhoods had enough comparable unconnected households to make contemporaneous comparisons, while we used baseline data (n=1228) collected in 2016 by the CDC for the other two neighborhoods since we couldn't find enough similar unconnected households in 2022. The 2016 baseline and 2022 survey used the same sampling methodology and repeated questions for comparability. We assessed water supply continuity, water collection behaviors, water consumption, expenses, household satisfaction, and tested water samples for free chlorine residual in both surveys. We balanced connected and unconnected households using coarsened exact matching (CEM) based on wealth quintile and home ownership.

Results:
LWSC installed 9,182 new water meters, benefiting about 90,000 people directly and 3,600 to 8,100 people indirectly through borrowed connections. CEM eliminated 134 and 238 households from the

baseline and endline data, respectively, but created balanced groups. In all four neighborhoods, LWSC provided intermittent service: two neighborhoods had over 80% of customers with 24x7 supply, while the other two had less than 65% and 20%. Connected households consumed up to three times more water per capita and spent 18-45 minutes less per week collecting water than unconnected households. The difference in water expenses between connected and unconnected households varied depending on the unit cost of piped water and consumption among connected households. Only 2 percent of tested piped-water samples had sufficient free chlorine residual.

Conclusion:
Connected households were able to access water on their premises, however, the intermittent service meant that water was not always available when needed and the lack of chlorination meant water was not free from contamination. However, it is important to note that households still experienced significant benefits from having piped water, such as increased water consumption and time savings, even if it did not meet the safely managed criteria.

Leveraging social media to bridge water management and planning data gaps: Case of New Delhi
Yugasha Bakshi, Virginia Tech University

Background:
New Delhi, one of the largest megalopolises in the world, has an all too familiar water problem. Water is increasingly becoming scarce due to systematic losses, crippling infrastructure, lack of adequate planning and worsening effects of climate change. Delhi's new master plan for 2041 envisions a megacity with resilient infrastructure that provides adequate and uninterrupted water supply. The Delhi Jal (Water) Board responsible for collection, treatment, and distribution of water to households in the city also manages the sewerage system. While the Board has the data on daily water demand and supply deficit, number of piped connections, and distribution of other water facilities for domestic use, it lacks information on the spatial-temporal occurrence of water main breaks, sewerage contaminated water, and delivery of unsafe quality of water. To move ahead on the promises laid out in the master plan, such issues need to be documented and quantified to feed into Delhi Jal Board's infrastructure management plan. The objective of this study is to fill in the water system data gap by moving beyond raw numbers and include indicators on systematic inadequacies hindering progress.

Methods:
This study presents a framework for processing tweets in a data-constrained environment to fill the information gap on water issues. The tweets by the Delhi residents were harvested by using a search query that mentioned water and popular hashtags associated with the Delhi Jal Board from 2015-2022. This resulted in over 7000 tweets that were then narrowed down using topic modeling analysis and word co-occurrence networks. Th methodology shared can be easily adopted to get a broader and more informed overview of infrastructure conditions in cities.

Results:
Results from harvested tweets demonstrated that the method is instrumental in identifying –
• Development needs in specific areas of Delhi
• Types of issues leading to health concerns
• Frequency of similar water issues
• Areas that encounter most water problems
Interestingly, the results did not show any relation between the tweets on a topic area and the season. For example, the volume of tweets mentioning water scarcity were consistent throughout the year disproving the assumption that water scarcity is prevalent more in the summers. However, the volume of tweets was higher in the summer months (May-July) and during festival months (September - November) than at other times of the year.

Broader Significance:
The importance of data to enable adequate functioning of a city's infrastructure cannot be underestimated. However, the current data systems do not reflect the requirements of the city. There is a

need to move beyond documenting the number of piped water connections and include more data fields that indicate the actual performance of the infrastructure and its responsible agency. This form of study also allows for a rapid appraisal of a city's water issues and even related health concerns. The study also demonstrates that social media can be effective in filling the gap in a data-constrained environment. This form of analysis can be used by engineers and planners to aid in evaluating area development needs and prioritizing infrastructure interventions.

Safe Drinking Water Act Compliance with or without POU/POE Devices
Taylor Simmons, Water Quality Research Foundation/University of Arizona
Addiitonal Authors: Dr. Marc Verhougstraete, Dr. Edward Dotherow

Background:
In the United States, public water systems (PWS) are protected under the Safe Drinking Water Act (SDWA) and regulated by the United States Environmental Protection Agency (USEPA). According to the latest USEPA report, 53,869 public water systems (PWS) were assessed in 2021, and of these PWS, 38% were determined out of compliance (n=20,326). The inability of treatment plants to remove all contaminants all of the time, requires the use of a secondary or final treatment barrier at the tap to minimize exposure risks. This last line of defense can come from point-of-use (POU) or point-of-entry (POE) devices. To help PWS maintain compliance with federal drinking water standards, congress authorized the use of POU/POE by PWS. However, rules governing procurement, implementation, monitoring, and other aspects of POU/POE

Objectives:
The purpose of this study was to compile state-level factors influencing POU/POE implementation for all 50 states.

Methods:
316 potential state primacy agency employees were identified, and in total, responses were gathered from 38 of 50 states.

Results:
Of the 38 responses, 61% (n=23) of states allow and implement POU and/or POE, and 26% (n=10) do not allow or implement POU/POE, whereas 13% (n=5) allow POU/POE but do not implement.

Impact:
This study highlights the successes and challenges when implementing POU and POE programs, which can be useful when determining solutions for water quality impairments. Future efforts should use this information to target specific systems with appropriate POU and POE devices coupled with a cost-benefit analysis demonstrating the strengths of specific devices for their system and water relative to disease outcomes or upgrading the centralized treatment plants.

Assessment of a local and low-cost passive in-line chlorination device in rural Guatemala
Dorian Tosi Robinson, Eawag
Additional Authors: Jael M. Locher, Dorian Tosi Robinson, Giezy Sanchez, Mario S. Muj, Yoshika S. Crider, Sara J. Marks

Background:
Achieving universal access to safe drinking water in low- and middle-income countries is a global challenge. The rural communities of Sololá's region in Guatemala have the third highest diarrheal incidence of the country. Efficient drinking water management and treatment systems are required to provide safe drinking water. In-line and low-cost chlorination technologies are promising to disinfect drinking water and to provide residual protection against recontamination during handling and storage. Helvetas Guatemala has developed an innovative low-cost in-line chlorinator, the "A'jin" chlorinator, which

is constructed locally with PVC pipe parts. The device is implemented through the water and sanitation RUK´U'X YA' program in Guatemala.

Novelty:
This research focuses on a newly developed low-cost and locally constructed passive in-line chlorination device. Such technologies are promising as they are scalable and replicable with readily available materials (PVC pipes) worldwide and could greatly contribute towards universal safe drinking water access for rural communities in Guatemala and similar settings.
Study objective: Eawag and Helvetas Guatemala jointly evaluated the performance of the A'jin chlorinator in the field and the operation and maintenance challenges of the device. Regarding acceptance, user's perception and behaviour towards the technology was studied.

Methods:
A total of 14 communities were enrolled into the study, with all receiving water, sanitation and hygiene capacity building trainings from the program. Of the 14 communities, 5 were defined as treatment because they additionally opted into receiving the chlorination device. Treatment communities received specific training for chlorination and the device was installed at the reservoir tank of the water distribution system. A baseline (August-September 2022, rainy season) and endline (November 2022 – January 2023, dry season) assessment was done across all the communities (pre- & post-installation of the chlorinators).
In each study community, 30 households were interviewed using a structured household survey, and a household tap water sample was collected and analysed for total coliforms, E. coli, pH and free residual chlorine (where applicable). Additionally, a structured survey was conducted with the water system operator in each community.

Results:
The preliminary results of the study show a significant decrease in microbial contamination (E.coli & total coliforms) for both treatment and control systems between baseline and endline (Wilcoxon signed-rank test, $p < 0.05$). The results showed that safe water standards of zero E.coli contamination were not reached for all samples of treatment systems with only 87% free from faecal contamination (n = 111).

Conclusions and next steps:
Preliminary findings indicate that chlorination is an important step towards safe water but is not sufficient by itself in such contexts. In the follow-up analysis, a linear regression model will isolate the effect of the chlorination itself from other factors such as environmental drivers to allow for specific conclusions on the performance of the chlorination intervention. Furthermore, user's acceptance and behaviour towards chlorination and the operation and maintenance needs of the device will be further analysed. These results will inform towards sustainable and broader uptake of the technology in rural Guatemala and other regions in similar settings.

Systematic Review and Meta-analysis of Toxic Metals in Drinking Water in Low- and Middle-Income Countries
Kyle Rezek, University of North Carolina
Additional Authors: Kylie Heilferty; Katharine Conaway; Michelle Cawley; Valerie Bauza; Siddhartha Roy; Michael Fisher

Toxic metals and metalloids (TMs) occur in drinking water and can cause organ damage, cardiovascular disease, cancers, and lifelong neurological and developmental impairment. However, little evidence is available on TMs in drinking water in low- and middle-income countries (LMICs; n = 136 countries). Available evidence is often highly localized, linked to localized sources of contamination, and/or obtained using unsuitable or insufficiently sensitive methods, limiting the internal and external validity of many studies.

We are conducting a systematic review and meta-analysis of peer-reviewed studies of TMs in drinking water in LMICs in accordance with PRISMA statement items. This review characterizes, synthesizes, and interprets available evidence on this topic, notes opportunities for exposure prevention, and reports evidence gaps. This study is the most comprehensive assessment and the largest systematic review of TMs in drinking water in LMICs to date.

PubMed, EBSCO Global Health, and Web of Science were searched for peer-reviewed studies published in English since 1980 that report quantitative primary data on TMs of interest in drinking water in LMICs: specifically, antimony, arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, tin, uranium, and/or zinc. More than 30,000 results were returned. A machine learning algorithm relying on supervised clustering (DoCTER [ICF, Virginia, USA]) was trained to prioritize the most relevant results, which were then manually screened at the title and abstract (n=7381) and full-text (~3500) levels. Included studies (~2000) are being extracted for review and meta-analysis. Preliminary results (based on full-text screening and extracted data to date) indicate that TMs were quantified in drinking water in 89 LMIC countries with 45% of studies from Central and Southern Asia and nearly 30% of studies from India or Bangladesh. Fewer than 7% of studies were from Latin America and the Caribbean (LAC). Arsenic presence was reported most frequently (36% of studies), while uranium, mercury, selenium, and antimony were quantified in 8%, 7%, 6%, and 3% of studies, respectively (many studies report on multiple metals). Fewer than 10 studies quantified uranium or antimony in the LAC region. More than 50% of studies reported on water from wells and boreholes, while fewer than 10% reported on piped sources. When data extraction is complete (July/August 2023), meta-analysis will be conducted to quantify occurrence of TMs of interest at levels exceeding WHO drinking-water guidelines in LMICs overall and disaggregated by water source type, SDG region, and income category. Preliminary analyses suggest substantive occurrence of arsenic, manganese, and lead at levels of health concern across multiple settings.

Results will define TM occurrence in drinking water in LMICs and inform potential next steps for policy, practice, and research. Anticipated actionable findings include reporting under-recognized TMs occurring at levels of health concern in multiple settings (e.g., manganese and lead), as well as gaps in TM occurrence data, such as limited evidence on occurrence of uranium, mercury, selenium and antimony, as well as the relative dearth of evidence on TMs in piped systems and in LAC settings.

Assessing piped water system safety in rural Ghana: system operation, water delivery, and household perceptions
Valerie Bauza, The Aquaya Institute
Additional Authors: Eugene Appiah-Effah, Godwin Armstrong, Karen Setty, Kwabena Nyarko, Ranjiv Khush, Caroline Delaire

Background:
Piped water systems delivering treated water to households and public standpipes are often regarded as one of the highest levels of water service. Yet little is known about the operation of these systems in rural areas of low-income countries, the practices and drivers around household use of multiple water sources despite access to piped water, and the willingness of households to pay for private household connections when they already have access to public standpipes.

Methods:
We selected 96 piped water systems operated by a safe water enterprise in small towns and rural areas of Ghana, interviewed each system operator and manager, surveyed 20 households per community (1,920 in total), and conducted focus group discussions with community members, including both users and non-users of the water system. We also conducted sanitary inspections of the water system infrastructure and measured several water quality parameters from five community standpipes per water system. This data was collected as part of the baseline assessment for a cluster-randomized controlled trial of rural water safety plans.

Results:

All systems except for one chlorinated their water, with 35% applying additional treatment such as iron removal (17%) and/or filtration (23%). Sanitary inspections of water system infrastructure frequently identified risks of potential system contamination across system components (e.g., boreholes, surface water sources, storage tanks, distribution lines, standpipes), particularly due to weather-related events such as heavy rain. Most system standpipes (83%) had no detectable E. coli contamination, with free chlorine residuals of at least 0.1 mg/l in 41% of standpipes and between the recommended levels of 0.2 to 2 mg/l in 31% of standpipes. However, only about half of households using the piped water used it as their main source of drinking water. The majority (64%) of other households used sachet water for drinking instead, often because they did not like the smell or taste of the piped water, believed sachet water was safer, or preferred the colder temperature of sachet water. When asked about issues with water quality supplied by the piped systems, only 43% reported no issues, while 19% reported issues with the color or appearance of water, 25% reported issues with odor, and 31% reported issues with taste. Odor complaints mostly (95%) stemmed from chlorine, whereas taste complaints resulted from both a chlorine (54%) and salty taste (43%). This presentation will give a detailed overview of operational characteristics and risks identified for piped systems, household acceptance and use of water from these systems, willingness to pay for household piped connections, and further details driving multiple water source use revealed from focus group discussions.

Conclusions:
Piped water systems studied in rural Ghana had several infrastructure and contamination risks, particularly due to weather-related events that may be exacerbated as climate change progresses. Additionally, many households used multiple water sources, and may prefer alternative drinking water sources as opposed to the gold standard of treated piped water available in their community. Understanding these factors is important for providing safe water access, and can be useful for water safety planning.

Nudging customers to pay their water and sewer bills: a field experiment in Nairobi, Kenya
Joe Cook, Washington State University
Additional Authors: David Fuente, Richard Mulwa

Background:
In order for utilities to provide high quality water and sanitation services to growing urban populations and improve and improve their health, they must have a sufficient and stable revenue stream. Utilities must price water and sanitation services to cover the cost of delivering services to existing customers and to invest in expanding the network to reach those who currently lack access to them. Even as utilities make progress in pricing water and sanitation services better, customer arrears – i.e., customers who do not pay their bills on time or in full – can undermine utilities' financial sustainability. Currently, nearly 50% of customers of Nairobi City Water and Sewerage Company (NCWSC) are in arrears. Although it is often assumed that affordability is a primary reason customers fail to pay their bills, a pilot survey of low-income connected customers in Nairobi in 2019 found that not to be the case. The empirical literature has largely ignored the issue of customer arrears in the water and sanitation sector. There are several ways utilities might improve customer bill payment, including information campaigns, enforcement of disconnections, and direct customer assistance programs (subsidies). We focus on the first tool. In cooperation with NCWSC, we implemented a large-scale randomized control trial (RCT) to test whether "nudges" sent via electronic (mobile SMS) messages improve customer bill payment. If so, which types of nudges are most effective?

Methods:
The treatment is a message sent by SMS to the mobile phone number on file with NCWSC. The message was sent between the 12th and 20th of each month during the study. Messages were sent once per month for six months, and we follow outcomes for six additional months after the last message was sent. There are five variants of the intervention SMS message. Each message variant was sent to n=10,000 customers (n=50,000 in the treatment group in total), and we observed bill payment for a control group of n~130,000 households who were not contacted. These variants test the efficacy of a descriptive norm, an injunctive norm, appeals to public health, and appeals to the capital intensity of

service delivery. Our key dependent variable is the level of customer arrears/debt, obtained through ongoing access to utility billing records. Other outcome variables include the probability of customers paying their bill on time, the probability of a customer making any payment towards their bill, and the percent of total billed amount paid over the study period. We publicly pre-registered the study design. SMS messages began in October 2022.

Results:
The final set of messages are to be sent in April 2023, and we have avoided analyzing the billing data (already in hand) until treatment ends. We therefore do not yet have results from the study but will by mid-summer and certainly by the time of the conference in in October 2023. As such, we also cannot yet offer any conclusions. We believe that our results – even null results - will be policy-relevant.

Does debt forgiveness improve water bill payment? A field experiment in Nairobi, Kenya
David Fuente, University of South Carolina
Additional Authors: Joseph Cook; Richard Mulwa, Mbutu Mwaura, Josiah Gitu

Background:
The World Bank estimates that it will cost approximately USD 100 billion per year to meet the Sustainable Development Goals' aspirations of ensuring safe and affordable water and sanitation for all by 2030 (Hutton & Varughese, 2016), with all the accompanying health gains. Donor funds are not sufficient to meet this funding gap, which means funds will need to be secured through tax revenue or user fees (i.e., tariffs). Utilities in low- and middle-income countries charge customers far below the full cost of providing water and sanitation services and tariffs will need to be increased to help finance the infrastructure needed to achieve universal access to water and sanitation services. Even at the relatively low prices utilities charge customers for water and sanitation services, many customers fail to pay their bills on time and have arrears (negative balances) on their accounts. Indeed, it is not uncommon for 40-50% of customers to have balances on their accounts. Reducing arrears and encouraging on-time bill payment is thus an important component of getting utilities in the Global South on the path to financial sustainability. In this study we examine whether one-time arrears (debt) forgiveness encourages future on-time bill payment (via a "goodwill" effect) or discourages it (via a "moral hazard" effect).

Methods:
In partnership with the Nairobi City Water and Sewerage Company (NCWSC), we randomly selected 1000 residential customers with arrears between 500 and 5000 Kenyan shillings and forgave their outstanding debt. Customers received a text message informing them of their eligibility for the debt forgiveness program and a call to obtain their acknowledgment that this was a one-time program. We observe monthly customer bill payment behavior to the utility for the treatment group, as well as a control group of ~40,000 households who did not have debts forgiven, for six months after the debt forgiveness.

Results:
The study uses a pre-registered study design with a defined trial start date (July 2022) and end date (June 30, 2023). As such, we do not have yet have results from the study but will by the time of the conference in October 2023. There are three main outcomes of interest. The first examines the total arrears (debt) accumulated over the six months following debt forgiveness. The second outcome measure is the number of times customers make any payment towards their water bill during the study period. The third outcome indicator measures whether the number of times the customer makes a payment that is greater than or equal to the billed consumption for that month.

Closing the loop: Transforming Faecal Sludge into Green Fuel as an alternative of Charcoal
Kalimuthu Arumugam Pillai, WASH Institute
Additional Authors: Dr. Arumugam Kalimuthu and Dr. N. Manikandan

In India, over 1.2 billion people generates nearly 1.75 million tonnes of excreta daily, which when properly used can serve as a potential source of energy. Faecal sludge generally has high calorific value which can be attributed to the organic constituents present in it. The organic matter in human excreta consist of a mixture of undigested fats, fatty acids bacterial biomass, polysaccharides (sugars), protein, completely undigested cellulose, dead cells gut secretions and other secondary organic matter derivatives etc. making it a rich source of biomass and nutrients However, it is treated as waste and generally not reused.

To address the issue, WASH Institute initiated a research to develop briquettes from faecal sludge (FS) that can serve as a replacement for charcoal obtained from wood and can be used in industrial applications. The project was piloted in Dindigul District of Tamil Nadu, India which has a Sewage Treatment plant (STP) with a capacity of handling 13.65 MLD of sewage, generating 4.5 tonnes of dewatered biosolids per day.

The methodology involved obtaining FS from the STP, drying it in a briquette-making shed for few days until it is 90% moisture free. A wooden stand with post was used for breaking down the dry sludge to fine particles and then sieving it. The FS was then mixed with biomass materials such as Cow Dung, Saw Dust, Coir dust, Ground nut husk in a 50:50 ratio. Standard size pellets were made by using a manual hand pelleting machine and dried for 3 days. The dried pellets were then carbonized, and the final product was tested for efficiency by burning it and measuring the amount of heat generated along with time taken by the briquettes to been completely.

The preliminary research showed that FS mixed with biomass showed promising results as it is rich in carbon and hence can be very well used as a replacement for conventional wood charcoal. In addition to this, reusing FS as a fuel can help in mitigating the environment pollution caused by unsafe disposal of FS. The potential uses and market places for the briquette have been identified and the use of briquette making is going to be adopted as a new approach in India, serving as a model for the entire section both domestically and globally.

Are water and health investments reaching impoverished households? It depends on how poverty is measured

Christine Pu, Stanford University
Additional Authors: Jenna Davis, Ian Kusimakwe, Lenny Gichia, Assefa Seme, Easmon Otupiri, Eric Lambin

Background:
Measuring poverty accurately is critical to evaluating policy effectiveness, targeting programs successfully, and equitably distributing the benefits from water and health investments. A wide array of public, private, non-profit, and international development organizations in the WASH sector incorporate poverty metrics as part of their regular data-collection efforts. They use a correspondingly diverse set of indicators to do so. This isn't necessarily a problem, so long as an organization's ability to assess progress toward its poverty alleviation objectives is not meaningfully influenced by its choice of measurement tool. Findings from our 3-country study in sub-Saharan Africa (SSA) suggest, however, that such methodological choices could indeed lead to different conclusions about the extent to which WASH programs and policies are reaching the poor.

Objectives:
We collected primary data from households in three SSA countries to assess the extent to which four commonly used poverty measurement tools consistently classify households into wealth sub-groups. We evaluated concordance of the tools for the full three-country sample, as well as by country, district, and urban/rural classification.

Methods:
We conducted 17,385 household surveys across Ethiopia, Ghana, and Uganda (7 districts in total). Households were selected using a stratified random sampling approach to ensure representativeness at the district level. During each interview, we posed questions about the household's wellbeing using four

poverty measurement tools: the Demographic and Health Survey's wealth index, the Poverty Probability Index, the Stages of Progress scale developed by Anirudh Krishna, and the household's spending on 'regular' items such as food, transport and airtime. Spearman's rank correlation coefficients (Rs) were used to compare poverty classifications across all four tools.

Results:
In a sample of 17,385 households, there is almost no agreement in how four commonly used poverty measurement tools rank their wellbeing. Pairwise comparisons of the tools demonstrate weak associations for the full sample; correlation coefficients range from Rs = 0 (95% CI [0, 0.02]) to Rs = 0.2 (95% CI [0.19, 0.22]). Correlations are just as weak at the district-level. Coefficients for urban and rural households within each district range from Rs = 0.15 (95% CI [0.03, 0.25]) to Rs = 0.68 (95% CI [0.61, 0.75]) and from Rs = 0.13 (95% CI [0.09, 0.17]) to Rs = 0.76 (95% CI [0.74, 0.78]), respectively. Even sub-analyses of households with the ten highest and ten lowest poverty scores reveal that no household is consistently classified by all four tools.

Conclusion:
Within our study districts in SSA, conclusions drawn by researchers and practitioners about how much their WASH programs are reaching the poor may in large part be an artifact of how they are measuring poverty. This result holds across all scales of analysis and in both urban and rural contexts. Given the considerable amounts of funding, time, and energy invested in WASH services with the deliberate aim of alleviating poverty, our findings are cause for concern. They also underscore the importance of clearly conveying how organizations are defining key concepts such as 'poverty' and 'vulnerability' so that valid and reliable indicators can be identified.

POSTER PRESENTATIONS

Assessing influences on the performance of rural water supply facilities in Ghana
Analia Saker, Aguaconsult
Additional Authors: Julia Boulenuar, Harold Lockwood, Jeff Albert,

Over the past three decades, community-based management (CBM) has become the predominant model for managing rural water supply in low and middle-income countries. Today, there is growing recognition that successful CBM may require considerable external support in the form of funding, capacity building, and the provision of technical and management assistance. The difficulties encountered by unsupported CBM have led to other management arrangements being put into place, including the delegation of operational responsibilities to small commercial enterprises as well as the assumption of service delivery by public utilities.

However, there are important knowledge gaps related to the effectiveness of different management arrangements for rural water supply as different approaches have been promoted as much based on the failure of previous approaches rather than documented successes of alternatives. In light of this evidence gap, this research aims to explain variation in the performance of piped rural water facilities in Ghana via quantitative surveys and field observations of 150 randomly selected management arrangements in seven regions: Ahafo, Ashanti, Northern, North East, Savannah, Upper West, and Volta. We are collecting information on three management approaches: public utility-managed piped water schemes, privately owned and operated piped water schemes and community-managed piped water schemes.

During our visits to each facility, we observe functionality, conduct interviews with operators and consumers, and measure turbidity, total and residual chlorine at multiple points within the network. We also conduct detailed interviews with the service providers responsible for each scheme as well as their governing oversight authorities (in this case, Metropolitan, Municipal, and District Assemblies), supplemented by interviews with officials operating at the national level. We employ multivariate analysis to estimate the drivers of performance, treating differing management arrangements, management practices, management conditions, and contextual factors as explanatory variables. Data collection is ongoing but will be completed by mid-May 2023, with data analysis to be completed by August 2023.

Improving access to water, health and other services through enhanced solar energy harvesting
Alberto Ibanez Llario, United Nations Agency for Migration
Additional Authors: Dr Salvador Seguit and his team

Background & Problem statement:
In humanitarian settings, energy is a critically enabling factor to address lifesaving needs, ensure provision of basic services -such as water or health- and improve social and economic well-being. Limited access to energy has severe repercussions on the provision of basic services and on the safety and security of crisis affected populations.

Financial and environmental costs are high where any energy needs are provided by means of diesel-based technology such as generators. This is frequently the case in off grid areas. The combination of fluctuating funding, protracted crisis situations and the need for continued provision of energy for basic services, requires more cost effective, sustainable and environmentally friendly approaches.
Solar photovoltaic is considered the most relevant and applicable technology to gain energy access in vast areas of Africa and Asia where fuel can be expensive to procure and transport, access to sites is limited, but solar irradiation is fairly constant and high.
Current energy practices in humanitarian situations remain often inefficient, polluting, unsafe, expensive, and/or inadequate. A notable exception is the extensive use of solar energy in the provision of water by humanitarian and development actors alike, with solar pumping systems being installed in their thousands every year.

Water pumps, however, can only use a fraction of the energy provided by solar panels, leaving a sizeable amount of surplus solar energy unused, and therefore wasted.
A better, more efficient harvesting of solar energy in solar pumping systems can make water schemes work for longer hours, provide clean energy for other basic services and open new ways for better financial sustainability and social engineering.

Methods:
In order to seize surplus energy, a Lithium-Ion storage and management unit was added to the common solar pumping layout used in humanitarian settings. Several pilots were run at a laboratory in Eastern Spain, where conditions were replicated to those of field sites selected for pilots in Zimbabwe, Nigeria and South Sudan.

Preliminary findings:
-        10% to 64% of the energy provided from solar panels in existing solar water pumping schemes, are never utilized by water pumps.
-        Amount of surplus energy is enough to power health centers and other institutions or extent pumping hours.
-        While technology is evolving, components are commercially available to make the idea viable.

Discussion:
Solar water pumping systems are one of the most common solutions to satisfy water needs in areas where power grids are weak or unavailable. The combination of solar water pumping with new energy storage technologies, such as lithium-ion batteries, can enable the implementation of more sustainable and renewable energy-based water supply systems.
Optimizing energy efficiency in battery-based solar pumping schemes results in a better use of solar energy, which means an increase in water pumped volume and increase access to clean energy for other powering purposes.
With the project still in progress, ongoing longer term monitoring of pilots and their management at field level will be needed to draw more robust conclusions on the sustainability of the proposed systems.

Results from a systematic review and meta-analysis of drinking water contaminants and health outcomes in Appalachia
Mohammad Rofi Uddin, icddr,b
Additional Authors: Jyoti Bhushan Das, Estiar Rahman, Mahbubur Rahman, Moogdho Mahzab, Nina Brooks, Norman Grantham Miller, Stephen Luby, Debashish Biswas

Introduction:
Bricks are a fundamental building material for Bangladesh. However, brick kilns across South Asia utilize 165-year old inefficient highly polluting technology and contribute substantially to poor air quality, greenhouse gas emissions, and poor community health. In Bangladesh, ~7,000 brick kilns produce 27 billion bricks each year, generating 11% of the country's particulate matter, 22% of black carbon, and 17% of total annual CO_2 emissions. During winter brick kilns contribute 30 to 60% of PM2.5 in Dhaka city and resulted in 5000 premature death each year. Working with existing brick manufacturers to improve the energy efficiency of production provides an opportunity to improve the dominant production model in order to save precious natural resources, lessen air pollution, and greenhouse gas emissions. icddr,b along with Stanford University recently implemented a pilot project aiming to improve combustion efficiency among operators of zigzag brick kilns by implementing a set of low-cost technical interventions. However, adopting rate was not 100%, and we qualitatively investigate the barriers and challenges for not adopting efficiency improvements by some kiln owners.

Method:
A team of Bangladeshi anthropologists conducted qualitative in-depth interviews with 30 brick kiln owners, 10 kiln managers, and 10 kiln workers at the end of the intervention trial between February to April 2022. We have analyzed data inductively using thematic analysis.
Result:

The primary reason brick kiln owners did not adopt kiln efficiency improvements was economic losses as these are new sets of interventions, brick kiln owners were to some extent risk-averse and wanted to learn if other kiln owners become successful. Once there is good news of higher quality of bricks in one kiln, that had external positive effects on other kiln owners to adopt and negative news on production did have an impact on lower adoption. Although, the efficiency improvement doesn't require additional

investment, but high price of coal and unskilled labor didn't motivate some kiln owners to take financial risk. Skilled workers are mainstay in kiln operation but despite receiving training from the project, workers were not confident enough to adopt technological modifications because the practices are new for them. Workers also demanded high pays as it requires time and effort to change their current practices but owners were reluctant to increase wages.

Moreover, kiln owners concerned the maintenance of the new techniques, but not aware of environmental damages and also had less knowledge of strategies to mitigate emissions. Price hike of coal and uncertain market of brick in Bangladesh also an important barrier. The Government of Bangladesh has frequently changed policies related to brick manufacturing technology and thus there is uncertainty about the future of this sector, which resulted continued operation of traditional technologies.

Conclusion:
Transforming brick manufacturing faced lots of challenges that require multi-faceted approaches (e.g. training &education, incentives, proper maintenance and supportive regulations) to overcome those challenges. Support from the government as well as proper training and financial incentives for the workers will be useful for energy efficient technology upgradation which will be beneficial for environment pollution and climate change.

Results from a systematic review and meta-analysis of drinking water contaminants and health outcomes in Appalachia
Amanda Darling, Virginia Tech University
Additional Authors: Hannah Patton, Md Rasheduzzaman, Leigh-Anne Krometis, Alasdair Cohen

BACKGROUND
Of the ~2 million Americans who lack reliable access to safe drinking water, many live in low-income rural areas of Appalachia, yet we know little about water contamination or associated health outcomes in the region.

METHODS
We conducted a systematic review of studies of microbiological and chemical drinking water contamination and associated health outcomes in rural Appalachia. We pre-registered our protocols, limiting eligibility to studies that collected primary data published from 2000-2019, and searched four databases (PubMed, EMBASE, Web of Science, and the Cochrane Library). We used qualitative syntheses, meta-analyses, risk of bias analysis, and meta-regression to assess reported findings, with reference to US EPA drinking water standards.

RESULTS
Of the 3,452 records identified for screening, 85 met our eligibility criteria. 93% of eligible studies (n=79) used cross-sectional designs. Most studies were conducted in Northern (32%, n=27) and North Central (24%, n=20) Appalachia, and only five (6%) in Central Appalachia. Across studies, E. coli were detected in 10.6% of samples (sample-size-weighted mean percentage from 4,671 samples, 14 publications). Among chemical contaminants, sample-size-weighted mean concentrations for arsenic were 0.010 mg/L (n=21,262 samples, 6 papers), and 0.009 mg/L for lead (n=23,259, 5 papers). 32% (n=27) of studies assessed health outcomes, but only 4.7% (n=4) used case-control or cohort designs (all others were cross-sectional). The most commonly reported outcomes were detection of PFAS in blood serum (n=13), gastrointestinal illness (n=5), and cardiovascular-related outcomes (n=4). Of the 27 studies that assessed health outcomes, most (62.9%, n=17) appeared to be associated with water contamination events that had received national media attention.

BROADER SIGNIFICANCE
Overall, based on the number and quality of eligible studies identified, we could not reach clear conclusions about the state of water quality, or its impacts on health, in any of Appalachia's subregions. More epidemiologic research is needed to understand contaminated water sources, exposures, and potentially associated health outcomes in Appalachia.

Effect of Pit Latrine Additives on Dewaterability of Faecal Sludge From Urban Slums

Anne Nakagiri, Kyambogo Uiversiy
Addiitonal Authors: James Mabaale, Swaib Semiyaga

Background:
There is prevalent dependance on onsite sanitation technologies, mainly pit latrines, in low-income establishments such as Kampala city slum dwellings. The most eminent sanitation challenges faced by slum dwellers are full and over-flowing pit latrines, odor and flies, which impact the health of slum dwellers and escalate environmental pollution challenges as pit contents are often discharged in open drains. High filling rates, limited money to spend on pit emptying and the persistent smell from the latrines has led to continuous adaptation and use of pit latrine additives. While some studies have reported ineffectiveness of pit latrine additives, they most likely have an impact of the properties of the faecal sludge (FS) accumulating in the pit latrines. The aim of this study was to assess the impact of pit latrine additives on the dewaterability potential of FS from pit latrines.

Methods:
FS was collected from lined pit latrines and characterized for TS, TVS, COD, TN, NH4-N and sand content. A model pit latrine with a squat hole was made from buckets, fed with FS and two commonly used additives A and B added. The dewaterability of FS was determined at 0, 10, 20 and 30 days from application time. The dewaterability of the FS was assessed by the determination of the dewaterability extent (capillary suction time (CST)) and dewaterability rate (percent cake solids). In addition, the physio-chemical properties of the FS after 30 days were determined.

Results:
The average CST after 30 days application period for additive A and B was noted as 582.1 ± 23.5s and 701.1 ± 54.1s, respectively. This indicated a dewaterability rate decrease of 57.9%, and 49.3% for additives A and B, respectively. The dewaterability extent, measured as the average percent cake solids for additive A and B was $17.8 \pm 1.8\%$ and $17.0 \pm 1.7\%$, respectively. The Percentage cake solids increased by 20.2% (additive A), and 16.5% (additive B). The physio-chemical properties noted to increase significantly were TS and COD (additive A) and TS and sand content (additive B). The crude protein content reduced to 16.8 ± 12.3 mg g-1TS and 27.0 ± 25.2 mg g-1TS for additives A and B, respectively compared to control (16.5 ± 2.6 mg g-1TS).

Conclusions:
FS with additives had high water holding capacity. Additives had an advantage of limited increase in dewatering extent, hence the ability to recover more solids after dewatering. In addition, the additives decreased dewatering rate, hence increased rate at which water is released from FS. Use of additives in pits could significantly decrease the use of conditioners in thickening and settling tanks of FS treatment plant and thus operational costs. However, the effect on biological processes needs to be ascertained.

Development and Validation of Flow-through Iron-Electrocoagulation Reactor for Rapid and Low-Cost Removal of Hexavalent Chromium from California Groundwater

Andrea Naranjo-Soledad, University of California, Berkeley
Additional Authors: Mohit Nahata, Siva Bandaru, Jasquelin Peña, Ashok Gadgil

Background:
Historically marginalized communities in the Western United States are disproportionately affected by hexavalent chromium, Cr(VI), a geogenic groundwater contaminant, and human carcinogen. Cr(VI) can be removed by current water treatment technologies such as reverse osmosis, but these are unaffordable for small, low-income communities that rely on groundwater as a water source. Additionally, the retraction of the 10 ug/L Maximum Contaminant Level (MCL) for Cr(VI) in 2017 in California due to lack of economic

feasibility underscores the need for low-cost technologies for rapidly removing Cr(VI) to meet the desirable 10 ug/L goal.

Recent studies, including ours, demonstrate the effective removal of Cr(VI) with iron electrocoagulation (Fe-EC). During Fe-EC, Fe(II) ions produced in-situ are oxidized by Cr(VI) to Fe(III), while Cr(VI) is reduced to Cr(III), the insoluble and harmless form of chromium. However, these studies have only been carried out in lab-scale batch reactors and have often used simple electrolytes, not representative of real groundwater. Furthermore, in current two-parallel plate Fe-EC designs, reducing the treatment time by increasing the Fe(II) production rates requires high voltage, especially for groundwaters with low conductivity. These high-voltage requirements complicate the development of safe engineering designs for real-world applications.

Methods:
We report on the development of and testing of a novel flow-through Fe-EC reactor with spiral wound plates. This design allows for high Fe(II) production rates and a higher ratio of electrode surface area to reactor volume. The experiments were conducted with realistic California groundwater, with pH values between 6 and 9, typical of California groundwater. Two different Fe(II) production rates were investigated, and batch experiments with two parallel iron plates were also studied for comparison with prior published results.

Results:
In batch reactors, Cr(VI) was successfully lowered from 500 ug/L to below 10 ug/L at the pH values and Fe(II) production rates investigated. However, a high Fe(II) production rate resulted in a high voltage requirement. The novel spiral design achieved a high Fe(II) production rate with a voltage requirement about 50 times lower than conventional Fe-EC. Our results suggest that even with a complex matrix of real groundwater, we could remediate 500 ug/L of Cr(VI) to below 10 ug/L rapidly and reliably without exceeding the 50-volt OSHA safety limit of the driving voltage.

Conclusions:
Fe-EC is a promising low-cost and effective water treatment technology for removing Cr(VI) from groundwater from 500 ug/L to below 10 ug/L. The novel spiral reactor design has the potential to continuously, rapidly, and effectively treat Cr(VI) at low voltage requirements. This suggests that Fe-EC is a viable low-cost treatment technology for small rural communities. Further research will investigate 1) the role of operating conditions and water chemistry in Cr(VI) removal from groundwater with Fe-EC, and 2) the immobilization of Fe-Cr-precipitates after treatment to ensure its safe disposal.

Developing and testing an easy-to-use tool to design tailored behavior change interventions
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Background:
The Hands4Health project targets handwashing with soap to reduce diarrhea among children and focuses on off-grid schools in rural Palestine and Nigeria. The holistic intervention approach of this project targets infrastructure improvements with subsequent behavior change interventions. For the behavior change part, we developed a theory-based automatic analysis tool that, being fed with some simple onsite questionnaire data, selects pre-designed, pre-tested and already contextualized behavior change activities targeting those behavioral factors that have been found most relevant in the selected schools.

The innovation:
Behavior change interventions are most impactful if they are precisely adapted to the behavioral factors that steer the selected behavior in a specific context. However, oftentimes behavior change interventions are developed for a country or a region, not taking into account school specifics. The Ranas4Schools toolkit needs a small dataset from students from each school to provide an automated analysis. The ready-made activities are then selected based on the data and are thus tailored to the specific school.

Theoretical background:
The tool was developed based on the RANAS model of systematic behavior change (Mosler, 2012). For each behavioral factor, a behavior change activity was developed and pre-tested together with local partners, resulting in a catalogue of 16 behavior change activities tailored to young school kids in Palestine.

Data:
Qualitative and quantitative data on the RANAS behavioral factors was collected in March 2023 from N=646 students aged 8-13 years (mean=10.9) from 26 schools in Palestine, N ranging from 23 to 27 per school. The total dataset was analyzed. Additionally, behavioral factors for "doers" and "non-doers" of handwashing with soap was compared separately for each school, using t-tests. "Doers" were defined as those who "often" or "always" wash their hands before eating and after toilet-use, the others were defined as "non-doers".

Results:
Results show a pattern for all schools, but also specific characteristics: while in the majority of schools, hand washing with soap is influenced by emotions related to the liking of getting wet with the cold water and to playing with water and soap, concrete barrier plans and demand expressed by teachers; in some schools other factors showed to be influential, for example, remembering to handwash in key situations or action control and planning. These behavioral factors can now be addressed specifically with targeted behavior change activities.

Conclusions:
Developing and using the Ranas4schools toolkit in Palestine proved to be feasible and practicable to be administered with minimal support by the local NGO. The implementation is planned to take place in May and September 2023, evaluation in March 2024.

Outlook:
The activity catalogue can be adapted to other contexts and countries, providing the advantage to apply data-based and tailored, thus more effective behavior change interventions with only minimal additional effort. Moreover, the approach is currently being tested in different institutional settings (e.g. health care facilities) and for different behaviors (e.g. waste management). Data from only around 25 randomly selected students per school using a standardized questionnaire is needed to serve as the basis for the analysis.

The development and validation of a survey to measure fecal-oral child exposure to zoonotic enteropathogens: The FECEZ Enteropathogens Index
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Child exposure to animal feces and associated enteropathogens contribute to a significant burden of disease in low- and middle-income settings . However, there are currently no validated or standardized

survey-based approaches to measure child exposure to zoonotic enteric pathogens. Standard, validated metrics are needed to enable comparisons of child exposure within and across communities and to ensure that exposure is accurately assessed. This study used a sequential mixed methods approach to develop and validate a survey-based measure of fecal-oral child exposure to zoonotic enteropathogens, the FECEZ Enteropathogens Index. First, to identify the critical attributes of child exposure, we conducted and analyzed data from in-depth interviews (IDIs) in northwestern coastal Ecuador among individuals who care for animals (n=29) and mothers of children under two years old (n=58). Second, we supplemented these data with a systematic review of existing exposure measures. Third, based on IDIs and the systematic review findings, we developed a survey consisting of 105 questions and administered it to 297 mothers with children under five years old in the same Ecuadorian communities. Questions asked how often a particular event or behavior occurred in the last week: never, rarely, sometimes, frequently. Fourth, we used principal component analysis with nonlinear optimal scaling to validate an exposure index and calculate unweighted summation exposure scores using the original, ordinal data. We used unweighted scores, as opposed to weighted scores using component loadings, to facilitate interpretability and exposure score comparisons in future research because loadings will differ by study population. Lastly, we conducted bivariate linear regression analyses to compare index scores to two commonly used measures of child exposure that have not been validated – household animal ownership and the presence of animal feces. The final FECEZ Enteropathogens Index consisted of 34 questions and two distinct sub-domains or -indices that constitute exposure: the child environment and child behavior. We found that exposure to zoonotic enteropathogens was ubiquitous. Only two children had no exposure (i.e., scores of 0). If we had used animal ownership or the presence of animal feces as a measure of exposure in this study, 44% and 33% of children would have been classified as having no exposure, respectively, highlighting the shortcomings of these common, unvalidated measures. We also found that the degree of exposure varied among children . This suggests that the common binary exposure measures may be inadequate because they do not provide sufficient information to identify individuals at highest risk if all children are exposed to some degree and are classified as such. The FECEZ Enteropathogens Index overcomes this limitation by assessing the magnitude of exposure, and is more appropriate given the pervasiveness of animals, animal feces, and child exposure in low- and middle-income settings. This index can help standardize measurement of child exposure, similar to what other types of validated measures have done (e.g., water and food insecurity). It will also enable researchers to evaluate the effectiveness of interventions that aim to reduce child exposure to zoonotic enteric pathogens and to assess how exposure affects child health.

We collected all this Data...now what? Utilising Data for informed decision-making in Uganda
Asiimwe Moses Jimmy Odour, IRC International Water and Sanitation Centre

Overall purpose
To conduct service level monitoring, asset inventory and vulnerability mapping in Kabarole district through identification, catalogue, and classification of water systems within the district including their current needs, level of water service provision, and general timeline for eventual repair and/or replacement of significant components.

Problem statement:
Traditionally, the rural water-supply sector only differentiates between having an improved or an unimproved water source. This dichotomy is not very meaningful because, from the perspective of a user, there is a difference between walking 300 metres to a borehole with a handpump and having access to a continuous flow of water from a household tap. A water service perspective demands differentiation of what users receive beyond the simple distinction between access to an improved or unimproved source. That differentiation is expressed through service levels: the service that users receive in terms of water

quality, quantity, reliability, and accessibility. National norms and standards determine the minimum service level people should receive.

Different service levels come at different costs and require different activities and capacities of a service provider, different systems for operation and maintenance and different rules for users. These need to be taken into account when developing water services and deciding on service levels. High service levels may go beyond the ability of users to pay, the capacity of the provider to operate the system or the capacity of the service authority to regulate or support. On the other hand, sometimes users want a high level of service to be able to use their water for productive activities alongside domestic uses. To increase the chances of sustainability, the intended level of service needs to be commensurate with the demand of users for that level of service and the ability and willingness to pay for it, and the management capacity of service providers and support agents. Using a service level perspective is a useful way to structure a discussion on the implications of a choosing a specific level of service.

Design:
Prior to the survey strategic engagements with key district offices of Water, Health, and Community Development were held to agree on potential resource persons with requisite technical competences and previous hand on experience in supporting similar or related surveys using digital data collection processes. Personal smart phones (Android supported) were used collect and later upload of surveys for water points, villages, and households onto the mWater platform. Data collectors were formally engaged through signing short service contracts in line with IRC's Financial Management Guidelines/Policies. Introductory letters to targeted villages were secured from the office of the Chief Administrative Officer through the District Water Office. Further survey data analysis was done using Water Point Data Exchange (WPDx).

Water quality testing was done independently in partnership with Albertine Water Management Zone (AWMZ) based on key parameters for drinking water (Total coliforms, Ecoli, EC, pH, Flourides) and presence of key metals that affect hardware like iron. Sampling of villages for surveys (water point, village, and household) was made in such a way that it was representative at district level. Using https://www.checkmarket.com/sample-size-calculator/ , at 95% confidence level and 5% margin of error, required sample was established at 384 households. To allow for potential mistakes and for practical purposes, a total of 400 households was taken to be the representative at district level.

Key findings:
Most, 70.6% of the HHs surveyed had access to improved source of water for drinking. The most accessed improved water point source was the hand pump i.e., shallow well or borehole (55%) and the least accessed water source accessed for drinking water is fetching from neighbor's piped connection (4%). 30% of the served population spend more than 30 minutes (round trip-including walking and queuing) to collecting water from the various improved water sources. 29% of the population still access unimproved water sources as primary source for drinking water. 41.2% of the households have no secondary source for drinking water, only 15.4% of the HHs have a secondary source that's improved. During the dry season, only 55% of the HHs have access to improved water sources for drinking water. 52% of HHs have previously drunk water from unprotected well/surface water.

Piped systems represent 40% of all water points in the district with functionality of 63%. Whereas protected springs are common in the district with high functionality of 88%, the deep boreholes with hand pumps account for 1% of existing water sources in the district. Over the years, functionality of water points has been increasing though at a low rate. For example, functionality of water points has risen from, 64% (2017) to 72% (2019) and now stands at 74% (2022).

With 2019 (census) and 2022 (sample) survey data sets combined, it emerges that functionality for water points stands at 69%, with the highest being for Kiosks (100%) and protected springs (91%), while the

least remains borehole at 50%. 11 water points changed status i.e., 9 from non-functional to functional (7 protected shallow wells, 1 public tap stand and 1 protected spring) while 2 changed from functional to non-functional (all protected shallow wells). Most protected springs and shallow wells remain very far for most HHs, requiring travel distance of longer than a kilometer radius to and from the source.

During the survey, it was also observed that most of the public tap stands were unprotected with either no fence at all or half fenced thus enabling ease access by animals, especially the cows and goats which graze near the water sources. Poor sanitation and drainage around the water sources were also observed and these make water sources prone to contamination due to clogging and water stagnating in one area as it doesn't flow freely. It was also observed that some of the water sources had direct water percolation from the surface due to the poor masonry since most of the tap stands and public tap stands had cracks, still increasing the chances of contamination.

Regarding physio chemical parameters, 97% of the water points whose samples were tested and analysed complied to the recommended standard (5.5-8.5). and for microbiology, only 30% of the water sources were free from E. coli contamination. Most (70%) of the water sources contaminated with E. coli were mainly shallow wells. The district's major threatening event emerges as drought with Kabende being the most affected, followed by flooding in Kasenda.

45% of the households have never made an effort to make water any safer for drinking, only 39% of the HHs had previously made that effort and majorly (93%) through boiling the water. 95.3% of the HHs live within 1 km of an existing water point and on average age, most of the water points are 3.2 years old. Between 2019 and 2022, the number of HHs walking for less than and more than 30 minutes (including queuing) to and from a water point increased by 26% and 22% respectively, however regular monthly financial contributions by water users reduced by 35%. Harugongo, Busoro and Hakibaale emerge as the top 3 sub counties of Kabarole to consider for new water service locations, with combined potential population reach of 5,828 people and potential capacity population reach of 6,000.

87% of the HHs have privately owned sanitation facilities, however most of these are traditional pit latrines (86%), only 14% of the HHs have VIP latrines, having increased by 9 percentage points from 2019 to 2022. Only 22% of the sanitation facilities have floors/slabs that are washable. For the 96% of the HHs when their cesspools or pits get full, they're not emptied but rather covered and a new one constructed. OD increased from 15% (2019) to 23% (2022). Only 10% of the HHs had handwashing facilities at the sanitation facilities. Only 14% (against national average of 20%) of the HHs had water/soap at handwashing facilities (basic access), and 13% for limited against national average of 17%.

For hygiene, the population with no hand washing facility increased by 6% from 2019 (71%) to 2022 (77%). Basic access reduced by 2% and limited access improved by 3% from 23% (2019) to 20% (2022), against the 2030 target of 100% (basic access).

How findings inform science, policy, and or practice:
There's urgent need to prioritise water points on which the population is 100% reliant and those that are close to functional ones but with high population within 1km radius for most HHs for rehabilitation. The high E. coli levels in the sources contaminated and even those that were negative indicate that there is a possibility of the source being contaminated by micro-organisms found in faecal matter of warm-blooded animals. The microbiological contamination of the water sources is majorly due to poor maintenance, poor sanitation, and human interference. The public tap stands need regular repair and maintenance if water quality is to improve. The sanitation around the water sources needs to be improved by fencing the water sources so that community members don't throw rubbish around the water sources. Water source protection plans should be made and adhered to protect the catchment. The district leadership through its relevant structures should intentionally sensitse and encourage served local communities to regularly boil drinking water regardless of the source and regular cleaning of the storage containers.

Open defecation-free slippage and its associated factors in Ethiopia

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Background:
Recent studies have shown an increase in open defecation and slippage of open defecation-free certified villages in Ethiopia, despite significant progress the country has made on sanitation programs. Hence, realizing existing facts, this study was conducted with the aim of conducting a critical review of the available literature and providing consolidated data showing the level of slippage and its associated factors in Ethiopia.

Methods:
Systematic literature searches were performed in four international databases. The search involved articles published from December 1, 2013, up to June 4, 2019. The Cochran's Q and I^2 test statistics were used to check for heterogeneity among the studies. To negotiate heterogeneity in qualitative data, we used a mixed method approach. The researchers also conducted a publication bias assessment and a sensitivity analysis. A random effect meta-analysis was employed to determine the pooled estimates of open defecation free slippage rate with a 95% confidence interval (CI). The data analysis was performed using the CMA V.3 software program.

Result:
After screening 1382 studies, 12 studies were finally included in this systematic review. The estimated pooled rate of open defecation-free slippage in Ethiopia was 15.9% (95% CI 12.9–19.4%). The main contributing factors for open defecation-free slippage were a lack of technical support, financial constraints, low-quality building materials, improper program implementation, and a lack of sanitation marketing.

Conclusion:
It was estimated that 1 out of 6 Ethiopian households engaged in open defecation after they achieved open defecation-free status, implying the low possibility of achieving the sustainable development goals of 2030, which aim to ensure sanitation for all. Therefore, the government of Ethiopia and donors should better give special attention to the following options: (1) raise awareness for open defecation-free slippage, (2) launch a post-open defecation-free program, and (3) encourage research on pro-poor sustainable sanitation technologies.

Studies to Accelerate Safe Water Services in Low-Income, High Population Density Urban Areas in Ghana

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There are huge challenges associated with meeting Sustainable Development Goal (SDG 6.1) in the urban sub-sector in Ghana. Between 1990 and 2015, the percentage of households in urban areas with piped water supply fell from 41% to 32%. This situation is largely attributable to the rapid urbanization experienced in recent decades as well as poor and insufficient urban planning that has not kept pace with the increase in the population, while there are evident challenges with the ability of segments of the population, especially within the lower wealth quintiles, to afford household connections.

Consequently, the use of packaged water for drinking purposes, especially in sachets, has grown

significantly in recent years, even though it is far more expensive per cubic meter of water accessed directly from the Ghana Water Company Limited (GWCL) the main urban water utility.

To address the underlying issues, the Ministry of Sanitation and Water Resources (MSWR), GWCL and other partners, since 2019, have undertaken a series of coordinated studies. These studies were designed to better understand the drivers and barriers to the subscription to household connections in low-income, high-density urban and peri-urban areas and to test the feasibility of some innovative approaches aimed at addressing the underlying issues such as the affordability of the up-front cost associated with household connections.

Methods:
The studies were carried out in 2 main phases as follows:
Phase 1: A study of the challenges to access safe water services in low-income, high-density urban and peri-urban areas mainly in Accra, primarily using mixed methods, including key informant interviews and focus group discussions.
Phase 2: Testing and assessment of the acceptability and practical possibility of providing households in the low-income, high-density communities with flexible options for affording and financing the up-front cost of household connections and, potentially, the payment of water bills on an on-going basis.

Results:
The study revealed, among other things, that the perceived superior quality of sachet water compared to other sources was the main reason for drinking it. Further, stronger, proactive engagement and feedback mechanisms with communities could enhance the subscription of people in low-income, high-density urban and peri-urban communities to GWCL's services. Apart from physical access to poorly planned areas, the financial cost of household connections was the most significant barrier to households taking up connections. The implementation of the flexible connection has demonstrated considerable potential in expanding the number of household connections in low-income urban settlements, where feasible.

Conclusion:
The studies provide insights into effective pathways for accelerating the achievement of SDG 6.1 in Ghana, through greater access to a strategic segment of the urban sub-sector in Ghana. In that respect, it identifies the factors that influence effective access to service in low-income, high-density urban and peri-urban communities. The findings of these studies are, therefore, intended to shape policy within the urban sub-sector.

Evaluation of biochar and point-of-use filters to reduce 1,2,3-trichloropropane (TCP) contamination in drinking water
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A toxic chemical, 1,2,3-Trichloropropane (TCP), was an impurity in soil fumigants used to kill plant-parasitic nematodes applied widely to agricultural soils from the 1940s to the 1980s. TCP is a suspected carcinogen and widespread contaminant that has leached into groundwater where it is highly persistent and ubiquitous. After contaminating thousands of wells in the United States, Europe, and Asia, TCP has proved both costly and difficult to remove from drinking water. Water consumers, particularly disadvantaged rural communities with small water systems, currently lack evidence-based information on the efficiency of sustainable and inexpensive methods for removing TCP from drinking water. Our research addresses this knowledge gap by quantifying the removal potential of carbon biochar derived from almond agricultural waste and evaluating point-of-use pitcher filters to reduce TCP concentrations in drinking water. Biochar is potentially an important carbon sorbent and might be a more sustainable treatment solution for TCP-contaminated water than the currently used imported coconut and coal-based

feedstocks. Carbon feedstock selection and pyrolysis conditions can affect pore size and the presence of particular surface functional groups, which in turn influence the binding affinity of organic sorbates. To investigate these characteristics, we analyzed biochar samples (n=5) using scanning electron microscopy (SEM) and X-ray photoelectron spectroscopy (XPS). The surface macropore pore diameter (n=200) of the almond shell biochar ranged from 4 – 41 microns with a mean of 19 microns. XPS results indicated the presence of nitrogen, potassium, and oxygen groups on the char's surface. To determine the adsorptive capacity of almond shell biochar for TCP we used a batch isotherm analysis. Isotherms are commonly used to determine the capacity of an adsorbent for a particular contaminant. An aqueous solution containing TCP was contacted with various amounts of prepared biochar and allowed to equilibrate so that the maximum amount of TCP removed at a given temperature could be determined. The absorptive capacity data were then fit to a Freundlich isotherm model which defines the TCP distribution between the adsorbed phase and the solution phase at equilibrium. Knowing the quantity of contaminant adsorbed per unit mass versus the concentration of contaminant remaining in solution at equilibrium is important to compare carbon sources to one another and to optimize adsorbent use. Results from this analysis will be compared to a previous study of TCP sorption using coal and coconut shell-derived GACs. Furthermore, since water consumers lack evidence-based information on the efficiency of POU treatments for removing TCP from tap water, we will test three common pitcher point-of-use treatments to remove TCP. Maximum removal efficiency between different filter types will be established for the lifetime of filters and at different checkpoints along the filter's lifetime (25%, 50%, 75%, 100%, and 125%). Preliminary results indicate that both almond shell biochar and pitcher filter material can absorb TCP from tap water spiked with TCP. Ultimately, the results from this study could inform affected communities of the most effective and affordable treatment technologies at the well and household level.

Can hygienic pit-emptying for hard-to-reach customers be extended? Lessons from Kampala and Kigali
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With 118 million onsite sanitation facilities in use in Sub-Saharan Africa, safe fecal sludge management is crucial. Households hire informal or formal businesses to empty those facilities. Despite improved sanitation services' presence, challenges in technology, accessibility, affordability, and formalization hinder their viability – making them inaccessible to all. Previous studies explored these challenges separately, but few provide a comprehensive analysis of pit-emptying enterprises' experiences. We aimed to fill this gap by comparing service providers' pit-emptying methods, tariffs, and operational needs. This study is the first to compare improved service providers working at scale in different countries.

This study involved two experienced sanitation businesses serving hard-to-reach urban communities: Forever Sanitation in Kampala, Uganda, and Pit Vidura in Kigali, Rwanda. To empty facilities, Forever Sanitation uses manual scooping or the Gulper, while Pit Vidura uses a portable vacuum pump (Pitvaq), with a flatbed or exhauster truck for transport. A data collector shadowed pit emptiers and recorded emptying methods, associated tasks, task durations, and operation needs from 208 jobs between June and November 2022. 1082 operational financial records from January 2021 to March 2023, were shared by both companies that included service tariff, volume emptied, and emptying method used. The quantitative analysis assessed emptying method frequency, mean, standard deviation, and distribution, while qualitative comparisons identified factors impacting emptying duration.

Small exhauster trucks can access some informal settlements but are not suitable for harder-to-serve customers – Forever Sanitation uses manual scooping for 68% of customers and Pit Vidura uses the Pitvaq for 28% of customers. These methods empty more slowly than exhauster trucks: 0.4m³/hour for scooping, 0.3-0.6m³/hour for Pit Vaq, and >2m3/hour exhauster trucks. Portable pumps reduce pumping duration compared to scooping but increase preparation and cleaning tasks' duration. Solid waste

removal accounted for 20-40% of the overall duration in Kampala but Forever Sanitation removed three times more solid waste than Pit Vidura. Pit Vidura employs 5 emptiers to accommodate challenging topography, accelerate barrel transport, and quicken the emptying duration, whereas Forever Sanitation employs two. Each emptier carries 1100kg/day at Forever Sanitation while Pit Vidura's carry 720kg/day. Regarding the tariff, Forever Sanitation charges $8 per 160-liter barrel, while Pit Vidura charges $81 for 2m³. We found that Pit Vidura's tariff discourages customers unable to pay 80$ or have small volumes to empty, while Forever Sanitation's is more inclusive with a larger proportion of lower volume and consequently lower tariff jobs.

The study found that a combination of manual and mechanical methods is necessary for safe and hygienic service delivery. In Kigali prohibiting improved manual methods leaves numerous facilities without safe options. Regulators need to recognize improved manual emptying that meets hygienic requirements. As businesses scale, there is a risk of exceeding recommended manual handling loads for emptiers, therefore, limits should be established. The different solid-waste collection systems in each city impact the trash disposal in facilities. Lastly, higher minimum tariffs are less inclusive; customers prefer lower emptying volumes but a minimum emptying volume is essential for financial sustainability.

Assessment of water quality at handwashing and drinking stations in schools in Belize: 2022
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Background:
Unsafe water is associated with the transmission of many diarrheal diseases among children. Clean water access at school is critical to preventing the spread of diseases, reducing student absenteeism, and promoting a safe learning environment. However, many lower- and middle-income countries lack the resources to regularly conduct water quality testing. Additionally, water quality assessment and monitoring were disrupted in many settings during the COVID-19 pandemic. In collaboration with the Belize Ministry of Health and Wellness and the Belize Ministry of Education, Culture, Science, and Technology, we conducted water quality assessments at schools across the six districts of Belize in March 2022.

Methods:
We conducted an online baseline survey among primary and secondary government and grant-aided schools in Belize (N = 312) during December 2021 – January 2022 to understand existing water, sanitation, and hygiene (WASH) infrastructure and resources at the schools. Among the 221 schools that participated in the survey, we selected 66 schools for onsite water quality assessments: 54 schools were selected based on their primary water source, perceived water quality concerns, and urban/rural classification; 12 schools were selected due to their inclusion in another arm of the project for a more comprehensive hand hygiene evaluation. At each of the selected schools, handwashing and drinking water stations were randomly selected to assess the free chlorine residual (FCR) levels. Water samples with a FCR level below the World Health Organization (WHO) recommended level for drinking water (0.2 mg/L) were sent to the National Drinking Water Quality Laboratory to test for the presence of total coliforms and E. coli. Descriptive statistics and unadjusted odds ratios were calculated to evaluate associations between school characteristics and water quality results.

Results:
Of the 65 schools we visited for the assessment, 54 (83%) schools had at least one handwashing or drinking water sample where FCR was <0.2 mg/L. Rural schools had significantly higher odds of having at least one water sample with an FCR below the WHO standard (OR = 6.13 p = 0.01). Total coliforms and E. coli were detected in at least one water sample at 43 (66%) and 14 (21%) of these 65 schools, respectively. Of the 14 schools where E. coli was detected, 13 (93%) were classified as rural, and 11

(79%) were located in one of the three southern lower resource districts of Belize.

Conclusion:
The results were shared with Belize governmental entities and the local water boards of communities where E. coli was detected. The local water boards immediately responded with interventions, including system flush-out, airlifting to remove debris, and superchlorination of the community water sources which supplied the schools. Additionally, these schools were included in a monitoring plan by the MOHW. The results from this study in Belize demonstrate the importance of water quality monitoring to guide public health interventions in community settings, especially in rural lower resource areas.

Key learning objectives:
• Assess drinking and handwashing water quality in schools in Belize
• Review interventions implemented by local governmental entities in response to assessment results

Sustainable Water Services: findings from 10+ years of Circuit Rider maintenance programs in fragile contexts
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Additional Authors: Andrew Wester, Adrienne Lane, Wesley Meier

Background:
The circuit rider (CR) model for professionalized maintenance for drinking water services relies on a series of deployed technicians (circuit riders), that visit a circuit of communities on a routine basis to provide preventative and on-call maintenance, technical assistance, and monitoring. EOS International, uses a CR model to support community water boards with the maintenance of passive in-line chlorinators in 1900+ communities serving 1 million+ people in Central America. Water for Good (WfG), uses a similar CR model to maintain 2,000+ handpumps and 111 piped-scheme tapstands serving 800,000+ people in the Central African Republic (CAR). CR models for professionalized post-construction support have a >50-year history, and this research builds on recent evaluations (Fink et al. 2021, Lockwood 2019, McNicholl et al. 2019, 2021) adding critical evidence on factors that influence effectiveness and financial sustainability.

Methods:
Between 2012 and 2022, CRs visited communities and recorded system functionality and the type of maintenance provided. In Central America CRs also monitored chlorinator functionality and chlorine. CRs have completed between 20,000-30,000 community visits since 2012 in CAR and Central America. Visit results were analyzed to calculate the costs of CR model implementation and programmatic effectiveness.

Results:
In communities where EOS and WfG operate, functionality was above regional averages. In CAR >90% of systems were functional. In Central America, >96% of systems were functional and >80% of all monitoring results had free chlorine residual > 0.2 mg/L. Frequency of CR visits positively affected outcome variables in both contexts. Analyses also indicated that communities visited by CRs have seen sustained access even as both programs have scaled into new communities.
In WfG's model, communities pay per maintenance visit for handpumps and a volumetric rate for piped-schemes. Over the analysis period, only 15% of communities with handpumps made payments whereas, communities with access to piped-schemes averaged an 80% collection efficiency.
In EOS' model, communities pay for chlorine tablets, and this revenue covers a percentage of CR expenses. Only 11% of instances of lapses in system effectiveness were attributed to lack of available funding for chlorine tablets assistance. In both contexts, local revenue covered less than 50% of circuit rider program costs on a per community, annual basis. However, innovative financing mechanisms through results-based funding or through alternative income models like sales of services to other NGOs have allowed EOS and WfG to subsidize their CR services.

Conclusion:

Findings from both studies suggest the importance of sustained post-construction support for service delivery. Both studies also suggest the importance of increasing community payment coupled with reliable subsidy sources. The enabling environments for financial viability and the level of services provided are also critical. In Central America where most communities have piped-schemes and water treatment is legally required, our results indicate stronger local capacity for payments. In CAR, there is limited local capacity and demand to pay for CR services for handpumps compared to piped-schemes. Further, EOS' and WfG's findings emphasize the benefit of innovative funding, like Uptime's results-based financing contracts, compatible with future uptake by public sector funding.

The use of machine learning to predict household water treatment practices and behaviors in Haiti
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Previous research assessing behavioral determinants of household water treatment (HWT) use and adoption has primarily used qualitative epidemiological analysis and statistical methodologies, such as regression. However, machine learning methods have been increasingly applied to understand behavior and predict public health outcomes. This study aims to assess current HWT adoption and factors influencing adoption of HWT over time in Haiti, which has faced recent emergencies, by using and comparing regression and machine learning methods of analysis.

We conducted a cross-sectional survey with households in mountainous, urban, and rural Haiti where non-profit organization partners had current project operations. The survey was designed to measure intent to perform HWT (HWT use, reported by respondents) and action to perform HWT (HWT use, measured via residual chlorine (TCR) presence), and more than 70 demographics and psychosocial determinants based on a hybrid behavior model combining the integrated behavior model and the theory of planned behavior. Analyses were conducted via stepwise logistic regression and using WEKA open-source machine learning models. Both methodologies were compared using categories of factors included in the model and area under the receiver operating characteristic curve (AUC ROC).

Overall, 650 people completed the survey in the urban, rural, and mountainous areas of Léogâne, Pignon, and Hinche in Haiti. In total, 376 respondents (58%) answered they treated their water or bought water, and among them 99 respondents (37%) who consented to the research team testing their water had TRC>0 mg/L at the time of the visit. This suggested low HWT adoption and that reported HWT use was not strongly correlated to TRC presence. Information related to demographics, risk beliefs, and WASH behaviors contributed the most to predicting HWT use (both intent and action). While demographic factors dominated with machine learning and risk beliefs factors were the main drivers of HWT adoption with regression, we observed demographic variables were a strong proxy for some psychological factors. Respondents from the two partner populations (one a water supply implementer and one a HWT implementer) could be distinguished from each other quite strongly with demographic and WASH behaviors factors, indicating the importance of long-term HWT programming on beliefs and treatment. Lastly, we observed high and similar AUC between regression and machine learning (between 0.77 and 0.82) to predict the outcomes, indicating that model performance was good and could sufficiently distinguish respondent HWT current use. Therefore, machine learning may not produce a more accurate model, but such models should be explored for other advantages.

Impacts of scheduled desludging on water quality for onsite sanitation services dependent cities: A case of Wai, India
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Background:
In India, more than 4000 cities are dependent on onsite systems, and this proportion is increasing. The

common practice for desludging of septic tanks is 'demand-based desludging' rather than regular service. In many cities, the septic tanks are not connected to soak pits and directly dispose their supernatants to the open drains which gets discharged into surface water. Such practices have adverse social and environmental impacts.

Scheduled desludging is advocated to maintain the performance of septic tanks and avoid adverse effects on the environment. In this, every property in the city receives a scheduled service to desludge its septic tank as per the plan. This ensure that all septic tanks are desludged on a regular basis.
This paper is based on the experience of scheduled desludging in the city of Wai in Maharashtra (India) and its impact on the quality of supernatants which further affects quality of river water and groundwater.

Methods:
A water quality monitoring plan was initiated to understand impact of scheduled desludging and sample locations were selected to follow the flow of septage and effluent from the household containment system into the urban environment. Seven sample locations of various residential typologies having septic tanks, 60 groundwater sample locations across city, four river water samples and 17 major drain outfall sample locations were identified. 119 septic tank composite samples, 300 groundwater grab samples, 85 drain water composite samples and 56 river water composite samples were collected and tested over three years. Quadratic mean values were derived for samples before and after implementation of scheduled desludging cycle for the analysis.

Results:
The study reflected the linkages of scheduled desludging and improved supernatants and drain water quality which as a result improves the river and groundwater quality. It showed positive impact on the performance of septic tanks with 60% of samples showing reduction in Total Suspended Solids and organic load in its supernatant. The quality of water in drains has improved progressively during scheduled desludging. 80% of samples of drains showed reduction in organic load, nutrients and pathogen content as more septic tanks were desludged. This has led in reduction of faecal coliforms in river and groundwater. Though we recognize that septic tank performance is also influenced by various factors of design, capacity, users and maintenance, regular desludging certainly helps in improving performance.

Conclusion:
The study gives positive association of regular desludging with improved septic tanks performance and improving environment. Such studies can inform decision making at state and national level to strengthen their recommendation of desludging. The state Government of Maharashtra in India has passed a Government Resolution to implement scheduled desludging in all its 400+ cities.

Regular desludging has shown positive impacts, however, since the drain water is a mix of effluent from septic tank as well as other wastewater from properties, it is recognized that further studies will be needed to isolate effect of septic tank effluent. The findings of this study can be further amplified over the next cycle of scheduled desludging.

Experimental Evaluation of UVC-LED Pre-treatment for Biofouling Mitigation in Reverse Osmosis Systems
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The United Nations Sustainable Development Goal (SDG) 6 has motivated significant progress towards providing access to clean water for all. Despite this, the United Nations reports that in 2020, there were 2 billion people without access to safe drinking water. There is an urgent need to tackle this SDG as increasing water demand from population growth, improper management of water supplies and infrastructures by governments, and climate change continues to exacerbate this issue; current

projections are that by 2030, there will still be 1.6 billion people without safely managed drinking water supplies. Among existing solutions, photovoltaic-powered reverse osmosis (PVRO) has emerged as a consistent method due to its performance and widescale availability. However, reliability issues like biofouling on reverse osmosis (RO) membranes, caused by the buildup of biofilm from microorganisms in feedwater, can quickly reduce its performance and shorten membrane lifetime. Membranes are one of the most expensive components to replace and in some areas, it may be difficult to even obtain them due to supply issues. Biofilm buildup can be an even greater challenge for remote areas, where RO systems are often operated intermittently resulting in stagnant water adjacent to the membrane during shutdown periods. Therefore, reducing the biofouling potential of RO membranes for low-cost, community-scale applications can enhance the accessibility of PVRO for a broad range of water-stressed communities. Ultraviolet light emitting diodes (UV-LEDs), particularly those in the ultraviolet-C (UVC) range (254 nm – 285 nm), have been shown to reduce the number of microorganisms in water by damaging their DNA; they are particularly attractive due to their compact size, economical price, low energy demands, and being ecofriendly compared to other solutions. Despite this promise, there is little quantified information on the efficacy and optimal parameters for use of UV-LEDs to reduce biofouling on RO membranes. Therefore, in this project, intermittent RO system operation, UV radiation in the range of 254 nm – 285 nm, and various UV doses are being used to pre-treat bacteria-dosed water to analyze their effect on membrane biofouling. Imaging using various microscopes will be a key method to study the membranes, and the images will be used in machine learning models to detect biofilms and to recognize any patterns. Ultimately, a field study will be conducted to validate the experimental results, and to record other factors that need to be incorporated into the system to improve results.

Small-scale experiments, where an E. coli water chemistry is exposed to UV light in petri dishes, are currently being conducted. The preliminary results from these experiments show that UVC-LEDs do reduce biofilm, and this was also verified through imaging instruments, such as a fluorescent microscope and a scanning electron microscope. These experiments will be repeated before conducting them on the large bench-scale system in the lab, which mimics systems typically found in the field.

Microbial characterization of Environmental Matrices in Maputo, Mozambique
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The Maputo Sanitation Trial is an ongoing health impact trial of shared sanitation facilities implemented in informal and semi-formal neighborhoods of Maputo, Mozambique. In addition to measuring health outcomes, we are measuring pathogens and fecal indicators across a range of environmental matrices to understand how the intervention is affecting the transmission of disease in the community.

We collected household bioaerosols (n=179, control [C] = 89, intervention [I]= 90), floor swabs (n=172, C=90, I=82), flies (n=29, C=14, I=15), latrine entrance soil (n=172, C=90, I=82), fecal sludge (n=97, C=50, I=47), prepared foods (n=151, C=72 , I=79), stored water (n=171, C=82 , I=89), source water (n=125 , C=65 , I=60), and animal waste (n=33, C=18, I=15) in or around household clusters served by good sanitation and control sites lacking good sanitation. We used the IDEXX Quanti-Tray 2000 method for total coliform bacteria and Escherichia coli (E. coli), with sample aliquots preserved for ongoing analysis for 40 enteric pathogens via multi-parallel qPCR. Arithmetic mean (mu) E. coli concentrations (MPN/100 mL) with standard deviations [sd] include: bioaerosols (mu= 59 [775]), floor swabs (mu= 4.0×10^3 [1.8×10^4]), flies (mu= 1.2×10^4 [4.0×10^4], latrine entrance soil (mu=2.9×10^4 [2.0×10^5], fecal sludge (mu=3.0×10^6 [2.5×10^7], animal waste (mu=4.2×10^7 [2.0×10^8] and prepared foods (mu=1.0×10^4 [1.2×10^5]), stored water(mu=40 [260]), and source water (mu=3.7 [35]). We conducted Wilcoxon rank sum tests on the log10 E. coli concentrations to determine median (η) differences between control and intervention arms. Bioaerosols ($\eta<1$, p=0.9), floor swabs (η= 200, p=0.2), flies (η= 126 , p=0.6), latrine entrance soil (η=410, p=0.8), fecal sludge (η=1.7×105, p=0.7), animal waste (η=5×105, p=0.2) and prepared foods (η=500, p=0.3) did not demonstrate a statistical difference between groups. However, preliminary findings indicate stored and source water samples were statistically different between control and intervention with a small effect size for stored (p=0.02, r=0.175) and source water

(p=0.01, r=0.220) with a decrease of E. coli concentrations in intervention versus control arms.

These findings imply that stored and source water exposure pathways may be different between compounds with improved shared sanitation facilities and those without. Additional analyses focusing on enteric pathogen detection and concentrations across the environmental samples collected will be a critical follow-up to expand on these results. This work on comprehensive environmental sampling in Maputo will assess the longer-term changes to environmental conditions associated with the implemented intervention.

Impact of a Novel Technology on Occupational Health Risks Related to Wastewater Treatment and Reuse
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India is struggling to manage high water demands from multiple sectors. The reuse of treated wastewater could help to meet these demands. A majority of wastewater in India is discharged without treatment or is treated but does not meet the effluent discharge standards. These practices lead to environmental and public health risks, especially if this effluent is reused for irrigation. To address and mitigate health risks related to wastewater handling and reuse the World Health Organization's Sanitation Safety Planning (SSP) approach was developed. This study uses SSP to explore how a novel technology impacts the occupational health risks associated with the existing wastewater treatment technology and reuse system in Kanpur, India.

Kanpur is at the heart of India's tannery industry. These tanneries use chromium and are known to discharge illegally into the sewer network, hence this study will consider risks associated with chromium VI (Cr VI) and faecal hazards. Jajmau Sewage Treatment Plant (JSTP) discharges effluent through a 4 km irrigation channel to 40 villages. This study focuses on two villages that have access to these channels. The novel technology explored is a combination of an integrated permeate channel membrane in sequence with a constructed wetland plus.
A participatory mixed methodology was used which included key informant interviews, structured observations, and E.coli and chromium VI analysis. Data was collected between July and August 2022 (E.coli campaign) and 2023 (Cr VI campaign).
The system boundaries include treatment processes, liquid flows, and downstream villages where effluent is delivered through irrigation channels for reuse in agricultural fields. The exposure groups identified are the workers at the wastewater treatment plant, farmers reusing the effluent for irrigation and consuming crops produced.
The treatment efficiency of JSTP for E. coli was 51%. The mean E. coli concentration (6.5 log10 CFU/100ml) of the effluent did not comply with the Indian discharge standards. The mean E. coli concentration of the effluent for the novel technology (130 CFU/100ml) did meet the discharge standard. The mean E. coli concentration at both sites for irrigation water from the channels and the fields was 6.1 and 4.8 log10 CFU/100ml.

A preliminary semi-quantitative risk assessment was undertaken including the E. coli data following the SSP approach. It was found that the impact of swapping to the novel technology increased the number of health risks which the wastewater treatment plant operators were exposed to, but the severities of the risks were lower. This was due to the different treatment processes and the associated infrastructure. The estimated health impacts on the farmers decreased, as the number and the severity of the risks decreased. These changes were due to improved microbiological quality of the irrigation water. When the Cr VI sampling campaign is completed in 2023 the participatory risk assessment will be repeated and the results of the microbial and chemical health risk assessment will be combined.

WasteWater equity: A comprehensive assessment in California
Gregory Pierce, University of California, Los Angeles

The UCLA Luskin Center for Innovation is leading a team, also including Sacramento State University, UMass Amherst and the UC Extension system, to conduct a 4 year, $4 million, comprehensive Needs Assessment on the state of wastewater systems in California for the state's primacy agency. This assessment will be the first of its kind nationally.

Overall, the study evaluates the baseline situation of wastewater infrastructure and services across the state, identify data gaps, develop a roadmap for data collection and develop a multifaceted risk/solution framework with Board staff and stakeholders. Additionally, this work will provide the California State Water Resources Control board with a framework for continuing to build on this process and a roadmap for the next four years of work.

The primary motivation for this work is that unlike publicly-owned wastewater treatment plants, information on the presence and integrity of OWTS in the United States is extremely limited: the last national-scale estimate of the prevalence of sanitation systems in the United States (or California) was conducted in 1990, at which time at least one-fifth of the United States population were reported to use OWTS. Much like with reliance on private wells and regulated community water systems, the Californian population is much less likely than the general United States population to be unconnected to regulated sanitary sewer systems. The most recent source of data available on OWTS reliance across California, the 2015 American Housing Survey, suggests that 6.4% of the state's households reported not being connected to sewer systems.

There is also generally less definition around, and understanding by, the broader policy and advocacy community of the performance of regulated sewer systems and onsite systems with respect to top-line human health protections. While just as with community water systems (via the Safe Drinking Water Act and additional state code), there are regulatory standards and associated enforcement codes for sanitary sewer systems, stemming from the Clean Water Act and additional state code. Unlike on the drinking water side, however, regulators have not shed a spotlight and a particular impetus for consolidation/investment on wastewater sanitation systems with chronic/severe failures.
Moreover, advocates and scholars have not focused nearly as much on gaps in the human right to sanitation in California; there is not a single analysis at the state level which does so which we are aware of, except one report from UC Berkeley, which focused on citizen enforcement of Sanitary Sewer Overflows. Analyses which do touch on these issues typically assume that connection to a sewer system is enough. But as has been seen on the drinking water system side, connecting septic systems into small sewer systems may in some cases be desirable but in others less prudent because of small sewer systems' own financial and broader technical, managerial, financial (TMF) difficulties in maintaining their infrastructure. Further defining the criteria for, and then set of, regulated system of highest concern, is essential to inform future funding and regulatory efforts to improve sanitation access.

A systematic review on faecal sludge emptying technology choices, challenges and improvement initiatives
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Additional Authors: Swaib Semiyaga, Musa Manga

Background and overall purpose:
The emptying and transport of faecal sludge (FS) is a fundamental aspect of the sanitation service chain and is mostly carried out by private operators. These operators face a lot of challenges which limit their efficiency and affect the profitability of their business. These challenges are linked to factors which affect the choice of emptying methods, and they also act as barriers to implemented strategies for improving the working conditions of the operators. To better understand the challenges faced by FS emptiers and provide recommendations that can be incorporated into policy framing and targeted behavior change strategies, our review assessed the interlink between challenges and influencing factors and how they act as barriers to improvement initiatives.

Study design/methods:

PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines was used to conduct a systematic review of peer-reviewed journals on FS emptying in sub-Saharan Africa, South and Southeast Asia published between January 2002 and December 2021. These regions were chosen because of their wide coverage of onsite sanitation systems and in turn widely spread emptying businesses. A total of 37 articles from 25 countries were included in the study.

Results and discussions:
Accessibility was observed to be the most documented influencing factor (n = 18). Other factors include cost, quality of service and faecal sludge thickness or density. Though accessibility was the most discussed influencing factor, cost was observed to have the most influence as it overrides accessibility and service quality when it comes to the selection of an emptying method. The challenges identified from the reviewed articles were grouped into five major categories which include financial, technical, institutional, health and social challenges with the last two being peculiar to manual emptiers. About one-third of the studies (n=13) discussed initiatives which have been put in place to make emptying business more lucrative and sustainable. The discussions on improvement initiatives were centered around public private partnerships and the involvement of non-governmental organizations and international donor agencies. Of all the influencing factors and challenges, cost/affordability of the service and access to finance by FS emptiers were observed to be the major barriers to improvement strategies.

Implications and Conclusion:
The limited number of studies discussing improvement strategies implies that a lot still has to be done to improve FS emptying business. Areas of future research identified from this study include the need for sensitization for those in rural areas on importance of FS emptying, financial modelling of manual emptying and studies on perceptions towards emptying for both users and FS emptiers. Addressing these research gaps will provide critical information needed by stakeholders in the sanitation sector to improve FS emptying business.

A Framework for Understanding and Modeling Reliability and Equity under Intermittent Water Supply (IWS)
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Background:
Water insecurity persists as a major health concern, with its prevalence expected to increase in the face of climate change and population growth. It is estimated that more than one billion people receive some form of Intermittent Water Supply (IWS), broadly defined as water provided through a piped network for fewer than 24 hours a day. Upon reviewing the literature, the most common consequences of IWS belong to four categories: (1) Health Risks: human-health concerns resulting from insufficient water quality and quantity; (2) Infrastructure: network condition, operation, and resulting deterioration; (3) Economic: consumer and utility cost burdens; (4) Social: decision making, management strategies, and consumer behavior.

Objective:
Investigations into the causes and consequences of IWS generally focus on water quality or equal supply volume. Existing literature fails to consider the impact of cooccurring features on their findings. Exploring the larger research question "How do we define and achieve equitable IWS?", this work sets out to (1) Develop metrics of equity for IWS to determine the factors affecting the differential impacts of IWS on households and utilities and (2) Investigate paths to improve equity through case study communities.

Methods:
To develop a novel conceptual model of IWS that quantifies system features at each point along distribution we combined the separate models (Network and Household) to create a single comprehensive IWS system model. This approach defines the overall impact of IWS through its sub-elements, resulting in an adaptive modular structure with broad applications. The Network Level Model addresses the impacts of IWS on the system itself. Causal Loop Diagrams (CLDs), a visual

representation of how key variables are interconnected, were used to address feature interdependence without overcomplicating the model. We subdivided each network feature, generating loops for the contributing sub-features. The Household Level Model, developed using the same approach, addresses the impacts of IWS on the households served by capturing how a household interacts with a given IWS system.

Finally, we extended our conceptual model using Bayesian Belief Networks (BBNs), to introduce statistical weightings and generate predictive outcomes. BBNs can incorporate uncertainty and other dynamic factors, which enables us to simulate the impact of management strategies, consumer behavior, and innovative technologies.

Results:
Data analysis is ongoing; however, we expect to be able to offer insights into the complex mechanisms of IWS operations. Our analysis thus far of previously collected datasets from Coimbatore and Hubli Dharwad, India investigates equity and fairness. Our results suggest that CLDs are effective at representing the impacts of IWS. The Coimbatore data analysis showed that households receiving the same supply frequency received different water volumes, suggesting equal service hours does not guarantee supply equity. Furthermore, despite similar supply differences, higher-income households had greater resources to cope with IWS, lessening their experienced disparity. The Hubli Dharwad data analysis produced similar results further suggesting that IWS features are interdependent. Next steps include implementing BBNs for both datasets to further understand equitable IWS and evaluate the effectiveness of proposed improvements.

Novel Time-Integrated Quantification of Sediment-associated Fecal Indicator Bacteria in Rural Alabama Creek with Straight Pipes

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In the Alabama Black Belt, widespread rural poverty, limited sewer access, and shrink-swell clay soils that preclude using conventional septic systems lead to failing septic systems and discharge of raw sewage from homes through "straight pipes." Discharged sewage pools until it is flushed with sediment into local waterways. The degree to which fecal microbes are associated with suspended sediment load has important implications for the sustained transport of contaminants within the waterway, with ~60% of fecal microbes in surface water during storms associated with particles. Therefore, an accurate and efficient method of capturing and monitoring suspended sediment and determining the microbial association is critical in understanding the impact storms have on fate and transport of fecal pathogens.

Sampling surface water for fecal contamination typically involves collecting grab samples. While this is technically simple, microbial surface water quality is highly variable and indicator bacteria are poorly correlated with waterborne pathogens. Therefore, grab samples tested for fecal indicator bacteria are inadequate to evaluate potential risk to human health from enteric pathogens in a waterway. Incorporating time-integrated sampling methods initially used in sedimentology into pathogen capture results in more representative data and significantly higher numbers of fecal microbes than grab sampling alone. The novel time-integrated methodologies for capturing suspended sediment and associated microbial load have been applied to three sites along Big Prairie Creek in Newbern, AL since 2021.
The time-integrated mass sediment sampler (TIMS) method was applied to quantify pathogens and other fecal microbes attached to suspended sediment. TIMS collectors were placed at locations upstream, adjacent, and downstream of a town with known straight pipe usage. Sediment characteristics were analyzed for particle size distribution and organic content (loss-on-ignition). Attachment of fecal indicator bacteria to sediment was evaluated using vortexing and centrifugation-based methodology. E. coli, thermotolerant coliforms, and total coliforms were analyzed using the IDEXX Colilert media and Quanti-Tray 2000 system. Results show an increase in proportionate fine particle load following precipitation, due to fine vertisol-clay soils runoff. Intuitively, the concentration of fecal indicator bacteria increased following rain events. The proportion of E. coli and coliform bacteria that are sediment-associated also increased

as bacteria partitioned to increased cumulative surface area.

Standard surface water sampling in Alabama and other states does not require continual monitoring and is typically measured during low precipitation periods. The TIMS sampler enables deeper understanding of surface water conditions and consequently better management from more robust data collection. The easy-to-install PVC device is an inexpensive alternative to conventional time-integrated sampling methods. This work reflects our efforts to enable affordable time-integrated approaches to quantify the pathogens in rural streams, differentiate sediment-associated fecal microbes, assess the potential of in-situ natural and engineered surfaces to capture significant portions of pathogens that current conventional approaches fail to reflect, and provide water managers with improved methods for evaluating the safety of water sources for drinking water supply and recreational use. A new clustered, decentralized wastewater system is being installed in Newbern; these time-integrated sampling methods will be used to monitor its surface water quality impact.

Evaluation of a WASH/MNCH targeted primary health care program in Uganda
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Additional Authors: Maureen Nankanja, Margaret Mugisa, Ojoro Valentine, Patrick Kagurusi

Background:
Evidence on the impact of Maternal Newborn and child health (MNCH) and Water, Sanitation and Hygiene (WASH) interventions on skilled birth attendance and neonatal sepsis remains unclear. We assessed the effect of WASH/MNCH integrated interventions on skilled birth attendance and incidence of neonatal Sepsis in a resource-constrained setting in Uganda.

Methods:
A quasi-experimental study design was conducted in Amuru district. The package of interventions implemented included; training of health workers, facilitation of integrated outreach services, construction of WASH facilities, and health education of communities. A digitized structured questionnaire was used to obtain data on ANC and skilled birth attendance, WASH practices and prevalence of pneumonia and diarrhea among 466 expectant mothers and caretakers of under-fives at baseline, midterm and endline. Data on the incidence of sepsis, ANC and skilled birth attendance, and WASH status was also obtained from 6 healthcare facilities. A total of 12 key informant interviews and 12 Focus group discussions were also conducted. Data were imported into STATA 15 for analysis. Two sample tests of proportions were used to compare findings at baseline and endline. Qualitative was analyzed using thematic content analysis.

Results:
There was a significant increase in the number of women delivering at the health facilities that were supported by the project from 41.4% at baseline to 63.0% at endline (p= <0.0001). There was a reduction in the incidence of neonatal sepsis from 0.6% to 0.2% (p = 0.0687), although the difference was not significant. There was an increase in the percentage of households with sanitation facilities and improved hygiene practices. Community-level findings also indicated a decline in cases of water-borne illnesses; cases of dysentery decreased from 10.0% at baseline to 0.6% at endline, cases of cholera decreased from 8.9% to 1.9% at endline, cases of typhoid decreased from 26.5% to 12.7% at endline.

Conclusion:
This study revealed that integrated WASH/MNCH interventions can significantly increase ANC and skilled birth attendance, reduce incidences of neonatal sepsis, diarrhea, pneumonia, and other related diseases and improve WASH practices in communities. Significant improvements in WASH/IPC in the maternity wards and the capacity of healthcare workers to deliver clean and safe MNCH services can also be realized. We recommend the integration of WASH/MNCH interventions for projects aimed at improving skilled birth attendance and WASH practices and reduction of childhood infections.

Empowering handpump mechanics through savings groups to provide professionalized maintenance services
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Additional Authors: Simon Mugume, Enock Obwon, Bena Nakabiri, Reagan Ajuna

Water points in rural Uganda require regular maintenance and repair, and unwillingness to pay and inadequate supply of maintenance services can both limit necessary maintenance and repair. The latter is often the case despite the existence of local handpump mechanics associations, which often struggle with limited organizational capacity and collective efficacy. The Water Trust's self-help group for sustainable water approach has demonstrated an ability to significant increase the collective efficacy and motivation of rural communities to pay for necessary maintenance and repair across more than 900 communities in western Uganda. However, the approach does not significantly increase motivation to engage in regular preventative maintenance (prior to functionality issues arising) nor does it increase the capacity of local mechanics to market and deliver such services. The Water Trust is piloting an intervention in Masindi district to support the handpump mechanics association to proactively engage local self-help groups to engage in simple, structured preventative maintenance contracts, as well as to form a mechanic association savings group that will not only provide access to personal savings and credit for mechanics, but also a mechanism to pool funds for purchases that will benefit the group, such as necessary tools and spare parts. Preliminary results will be shared on the adoption rate of preventative maintenance contracts, usage of the savings group to support handpump mechanic work, and the qualitative experience of hand pump mechanics attempting to engage communities to pay for preventative maintenance.

Does private administration of water companies increase investment in water and sanitation? Evidence from Brazil
Carlos Nunes, University of North Carolina

Background:
In Brazil, 93.4% of the urban population has access to water supply services, but only 64.1% have access to sanitation. In a country with 179 million living in urban areas, this means that 12 million people don't have access to public water supply services and 64 million lack access to sanitation. Aiming to revert these figures and improve coverage, especially in sanitation services, the country reformed the water sector in 2020, by, among other measures, removing barriers to entry for the private sector in the provision of services. This was justified by the presumption that the private sector would have a greater investment capacity than the public sector.

Objective:
The objective of this study is to determine whether that presumption was correct based on historical data on investment in water and sanitation at the municipal level until 2020.

Methods:
The study used data from the National Water and Sanitation Information System (SNIS) between 2002 and 2020. This dataset contains data on water utilities' operations in Brazil since 1995, covering more than 90% of Brazilian cities. It presents annual data aggregated by the municipality and by the water utility. The dataset was complemented with official economic data from the Brazilian Institute of Geography and Statistics.
Multivariable linear regression was used to evaluate the effect of the type of administration of water companies, whether public or private, on the level of investment per capita in each of the 4,410 out of 5,570 Brazilian municipalities included in the dataset between 2002 and 2020. The model included time-fixed effects and controlled for government grants received per capita, operating expense margin, debt service coverage ratio, water and sanitation coverage deficit, and GDP per capita at the municipal level.

Results:
On average, privately administrated companies invested 115% more than public ones, holding all else constant, and the result was statistically significant (SE=0.054, p-value <0.01). Particularly, the Northeast

and North regions had the largest differences with a 2,436% (SE=0.4491, p-value <0.01) and 1,144% (SE=0.087, p-value <0.01) increase in investment, respectively, compared to the public administered. On the other hand, in the South region, privately managed companies invested 14.9% less than public companies (SE=0.059, p-value <0.01).

The city's GDP per capita and government grants received were the most significant covariates. An increase of 1% in the former was related to an increase of 0.35% in investments per capita, while an increase of 1% in the latter was associated with an increase of 0.27%.

Conclusion:

The results suggest that the type of administration of water companies, public or private, is strongly associated with the average annual per capita investment in water and sanitation in Brazil. It also suggests that private administration was more significant in the poorest regions of the country. The findings support the Brazilian government's decision to remove barriers to private sector entry into the water sector. The implication is that if the country wants to reduce the coverage deficit in the shortest possible time, it should continue to incentivize private participation in the water sector.

IT enabled FSSM monitoring at scale in Maharashtra
Aditi Dwivedi, CEPT University
Additional Authors: Dhruv Bhavsar, Aasim Mansuri, Meera Mehta, Dinesh Mehta, Jay Shah

Maharashtra is one of the most urbanized states in India with 60 million urban population living in 400+ urban centres. Implementation of the Swachh Bharat Mission (SBM, Clean India Mission) in the state has aims on achieving safely managed sanitation across the service chain in all urban centers. After declaring all its cities as Open Defecation Free (ODF) in 2017, the state's focus has been to sustain the ODF status and close the infrastructure gaps in safe transport and treatment of wastewater and feacal sludge. To address treatment, the state government has adopted a two-pronged approach where independent faecal sludge treatment plants were commissioned in 311 cities and another 70 cities were instructed to commence co-treatment of septage at their own Sewage Treatment Plants (STP) or at neighboring city's STP. Furthermore, the state has also directed implementation of scheduled desludging of septic tanks in all cities. To monitor and track these activities and to make the process smoother and more transparent, a gamut of IT enabled monitoring systems has been introduced across the sanitation value chain.

SaniTab, a mobile based application has been developed to use as a citywide digital data collection tool to capture household / property level data. It was first used by the model cities of Wai and Sinnar for baseline assessments and for building a database of septic tanks. Since then it has been deployed in 5 more cities to track desludging operations. It consists of an app where customized forms can be deployed. Surveyors enter data into the form and submit it to generate a database. In addition to text-based questions, the application also allows capture of photos and GPS coordinates for quick and easy spatial mapping. Capturing spatial details makes it possible to identify and focus more on the vulnerable areas. The collected data can be viewed in the form of processed charts, tables and maps on online dashboards for informed decision making.

SaniTrack, a GIS-GPS based online monitoring system has been developed to track collection and safe transport of septage to the treatment facility. It consists of a mobile app-based module for desludging operators for day-to-day scheduling and then recording details of each desludging with acknowledgement by household respondent through signature on the mobile app. Along with signatures, geo-location and timestamp is captured automatically, and the operator will also be able to collect data about type of property, sludge volume, household details, ward etc. It will also capture the safe unloading of collected septage at the FSTP through similar acknowledgement. A centralized web portal also allows registration of new households, desludging service operators/contractors, ULB's treatment facilities. This MIS then displays the information on a web map as well as allows the administrator to download the information in pre-configured formats. The app is especially developed to offer a simplified click-and-select type user interface which makes the monitoring process smooth and easy for the truck operators. It was first implemented as customized versions for the cities of Wai, Sinnar, Kolhapur and Satara. Using the lessons from these cities, a multi-city version of the system is now being developed which can onboard a large number of cities and provide information at the state level also.

Whatsapp chatbot system is being implemented at scale for daily monitoring of the independent FSTPs. As the Government of Maharashtra has adopted the approach of constructing FSTPs across the state, as of Match 2023, a total of 222 FSTPs are functional across the state and it is vital to keep track of the quantity of sludge being received and treated at the plants. The FSTP operators at the plants will use the Whatsapp chatbot system for daily reporting of data such as the number of septic tanks emptied, the amount of sludge received, and reasons if the sludge is not received at the plant. This data will be received at the State. This will be a real-time data reporting system by the operators on the ground which the state can access and see on the dashboard. This system will streamline the data reporting process across all the ULBs having FSTPs, allowing the State to understand the performance of the ULBs in terms of sludge treatment.

Online water quality monitoring systems have been introduced at the FSTPs of Wai and Sinnar. These will consist of multi parameter monitoring for measuring of liquid flows across the units, pH, BOD, COD, TSS, TOC, nitrate and turbidity to give real time results for the faecal sludge being treated. Implementation of these systems is done with the support of Center for Water and Sanitation at CEPT University through its partnerships with the city governments of respective cities as well as its partnership with the State Government of Maharashtra for the Swachh Bharata Mission.
Simple user interfaces, user manuals, training and extended technical support by developer and city support teams are some of the steps that have been taken to ensure smooth transition and adoption of these systems. Databases created though these systems will be unique and help deliver smoother better informed and more transparent services. It is proposed that these monitoring systems, once properly established, will be linked to payment structure of the private service providers according to the performance-based contracts with the city government thus providing complete transparency and efficiency in desludging operations.

Systemic impacts of Performance Assessment System for consistent monitoring of water and sanitation service levels
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Reliable, consistent and, wherever possible, disaggregated data are essential to stimulate political commitment, inform policy-making and decision-making, and enable well targeted investments that maximize health, environmental and economic gains" (UNICEF and WHO, 2020). To generate a reliable data at local level, the Performance Assessment System (PAS) program was initiated by the Center for Water and Sanitation (CWAS) at CEPT University. The project not only focused on generating reliable data but also facilitated the use of data evidence by various levels of governments (national, state, and city) and institutions to make informed decisions.

The PAS program was started in India in 2009 as the first system for measuring and monitoring water and sanitation service performance at scale. Earlier programs for monitoring WSS levels were one-time studies that only covered a few cities in India. And some of the pressing issues such as the provision of services in slum areas and the efficiency of onsite sanitation were left unaddressed. However, the PAS measurement framework includes assessment of service provision in slum areas, as well as evaluations of the performance of on-site sanitation systems, which were previously neglected. The PAS program was initially rolled out across all cities in the states of Gujarat and Maharashtra, covering a population of 58 million, in collaboration with the state governments. The governments of these states viewed the PAS program as an opportunity to build on their ongoing efforts to reform the water and sanitation sector. Since its inception, the PAS program has expanded to include over 1,000 cities in five states and smart cities in India, with a combined population of 160 million. These cities and states are of diverse geography, varied level of development and are of various sizes, ranging from 2,000 to 14 million population.

The data provided by these cities is used to inform policy development at the state level and to create improvement plans at the city level. Capital investments alone cannot improve performance in the water

and sanitation sector; policy advocacy and process changes are also necessary. For instance, the Swachh Maharashtra Mission for Urban Areas (SMMUA) in Maharashtra utilized PAS data related to sewage, fecal sludge, and septage management to develop strategies for the safe transportation and treatment of sewage and fecal sludge, resulting in the "open defecation free plus plus" (ODF++) certification for cities. The PAS program plays a vital role in ensuring that WSS services are provided in an environmentally and financially sustainable manner over the long term by identifying priority areas for resource allocation and promoting accountability and good governance.

Reference:
State of the World's Sanitation: An urgent call to transform sanitation for better health, environments, economies and societies. New York: United Nations Children's Fund (UNICEF) and the World Health Organization, 2020.

Creditworthiness Assessment and Shadow Rating- An Approach for Urban Local Governments in India
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Additional Authors: Meera Mehta, Dinesh Mehta, Dhruv Bhavsar

Background:
Urban infrastructure projects tend to be capital intensive and not only require upfront capital investment but also annually recurring operations and maintenance expenditures. With the current rate of urbanization, the High-Powered Expert Committee (HPEC) for Estimating the Investment Requirements for Urban Infrastructure Services (2011) had estimated a requirement of Rs 39 lakh crore (at 2009-10) prices for the period 2012-2031 for India. (HPEC, March 2011) As per their framework, the investment in urban infrastructure in India should increase from 0.7% of GDP in 2011-12 to 1.1% of GDP by 2031-32. In 2021-22, total expenditure on urban development by states and center is estimated to be 0.7% of GDP. (GoI, 2022-23). The Ministry of Finance (2017) had noted that only budgetary outlays will not be enough to cater the growing demands on local governments for improving their infrastructure. (Department of Economic Affairs, September 2017)

There have been attempts to explore innovative financing requirements for meeting urban infrastructure expenditure requirements. To attract investment from private sources cities need to first be creditworthy. Recent estimates from World Bank show that less than 20% of the largest 500 cities in developing countries are deemed creditworthy in their local context, severely constricting their capacity to finance investments in public infrastructure. Supporting cities on the path to creditworthiness is the crucial first step in unlocking larger, longer-term, sustainable investments. Formal credit rating agencies are expensive and lengthy process and take almost two years to assess the creditworthiness of a city.

Approach and Methodology:
In this context, the creditworthiness scoring methodology developed by CEPT assumes importance. It attempts to arrive at a shadow credit rating for a municipal bond which is very close to the actual credit rating assigned to these borrowers through formal credit rating exercises undertaken by accredited Credit Rating Agencies. This methodology relies purely on indicators derived from past financial performance of the Urban Local Body and its operational parameters as finetuned by the CEPT's CWAS Team. The main benefit of this methodology is that cities planning to issue municipal bonds or raise other forms of debt can get an indication of their creditworthiness score and likely credit rating. It assesses creditworthiness of the city using the shadow credit rating tool developed by CEPT in a very brief period. This tool can evaluate municipal financial and operational performance because improvements in credit scores over the years under this model indicate definitive improvements in certain operational and financial parameters. It acts as a pre-cursor to actual credit rating process, is less time consuming than actual credit process and will help assess and improve city's performance. The framework has a set of total 45 indicators which benchmark and evaluates revenue size, expenditure performance, liquidity, solvency profile, accountability of an urban local government. Additionally, it also evaluates operational services like WASH coverage, adequacy, treatment, human resources, and complaint redressal mechanisms by aligning with Ministry of Housing and Urban Affairs (MOHUA's) flagship service level benchmark. The tool

derives a score based on which rating is assigned to the cities from AAA to no rating. The PAS creditworthiness framework has been tested on a universe of 30 municipal corporations ranging from a population of less than a million to four million plus from 9 states across India. It clearly defines cities that belong to the investment grade and sub-investment category and those which need improvement.

Key results and way forward:
The framework assesses debt borrowing and repayment capacity of an urban local government, lenders and investors will normally use the PAS creditworthiness rating as a screening process and then may perform an independent financial and due diligence analysis of borrowers that apply for loans and the proposed projects they intend to finance. The results derived from the tool also helps urban local governments monitor their own revenues, expenditure management and keep a track on its cash balance and asset management. The creditworthiness assessment or shadow rating can also be used by an issuer to test the waters before deciding to issue bonds without causing investors to react. The toolkit comes with a set of improvement actions that governments can undertake to improve their ratings. Scaling up of the creditworthiness assessment and improvement framework is planned across Indian cities. For investors who are interested in investing in cities for which credit rating is not done (example - small and medium towns in India), the investor can consider the shadow rating in their evaluation of the creditworthiness for the targeted investment.

Applying costs data for advocacy and policy development for WaSH in healthcare facilities
Laxman Kharal Chettry, Terre des hommes
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Water, sanitation, hygiene, waste management, and cleaning (WaSH) in healthcare facilities are essential for safe care. Key barriers to achieving and sustaining universal access are adequate funding and a supportive policy environment for long-term operations and maintenance. While various guidelines exist for assessing access and making initial infrastructure improvements, there is little guidance on how to develop budgets and policies to sustain WaSH services in the long-term. In response to this need, we conducted a WaSH assessment, costing, and government engagement activities in Thakurbaba municipality, Nepal, with the aim of developing a budget and policy for operations and maintenance of WaSH in healthcare facilities in partnership with the municipal government. In this study, our objectives are to describe (1) the methods used for the WaSH assessment and costing, (2) costs of achieving basic WaSH services, and (3) the process and outcomes of government engagement activities. The WaSH assessment was based on an adaptation of the Water and Sanitation for Health Facility Improvement Tool (WASH FIT) and showed that most facilities had some water, sanitation, and waste management infrastructure, but upgrades were needed to achieve basic service (e.g., disability accessibility of toilets). Software for hygiene and cleaning were lacking. Costing applied bottom-up methods to enumerate the resources necessary to achieve basic WaSH services and their costs. The current expenditure on WaSH services in all eight facilities in Thakurbaba municipality is USD 31,250 per year (including operations and maintenance and annualized capital investment costs). An additional one-time investment of USD 20,500 to upgrade capital and USD 12,850 per year for operations and maintenance is needed to achieve basic service. Cost findings were used to prepare annual budgets recommended to achieve basic service, which were presented to municipal government and incorporated into an operations and maintenance policy. To-date, the municipality has adopted the policy and established a revolving fund of USD 5,325 for implementation. Thakurbaba municipality is currently leading advocacy at the national level as part of this work. Findings are being used to advocate for development of a national roadmap for universal access of WaSH in healthcare facilities. This study is intended to provide a roadmap for how cost data can be collected and applied to inform policy making. This study also contributes to implementation science research in WaSH by examining how policy and finance impact service delivery for WaSH in healthcare facilities, and how researchers and non-governmental organizations can collaborate to leverage WaSH data for improved policy and practice. The learning objectives for this presentation are to understand (1) methods for collecting costs data related to WaSH in healthcare facilities and applying it for budgeting and policy development and (2) good practices for collaborating with government stakeholders in the budgeting and policy development process.

Transforming the Haitian water sector one leak at a time
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Additional Authors: Ryan Rowe, Neil VanDine, James Adamson, Fritz Chery, Gulderne Dessalines

Nearly every aspect of the water supply sector in Haiti is hampered by a lack of domestic funding. Financial support in excess of $USD 110 million per year has been mobilized from foreign partners. Meanwhile, we have found that more than 90 percent of water produced is not paid for. Rather, it is lost to leaks, illegal connections, and mis-management. With so little water reaching the end user, the population has turned to the private sector, paying a rate of 4-5 times more than that charged by state-owned and operated water utilities. Tracking down and repairing leaks can reduce the cost of water, improve the level of service and generate a local source of funding.

Transforming the Haitian water sector sounds like a lofty ambition. But a collaboration between Haiti Outreach, HANWASH, the Rotary Club of Pignon, Rotary International District 6940 of Florida, Northwater International and Operators Without Borders has achieved the impossible in Pignon, Haiti. The team has managed to reduce non-revenue water from 94 percent to less than 25 percent in the Pignon municipal water system. Previously, water was available for 1-2 hours a day to less than 20 percent of the network located at lower elevations. The team developed a set of 14 strategies to to reduce non-revenue water and began implementation in April 2022. To date, more than 100 leaks and 45 illegal connections have been repaired, leading to 24/7 water service across 70 percent of the network.

Prior to this intervention, the operator was losing money and required subsidies from the government water ministry to continue operation. But an increase in revenue from the sale of water that was previously lost to leaks and illegal connections has allowed the operator to begin generating a small profit.

The operator is using the increased revenue to re-invest in the network.
Water meter data has been the core driver of this initiative. Accurate meter data from the source and end users is necessary to identify the scale of the problem and track progress. But many other skills have proven critical to the success of this effort. They include perseverance and creativity by the water system operator; collaboration with law enforcement, judicial authorities and local leaders; technical mentoring; and constant and careful management by the operator over a multi-year effort.

From the beginning, the team has tried to create procedures that can be replicated throughout Haiti. The reality of 24/7 water service available to a community the size of Pignon for more than a year is simply shocking for anyone familiar with the challenges present in the water sector in Haiti. We have shown that it can be done and our team is committed to replicating these strategies throughout Haiti.

Efficiency Evaluation of Domestic Wastewater Treatment by Three Macrophytes Using Pilot Constructed Wetland System in a Nigerian Community
David Olukanni, Covenant University
Additional Authors: Justin Lazarus

As the demand for water is rising due to rapid population growth, urbanization and increasing water needs from agriculture, industry, and energy sectors, a study on the use of Constructed wetland systems (CWS) as compared to traditional treatment technologies for the treatment of municipal wastewater was carried to explore its efficiency and advantages in terms of cost-effectiveness. The effectiveness of the CWSs is largely dependent on the capacity of plants (aquatic macrophytes) used for the wastewater treatment. Thus, this paper focuses on investigating the wastewater treatment efficiency of water hyacinth (Eichhornia crassipes), water lettuce (Pistia stratiotes) and duckweed (Lemnar minor) using pilot scale CWS. Three pilot CWSs (including control reactor) were set up with sand and gravel as substrates. As for the volume of reactors, a 150L tank each was used. Sample collection was done every 7 days for 3 weeks. Upon initial examination of the raw wastewater, Six (6) parameters were taken into consideration for examination based on the standard discharge limits. The findings revealed that Eichhornia crassipes

and Pistia stratiotes reached peak TP and COD reduction rates of 99.30% and 99.35%, respectively, at 14 days hydraulic retention time, while Eichhornia crassipes showed a better removal efficeinecy of BOD (91.31%), COD (85.04%), EC (90.35%), TDS (89.66%) and TC (65.99%). Albeit, Pistia stratiotes indicated better results for TSS (96.24%), TP (97.55%) and E.coli (94.43%), while duckweed was better in TN removal with 90.83% efficiency. The results showed that Eichhornia crassipes was more effiecient in the treatment for the community wastewater. The study suggests that the implementation of this project in large scale in the community is as a major contributor to actualizing SDG target 6.3 of ensuring access to safe water and sanitation for all and halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally by the year 2030.

Keywords: Domestic Wastewater, Wastewater Treatment, Constructed Wetland, Phytoremediation, Aquatic Macrophytes, Sustainable Technology.

Demonstrating Best Practices for Operations and Maintenance of Community and Public Toilets in Chennai
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Additional Authors: Santhosh Ragavan KV, Swapnil Barai, Sunil Nepak, Sasikumar E, Subashini M, Sakthi B, Abhilaasha Nagarajan

Background:
An assessment of 62 out of 800+ Community and Public toilets (CT/PTs) in Chennai highlighted the need for renovations, improved facilities for women, increased accessibility for elderly and disabled individuals, and enhanced cleanliness and hygiene. The Government of Tamil Nadu (GoTN) and Greater Chennai Corporation (GCC) sought assistance from Tamil Nadu Urban Sanitation Support Programme (TNUSSP) to initiate a two-year demonstration of operations and maintenance (O&M) in nine CT/PTs in Chennai, to showcase sustainable solutions for service provision.

Objective:
The objective of the project is to:
● demonstrate service models for CT/PT O&M with inclusive facilities and free toilet access for all users, while ensuring safe and hygienic conditions, effective waste management systems, and revenue generation alternatives for long-term financial sustainability.
● recommend scalable service models by GCC for widespread implementation and impact across the 800+ CT/PTs in Chennai.

Methods:
The CT/PTs for demonstration were selected based on location, footfall, and UGSS/OSS connections. Three service models were proposed, including private enterprise, women self-help groups/federations, and individual entrepreneurs. Each service provider had their own O&M methods. Uniform record maintenance, Service Level Agreements (SLAs) for monitoring and grievance redressal mechanisms were introduced. Innovative on-site treatment - Multi-user Reinvented Toilet (MURT) technology was installed for recycling used water. Monthly progress updates are shared with GCC and GoTN.

Reflections/Key Learnings:
The initiative ensured availability of staff during functional hours, round-the-clock access to five out of nine toilets, SLAs adherence, and a grievance redressal mechanism. These efforts saw a 360% increase in users of CT/PTs and 43% increase in female users. Over 95% users reported toilet cleanliness. However, challenges such as differing priorities among stakeholders, operational difficulties, finding suitable service providers, and addressing user behaviour issues must be addressed through behaviour change campaigns and community engagement for sustainability.
Discussion to inform practice:
Sustainability, replicability, and scaling-up of improved services in CT/PTs are crucial for wider benefits. Scaling SHG and individual entrepreneur models require skill training, resources, and support, while private companies need sufficient incentives to meet their revenue needs. Clean and hygienic toilets attract hesitant users, leading to increased usage, but adequate staffing and revenue sources are

essential for efficient O&M. Advertisements and other potential revenue sources are being explored. Future focus is aimed at enhancing service provider capacity, modifying user behaviour, and community engagement, improved management, and potential revenue from donations and CSR funds.

Variability in drinking water contamination estimates from utilizing different flood mapping techniques following Hurricane Florence
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Additional Authors: Colin Richardson, C. Nathan Jones, Andrew Summerfield, Wesley Hayes, Jacob Hochard, Wilson Mize, Chris Goforth, R. Edward Beighley, Kelsey J. Pieper

Groundwater is a crucial drinking water source worldwide. However, groundwater-supplied wells are prone to contamination during flooding events. In the United States, four common methods are used to delineate floodwater extents: FEMA disaster designated areas, FEMA 100-year floodplains, Height Above Nearest Drainage (HAND), and satellite derived products like Dartmouth Flood Observatory (DFO) modeled inundation. These techniques predict different areas of impact, resulting in different conclusions about the location and identities of populations impacted by flooding. In this study, we used these floodwater delineation methods following Hurricane Florence in North Carolina to evaluate impacts on the well using population. The objectives were to (1) determine uncertainties in estimates of area impacted and number of wells inundated, (2) analyze testing rates and contamination rates, and (3) examine changes in microbial contamination before and after Hurricane Florence.

The FEMA counties method is a damage-based approach, including areas eligible to apply for services following Hurricane Florence. The FEMA 100-year flood map includes areas predicted to be flooded during a 100-year storm event, not Hurricane Florence specifically. The DFO method utilizes satellite optical and radar imagery data, which are used to detect changes in water extent, for time during Hurricane Florence. HAND is also a flood and storm specific tool, utilizing a generated digital elevation model to calculate the vertical distance between different points and the nearest stream or drainage channel. We used the EPA method which estimates well counts by Census blocks to estimate well locations. Contamination data within the study area for pre-Florence (Sept-Nov 2009-2017 n=12,912) and post-Florence conditions (Sept-Nov 2018, n=947) were obtained through the North Carolina Department of Health and Human Services (NC DHHS).

Our findings indicated discrepancies between floodwater delineation methods. Estimated showed between 207 km2 and 44,210 km2 of land (8%-31% of the total area of the state) flooded during Hurricane Florence. FEMA counties estimated the largest inundated area, followed by the 100-year flood plain boundary, HAND boundary, and the DFO modeled inundation. Estimates of wells flooded within each boundary also differed and increased by amount of flooded area (1,382-311,843 wells). We observed 35.4-55.5% of flooded wells were contaminated with total coliforms (TC) and 9.1-27.9% with E. coli (EC). While the DFO method estimated the highest contamination rate for both TC and EC, the modeled inundation area was lowest, suggesting this method only captured severe flooding. All methods reported increased contamination from pre-Florence conditions, although the degree of impact varied. Problematically, some methods reported increased contamination rates in wells that were not within the estimated flood boundaries, suggesting error in predictions and/or non-flooding related contamination concerns.

Overall, floodwater delineation methods that estimated smaller impacted areas identified areas with higher rates of contamination but may not have captured the full impact extent of the storm. Understanding the biases each method is essential when selecting the approach to use. This study demonstrates the need for more comprehensive and accurate mapping techniques to ensure that well users impacted by flooding are identified. Such information is necessary for dissemination of resources and support.

Harnessing Wastewater for Sustainable Sanitation and Aquaculture
Daniel Sarpong, University of Environment and Sustainable Development

Additonal Authors: Mabel Kwakoa; Stephen Ackon; Janet Atim

The use of treated municipal wastewater in aquaculture is becoming increasingly popular due to water scarcity and pollution concerns. The United Nations and its member nations have committed to addressing global concerns such as poverty, famine, and disease through sustainable development goals, which require tackling the challenges of water scarcity and sanitation. One solution is to integrate tilapia farming with wastewater reuse, but the feasibility of using this type of wastewater in caged aquaculture systems in Ghana has not been thoroughly evaluated. Despite the potential benefits, there are concerns about the safety of using treated municipal wastewater in aquaculture. Research is needed to identify any potential risks and develop strategies to mitigate them. This study aimed to explore the feasibility of turning wastewater into a valuable resource in developing countries, such as Ghana, and evaluated water quality, nutrient content, and potential contaminants in the wastewater. The average mortality of tilapia fry in the final effluent was 19%, whereas in the primary effluent, it was 39%. The findings of the study showed that treated wastewater can be a viable alternative to freshwater sources for fish farming in Ghana. Water quality parameters were found to be within acceptable limits, and fish growth rates were similar to those observed in fish farms that use freshwater. The study concludes that the use of treated wastewater can provide a sustainable solution to the water scarcity challenges faced by the aquaculture industry in Ghana. Further research is needed to evaluate the long-term effects of using treated wastewater on fish health and the environment, but this study provides evidence that treated wastewater can be a viable alternative water source for cage fish farming in developing countries such as Ghana.

Evaluating the Risk of Residential Exposure to Antibiotic-Resistant Bacteria from SSOs and Basement Backups

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Infections from antibiotic-resistant (AR) bacteria are an increasingly common public health threat. Black and African American communities experience disproportionately higher infection rates from AR bacteria, compared to White communities. Once thought to have healthcare origins, studies over the past decade have shown that wastewater is an environmental source of AR bacteria. AR bacteria, such as methicillin-resistant Staphylococcus aureus (MRSA), can enter the wastewater stream when colonized humans shed bacteria from the nose, skin, and feces. One way that individuals may be exposed to AR bacteria in wastewater is when untreated sewage enters their homes due to sanitary sewers overflow (SSO) events. The U.S. Environmental Protection Agency estimates that 75,000 SSOs occur per year in the U.S. This estimate does not include sewage backups in homes. Exposure to wastewater, and waterborne pathogens, in residential homes impacted by SSOs and backups has not been previously explored. To understand the risk of AR exposure due to SSOs and backups, we evaluated the presence of MRSA, methicillin-susceptible Staphylococcus aureus (MSSA), methicillin-resistant coagulase-negative staphylococci (MR-CoNS), and coagulase-negative staphylococci (CoNS) in impacted homes in

Baltimore, Maryland, a city with 63% Black or African American residents and 19% of the population living in poverty. In addition, the presence of Escherichia coli was evaluated to indicate the occurrence of fecal contamination within homes. We collected surface swabs (n=40) and standing water (n=6) from 39 homes in Baltimore where SSOs or backups had occurred. Samples were processed using modified standard membrane filtration and selective media. Isolated bacteria were confirmed with biochemical tests and a multiplex PCR. Eight homes (20%) had E. coli on surfaces impacted by SSOs and backups. No MRSA was found on surfaces, but 3 homes (7%) had MSSA isolated from impacted surfaces. Additionally, 3 homes (7%) had CoNS and 1 (2%) had MR-CoNS present on impacted surfaces. Of the 6 homes with standing water, 3 (50%) had E. coli, 1 (16%) had MRSA, and 1 (16%) had CoNS present in water samples. Neither MSSA nor MR-CoNs were isolated from any water samples. To our knowledge, this is the first time that AR bacteria have been isolated from homes impacted by SSOs and sewage backups. Our results suggest that SSOs and backups could expose communities to AR bacteria. Additional sampling is needed to further assess the risk of AR bacteria exposure from SSOs and sewage backups in underserved communities.

Menstrual-related drivers of sub-optimal school attendance and participation among adolescent girls in NW Tanzania

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Background:
Achieving gender parity in education has been recognized as an important step towards more inclusive and sustainable development. Tanzania, like many other LMICs, is making deliberate efforts to close the gender gap in secondary school enrolment. Unfortunately, girls who manage to enroll in secondary schools are still unable to fully participate in academic and other school activities partly due to menstruation-related challenges. The challenges include among others a lack of comprehensive knowledge of menstruation at menarche, painful periods, and a lack of access to resources to manage menstruation. This paper examines menstrual-related drivers of sub-optimal school attendance and participation among adolescent girls in selected secondary schools in northern Tanzania.

Methods:
A cross-sectional survey was conducted among 486 girls in four secondary schools in two districts in the Mwanza region, northwest Tanzania. The participating schools were sampled from medium-sized, gender-mixed government secondary schools in two districts. Participants were girls in the second and third years of secondary school. Data were collected using a self-completed questionnaire. The questionnaire contained socio-demographic questions, knowledge of puberty and menstruation, self-reported number of missed school days or school sessions, reasons for missing school, and self-reported level of pain at the last menstrual period. The menstrual practice needs scale (MPNS) was used to assess the extent to which an individual's menstrual management practices and environment are perceived to meet their needs. We also assessed menstrual-related anxiety.   Data were analyzed using descriptive statistics, chi-square, and t-tests performed to determine associations between socio-demographic characteristics, menstrual management practices, and school attendance. The level of statistical significance was set at 0.05.

Results:
The mean age was 15.6 years old (SD 1.3). Eighty-seven percent of girls had started menstruation and the average age of menarche was 14.2 (1.15). The mean score on MPNS sub-scales were 1.4 (SD 1.0) for transport and school environment needs; 1.6 (SD 1.2) for reuse needs; and 1.1 (SD 1.0) for reuse insecurity compared to a maximum score of 3 in each MPNS sub-scale. Of 424 girls who had started menstruation, 84% reported either missing sessions or days of school in their last menstrual period. Reasons for girls missing school included dysmenorrhea (52%), lack of absorbent material (42%), scared of staining uniform/leaking (38%), ashamed or embarrassment (27%), lack of place for changing (25%) and refused to go to school (20%). A significant proportion (65%) of girls reported experiencing menstrual-related anxiety with 45.1% of girls reporting mild, 17.3 % reporting moderate, and 2.9% reporting severe menstrual-related anxiety. Factors associated with girls missing school during menstruation were high levels of menstrual anxiety (89% versus 74%; p = 0.016); and failure to use painkillers to help menstrual pain (79% versus 61%; p = 0.011).

Conclusion:
Menstrual-related pain coupled with a lack of clear pain management strategies and menstrual-related anxiety influenced girls' school attendance and participation. This highlights the need for menstrual health interventions that include robust menstrual pain and anxiety management strategies for adolescent girls in order to improve school attendance and participation.

Evaluating the effectiveness of climate-targeted sanitation subsidies in rural Cambodia
Elise Mann, iDE

Additonal Authors: Tyler Kozole Marlaina Ross Jennifer Roglà, PhD Chris Nicoletti Prom Ratsamnang Amjad Ali

Background/challenge:
In Cambodia's Tonle Sap Lake region, the health, lifestyles and livelihoods of households are tied to the lake and massively impacted by changes in the climate and environment. Seasonal variation in water levels, heavy rainfall, and sporadic flooding render basic sanitation technologies ineffective and unsafe. Limited affordability and access of appropriate technology and services in these areas has prevented households from adopting safe sanitation.

Methods:
With the support of Australian Aid's Water for Women Fund, iDE and Causal Design conducted mixed methods research (January – August 2022) to better understand and develop means for empowering the most marginalized households in flood-prone areas to invest in safe, resilient sanitation.

Key components of the project included:
Conducting human centered formative research on how to define and verify vulnerabilities in this context, including household-level measures related to climate, socio-economic, and gender
Executing a market trial to develop products, sales approaches, and subsidy delivery mechanisms
Conducting a randomized controlled trial (RCT) to assess the impact of targeted subsidies on latrine uptake for social and climate marginalized households.

Quantitative data from the RCT (2821 sales presentations across 30 villages in Kampong Chhnang Province) was analyzed alongside a series of qualitative interviews (13 in-depth interviews) with key stakeholders to investigate the impact of subsidies on sanitation uptake, market-distortionary effects, opportunities for scale, and cost-effectiveness.

Results:
Subsidy eligibility was evaluated using the Poverty Probability Index (PPI) for Cambodia and households' individual and community level climate vulnerability. In the RCT, in treatment areas, the sales closing rate among households who were offered a subsidy was six times higher than the sales closing rate among ineligible households (38% versus 6%, respectively; $p = 0.00$). Being offered a subsidy increased the marginal probability that a given household would purchase a latrine by 31-percentage points when compared to ineligible households (from 6% to 37%; $p = 0.00$). When offered a subsidy, households who were climate-vulnerable at the household level were most likely to purchase a latrine. There was no evidence of significant or widespread market distortion identified as a result of the subsidy mechanism.

In the RCT, the programmatic cost per latrine was $602.07 in control areas and $224.22 in treatment areas offered subsidies. Higher cost effectiveness was achieved through more latrines sold in treatment areas.

Qualitative interviews found that although the subsidy mechanism was generally perceived positively, there were challenges with understanding subsidy eligibility criteria and a perception among sales agents that in some cases, the PPI did not accurately capture household poverty levels. While there was no evidence of widespread manipulation of the eligibility survey, manipulation by households or sales agents was identified as a risk.

Conclusions:
Low income, climate-vulnerable households are market participants and exercise agency in sanitation investments. By integrating targeted subsidies, including in climate vulnerable areas, market-based sanitation programs can reach wider segments of populations and achieve higher cost-effectiveness. Sanitation actors should include climate vulnerability as a metric for assessing subsidy eligibility in order to accelerate sanitation coverage in vulnerable and marginalized areas.

Leveraging the Social Ecosystem of Girls to Shift Menstruation Norms - A Longitudinal Impact Evaluation

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Starting in 2019, the Splash Menstrual Health team set out to design a suite of unique, research-informed programs that target three groups of social stakeholders shown to be critical in the lives of menstruating girls: parents, male peers, and older peers. The Splash team conducted a formative assessment with 150 parents, peers, boys, teachers, and school administrators. The findings informed the selection and design of the social ecosystems program components: Peer Mentoring, Boys Puberty Workshop, and Parent Capacity Building Program. These Social Ecosystem programs aim to increase knowledge, shift norms, and target the internal motivations of the social stakeholders within girls' lives to create a more supportive social environment. To date the programs have reached 16,733 girls, 4,256 boys, and 8,686 parents across more than 140 schools. With the addition of these social ecosystem's programs to our existing menstrual health curriculum and girl friendly sanitation, Splash aims to promote comprehensive social normative change, improving more than educational outcomes and stretching beyond the school to improve gender equity.

To assess the impact of the Social Ecosystems Program, we conducted mixed methods longitudinal research at ten primary and secondary schools in Addis Ababa, Ethiopia. Boys, girls, and parents at these schools were interviewed using a behavioral survey and a knowledge assessment. The combined behavioral and knowledge-based data collection tools will be used to assess the impact of:

- A boy-facing puberty workshop in increasing rates of empathy and allyship for menstruating female peers.
- A parent support and education group in increasing parent knowledge, addressing stigma and misinformation, and increasing self-efficacy to support their children during puberty and menstruation.
- A peer mentoring program in building leadership skills for girls, addressing social taboos related to puberty and menstruation, and creating a supportive peer network among girls.

To date, Splash has completed baseline data collection and has plans for midline data collection in June 2023 after all program interventions are completed at the study schools. Using a semi-structured interview with observations, we will describe how the applied interventions change boys', parents', and peers' perspectives on menstrual health and their support for menstruating girls in their lives. Multivariate regressions will be used to answer all three research questions, and data will be disaggregated by relevant factors, including age and education, related to menstrual health topics. At the UNC Water Conference, relevant associations and frequencies will also be reported. Impact of the program will be evaluated using a difference-in-differences study design to describe in detail how well the programs' goals were achieved. We will also provide recommendations that other implementors should consider when designing and evaluating a multi-faceted menstrual health management program.

Exploring the Pathogen Profiles of Ancient Feces

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Analysis of ancient fecal material – termed paleofeces – can unlock insights into the migration patterns, dietary practices, and pathogen exposures of ancient people. We collected paleofeces from caves in the Rio Zape Valley in Mexico (dated to 600-800 CE) and the Paisley Caves in the United States (dated to 10,000-12,000 BCE). Given the desiccated conditions of the ancient fecal material – and substantial degradation of the nucleic acids contained within – we developed a novel workflow to detect enteric pathogens. Following DNA extraction with methods previously optimized for paleofeces, we first pooled primers corresponding to the 30 pathogens of interest and conducted a PCR pre-amplification assay to increase our analytical sensitivity. Then, we analyzed the pre-amplification product on a custom TaqMan Array Card (real-time PCR) – a highly sensitive modern molecular platform – to assess the presence of

30 enteric pathogens. We detected ≥1 pathogen associated gene in each of the ten samples from Mexico and a mean of 3.9 pathogens per sample. The targets detected included Blastocystis spp. (n=7/10), atypical enteropathogenic E. coli (n=7/10), Enterobius vermicularis (n=6/10), Entamoeba spp. (n=5/10), enterotoxigenic E. coli (n=5/10), Shigella spp./enteroinvasive E. coli (n=3/10), Giardia spp. (n=2/10), and E. coli O157:H7 (n=1/10). No pathogen associated genes were detected in the samples from the United States. These results suggest that sensitive modern molecular tools, such as PCR, can be used to evaluate ancient materials for genes of interest. In addition, the methods developed are transferrable to modern applications, such as the detection of enteric pathogens in environmental samples that may be present at low concentrations (e.g., air, drinking water, flies, and food).

Evaluation of Bacterial Communities and Seasonal Bloom Dynamics in a Drinking Water Reservoir

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Access to safe and clean drinking water is essential for human health and economic and social development. Around the world, rivers, lakes, and reservoirs provide the source water for drinking water systems. These water sources can be subject to fecal contamination; recently, there have been reports of elevated coliform bacteria levels in protected reservoirs, which may become more pronounced with a changing climate, temperature rises, and precipitation changes. While total coliform is often used as an indicator of water quality worldwide for regulatory purposes, its usefulness as an indicator of health is often questioned. This is because coliform bacteria freely occur in the environment; thus, their health implications are still up for debate. It poses a challenge in bacterial contamination monitoring and consequently demands an extensive investigation of coliform bacteria and bacterial community variations in drinking water sources

Our study identifies the communities of coliform bacteria associated with summertime blooms from 2021-2023 in the Quabbin Reservoir and its tributaries, which provide drinking water for more than 50 communities throughout the state of Massachusetts. In addition, we incorporated data-driven models to analyze and understand the relationship between elevated total coliform levels and multiple physio-chemical parameters over ten years (2012-2021). Microbial community sampling was carried out between July 2021 and May 2023 in the Quabbin MA Reservoir. Raw water and IDEXX Colilert samples were collected from two tributaries, three reservoir sampling sites, and treatment plant intake. Samples from the reservoir sites were obtained at surface, mid, and deep levels. The depth of the levels varied at all sites except for the surface level at 0.5m. For our characterization of bacteria communities, we employed a 16s rRNA amplicon sequencing approach to evaluate our environmental samples. In addition, we sequenced seven IDEXX samples each (n=14) from 2021 and 2022.

Our preliminary analysis of 2021 samples showed less diversity and indicated Enterobacter as the most abundant species. Our 2022 samples indicated more diversity and illustrated Yersinia, Enterobacter, Serratia, Pseudomonas, Plesiomonas, and Escherichia, as the more abundant genus across all sampling sites. Considering the differences in the relative abundance of species during 2021 and 2022, the bacterial communities associated with seasonal total coliform blooms look to be changing over space and time. In addition, the presence of Plesiomonas and Pseudomonas from some of our samples indicates potential false positive incidences for total coliform quantification via the IDEXX Colilert test. The 10-year dataset analysis showed no clear association with total coliform. However, there are some associations between temperature increase and a slight association between algae die-off and increased levels of total coliform.

Once completed, our analysis will provide metrics on total coliform as an indicator and utilization of rapid and real-time next-generation sequencing technologies. These metrics can be used to weigh decisions for microbiological monitoring to assess water quality and implement improved management concepts and regulations for drinking water production.

Mixed methods evaluation of hand hygiene resources and practices at rural health centers, Belize 2023

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Introduction:
Hand hygiene is a critical public health measure to reduce the spread of healthcare-associated infections. Hand hygiene practices among healthcare workers depend on multiple factors, including access to resources, knowledge and perceptions of hand hygiene methods, and perceived challenges associated with practicing hand hygiene at their facility while working. In Belize, government-operated, primary care polyclinics and health centers distributed around the country are the main sources of care in many communities, especially in rural areas. We used a mixed-methods approach to assess the baseline availability and use of hand hygiene resources among healthcare workers at these healthcare facilities in Belize to inform interventions.

Methods:
During February 2023, we conducted facility assessments at 26 polyclinics and health centers across the six districts of Belize to document the presence of hand hygiene resources, including handwashing stations and alcohol-based hand rub (ABHR) dispensers at patient care areas. Of these facilities, 2 per district (n = 12 for 6 districts) with the highest number of staff were selected for a more in-depth evaluation. At each of these 12 facilities, we observed hand hygiene practices among healthcare workers before and after patient contact and calculated hand hygiene adherence (HHA: washed hands with water and soap or used ABHR). We also conducted interviews with healthcare workers to understand their usual hand hygiene practices, priorities, management, and perceived challenges. Descriptive statistics were calculated for data from the facility assessment and hand hygiene observations. Interviews were recorded, transcribed, coded, and analyzed using a thematic analysis approach. Stata and MAXQDA were used for quantitative and qualitative analyses, respectively.

Results:
A total of 140 patient care rooms were assessed at the 26 healthcare facilities, and of those, 87% had either a functional handwashing station with soap or a functional ABHR dispenser. Hand hygiene practices were observed at 256 hand hygiene opportunities before and after patient contact. Overall, HHA was 23% of these hand hygiene opportunities. HHA was higher after patient contact (27%) compared to before patient contact (20%). Additionally, HHA when working with clean/aseptic procedures (30%) was more common than during other procedures not requiring clean/aseptic techniques (22%). Overall, ABHR use (19%) was more common than washing hands with soap and water (5%); one person used both methods. During the interviews, healthcare workers shared that they prefer to wash their hands rather than using ABHR during the workday; however, participants reported that ABHR is often used when they need to clean their hands quickly. Some healthcare workers shared that the COVID-19 pandemic increased awareness of hand hygiene, but hand hygiene practices were already a habit for them.

Conclusion:
Despite the availability of hand hygiene resources in almost all patient care rooms, proper hand hygiene practices only occurred during about one-quarter of observations. Based on these findings, we will collaborate with the Ministry of Health and Wellness to develop interventions to improve hand hygiene practices.

Key Learning Objectives:
• Assess hand hygiene resources and practices in primary care facilities in Belize
• Understand preferences and perceived challenges for practices from healthcare workers

Climate Risk and Passive Chlorination Programs in Central America, Partnerships to support Resiliency
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Background:
Climate change is an increasingly incipient threat to both access to safe drinking water and to the safety of drinking water itself. Limited access, due to drought and changing land use, has been associated with households shifting to less safe or untreated sources. Increased temperature and increasingly dramatic precipitation events have also been linked to the increased prevalence of waterborne pathogens. In Central America, where the magnitude of seasonal variability is already quickly growing, performance of drinking water services is likely to decline. Therefore, intentionally climate resilient strategies and partnerships are necessary to secure safely managed drinking water.

Methods:
Over the last 10 years of operation, EOS circuit riders have completed over 30,000 community visits to provide training, technical assistance, and chlorinator monitoring to 1900 communities with passive in-line chlorinators across Honduras, El Salvador, and Nicaragua. Each time a circuit rider visits, they report system functionality, flow, chlorine concentration, and the types of services delivered. Using data collected during these visits we evaluated changes in water availability, seasonal variability in chlorine concentration, bacteriological tests.
Additionally, EOS partnered with the US Forest Service, Youth Corps Program operating in Honduras, and a conservation-focused Puca Fundacion to support joint efforts for climate resiliency. Specifically, EOS circuit riders have provided training on drinking water treatment and provision for the USFS Youth Corps and participated in joint reforestation efforts.

Results:
Since 2013 lapses in chlorination caused by lack of flowing water have increased in proportion, from 0% of lapses in 2013 to 21% of lapses in 2021. In comparison, no other lapse category has increased in proportion so significantly in that same period. Additionally, significant patterns emerge from the dataset suggesting seasonal impact on water availability and quality, with increasing magnitude year over year. Since 2021, in partnership with USFS and PUCA, we have supported 10 watershed reforestations, planted 2550 trees, and supported planting of 16,000 more trees in PUCA nurseries for future planting. This partnership has also led to expansion of the circuit rider model into 65 new communities and the hiring of 3 Youth Corps Program graduates as EOS circuit riders post-graduation to support these new communities. This partnership has motivated the addition of water shed protection training to our circuit rider's regular trainings provided to community water boards, ensuring that the impact of this partnership is not just local in Honduras but crosses the borders into Nicaragua and El Salvador.
Conclusions:
There is a growing need for the WASH sector to not only address climate risk but to also explore climate resilient strategies to ensure continued access to sanitation and drinking water for all, even in the face of a changing planet. Already, changing climate is evident in EOS' program area, and the impact on both water quality and quantity is increasing rapidly. To take on these increasingly severe challenges, identifying key partners with sector expertise like the USFS can support these efforts and drive lasting impact in the region

A field method for evaluating chlorine acceptability to inform drinking water chlorination in Kyaka Uganda
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Introduction:
The Safe Water Optimization Tool (SWOT) assists water system operators by generating site-specific evidence-based free residual chlorine (FRC) targets that ensure water safety up to the point-of-consumption and prevent waterborne infectious disease. Chlorine taste and odor (T&O) rejection is a common concern with any chlorination program, and therefore, needs to be properly accounted for to balance the risks of under- and over-chlorination (inadequate protection and non-use of treated water, respectively). This research aimed to estimate the chlorine T&O rejection threshold among water-users during a SWOT implementation at the Kyaka II refugee settlement in Uganda and improve the rapid T&O field method to help humanitarian responders better integrate user preferences into safe water programs.

Methods:
Chlorine T&O tests, using adapted standard methods of forced-choice triangle test and flavor rating assessment, were conducted with five population age and sex sub-groups to assess chlorine T&O detection and rejection thresholds in two sectors of Kyaka II served either by a piped water system or by water trucking. T&O tests were conducted with those local water sources, but also with purchased water. FRC concentrations tested ranged from 0.01 to 2.0 mg/L. Short surveys were conducted to identify potential predictors of chlorine T&O rejection. Additionally, focus group discussions (FGDs) were conducted with water users, and surveys with data collectors, to understand perceptions of the tests with a view to improving the method for field use.

Results:
Overall, 410 chlorine T&O tests and surveys were conducted between May and August 2022. The median population detection threshold was estimated at 0.56 mg/L and 1.48 mg/L, for piped and trucked water sources respectively, and the rejection threshold was 2.2 mg/l and 1.86 mg/L, respectively. The detection threshold for purchased water was higher than the local sources (1.67 mg/l) but the rejection threshold was similar (1.75 mg/l). These thresholds were integrated into the modeling of the SWOT to recommend appropriate delivery FRC targets for the two water systems. The rejection threshold was associated with water quality parameters other than FRC ($p < 0.041$ for temperature, $p < 0.016$ for electrical conductivity, and $p < 0.016$ for turbidity), indicating the importance of conducting T&O tests with each unique water source. We did not consistently observe significant differences between ages and sexes throughout the tests. In the 30 FGDs that were conducted, water users reported appreciating being involved in T&O testing as they felt included (described in 19 FGDs) and learned more about chlorinated water (12 FGDs). However, tasting highly concentrated chlorine solution (mentioned in 24 FGDs) and being time-consuming (10 FGDs) were the main drawbacks of the method. Data collectors recommended shortening the protocol and not considering children below 10 because of the difficulty to explain the purpose of the test.

Nature-based Faecal Sludge Treatment Plants at scale in Maharashtra, India
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Background:
Maharashtra has about 60 million urban population and is the second most populous state in India with 412 Urban Local Bodies (ULBs). Since becoming Open Defecation Free in 2017, Maharashtra has focused on faecal sludge and septage management for ensuring safe management of human waste. The Urban Development Department (UDD) at the State Government, with the support of CWAS, prepared a plan for design and execution of nature-based treatment FSTPs with an objective of providing a cost-effective and nature-based solution. Over 220 Faecal Sludge Treatment Plants (FSTPs) have become operational and another 10 FSTPs are in construction phase.

Method:
All cities dependent on on-site sanitation systems were identified for setting up independent FSTPs in Urban Maharashtra. The nature-based technology makes use of simple systems like gravity flow, drying beds and planted gravel filters which helps in reducing construction and operational costs, energy

requirements, and ensures fast-track implementation even with limited technical, financial and human resource capacities of cities. Pre-approved design templates for five different capacities were developed and a single-window approval system was set-up to curtail the complex and lengthy approval process. Preparation of guidelines, state level monitoring system and quality assurance framework has been established for monitoring.

Analysis and results:
FS reaching the treatment plant is first treated at the drying beds that dries the solid particles within 10 days, by capitalising on the hot and temperate climate of the region. Liquid percolate from the drying beds is further conveyed using gravity to Baffled Reactor and Planted Gravel Filter, units that work on the principle of plant-based treatment and filtration through locally available natural resources.
The inlet and outlet samples from the FSTPs were tested to evaluate its performance. 15 sample FSTPs were selected based on management, efficiency, and pro-activeness. The results show good treatment efficiency of the treatment plants. The parameters such as BOD, COD, faecal coliforms, suspended solids, have shown great reduction in their values after treatment. These have complied with the national disposal standards(CPCB and MoEF&CC, 2017).

The treatment plants constructed across the state helped more than 200 ULBs in successfully treating their Faecal Sludge and achieving safe sanitation. This also facilitated the cities in attaining better sanitation status, linked with the national programs. Reuse of treated end products have encouraged development of new green spaces and local women groups have been involved in the operations of the treatment facilities to promote livelihood opportunities.

Conclusions:
The state further aims to provide treatment facilities to all the ULBs of Maharashtra. Several ULBs have also taken up FSTP operation reviews to understand the on-site O&M practices, evaluate performance and provide recommendations for improvement. A state-wide monitoring system and dashboard is developed to track the implementation of FSSM plan.
The methodology adopted by Maharashtra has facilitated quick implementation of treatment facilities at a large scale and has impacted almost 12 million lives. Similar model can be adopted in 4000+ cities of India and other similar cities around the globe for treating FS.

The Design and Evaluation of a New SYBR-Green Quantitative PCR Assay for the Diagnosis Of Schistosomiasis
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The application of quantitative PCR has been useful in the diagnosis and management of parasitic diseases. In the case of schistosomiasis, different qPCR assays have been developed from different target sequences. The mitochondrial genome has been established to be ideal for the development of a diagnostic assay since it is highly conserved and numerous in a single cell. Moreover, a well-designed SYBR Green qPCR assay is cost-effective compared to a TaqMan probe-based qPCR assay. With schistosomiasis still devastating many developing countries, it is imperative to have a cost-effective diagnostic qPCR assay which sensitive and specific. Therefore, we developed a schistosome species-specific SYBR green qPCR assay to independently target the COX 1 gene of S. haematobium and S. mansoni. This study used previously extracted DNA samples from 200 stool and 150 urine specimens collected from an epidemiological survey conducted at Tomefa, an endemic schistosomiasis community. Schistosome species-specific primers were designed and synthesized from the COX1 gene of S. mansoni and S. haematobium for the SYBR green qPCR assay. The lowest DNA detection limit was estimated as 0.122 pg and 1.216 pg for S. mansoni and S. haematobium, respectively. The outcome of the diagnostic parameter estimation by the bayesian latent class analysis (BLCA) showed a prevalence of 36.0% and 91.7% for S. haematobium and S. mansoni, respectively. Test sensitivity and specificity were estimated as 93.7% and 92.3%, respectively, for the detection of S. haematobium, whereas the sensitivity and specificity of S. mansoni were 82.6% and 90.3%, respectively. The Ct values of the positive

diagnostic test ranged from 19.93 to 31.16 for S. mansoni and from 27.43 to 37.09 for S. haematobium. The correlation between the Ct values and microscopic egg counts for both S. mansoni in stool and S. haematobium in urine estimated r values of −0.365 (p < 0.01) and −0.253 (p < 0.035), respectively. The developed COX1 SYBR Green qPCR assay for S. mansoni and S. haematobium detections presented in this paper has proven effective and could be applicable to epidemiological surveys for treatment monitoring. It is a quick, efficient, and accurate procedure, which can be a good substitute for schistosomiasis qPCR assays that rely on probes.

Systematic reviews of microbiological performance of household and community drinking water treatment technologies
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The World Health Organization's (WHO) Guidelines for Drinking Water Quality (GDWQ) provides guidance on managing risks attributable to degraded drinking water quality, including an overview of treatment technologies and their effectiveness. The current GDWQ includes log-reduction value (LRV) tables based on performance of common water treatment technologies in reducing bacteria, virus, and protozoa in both community-scale systems (Table 7.7) and in household drinking water treatment (Table 7.8). Our team worked closely with WHO to update the current tables to be included in the next (i.e., fifth) edition so that it will reflect a wider selection of recently published studies. To this end, we conducted parallel systematic reviews of microbial performance in both community and household-scale drinking water treatment technologies, including both laboratory efficacy studies as well as at-scale effectiveness studies. We conducted literature searches covering the period of 1997-2021 using standardized search string queries for target databases. We followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) best practices were followed for the reviews.

Preliminary results for household water treatment included mean LRVs and 95% confidence intervals [CI] across bacteria (B), virus (V), and protozoa (P) categories for chlorination (n=39; B= 3.0 [2.5—3.4], V= 3.4 [2.7—4.2]), coagulation/disinfection (n=18; B= 6.3 [5.7—6.9], V= 5.4 [4.4—6.5], P= 2.6 [1.3—3.9]), solar (n=86; B= 3.6 [3.3—3.9], V= 3.5 [3.0—4.0], P= 2.4 [1.6—3.3]), UV (n=64; B= 3.5 [3.0—3.9], V= 3.4 [3.0—3.8], P= 2.8 [1.9—3.8]), thermal water treatment (n=17; B= 3.0 [2.1—3.9, V= 4.4 [2.4—6.4]), and additional categories. We further disaggregated data between efficacy and effectiveness studies.

We divided results for drinking water treatment plants into physical approaches of pathogen removal and primary disinfection approaches. Physical removal approaches included the technologies presented in the current GDWQ as well as data on Granular Activated Carbon, Ceramic Membranes, and Soil Aquifer treatment for possible inclusion in the 5th edition. While the primary disinfectants included are the same as those in the current GDWQ, results reflect ranges of contact times that could provide 1, 2, 3, and 4 LRVs for each pathogen type.

Updated LRVs indicate a variety of effective water treatment options for bacteria, viruses and protozoa in the drinking water treatment plant and household treatment alike. Practitioners and researchers can use the updated microbial LRVs to inform the selection of candidate technologies, evaluate the performance of existing treatment methods, and develop national or international standards performance. Our reviews also highlight the need for standardized reporting from performance testing studies to improve the quality of future reviews.

What sparks behavior change? The impact of personal perceptions, beliefs, and attitudes
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A substantial body of evidence confirms that the provision of water supply and sanitation infrastructure contributes to human health and well-being. Scholars and practitioners alike also highlight the importance of behavioral factors in reducing water- and sanitation-related illness. However, there is a dearth of scholarship on how behavioral decisions related to water, sanitation and hygiene are made. The

knowledge-attitudes-practices (KAPs) model is widely deployed in public health interventions to describe the pathway to behavior change. The KAPs model characterizes the process of behavior change with three steps: acquiring knowledge, generating attitudes and beliefs, and forming practices or behaviors. A natural hypothesis following this model would be that those who experience a greater shift in perceptions, beliefs, and attitudes would also experience a greater change in related behaviors. However, knowledge acquisition and attitude generation can be slow processes, and thus requires substantial intervention and investment to see lasting change. This begs the question: Is knowledge acquisition and attitude/belief formation required to achieve behavior change? Is behavior change sustained in the absence of supporting knowledge and attitudes?

In partnership with Muhimbili University of Allied Health Sciences (MUHAS) and the Dar es Salaam Water Supply and Sanitation Authority (DAWASA), we collected data from 1000 female heads of household in households with children under the age of 5 in Dar es Salaam, Tanzania. This data collection effort was part of a cluster randomized controlled trial testing the effect of a personalized informational intervention on health behavior change, child health, and household contamination. Each randomly selected household was interviewed 5 times during a 12-month period from 2011-2012. Each round of data collection included a survey as well as hand and stored water testing. Surveys included topics such as (1) characteristics of current water supply services, water treatment and storage practices; (2) characteristics of the household's current sanitation facilities and hygiene practices; (3) health status of household members; (4) knowledge, attitudes, and perceptions related to links between water supply, sanitation, hygiene, and health; (5) community characteristics, values, and norms, and interactions within the community.

When data analysis in complete (July 2023), we will know how much, if at all, (1) acquisition of knowledge and (2) formation of attitudes/beliefs predicts reported changes in (i) water management behavior and (ii) hand hygiene behavior among mothers in Tanzania. Preliminary data analysis indicates we will employ a spline growth model to characterize growth and decay of knowledge, attitude, and behavior outcomes over time. Outcomes will be modeled at the household level to identify interindividual differences in intraindividual change. We will also explore the influence of time-invariant covariates such as age and highest level of education attained. Results will inform strategic investments for WASH behavior change programming and elucidate some of the necessary pre-conditions for sustainable behavior change.

Outcome Evaluation of WASH intervention in rural households at (REDACTED), North West Ethiopia, 2021, Mixed method design
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Background:
The government of Ethiopia revealed that GTP II and SDG were achieved through one Water Sanitation and Hygiene (WASH) program. According to the 2016 Ethiopian Demographic and Health survey, the rural population was more affected by poor sanitation and hygiene. To address this Ethiopian government ratified Rural WASH sanitation and hygiene promotion through a community-centered approach, and to improve WASH service evidence on the effectiveness of an intervention at the household level is needed in developing countries. However, in our country one WASH in rural areas called community centered approach intervention was planned and delivered for the last 3 years (2018-2020).). Nevertheless, as to our review and researchers knowledge, the effectiveness of this intervention is not evaluated yet in our country as well as in this evaluation

Objective:
To evaluate the outcome of WASH intervention in rural households of Jawi district, North West Ethiopia, 2021.

Method:

The evaluation was conducted in rural households of Jawi district by a Quasi-experimental design supplemented with a qualitative in-depth interview from 3/14/2021-3/28/2021. Intervention groups were households that takes community centered approach while the controls did not. The evaluation approach was summative and counterfactual plus participatory and focuses on program outcome theory. A total of 1280 households were selected using two stage sampling and lottery method simple random sampling. We collected quantitative data through survey and structured observational checklist, while qualitative data through key informant interviews using a semi-structured questionnaire. We assessed program effectiveness and also the analytical study was conducted through propensity score matching to assess program effect through Stata 14.1. Qualitative data were transcribed and translated to English and thematic analysis was done using Atlas.ti.9.

Result:
Five hundred ninety-one intervention and 600 control households were involved in the study. In intervention households, 65.24% of them used water treatment, while 99.32% were having a latrine but only 73.77% used the latrine exclusively. Besides, 46.77% and 59.7% washed their hands by using water and soap before eating and after defecation respectively. This intervention increased water treatment utilization in 41.7% (ATT = 0.417, and 95% CI= 0.356, 0.478), 20.2% percentage point (ATT=0.202, 95% CI =0.135, 0.269) in improved latrine availability, 24.3 percentage point (ATT =0.243, 95%CI=0.180, 0.300) in exclusive latrine utilization, 0.124 (ATT=0.124, 95%CI= 0.081, 0.167) in hand washing before eating, 41.9 percentage (ATT=0.419, 95%CI = 0.376, 0.470) in hand washing using water and soap before eating, 13.6 percentage point in hand washing after defecation, 50.2 percentage point(ATT=0.502, 95%CI=0.450, 0.550) in hand washing after defecation by using water and soap in intervention households. Our qualitative finding revealed that unable to afford soap and their working place far away from their home were the most frequent reason reported by the respondent for not using soap for hand washing and latrine utilization respectively.

Conclusion and recommendation:
The overall program effectiveness was very good but the effectiveness in hand washing before eating using soap and water was poor. The intervention attributed to a statistically significant effect on the improvement of water treatment utilization, availability of improved latrine, exclusive latrine utilization, and hand washing before eating and after defecation and utilization of soap and water for hand washing after defecation and before eating in intervention households. This intervention should be scale-up and the intervention should pay greater attention to the improvement of hand washing practice and exclusive latrine utilization. Public latrines should be constructed in their working place and possible strategies should be developed to deliver soap at an affordable cost.
Key words- WASH, program, Project, Outcome Evaluation, Community centered approach, Ethiopia

"Best of" low-resource cities pioneering water and sanitation improvements among the poor
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Additional Authors: John Trimmer, Caroline Delaire, Miriam Otoo, Liz Jordan

Purpose:
The WASH Sustainable Development Goal to leave no one behind requires closing the gap in cities with significant inequality between underserved and served populations. As of 2020, an estimated 42% of urban residents in low-income countries lacked safe water and 79% lacked safe sanitation. This work sought to understand factors that make inclusive, citywide water and sanitation service delivery possible.

Method:
Using a modified social-ecological systems framework, we conducted a detailed, comparative case study analysis to learn from institutional arrangements in 11 cities with either high historical performance or ongoing efforts to pioneer new approaches in expanding equitable access to safe water and sanitation. We assessed and compared literature (n = 64) and expert interview (n = 16) data sources by developing timelines, institutional maps, and case narratives, employing these to identify common elements and patterns across cases.

Findings:
The case study cities' various institutional and service provision arrangements, often shaped by historical legacies surrounding colonization, contamination, or disease outbreaks, illustrated multiple models for effective progress. Across different contexts, utilities, regulators, or municipalities played more central roles, indicating multiple possible entry points for those seeking to foster reforms. Varied approaches included institutional reforms, increased metering, appropriate tariff or tax increases, public engagement, sector monitoring and coordination, performance tracking, holistic low-income area upgrading programs, and partnerships with informal workers. Additionally, shifting perspectives on residents' rights in informal low-income settlements have nurtured explicit pro-poor policies that work to establish rather than deny services.

Discussion:
The review identified multiple possible entry points (service providers, regulators, local governments) and strategies to foster progress in inclusive service delivery. Among 18 enabling factors identified across different models of progress, explicit pro-poor measures such as water connection subsidies and participatory budgeting have been particularly valuable in improving access among low-income households. Two primary challenges have revolved around water service provision on contested land and the lack of incentives that encourage small-scale, informal water and sanitation providers to deliver safe services. Appropriate strategies to overcome these barriers include withdrawal of land tenure requirements (similar to the electricity sector), financial rewards to pit emptiers, and worker cooperatives.

Impact of Water System and Community Characteristics on Drinking Water Quality Violations in Puerto Rico
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Background:
Prevalent water quality concerns have long plagued Puerto Rico with fears of emerging contaminants, hurricane-induced flood contamination, and deteriorating water infrastructure. Novel research into baseline community water system (CWS) characteristics and violations would provide a valuable guide for public-health policymakers. The Safe Drinking Water Information System is a commonly used research tool provided by the EPA that publishes water system information and Safe Drinking Water Act (SDWA) violations for water systems across the United States. In Puerto Rico, SDWA violation data has not been previously evaluated. The objective of this research is to: (1) characterize the type, size, and source of systems providing drinking water to Puerto Rico, (2) analyze violation and violation duration over time with respect to system characteristics, and (3) evaluate the impact of system, demographic, and community characteristics on violation count and duration.

Methods:
Water system data was pulled for 977 systems, of which 808 where CWSs and 400 were active CWSs. System service population, source, and type were reported to provide an overview of drinking water infrastructure in Puerto Rico. Between 1979 and 2022 there were 28,040 violations recorded on drinking water systems in Puerto Rico. Violations were analyzed temporally and aggregated by type, with a particular focus on health-based violation and violations of common contaminants like total coliform. Ongoing work will include geocoding water system locations, pairing demographic data to identify system service populations, and performing regression analysis to evaluate the impact of system characteristics, demographics, and community characteristics on the frequency and duration of SDWA violations.

Results:
Of the total quantity of violations, 58.1% (n=16,285) occurred in very small systems (those serving less than 500 people), while 4.1% (n=1143) occurred in very large systems (those serving greater than 100,000 individuals). Water systems are also classified by the source, with groundwater and surface water being the two most prominent. Ground water sourced systems accounted for 39.2% (n=10,987) of violations while surface water sourced systems accounted for 60.4% (n=16,939). Most of these violations

(86.4%, n=24,216) were related to system monitoring and reporting and 13.6% (n=3,824) were health-based, either treatment technique violations or violations of maximum contaminants levels. Within both health-based and monitoring and reporting violations, 60.8% (n=17,070) of violations were related to microbial monitoring, reporting, and contamination. This included 2,019 microbial violations in 2013, 1,912 in 2014, and 1,889 in 2015, representing a violation spike well above the 637 average violations per year observed across the 43-year period in Puerto Rico.

Conclusions:
Initial results suggest that SDWA violations are prevalent across Puerto Rico, particularly in systems servings smaller populations. While specific health-based violations were observed, the larger problem was monitoring and reporting violations, suggesting a lack of up-to-date and accurate knowledge on the state of drinking water in a territory with a widespread history of water-based public health concerns. Continued analysis will seek to evaluate the relationships between these violations and community characteristics in the hope that policymakers, community leaders, and stakeholders can allocate resources where problems have persisted.

The Household Resilience In Vulnerable Environments (THRIVE) Scales: Development and Validation for Urban Informal Settlements
Hemali Oza, Emory University
Additional Authors: Allison Salinger, S. Fiona Barker, Karin Leder, Autiko Tela, Ruzka Taruc, Matthew Freeman, Thomas Clasen, Sheela Sinharoy

Introduction:
Climate change poses substantial threats to the health and wellbeing of populations , especially those in low-income households and informal settlements. These threats include environmental disturbances such as floods and droughts, which are occurring with increased frequency and severity. Resilience, defined as the ability to cope, adapt, and recover, is critical for communities to manage these evolving threats. While there has been increased interest in ensuring that water, sanitation, and hygiene (WaSH) programming contributes to resilience, the lack of valid and user-friendly resilience measurement tools limits the evidence base on the effectiveness of interventions to do so.

Objective:
To address this gap, we developed scales to measure three domains of urban household resilience (economic, environmental, and social) and validated them for use among coastal, urban, informal settlements   facing environmental disturbances.

Methods:
We proposed an evidence-based conceptual framework of resilience that extends existing frameworks and addresses major measurement gaps. We developed survey questions (or items) based on the framework and collected data from 882 households in coastal urban informal settlements in Suva, Fiji, and Makassar, Indonesia. We used exploratory and confirmatory factor analysis to test the factor structure. We assessed scale reliability by calculating coefficient omega for internal consistency and used multiple group confirmatory factor analysis to test for measurement equivalence between populations in Indonesia and Fiji. We also tested for construct validity to understand whether our scales were measuring the concept of resilience as intended.

Results:
The factor analyses confirmed the three hypothesized scales for economic, environmental, and social resilience. The economic scale had 6 items that loaded onto two sub-scales, representing financial stability and financial resources. The environmental scale had 8 items that loaded onto two sub-scales, representing water and infrastructure/energy. Lastly, the social scale had 16 items that loaded onto 5 sub-scales representing emergency response , inclusion, social cohesion, collective efficacy and action, and knowledge and preparation. The scales showed high reliability and construct validity, indicating their appropriateness as a measurement tool for resilience. We also found evidence of measurement

equivalence, demonstrating the scales' comparability across the two countries.

Conclusions:
Our scales provide a valuable tool for measuring resilience in the economic, environmental, and social domains, enabling a comprehensive assessment of resilience-building efforts, such as WaSH programming. We recommend using these scales in designing, monitoring, and evaluating resilience-building programs and policies for urban households in low-income settings.

Learning Objectives:
Attendees will:
1. be introduced to a set of three urban household scales for economic, environmental, and social resilience to environmental disturbances and the scales' ability to be operationalized in a field setting for WaSH program monitoring and impact evaluations.
2. explore and understand the construct of resilience and how it pertains to urban households, and the importance of capturing resilience to environmental disturbances in the context of WaSH.
3. be able to identify and provide examples of how the resilience measurement scales can be applied to inform the design, monitoring, and evaluation of WaSH programs and policies for vulnerable populations in coastal, urban communities of low- and middle-income countries.

Targeting piped water to maximize impact in rural Uganda
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Piped water systems are necessary to achieve the Sustainable Development Goal of safely-managed water, which is defined as water access on-premise and free from contamination. In western Uganda, piped systems generally connect to public tap stands, with few households paying for household connections. The systems vary significantly in cost per capita, often costing several multiples of the per capita cost of borehole wells without delivering on-premise water access. Yet there is little guidance on how to target, design, and prioritize piped schemes to maximize impact on access to water, sanitation, and hygiene. This study's cost-benefit analysis utilizes cost data from Uganda and geospatial water access and population data from Masindi and Kiryandongo districts in western Uganda to contrast the costs and benefits of plausible design principles for small piped water schemes (<4,000 people). The design choices that are evaluated include installing a scheme based on a) availability of an existing high-yield borehole, b) high density of an unserved rural population, c) proximity of multiple target schools, d) proximity of a target health center and neighboring catchments, e) presence of a target rural trading center. The analysis explores the additive benefits of piped water for passive chlorination and handwashing, and critical per-capita cost variables, such as population density. The study also highlights questions concerning how to weigh the relative benefits of different water access improvements (e.g., changes from handpump access to tap stand access) where the underlying empirical data is limited. This study provides some preliminary insights to help policy-makers and implementers who lack guidance and general principles on how system design choices can lead to higher or lower social impact returns on their investment.

Multi-pathogen Environmental Surveillance in 2 districts in Ghana with no reported COVID-19 cases: Evidence to inform Public Health Interventions
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Environmental surveillance (ES) is a convenient, sensitive, low-cost method to estimate disease prevalence. Most ES in high-resource countries is implemented in sewered systems. Non-sewered sanitation is common in low-resource settings, and few studies have deployed ES in such environments. We applied ES to detect COVID-19, Salmonella Typhi, Vibrio Cholerae and Rotavirus A in two districts

with no reported cases of COVID 19 since the beginning of the pandemic to inform public health policy and practice. Mion (pop. 94,930) and Nanumba North (188,680) are rural areas in the Northern region of Ghana. Both localities are sparsely populated. Neither district has a sewerage system, and >70% of the population rely on shared public toilets. Stakeholder analysis was deployed to identify population centers in the community that should be targeted for wastewater or fecal sludge sample collection. Schools (primary, secondary, and college), healthcare facilities, markets, and streams were identified and mapped. From September to November 2022, grab and Moore swab samples were collected daily from septic tanks, pit latrines and surface water. Samples were stored and transported weekly to a central lab in Accra. Liquid samples were concentrated using Nanotrap particles, RNA extraction, and analyzed by multiplex RT-qPCR. Solids samples were processed by centrifugation and then, the supernatant was processed as a liquid sample.

47 sampling sites were identified, and 193 samples (126 solids samples, 3 Moore swabs, and 64 liquid samples) were collected overall. In all, 15.6%, 33.3% and 18.2% of the liquid, Moore swab, and solid samples tested positive for SARS-COV-2 RNA, respectively. Liquids (7.8%), solids (0.8%) and Moore swab (66.6%) samples, tested positive for Vibrio Cholerae. Only 3.1% (all liquid samples) and 0.89% (all solid samples) of the samples tested positive for Rotavirus and Salmonella Typhi respectively. Positive SARS-COV-2 samples were from healthcare facilities (6.6%), public latrines (17.4%) and schools (21.9%). The median concentration for liquid samples was 4.6log genomic copies per liter (gc/L) for SARS-COV-2, 5.9log gc/L for Vibrio Cholerae and 6.91log gc/L for Salmonella Typhi. For solid samples, the median concentration for solids was 4.4log genomic copies per dry gram (gc/gram) for SARS-COV-2, 5.1log gc/gram for Vibrio Cholerae, and 7.7 log gc/gram for Salmonella Typhi. 8.9% of the 78 samples from Mion were positive for SARS-COV-2. Out of the 116 samples from Nanumba North, 24.3% tested positive for SARS-COV-2. No COVID-19 or Cholera cases were reported from either district during the study period. The Ghana Health Service used the results to develop action plans and implemented public health intervention activities -including health education and targeted mass vaccination in schools and communities. These findings demonstrate the value of ES to guide the public health response in remote low-resources settings even when clinical cases are not detected.

Exploring WASH services delivery chain in informal settlements: A case of two selected informal settlements
Carolina Kabaria, APHRC
Additional Authors: Ivy Chumo and Blessing Mberu

Introduction:
Universal access to basic water, sanitation and hygiene (WASH) services remains a global challenge, particularly in low- and middle-income countries. Efforts are underway to improve access and use of WASH service delivery in informal settlements, often through enhancing safety and security. However, access and use of these facilities and their potential health gains may be hampered by contextual aspects related to the safety, security and physical environment. This study explored associations between the access and use of WASH facilities and perceived safety to access and use the WASH facilities.

Methods:
A cross-sectional study was carried out between January and June, 2022, including 1706 households in two informal settlements in Nairobi (Kenya). We employed adjusted odds ratios (aORs) obtained from multiple logistic regressions (MLRs) to test whether the access and use of WASH facilities was associated with a perceived lack of safety to access and use the facility at any time. The MLRs included several exposure and control variables, being stratified by study site, sex, and age groups. We employed bivariate logistic regressions to test whether the perceived insecurity was associated with settlement morphology indicators derived from the built environment.

Results:
Use of WASH facilities was associated with a perceived insecurity both in Korogocho [aOR = 3.14, 95% confidence interval (CI): 1.13–8.70] and in Viwandani (aOR = 7.97, 95% CI: 3.93–9.53). Accessing the WASH facilities was also associated with perceived insecurity of the location of the WASH facilities

(aOR = 1.90, 95% CI: 1.29–2.79 in Korogocho, aOR = 1.69, 95% CI: 1.22–2.34 in Viwandani. Several settlement morphology features were associated with perceived insecurity, namely, buildings' compactness, the proportion of occupied land, and angular deviation between neighboring structures.

Conclusions:
Location of WASH facilities is a critical determinant of perceived security, and hence, must be adequately addressed when building new facilities. The sole availability of facilities may be insufficient, but people must also be safe to use them. Further attention should be directed toward how the built environment affects safety.

Beyond a facility: A cross-sectional survey on WASH service levels and informal social accountability
Ivy Chumo, APHRC
Additional Authors: Blessing Mberu and Caroline Kabaria

Background:
Growing up in a safe environment is every child's right. Access to clean water, sanitation, and hygiene (WASH) practices not only keep children thriving, but also gives them a healthier start in life. A scale of the level of WASH services, i.e no service, limited service and basic service, has been developed as a ladder to measure service. It may be valuable as a predictor of health and education outcomes such as in childcare centres. Social accountability is potentially an important contributor to improved WASH services in childcare centres. To the best of our knowledge, no studies have explored how informal social accountability (iSAMs) contributes to WASH service level in the ladder. This study assessed the association between iSAMs and the WASH service ladder in childcare centers in two Nairobi informal settlements.

Methods:
A cross-sectional survey was conducted with one childcare provider from each of the 40 and 37 childcare centers in Korogocho and Viwandani respectively. We used a structured questionnaire with questions on WASH and iSAMs identified during a qualitative data collection phase. Rewards, sanctions, voice/feedback reports and responsiveness were used to measure iSAM. We explored the association between the WASH ladder variables (dependent variable) and iSAM (independent variable), using multinomial regression with a robust error variance estimator. Model 1 assessed no service versus limited services, while model 2 assessed limited versus basic service, using adjusted relative risk ratio (aRRR). Through the parsimonious model, level of significance is reported.

Results:
Access to basic WASH was relatively higher on the measurement ladder in childcare centers in Korogocho than in Viwandani. 78% and 65% of centers had access to basic hygiene, 68% and 59% had access to basic water and 40% and 27% had access to basic sanitation in the Korogocho and Viwandani study site respectively. A higher proportion of centres had access to basic WASH services compared to limited and no services in both study sites. There was a strong association between rewards, sanctions and responsiveness and WASH service level, with a ~5-fold fold higher level of rewards (aRRR 5.14; 95% CI 3.71, 9.1); and ~2-fold higher level of sanctions, (aRRR 1.8; 95% CI 1.39, 9.36) and responsiveness, (aRRR 1.6; 95% CI 1.4, 16.57) associated with basic sanitation services compared with no services. Water services, reported use of sanctions was strongly associated with basic service compared with no services (aRRR 6.7; 95% CI 2.97, 9.5). For hygiene services, there was a significant association with basic versus no services in childcare centres reporting responsiveness (aRRR 3; 95% CI 2.27, 8.46), sanctions (aRRR 2; 95% CI 1.16, 4.12), and feedback reports (aRRR 1.97; 95% CI 1.29, 3.27). Notably, relative risk ratios on association of basic water and hygiene were higher in no service compared to limited services and were less likely associated in basic sanitation verses limited sanitation service delivery.

Conclusion:
iSAM sanctions were highly associated with all the WASH service levels, suggesting these

informal mechanisms play a critical role in WASH services. These data contribute toward limited understanding of the role of informal social accountability as a key component for strengthening WASH service delivery. We conclude that iSAMs can play an important role in provision of WASH services in childcare centres in informal settlements.

Addressing negative Gender and Social Norms in South Sudan through community dialogue and WASH
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Additional Authors: Gire Gladys- Deputy Chief of Party- Afia WASH and Francis Lokong- MEL Advisor-Afia WASH

Purpose of study:
Gender Based Violence and harmful gender social norms are extremely high in South Sudan. This Gender Transformative WASH program is aimed at to improving women's agency, gender equality and WASH use and access. This study gave us a baseline idea of the current situation to inform our approach.

Study Design and research questions:
USAID Afia WASH project was designed to implement Gender Aware Sustainable Water, Sanitation and Hygiene activities in South Sudan. This project commissioned baseline assessment in five counties that focused on three gender-specific outcomes which includes 1) leadership, 2) roles and responsibilities sharing, 3) resources ownership, distribution, and usage. The main questions behind the baseline were: What is the current WASH situation, and what is the breakdown of gender roles regarding WASH?

This baseline was administered to 2,547 respondents including 2,265 respondents reached through household survey, 37 key informant interviews and 245 through focus group discussions (FGDs).

Key findings:
It was found that 90% of household role is done by women including for WASH roles, 23% of the available WASH Committees were headed by men, decision making for resources/location of WASH infrastructure are done by men, 100% of people working on WASH paid activities are men. Women are given soft hygiene promotion activities without payment attracted. Men pay water user fees – but due to lack of communication at home, women collect water from unprotected sources because they are not aware of their husband's payment to the water committee. This also means that women had little to no say in management of the WASH facilities.

Intervention & Strategies:
Key overarching intervention that leads to building Agency, changing Relations, and transforming Structures was developed and implemented through Social Analysis and Action (SAA) to influence the changes in the negative social norms that existed in communities. Community Influential Leaders were engaged to conduct mobilization. Community dialogue groups initiated, and weekly dialogues were conducted in the target geographies.

Result and lesions learnt:
The initial result indicated resistance from communities where intervention took place. Some heated discussions attracted resistance and rejection – example discussions on women leadership, role, and responsibilities allocation especially for WASH and Menstrual Hygiene Management. As result led to request for removal of some Government representatives- County Commissioner for Kapoeta North County.

As result of community influential leaders were engaged which made shift to the myths and believes people have towards Gender in WASH. 51% of leadership of Water Management Committee have become women. There is now more awareness by men and boys in discussing the challenges women and girls are facing while accessing WASH services.
USAID partners doing Backbone Coordination helps to bridge Humanitarian and Development Triple

Nexus issues.

Conclusions:
Afia WASH have recorded massive changes in the behaviors of beneficiaries related to Gender and WASH. Backbone coordination helps to shape idea of development in WASH infrastructure as opposed depending on Humanitarian Assistance.

A Deep Learning Approach to Water Point Detection and Mapping Using Street-Level Imagery
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Purpose:
Households in developing countries often rely on alternative water sources such as private vendors and community-managed standpipes due to the limited capacity of public service providers to extend piped infrastructure to all households within their service area. These water points often exist outside of the datasets of public service providers, and accordingly, it's difficult for service providers and governments to monitor the safety, accessibility, and distribution of such sources. This poses a significant challenge to accurately measuring the number of households outside the public service system that use a safe and accessible water source. This paper proposes a novel deep learning approach that utilizes a convolutional neural network to detect water tanks in public street-level imagery from Google Street View. In doing so, it presents a low-cost, time-efficient, and scalable method of collecting spatial data on alternative forms of water access in developing countries.

Methodology:
The training dataset is comprised of a sample of street-level imagery from Lagos, Nigeria retrieved using the Google Street View API. At each sample location,
four images staggered at a 90 degree panoramic angle direction were retrieved and compiled in a city-wide dataset, which was then partitioned into training, validation, and testing sets. Each image was manually annotated using bounding boxes to outline the region of each image containing the water tank.

The object detection model uses a convolutional neural network built on the YOLOv5 architecture, which is designed to extract a vector of features from each image and predict bounding boxes and class labels for each box. The model was trained using the annotated street-level images from Lagos to detect the location of water tanks in each image.

Findings:
Preliminary results suggest that this methodology is able to accurately detect water storage tanks across a variety of urban settings and obstruction levels, with about 88–95% accuracy in the validation dataset [88.0% recall, 93.7% precision, 95.0% mean average precision (mAP)]. Overall, these results support the potential of using deep learning to augment data collection on WASH access for households that access water from providers sources outside of the public system. The model is piloted using the case study of Lagos, Nigeria to demonstrate the efficacy of this approach, and is then applied to street-level imagery to similar cities with strong GSV coverage in other developing countries to generate maps of water points.

Conclusion:
Convolutional neural networks offer a cheap, quick, and scalable method of mapping alternative water sources in developing countries. The CNN can automate the process of detecting and mapping the physical location of water points, thereby saving time and resources and unlocking critical missing data in the race to achieve universal access to safe and reliable water.

Understanding the shift in the working and living conditions of sanitation workers in a small town in India
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Additional Authors: Prof. N C Narayanan, Prof. Pankaj Sekhsaria

The sanitation sector has witnessed a transformative shift, particularly in low and middle-income countries like India, with the proliferation of non-sewered sanitation systems. However, academic literature has been lacking in providing insights into this shift and the emergence of a new workforce in this sector. Such an understanding is imperative to chart a course for the enhancement of the living and working conditions of sanitation workers. These workers play a pivotal role globally by bridging the gap between sanitation service provision and infrastructure, often at the expense of their safety, well-being, and dignity. This study endeavors to comprehend the transitions in the working and living conditions of sanitation workers in urban Kerala, specifically in Alleppey town. These transitions have been catalyzed by the adoption of new toilet technologies and related sanitation systems. The research explores the evolution of sanitation work and workers in Alleppey from 1947 to 2021 to understand the shift from manual scavenging to contemporary fecal waste management, particularly pit-emptying or septic tank cleaning.

A qualitative research approach was employed for the study and the data was collected through in-depth interviews with sanitation workers, government officials, local historians, and community members. Additionally, historical documents from government offices, digital archives, articles, and autobiographies were utilized for thematic content analysis. The research shed the light on the evolution that transpired post-independence. The findings reveal that the introduction of new sanitation technology in Alleppey and across the state since 1970s has created a window of opportunity for transformative change in the conditions of sanitation workers, particularly in urban settings. This transformation was further reinforced by legislative actions in India in 1993 and 2013 aimed at eradicating manual scavenging practices. Consequently, manual scavenging ceased, and fecal waste management shifted from state-controlled formal employment to an informal and precarious occupation involving the cleaning of septic tanks and pits. The transition to new toilet technologies was predominantly steered by various state and non-state actors, including UNICEF. The study illustrates that sanitation work underwent changes in terms of its scale, frequency, and the role of the state in the work. Moreover, the living and working conditions of sanitation workers has also witnessed substantial shifts, encompassing alterations in social backgrounds, gender participation, contract terms, collective bargaining power, work schedules, wages, social discrimination, occupational health, and worker safety. Even the residences of sanitation workers transitioned from recognizable "scavenger colonies" to individual households throughout the region. The study argues that the emergence of sanitation technologies addressing issues of open defecation and containment (first-generation issues) significantly influenced the nature of sanitation work and the composition of the sanitation workforce. To further improve working conditions, attention must now be directed toward addressing second-generation issues, such as transportation and fecal waste treatment, in off-grid towns.

Setting the research agenda for Water, Sanitation and Hygiene (WASH) in humanitarian crises
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Introduction:
Humanitarian crises are occurring at increasing rates. Evidence-based strategies to aid decision-making and selection of effective and appropriate interventions to populations affected by or at-risk of crises are increasingly important. While WASH interventions are commonly implemented as part of response activities, there is limited good-quality evidence on the effectiveness of WASH programmes and interventions in humanitarian crises. Therefore, setting a consensus-based research agenda to lead the WASH in crises sector is key to progress in global health and responding to people in need. This project aimed to develop an agenda to serve as a guide for researchers, practitioners, and funding agencies by providing a prioritised list of research questions that, when answered, will contribute to improved WASH

policy and practice in humanitarian crises.

Methods:
A consultative approach, based on the Child Health and Nutrition Research Initiative method, was used to identify WASH research priorities in a consultative and replicable way. A ten steps process was followed to: create a systematic listing of research questions (based on a literature review of 498 papers, 27 key-informant interviews, and four focus-group discussions with WASH stakeholders); reduce the list of questions from 932 to 128 (by removing duplication and with input from 14 technical advisors); and judge the questions by global survey according to five criteria identified by the sector. A research prioritisation score was calculated for each question and questions were ranked in order of priority. The scope of the selected research was for all countries and communities affected by or at-risk of humanitarian crises, any geographical scope and outcomes of interest, and from the present day to 2030.

Results:
The research prioritisation scores were computed based on the collective perspectives of 286 individuals based in 65 countries, with on average 13 years of experience in WASH interventions or other aspects of humanitarian programs. The score in the top 20 research questions was high (85.6–100%), indicating a good level of agreement among respondents. Those questions mainly focused on research related to the: distribution of hygiene materials or non-food items (NFIs); improvements to design and implementation of WASH in crises programmes; and improvements to access to and use of sanitation facilities and reducing exposure to faeces (with four prioritised questions in the top 20 for each of those categories). The identified priority research questions highlighted the need to optimise delivery of existing interventions to maximise impact on populations affected by or at-risk of crises, as well as the need to develop or improve existing interventions and strategies, rather in invent new interventions.

Conclusions:
The WASH in Crises Research Agenda serves as a guide for researchers, humanitarian practitioners and funding agencies by providing a prioritised list of research questions that, when answered, will contribute to improved WASH policy and practice in humanitarian crises. The WASH community collectively should use the WASH in Crises Research Agenda to align efforts to build the evidence-base and guide investments in appropriate and effective WASH programmes

Hydroclimatic risks to household water access and food security in Bangladesh
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Additional Authors: Emily Pakhtigian, Alfonso Mejia

Key Learning Objectives:
(1) Understand the effects of different flooding scenarios on household water access and food security among families with young children.
(2) Comprehend how geographical and timing differences in floods influence variation in flood effects on household water access and food security.
(3) Learn what are the effects of seasonality on household water access and food security after controlling for flood exposure.

Background and Problem Statement:
Water and food security are critical for health and well-being, yet globally billions still lack access to safe water and adequate nutritious foods. This leaves households, particularly those with young children, vulnerable to negative health effects. Attaining global targets for safe and affordable water for all and eliminating hunger and malnutrition have been complicated by shifting patterns of climate seasonality and extreme weather events. Floods and droughts disrupt safe water systems and decrease agricultural productivity. Accordingly, there is a pressing need to understand how hydroclimatic risks influence household water access and food security.

Objectives and Methods:

We test for the impacts of flood events and monsoon seasonality on household water and food security in Bangladesh. We link three difference data sources: (1) the Bangladesh Demographic and Health Survey; (2) the Indian Monsoon Data Assimilation and Analysis project; and (3) the EM-DAT Disaster Database. We then compare three different flooding scenarios from 2011 (n=17141), 2014 (n=17300), and 2017 (n=19457). For each cross-sectional wave, we use difference-in-difference models to estimate the effects of flood exposure on household water access and food security, comparing outcomes among households living in flood-affected and non-flood affected regions before and after flood events. To assess the validity of our difference-in-differences designs and provide insight into the longevity of flood effects, we conduct event study analyses for each wave. Finally, using a two-wave panel from 2011 and 2014, we assess effects of seasonality and extreme weather events on household water access and food security.

Results:
Effects of flood exposure varied geographically and by duration and extent of the flood event. In 2011, severe floods, which lingered up to 3 months, negatively affected household water access (OR:0.24, p<0.001) and food security (OR:0.34, p<0.001). In 2014, on the other hand, when flood exposure was less severe and only lasted one month, we find that those living in flood affected areas interviewed after the flood experienced improved water access (OR:1.84, p<0.001). This result holds primarily in non-coastal areas (OR:1.833, 95%, p<0.01), suggesting differential effects by geography. Panel analyses between 2011 and 2014 demonstrate that compared to the beginning of the monsoon, the first month of the dry season shows less water access (OR: 0.80, p<0.05) but higher food security (OR: 2.11, p<0.05). Finally, in 2017, after severe country-wide flooding and an unusually wet end to the monsoon and start to the dry season, we find slightly higher water access one month after the transition into the dry season (Coeff: 0.10, p<0.05).

Conclusion:
We find different effects of flood exposure on household water access and food security, where effects vary over time and geography. This emphasizes differential water and food-related health impacts depending on flooding extent and severity. Understanding these relationships across diverse social groups and geographies is necessary for appropriate allocation of engineering and policy resources to address growing costs of climate change adaptation and mitigation.

Occupational hazards and PPE use among sanitation workers in fecal-waste management plants; Qualitative study
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Introduction:
Uganda is experiencing a rapid urban growth which has led to increased need for on-site sanitation technologies which require functioning fecal waste management systems and institutions to operate. Increased urbanization in Uganda has exerted pressure on the existing sanitation facilities including sewer systems and fecal waste treatment plants. With the poor knowledge and attitudes towards utilization of personal protective equipment (PPE) while working in hazardous environments. Therefore, this study focused on understanding occupational hazards and use of PPE among sanitation workers in fecal waste management plants in Uganda.

Methods:
Our study utilized a qualitative cross-sectional design among key informants. A total of 18 key informants conducted from 9 districts were recruited and interviewed of which these were key stakeholders. These included; health officers, selected fecal treatment plant, officers in the city public health department, Ministry of Health official and Ministry of Water and Environment official. All audio recordings were transcribed into verbatim and analyzed using qualitative content analysis. Using NVivo (Version 12.0) pro, codes were developed from the identified topical sentences. Our results were presented using the five themes were developed and these include: Occupational hazards, Protection against occupational hazards, Facilitators to use of PPE, Barriers to PPE use and Recommendations for improved use of PPE.

Results:
Occupational hazards: participants related occupational hazards to things in the fecal waste and surrounding environment that could cause harm to their lives in the course of handling fecal waste. In addition to the risk, exposure to poisonous gases on opening manholes that potentially result into respiratory effects and suffocation and exposure to biological hazards such as pathogens and hookworms that can access the body and cause ill health. Protection against occupational hazards: Protective equipment that reduce exposure of different portals of entry to pathogens and other occupational hazards worn by the sanitation workers especially while at fecal waste collection points and at fecal waste disposal areas. Facilitators to use of PPE: The institution with other stakeholders such as department of Environmental Health builds the capacity of their sanitation workers and private fecal waste collectors about occupational safety and PPE use while at work to prevent disease and adverse effects. Barriers to PPE use: There are two categories such as individual and institutional challenges. Joining the private fecal waste collection is unregulated and participants reported low knowledge levels of sanitation workers about occupational health and safety in fecal waste management. Institutional challenges included presence of weak guidelines and regulations for safety in fecal waste management. Recommendations for improved use of PPE: Participants urged employers in fecal waste private companies and fecal waste treatment plants to regularly avail PPE to their sanitation workers and provide refresher trainings to reduce exposure to occupational hazards in their work places. In addition, policy makers should amend the present acts and regulations regarding safety of sanitation workers for easy implementation and enforcement of the such laws.

Conclusion:
Amendment of the present acts and regulations regarding safety of sanitation workers for easy implementation such as provision of PPE, regular training for the sanitation workers, infrastructure and work culture improvement.

Image-based Tools Development for Improved Water Quality Testing and Insights in Decentralized Systems
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Despite ongoing global efforts to meet UN SDG 6 on water and sanitation, communities lacking continuous access to piped water struggle to make progress. Decentralized water reuse and harvesting techniques, such as household and community-level rainwater harvesting (RWH), are vital for addressing these issues. However, the water quality is often put at risk due to the absence of proper treatment processes and the neglect of maintenance and monitoring of the water distribution systems and constrain the adoption and long-term use of decentralized water solutions. Herein, we aim to (a) design a user-friendly image processing tool to enhance bacteriological water quality monitoring (using standard protocols such as US EPA's Method 1604), (b) test water quality at rural and peri urban RWH sites in Mexico, and (c) map the impact of water quality awareness on consumer behavior. Water samples at the point-of-use from household RWH systems are being collected in partnership with a local social enterprise and fundamental physicochemical properties and bacteriological water quality tests are being completed. The preliminary version of the image processing tool, incorporating thresholding, contrast adjustment, and shape identification algorithms, has demonstrated promising results in identifying and estimating the bacteriological quality of water with a high level of confidence. For instance, in initial testing, the tool successfully identified and quantified E. Coli colonies from smartphone images of different water samples, with significant improvement in accuracy compared to manual counting methods. Currently, this tool is being further tested utilizing the K-Means clustering algorithm and packaged as a smartphone app to use in the field. Following this step, a randomized control trial will be completed to analyze the effect of water quality awareness on RWH usage pattern. This advanced measurement of the RWH water quality and improving awareness among the consumers can encourage the adoption of the technology and prompt regular maintenance action from the users by educating them about the potential health hazards associated with consuming contaminated water. Additionally, simple, low-cost methods of water quality testing and regular maintenance can also encourage users to take ownership of their water

sources and treatment systems, which is crucial for long-term sustainability of decentralized water systems.

Women, Water, and Wrenches: Narrowing the Gender Gap Through WASH Infrastructure Training
Lucas Pastorfield-Li, DT Global. Inc

In the arid flatlands of Kapoeta North, South Sudan, the Toposa people depend almost entirely on women to construct and maintain their communities' structures. As a tribal, semi-nomadic people, this work entails the consistent installation of homes, walls, granaries, kitchens, livestock pens, and latrines. Though responsible for most community-built WASH construction, Toposa women are historically removed from WASH infrastructure management and remain unpaid for their skills. When repairs to WASH facilities are needed, an outside, oftentimes male, technician must be contracted to perform them. Such expertise could instead be sourced from within. The USAID/South Sudan Afia WASH Project sees Toposa women as a viable, sustainable cohort for both attaining local WASH security and progressing gender equity.

This presentation explores three primary motivations for expanding the role of Toposa women in WASH infrastructure management:

First, limited water access poses a persistent and worsening health challenge to the Toposa people with 47.8 percent of their water points identified as non-functional. Communities require both improved water infrastructure operations and maintenance training to enact repairs following breakdowns. Given Toposa women's preexisting experience in construction, establishing them as a locally available skilled WASH workforce can strengthen self-sufficiency and the surrounding WASH network.

Second, compensation for "hard" labor in WASH remains inequitable for women. During an IOM site visit to a different WASH project in South Sudan, all contracted positions (paid in USD at higher rates) were held by men while women occupied 56 percent of the "rotational" jobs that received low to no pay in SSP. Especially considering South Sudan's economic fragility, technical training in WASH infrastructure maintenance and management can provide a meaningful, marketable skillset Toposa women can employ at home and throughout the region.

Lastly, women are bereft of prestige and social capital within Toposa communities. While vital to their villages' wellbeing, they are relegated to a low standing and often barred from major decision-making on their families' or their own behalf. By having responsibility over a critical aspect of their village's welfare, Toposa women can narrow the existing gender gap and garner a stronger social position.

Less than two years into implementation, Afia WASH has laid significant groundwork for involving women in WASH oversight. The project has established 10 Water Management Committees (WMCs) in Kapoeta North tasked with overseeing the functionality of community water points. Occupying 61.2 percent of all WMC rosters and 29.5 percent of leadership positions, Toposa women are developing familiarity with their WASH infrastructure and the means for sustaining them.

Looking forward, the project can expand on the WMC model to provide technical training and establish teams of skilled women to repair boreholes and eventually earn payroll positions on Afia WASH and other similar projects. Between 2021 and 2022, Afia WASH rehabilitated 35 boreholes providing water to 41,592 people. With each borehole repair costing an average of 10,000 SSP, female technicians can earn significant supplementary revenue, ensure continued water access for their communities, and elevate their standing in the process.

Disability-inclusion in hygiene promotion messages in three Low-and-middle-income countries
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Background:
People with disabilities in low-and-middle-income countries are often overlooked from mainstream hygiene behaviour change messages. During COVID-19, the UK government and Unilever provided hygiene promotion messages in Indonesia, Kenya and Zambia to improve hygiene practices of people, with a focus on reaching vulnerable groups, including people with disabilities. As the evidence showed that people with disabilities may miss important behaviour-change messages if communication methods and resources are not accessible, we sought to understand how disability-inclusive those messages were.

Method:
We used a participatory evaluation approach to conduct a mixed-method study in Indonesia, Kenya, and Zambia. From February-July 2022, we conducted the study as external evaluators, which included household screening (Indonesia: 478, Kenya: 591, Zambia: 585) to identify people with disabilities using "Washington-Group shortset questions", and detailed-survey with 615 people with disabilities (Indonesia 173, Kenya 282, Zambia 160) and 588 people without disabilities (Indonesia 167, Kenya 260, Zambia 161) to explore their experience in accessing the messages; We conducted 62 key informant interviews (Indonesia 16, Kenya 28, Zambia 18) with implementing organizations, government bodies, and disabled people's organizations, and 92 in-depth interviews (Indonesia 30, Kenya 30, Zambia 32) with people with disabilities and their caregivers. We performed descriptive and multivariate logistic regression analysis adjusted for the cluster-level correlation. Qualitative data were analyzed thematically.

Findings:
Overall, around 90% of people from three countries received behaviour change messages. However, people with disabilities were around 10% less likely to receive messages than people without disabilities in all three countries. Message reach was 1.6 times higher among female people with disability than male people with disability. People with disabilities from the highest socio-economic groups (richest) were 4.53 times more likely to receive the intervention messages than the poorest. Message reach also significantly varied by disability type. In Indonesia and Kenya, people with hearing, communication, cognition/remembering and self-care difficulties had a lower reach (4-27%) of the messages than other functional limitations. In Zambia, people with self-care difficulties had 8-13% lower reach than other functional limitations. Most people receive messages through TV/radio programs, and community-level campaigns. However, in Indonesia and Zambia, people with disabilities were significantly less likely to receive messages from the community-level campaign, and social media. Additionally, all the country programs rarely discussed the vulnerability and support needed for people with disability, and these messages reached only a few people (reached only 1-3%) in three countries. Qualitative exploration shows the lack of disability-inclusive communication materials (lack of braille, sign language, and audio resources, and use of confusing or complex language), social stigma around disability, and inadequate involvement of disabled-people organizations in intervention design/delivery acted as major barriers to inequitable access. Moreover, as the implementing partners did not collect disability-disaggregated data to monitor reach, they could not make them more tailored for people with disabilities.

Conclusion:
Access to the messages was inequitable for people with disabilities compared to people without disabilities. Monitoring disability-specific indicators during program implementation can help the program address the diverse need of people with disabilities.

Microbial Hazards and Household Use of Alternating Dual-Pit Latrines with Lime in Rural Cambodia
Rana Abdel-Sattar, iDE
Additional Authors:Jennifer Roglà, PhD; Toeur Veasna; Tyler Kozole; Chris Nicoletti; James Harper, PhD, PE

Background/Problem Statement:
Basic sanitation coverage in rural Cambodia has improved markedly in recent years; however, safely managing sanitation (SMS) remains challenging to achieve. In 2017, iDE introduced an affordable fecal sludge management (FSM) product-service combination to the rural Cambodian sanitation market: the alternating dual-pit latrine upgrade (ADP) with lime treatment. ADPs provide on-site FS treatment by storing FS underground in a sealed pit for a minimum of two years (per the World Health Organization, 2006) and further inactivates pathogens via lime treatment. With 17,000+ ADPs now installed in rural Cambodia, ADP treatment effectiveness and related household practices can now be evaluated at scale in real-world conditions.

Objective:
In partnership with Causal Design, iDE explores ADP microbial hazards and ADP-related household sanitation practices and perceptions. This study seeks to answer: 1) can lime-treated pits be emptied safely without specific techniques or equipment after the WHO-recommended 2 years of storage treatment? and 2) in rural Cambodia, do households appropriately operate and maintain their ADPs based on recommended practices?

Methods:
E. coli and fecal coliforms are enumerated in fecal sludge samples from 147 pits, and 770 ADP-owning households in five Cambodian provinces are surveyed to describe how they operate and maintain their ADPs compared to recommended practices. Data is then analyzed using frequencies, associations, and regressions.

Results:
E. coli and fecal coliforms were relatively common (46% and 74%, respectively). 31% of all pits were found to have E. coli levels that exceeded 100 CFU per dry gram of fecal sludge, posing a risk to public health.

Many ADPs were not operated per recommended practices, and the worst observed practice was pits being reconnected to a toilet or to another pit, which likely introduces live pathogens into the FS undergoing treatment. A lack of or incomplete lime mixing also likely contributed to reduced treatment effectiveness.

The recommended practice of pit switching was more common in flood-prone areas (63%) compared to non-flood-prone areas (36%); however, only 16% of households treated their new pit with lime. Most importantly, no household waited 2 years to empty their old pit, and 59% waited less than 1 year. 51% switched their latrine back to their old (now dewatered) pit without first emptying it when their new pit filled, negating the treatment of their old pit. Various associations were found between household ADP practices, perceptions and household characteristics and will be reported at the conference.

Conclusions:
This study provides a novel perspective of real-world FSM with a common on-site sanitation system. We call into question the sector-standard two years of storage treatment for FS, which may have wide-reaching effects on FSM and latrine design. This study also assesses progress towards reaching UNICEF/WHO's standards for SMS using quantitative data and prioritizing user-centered, context-driven approaches.

Based on our findings, we suggest that the sector: 1) monitor and evaluate existing on-site FSM solutions to improve SMS interventions; 2) consider technical (treatment and disposal) and behavioral (household practices) aspects when designing FSM solutions; and 3) develop more practical tools to easily, accurately and affordably monitor progress towards rural SMS.

Effectiveness evaluation of bio-additives to reduce sludge accumulation at source in informal settlements in Lebanon
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Additional Authors: Daniele Lantagne, Tufts University, Mayssam Nasser, Nour Ghuneim, Rida Jomaa, Baptiste Lecuyot, Solidarités International

Key Learning Objectives
• There is a lower accumulation of fecal sludge in the systems with bio-additives, but the desludging frequency is unchanged, probably due to low infiltration in the soak pit.
• Adding bio-additives in the containment systems has little to no effect on E. coli concentration, odors and fly presence.

Introduction:
Construction of pit latrines to limit open defecation and confine excreta is often the first sanitation response implemented in emergencies. Due to limited storage volume and misuse of latrines, the pits soon fill up and need to be emptied. A solution to limit the accumulation of sludge at the source is to add biological additives (or bio-additives) into the latrine containment systems. Bio-additives are designed to enhance biological activity, through the addition of organisms such as bacteria. However, scientific evidence showing bio-additives effectiveness is weak, particularly in humanitarian contexts. This study aimed at evaluating Sanipit bio-additive effectiveness to: 1) reduce the accumulation of fecal sludge; 2) reduce odors and presence of flies; and 3) reduce E. coli concentration in sludge.

Methods:
The study was implemented in Syrian informal settlements in Bekaa Valley, Lebanon, from September 2022 to March 2023. Twenty-seven containment systems were included into the study, 13 with bio-additive added, and 14 without. The containment systems were composed of three watertight holding tanks and a soak pit in series, connected to flush latrines by a manhole. All containment systems were completely desludged at the start of the study. The Sanipit bio-additive was added each week following manufacturer's instructions. We measured weekly pH, temperature, odors, fly presence, and sludge level in the first and third tanks of the containment system. We collected weekly samples from the third tank and analyzed them for E. coli. Household surveys were conducted monthly to collect information on latrine use and satisfaction.

Results:
Results indicate a lower volume of sludge in exposed systems (182 L/d) than in unexposed systems (275 L/d) over the study period (p<0.05). Exposed systems had a higher sludge volume than unexposed ones during the first seven weeks of the study, when biological activity was being established (not statistically significant, p>0.05). We found no difference in desludging frequency between exposed and unexposed, likely due to low infiltration in the soak pit. We found a lower concentration of E. coli in the third tank of the exposed systems (2.80×10^2 CFU/mL/d) than unexposed ones (3.21×10^3 CFU/mL/d) (not statistically significant, p>0.05). We found no odors and no flies for more than 97% of both exposed and unexposed latrines. The same percentage of exposed (22%) and unexposed (18%) systems had odors in their first tank. We found flies in the first tank in 10% of exposed systems and 21% of unexposed ones. Analysis of results is ongoing and will be finalized by October 2023.

Conclusion:
Preliminary results show that the Sanipit bio-additive is effective in reducing the accumulation of sludge in containment systems, once the biological system is functioning. Adding bio-additives had no discernable effect on odors, and slightly reduced fly presence in the first tank and E. coli concentration in the third tank of the containment systems. These results should be confirmed with similar studies conducted with other types of containment systems in other humanitarian contexts.

Surveillance of extended-spectrum beta-lactamase (ESBL) producing Escherichia coli in four North Carolina communities wastewater treatment plants.
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Background:
Antimicrobial resistance (AMR) is an ever-expanding global health threat implicated in increased morbidity and mortality in humans and animals. Surveillance is an important tool for monitoring the development and spread of AMR bacteria in these populations. Municipal wastewater treatment plants (WTPs) can be used for surveillance to monitor clinically relevant AMR bacteria circulating in the community. This ongoing study is characterizing extended-spectrum beta-lactamase-producing Escherichia coli (ESBL-EC) present in WTPs influents (pre-treatment) and effluents (post-treatment) in four North Carolina communities.

Methods:
This cross-sectional study collects six composite samples monthly (3-influent; 3-effluent; January – September 2023) from four WTPs receiving domestic, industrial, and hospital influents, totaling 216 samples. To date, 96 samples have been processed. Bacteria are isolated and quantified by culture to determine the total E. coli and ESBL-EC concentration for each sample according to the World Health Organization tricycle protocol. Field measurements of pH, temperature, and flow rate are collected at sampling sites. Antimicrobial susceptibility testing by broth microdilution is used to characterize AMR and ESBL-EC isolates are confirmed using disk diffusion. Multidrug resistance (MDR) is defined as resistance to three or more classes of antimicrobials. ESBL-EC genes are detected using multiplex polymerase chain reaction (M-PCR). Data are analyzed using descriptive statistics.
Results
Liquid chlorine disinfection is used by two WTPs (B & C) while two WTPs (A & D) use ultraviolet disinfection for wastewater treatment. Currently, ESBL-EC have been isolated from influents in 50% (n=48) of samples however, no ESBL-EC have been detected in effluents from any WTPs. The median ESBL-EC concentration in influents was WTP specific, ranging from 2.7 log10 CFU/100mL in WTP-C to 3.2 log10 CFU/100mL in WTP-A. Generic E. coli isolates (one each) were detected in effluents from WTP-B and WTP-C. Other opportunistic bacteria including Acinetobacter (n=1), Citrobacter (n=12), Enterobacter (n=13), Klebsiella (n=3), Pseudomonas (n=1), Raoultella (n=10) and Serratia species (n=20) were detected in effluents from WTP-B, WTP-C, and WTP-D. In WTP-A, no effluent bacteria were isolated. Water temperature and pH at time of collection were similar across WTPs (mean=17.58°C + 1.71 and 6.54 + 0.17 respectively). All influent ESBL-EC isolates (n=48) were MDR; resistant to ampicillin, azithromycin, ceftiofur, and ceftriaxone. One effluent E. coli isolate was resistant to six antimicrobials but was not an ESBL-EC. M-PCR showed the presence of blaCTX-M-1 (66.7%; n=32); blaTEM (54.2%; n=26); blaCTX-M-9 (25.0%; n=12); blaSHV (6.3%; n=3) and blaOXA (4.2%; n=2) genes in ESBL-EC. The blaTEM gene coexisted with blaCTX-M-1 and blaCTX-M-9 genes in 41.7% (n=20) and 8.3% (n=4) of isolates, respectively.

Conclusion:
Although bacteria are escaping wastewater treatment into the environment, no ESBL-EC were detected in effluent samples. The prevalence of ESBL-EC in WTPs influent in North Carolina demonstrates that wastewater is a reservoir of resistant bacteria. The ultraviolent disinfection implemented in WTP-A and WTP-D effectively reduced the occurrence of ESBL-EC. Notably, some differences were observed in the resistance profiles of ESBL-EC isolated from influent and E. coli isolates from effluent wastewater, demonstrating that WTPs can serve as a viable site in a surveillance system.

SARS-CoV-2 and enteric pathogen environmental surveillance in Cox's Bazar, Bangladesh: Challenges and opportunities.
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Background:
Nearly one million forcibly displaced Rohingyas have been living in crowded camps in Cox's Bazar. The Rohingya camps and adjacent host communities are favorable for waterborne and respiratory diseases. Regular monitoring of SARS-CoV-2 and vaccine preventable diseases, and scaling up in critical geographic areas are needed to track disease outbreaks. However, environmental surveillance to monitor SARS-CoV-2 and other pathogens is challenging and has not yet been attempted in humanitarian settings. We conducted environmental surveillance to explore the spatial and temporal trend of four vaccine-preventable diseases causing pathogens—SARS-CoV-2, Group-A Rotavirus, Salmonella typhi, and Vibrio cholerae in Rohingya camps and Cox's Bazar municipality. We also documented the challenges encountered during the pilot-phase of the environmental surveillance.

Methods:
From October 2022-February 2023, three camps (4-extension, 9, and 13), and Cox's Bazar municipality were selected. To understand the sanitation system, faecal sludge management (FSM), available network mappings (e.g., latrine distribution, drainage networks), and ongoing clinical disease surveillance, we held several stakeholder meetings with WASH and Health Sector-coordination Groups, UN organizations, and NGOs. We also conducted scoping visits to the selected camps and host communities to explore appropriate sampling points. We selected 12 sampling points (camp=8 and municipality=3) and collected weekly samples. The samples were transported weekly basis to the icddr,b laboratory, where they were analyzed using multiplex PCR.

Results:
192 samples (camp=153 and municipality=39) were collected from the end of drains. The prevalence of Rotavirus was high in both camps (97%) and the municipality (100%), while S. typhi was less prevalent (camps=5% and municipality=18%). SARS-CoV-2 was higher in the camps (68%) compared to the municipality (31%), whereas V. cholerae was more prevalent in the municipality (51%) than in the camps (29%). The highest concentration of SARS-CoV-2 gene copies/Liter (gc/L) was found in camp 4-extension [median=5.3 gc/L (range=4.2-6.9)], while Rotavirus had the highest concentration in camp-9 [median=9.3 gc/L (range=6.9-10.8)], V. cholerae in camp-15 [median=6.3 gc/L (range=5.4-6.9)] and S. typhi in camp-15 [median=5.7 gc/L (range=4.9-6.4)]. The detection rates of SARS-CoV-2 (100%-47%) and V. cholerae (55%-13%) decreased over time, but no temporal trends were observed for the other two pathogens. We identified several challenges in conducting wastewater-based environmental pathogen surveillance in onsite sanitation settings, including limited access to high regulation sanitation and drainage network maps in Cox's Bazar, difficulty in defining the catchment area and population, lack of clinical enteric disease surveillance data that correlate with environmental surveillance data, and limited understanding of faecal sludge management and faecal pathogen exposure in the surrounding neighborhoods.

Conclusion:
Wastewater-based surveillance in humanitarian settings is challenging but necessary to track disease outbreaks. Our study found a high prevalence of Rotavirus and SARS-CoV-2 in Rohingya camps and Cox's Bazar municipality and identified challenges in conducting surveillance. Regular monitoring of SARS-CoV-2 and vaccine-preventable diseases is needed in critical geographic areas. Scaling-up environmental surveillance can provide valuable information to track disease outbreaks. Efforts should be made to address the challenges identified in this study, including improving access to sanitation and

drainage network maps, and establishing better coordination between clinical and environmental disease surveillance.

Disinfection by-product occurrence in small water systems in two rural counties in Appalachian Virginia

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Background:
Of the ~345 EPA-regulated community water systems (CWS) in Central Appalachia, ~20% serve populations of less than 500 people, and many CWS in the region have histories of Safe Drinking Water Act violations. Following treatment, relatively low concentrations of chlorine are added to the treated water for distribution. However, the use of disinfectants such as chlorine is not without risk, because of the formation of disinfection byproducts (DBPs) which have various negative health impacts, such as cancer, liver disease, and kidney disease. The EPA has set limits on several types of DBPs, including trihalomethanes (THMs), and haloacetic acids (HAAs). However, the combination of prolonged water age and resource constraints in many lower-income rural settings makes it challenging for many smaller CWS to control DBPs.

Objectives:
We aimed to characterize the concentration of THMs, a measure of DBPs, in household-level drinking water samples for households with utility-supplied water and compare THM concentrations with EPA standards. We also investigated how factors such as pH, free chlorine, and metal ions may affect the formation of THMs.

Methods:
This study was conducted in Wise and Lee counties. Water quality was examined in each household by collecting tap water (first flush), source water (tap after a 5-minute flush), and bottled water samples (if bottled water used as a primary drinking source). In situ measurements were taken for pH, temperature, and conductivity. Samples were tested for free chlorine, THMs, and metals such as copper, and iron (via ICP-MS). Statistical modeling, including generalized linear models, was used to identify factors that may influence THM formation.

Results:
Samples were collected from 27 households with utility-supplied water (from 7 different utilities). Free chlorine concentrations in all samples were found to comply with the EPA guidelines. We found that 7% (n=2) of tap samples and 9% (n=3) of source water samples exceeded the EPA MCL threshold for THMs of 80 ppb. None of the bottled water samples exceeded the MCL. About 56% (n = 15) tap samples and 11% (n = 2) bottled water samples exceeded the EPA SMCL for aluminum. The results from the regression models analyzing utility source water samples indicated that higher levels of free chlorine, pH, and conductivity are positively associated with the formation of THM levels above the EPA MCL. However, none of the associations were statistically significant, and temperature was found to have a negative association (OR=0.837, p=0.484). We observed no significant variation in THM formation detected among water samples from different utilities. Non-significant positive associations were also observed for aluminum and chlorine, while iron and copper were negatively associated with THM concentrations.

Conclusions:
The results of this study indicate that most THM levels in utility drinking water in this region are within the EPA's standards, though a minority of households have THM concentrations above the MCL. Additional research is needed to better understand the extent to which these results may or may not be generalizable to other counties in Central Appalachia, and the potential drivers of DBP formation in smaller rural systems.

Maintenance of Handpumps in Rural Sub-Saharan Africa: Costs and Trends

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Introduction:
Approximately one in four handpumps in rural Sub-Saharan Africa are non-operational at any one time; this non-functionality is often attributed to inadequate maintenance. Regular maintenance is well-established as an important factor for maximizing handpump functionality, but less is known about optimal repair frequencies, minimizing downtime while balancing cost concerns. This ongoing work uses several years of maintenance records for more than 1,000 handpumps in rural Malawi to compare actual and recommended maintenance intervals, and estimates costs associated with regular maintenance of a handpump.

Methods:
We used maintenance and inspection records to explore how the need for maintenance could be predicted, what kind of maintenance is most commonly needed, and how much that maintenance costs. Maintenance is conducted by an external support organization and by communities. We used data from phone and in-person surveys to determine if the need for maintenance can be predicted based on pre-breakdown changes in stroke volume. We quantified the performance improvement associated with a maintenance visit (measured in the reduction in number of strokes required to produce 20L of water). Finally, we estimated the expected annual costs of maintaining an Afridev handpump in rural Malawi based on observed repair frequencies and costs for handpump components (materials and transport) and labor.

Preliminary Results:
We observed an increase in the number of strokes required to produce 20L of water on the inspections preceding maintenance, and a decrease in number of strokes required to produce 20L immediately following maintenance. On average, repairs reduced (improved) the number of strokes required to produce 20L of water by 5 strokes, equivalent to a reduction of 62.5 strokes per day for a household of 5 each consuming 50 liters per day. Handpump parts most commonly replaced include bush bearings, pipe and rod centralisers, rods, rising pipes, and sockets. We estimated an annual cost associated with materials, labor, and transport for regular maintenance needs, which is higher than other estimates in the literature.

Discussion:
Non-functionality of communal water points in rural Malawi and throughout Sub-Saharan Africa is often attributed to inadequate maintenance. This ongoing study identifies the costs a water committee in Malawi could expect to incur annually for operating expenses associated with maintenance, and how regular monitoring of stroke volumes can indicate the need for such maintenance. Findings could be used by handpump managers to design revenue generation schemes as well as monitor their water point and conduct maintenance to minimize handpump downtime.

Development and delivery of the Faces of Dignity face washing intervention for the Stronger-SAFE trachoma trial

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Background:
The face washing component of the SAFE strategy aims to maintain clean faces in the community to reduce eye-seeking flies and person-to-person transmission of trachoma. Few studies have investigated whether facial cleanliness programmes substantially reduce the prevalence of trachoma in communities.

This is one of the primary aims of the 68 cluster, 4-arm Stronger-SAFE trial. In order to study this, a face washing intervention first needs to effect and sustain face washing behaviour change. Evidence suggests that behaviour change is more likely to occur when multiple, locally important determinants of behaviour are targeted in a multimodal intervention.

Methods:
Formative research was conducted to improve understanding of current practices hypothesised to facilitate transmission of Chlamydia trachomatis (Ct), the causative agent, and their determinants in different seasons. We carried out in-depth observation of behaviour in nine households over 27-hour periods at three times of year, enrolled 83 children aged 1-9 years into a small microbiological study into the effectiveness of washing and face wiping practices for removal of Ct from faces, and held focus groups and interviews to understand community perceptions and drivers of behaviour. A feasible behaviour change goal with the potential to interrupt trachoma transmission in the trial setting was selected and intervention content was developed to influence behavioural factors identified during the formative research. Both the formative research and subsequent intervention development process were guided by theories of behaviour and behaviour change. All intervention content was co-developed in collaboration with the community and was intended to form a low-cost, sustainable enhancement to the standard F package. An extensive process evaluation assessed aspects of implementation and participant engagement and responses.

Results:
Current face washing is infrequent and soap use is often lacking. The behaviour change task for the Stronger-SAFE intervention aims to increase the frequency and quality of face washing, such that faces (and hands) of all family members, particularly pre-school children, are thoroughly washed with soap three times a day. The main intervention consists of five contact points over one month: a community-wide event; two small-group meetings delivered to groups of five households; and two individual household visits. This intervention is followed by regular household visits and seasonal reinforcement events to help maintain behaviour and overcome specific seasonal barriers to face washing with soap. Intervention content is linked to a central concept associating face washing to dignity to gain attention, memorability and motivate behavioural change. A range of behaviour change techniques were used to target numerous behavioural factors. Intervention delivery is underway in 34 trial clusters.

Conclusions:
The theory-based face washing intervention being delivered in the Stronger-SAFE trial aims to achieve a sustained increase in face washing behaviour by addressing a range of contextually relevant determinants of behaviour. A theory-based approach to behaviour change for trachoma control remains uncommon in trachoma interventions. The success of this approach is being assessed through an ongoing process and outcomes evaluation as part of a large trial with trachoma outcomes at endpoint.

Financial Disclosures: None to declare.

Menstrual health and hygiene among transgender and non-binary populations: A global systematic review
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Significance:
Transgender and non-binary (TNB) persons having to navigate menstrual hygiene management (MHM) in a social context where their gender may not be recognized may increase challenges in accessing MHM resources. This study aims to systematically review and synthesize the current global literature on MHM

among TNB populations and identify future research needs.

Methods:
We conducted a systematic review of global quantitative and qualitative studies of lived experiences of MHM among TNB populations. We searched six databases for peer-reviewed literature, published in English up to April 2022. We used Covidence to screen eligible titles and abstracts, and at least two reviewers reviewed each title/ abstract and full-text record. We then extracted, coded, and analyzed the results of included papers.

Preliminary results:
The search strategy yielded 3651 records, of which 28 studies met the inclusion criteria. Fifteen of these studies used quantitative methods, and almost all studies were based in the global north. Twenty-two studies were conducted in the last three years. Studies described menstruation as a source of gender dysphoria. Amenorrhea, the absence of menstruation, is a welcome relief. Quantitative studies focused on various contraception and hormonal therapy options to achieve amenorrhea, whereas qualitative studies focused on the MHM's physical, emotional, and environmental aspects. 'Othering' of the TNB population in all aspects of MHM, including the idea of menstruation associated with women alone, accessibility of public bathrooms, and availability of menstrual products, was highlighted across several studies. A need for comprehensive guidelines on menstruation-related and overall reproductive health care for TNB persons, gender-inclusive menstrual products, and resources was emphasized across many studies.

Discussion:
This systematic review highlighted several challenges and unique needs for MHM vocalized by TNB populations, as well as an urgent need for more research to guide intervention and policy development.

Detection and Discrimination of O. volvulus and O. ochengi from Blackfly Pool DNA using a Novel Polymerase Chain Reaction – Restriction Fragment Length Polymorphism (PCR-RFLP) Technique.
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Molecular xeno-monitoring has been a significant technique used to study the impact of vector-borne pathogenic diseases on humans and animals by employing disease surveillance in vector populations. It uses insects carrying pathogen genetic material as a non-invasive surrogate for infection in the human or animal population. In the case of onchocerciasis, the WHO has approved the O150 PCR in blackflies, a molecular xenomonitoring technique, as part of the Onchocerciasis Elimination guideline. However, this technique is laborious and time-consuming, which could be influenced by human errors. Also, the high cost, non-availability, and delay of the ELISA component make the application of the O150 PCR difficult in resource-limited settings. Therefore, this study focused on developing a PCR-RFLP assay to detect and discriminate O. volvulus and O. ochengi in blackflies.

Bioinformatics analysis was employed to identify a unique restriction site within the COX1 mitochondrial gene sequences of O. volvulus and O. ochengi. HaeIII, unique to O. volvulus only, was identified as the restriction enzyme of choice for the discrimination. Onchocerca-genus primers were designed in the conserved regions of both O. volvulus and O. ochengi sequences to amplify a 650 bp fragment, which flunks the restriction site. From the conserved sequences, Onchocerca-COX1 probe was also designed to be used in the magnetic beads capture of Onchocerca-DNA from blackflies DNA pool. Assay validation was done with Onchocerca sp. sequence data retrieved from the NCBI Genbank. The wet-lab validation of this assay was performed with archived blackflies (S. damnosum sensu lato) collected in 2011 from Agbelekeme, an endemic onchocerciasis community. Triplicates of 50 and 100 Blackfly pools were performed separately for heads and bodies. Blackfly pool DNA was extracted, and the Onchocerca-DNA was captured with the Onchocerca-COX1 probe and magnetic beads. The PCR-RFLP assay was applied to the Onchocerca-captured samples, after which the PCR products were sequenced and analyzed. The restriction site, GG|CC (HaeIII), was unique to only COX1 O. volvulus sequences in the NCBI

GenBank since they produced 456 bp and 194 bp fragments from the 650 bp PCR product. Of the three 50 blackfly head pools, only 1 (1/3) carried infective O. ochengi larval stage. All three 100 blackfly head pools (3/3) carried infective O. volvulus larval stage. However, two of the three 100 blackfly body pools (2/3) were infected with O. ochengi. Only one of the two infected 50 blackfly body pools carried both O. volvulus and O. ochengi. The PCR amplicons with the restriction sites showed high homology with O. volvulus, whereas the unrestricted amplicons were highly homologous to O. ochengi after the DNA sequence analysis.

The novel PCR-RFLP assay has demonstrated its effectiveness in detecting and discriminating between O. volvulus and O. ochengi in blackflies. In addition, with zoonotic onchocerciasis in sight in some parts of the world, this tool will be useful for the early detection of potential zoonotic transmission of the bovine onchocerciasis in the human population, especially in Sub-Sahara Africa.

Water, sanitation, and hygiene vulnerability in child stunting in developing countries: A systematic review and meta-analysis
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Background:
Stunting is a public health problem for approximately 149 million preschool children in developing countries. Stunting is related to several social, economic, and environmental determinants of health. Does water, sanitation, and hygiene (WaSH) vulnerability result in children's growth deficits? Which components of WaSH (water, sanitation, and hygiene) are most significant in generating child growth deficit? This study aimed to perform a systematic review and meta-analysis to assess the scientific evidence of the relationship between vulnerability to access to safe WaSH practices on stunting in children under five years of age in developing countries. Understanding the significance of each component of WaSH on childhood stunting is crucial to improve the focus of public policy investment.

Methods:
The systematic review and meta-analysis were performed according to the PRISMA methodology (PROSPERO protocol number 326671). The following databases were used: LILACS, MEDLINE (via PubMed), SciELO, Web of Science, ScienceDirect, SCOPUS, and Embase. All included studies investigated WaSH vulnerability to stunting in children under 5 years of age in developing countries. Two meta-analyses were performed considering the height-for-age data (Z score) by the values of 1) ODDS Ratio (OR) and 2) mean with the confidence intervals. The statistical software STATA version 11 was used. Cochran's Q test and Chi-square test (I2) with 95% significance were used to assess the heterogeneity of the studies.

Results:
The search resulted in the initial identification of 2047 articles. After the screening process, 14 articles were included in the systematic review, and of those eight were eligible for the meta-analysis. The selected studies were published between the years 1992 and 2021 and conducted in eight countries, namely, Ethiopia, India, Indonesia, Bangladesh, Tanzania, Peru, China, and Lesotho. For analysis of the ODDS ratio values, five articles were eligible and grouped by WaSH components (water, sanitation, and hygiene). It is observed that there was a significant difference when relating WaSH vulnerability to children's height, OR 1.23 (95% CI 1.05-1.41) with emphasis on sanitation, OR 1.56 (95% CI 1.28-1.84). For the analysis of mean values with confidence intervals, three studies were eligible. Most of the studies indicate that there was a significant reduction in children's height when compared to the WaSH vulnerability. The meta-analysis also shows that the impact of WaSH on child stunting is significant when it comes to lack of sanitation. Sanitation vulnerability was found to be significant to child stunting in 72% of the studies included. The studies concluded that children living in homes that have access to improved sanitation are less likely (10 percentage points; 29%; and 46%) to be stunted compared to children in homes without improved sanitation.

Conclusions:

The results confirmed that stunting in children under five years of age is greater in locations with higher vulnerability to WaSH. It was also shown that lack of improved sanitation is a component of WaSH that is significantly associated with child stunting. Based on our findings, we recommend incorporating WaSH strategies, especially sanitation, in formulating interventions that integrate with policies to promote early childhood health.

Towards a data-driven decision making; Factors driving WASH inequities in healthcare facilities in Ghana
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Background:
Basic water, sanitation, and hygiene (WASH) services are increasingly needed in healthcare facilities (HCFs) as a foundation to infection prevention and control in healthcare settings to improve quality of care and patient safety. Additionally, robust WASH services are recommended to enhance healthcare worker safety, control antimicrobial resistance, prepare and respond to global health securities among others. Basic wash services are therefore critical to universal health coverage and primary healthcare. In Ghana however, little is known about the factors related to the provision of basic WASH services in HCFs. We evaluated the status of WASH services in HCFs and its drivers through a systems approach of a national WASH in healthcare facilities program in Ghana.

Methods:
This survey involved an analysis of routine health service data submitted to the District Information Management System 2 (DHIMS 2) by HCFs in Ghana. Data were analyzed using descriptive statistics, and logistic regression analysis.

Results:
Complete data were available for 1,646 HCFs across Ghana for analysis. More than half (52%) of the facilities were CHPS compounds, and hospitals accounted for about 17% of the facilities. Coverage of basic water, sanitation, and hygiene service was 69%, 58%, and 64%, respectively. About 50% had a WASH-IPC action plan, 67% had WASH-IPC focal person and only 56% had toilet facilities for disabled persons. The segregation of the data showed regional inequalities in access to basic WASH services, with the newly established administrative regions and those in rural Ghana being disadvantaged. Significant drivers of basic WASH services were location of HCF, level of HCF, availability of: trained assistant WASH-IPC focal person, and toilet facility for the disabled. The presence of a trained assistant WAHS/IPC focal person resulted in an increased likelihood of having basic WASH services.

Conclusion:
WASH services in Ghanaian HCFs have improved, but it is still not up to the standards set by the Sustainable Development Goals (SDGs) for WASH in HCFs. However, it is clear that universal access to basic WASH services can be attained by a culture that uses data to drive decision making through a systems thinking-oriented national WASH program to address inequalities in access to WASH services and ensuring the availability of WASH/IPC personnel to govern WASH program implementation at all levels of the health system.

The Effect of Soap on the Transmission of E.Coli and Coliforms during the Communal Hand-washing Process Before Mealtime in Households using the Same Water in One Bowl
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Background:
Diarrhea is a leading cause of death in Sub-Saharan Africa, including Mali, where improper handwashing techniques like communal bowl handwashing are still common. This practice may increase the risk of hand contamination, especially for younger family members who tend to wash their hands last. We aimed to conduct a low-cost feasibility trial to test a culturally acceptable intervention for reducing the impact of communal handwashing.
Research questions: Will adding soap and a rinse bowl during C-HW reduce hand-swab microbiological contamination compared to regular water-only single bowl use for C-HW?

Methods:
We conducted a study to test a low-cost intervention that aimed to reduce cultural barriers to behaviour change around communal handwashing (C-HW). We randomly assigned 280 households from 3 villages and 2 urban Bamako communities, known to practice C-HW, to intervention or control groups. Intervention households were asked to wash in a usual communal bowl with soap and rinse in a separate communal bowl of water, while the control group continued with the usual C-HW practice of using one bowl of water without soap. Water and hand-swab samples were taken from the last person before and after C-HW and were tested for E.coli and coliform using standard techniques.

Findings:
The characteristics of the households and the last person washing their hands were balanced between the arms. There were no deviations from the intervention. Mean E.Coli colony counts for handswabs were 0.97(6.16) before in intervention, and 0.76 (4.21) in the control group, resulting in a rate ratio reduction of 55% (95% CI: 71%, 34%) in E.Coli colony growth (indicator for faecal coliforms) from hand-swabs after washing hands with soap in the intervention group. Reductions in water sample colony counts had credible interval from a 67% reduction in the intervention to a 55% increase in the control. Control participants with no hand-swab contamination before traditional C-HW, on average, had double the rate of E.Coli contamination after C-HW.
Questionnaire data provided insights into the reasons and context surrounding the practice. For instance, 55% of households in rural areas and 60% in urban areas possessed a low-cost handwashing device for pouring water over hands but refrained from using it. In addition, data indicated that approximately 60% of rural and 80% of urban households were willing to always include soap and rinsing in their C-HW practice before meals if they were convinced of its hygienic benefits. 89% of households in both groups reported using C-HW to maintain tradition and exhibit solidarity with other family members. Further data on the growth of other organisms, household behaviors, and beliefs regarding C-HW will be presented.

Conclusions
C-HW was seen as a deeply rooted tradition and bonding practice in households. Adding soap and rinsing during communal handwashing reduced the bacterial count of household members hands compared to the control households. This was an acceptable and feasible practice for urban and rural communities which allowed the members to still practice their household bonding tradition while improving hygienic handwashing before meals.

Associations of drinking water access, household water and food security, and mental well-being of prenatal women in low-income, urban neighborhoods of Beira, Mozambique
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Introduction:
While inadequate drinking water and food access can have significant physical health implications, growing evidence has also identified linkages with mental health. Many individual associations have been found among the factors of drinking water access, water security, food security, and mental well-being, but there has yet to be a full, quantitative analysis of all these factors, specifically among prenatal women. This may be particularly important among prenatal women, as prenatal food insecurity and poor mental

well-being have been associated with negative impacts on fetal and child development.

Objective:
This study aims to address current gaps by comprehensively analyzing the relationships between drinking water access and water and food security with mental well-being amongst prenatal women in low-income, urban neighborhoods of Beira, Mozambique.
Methods: Data for this cross-sectional analysis were collected among pregnant women in their third trimester in Beira, Mozambique from February 2021 through September 2022. Validated, cross-cultural scale measures of mental well-being (WHO-5 Well-being Index), household water security (Household Water Insecurity Experiences Scale) and food security (Household Food Insecurity Access Scale), and demographic questions were incorporated into a survey and administered to 900 participants, 741 of which met inclusion criteria for this analysis. Drinking water access was categorized as either on-premise (inside the household's compound) or not. We used generalized estimating equations, binary logistic regression, and causal mediation analysis to quantitatively examine the associations and mediation of factors along the pathway of drinking water access to mental well-being.

Results:
36% of our prenatal participants indicated probable depression. We did not find drinking water access to be associated with mental well-being (OR 1.01; 95%CI 0.73, 1.39), water security (OR 0.86; 95%CI 0.60, 1.25), or food security (OR 1.01; 95%CI 0.70, 1.46). We found evidence that food security (OR 2.23; 95%CI 1.50, 3.31) and potentially water security (OR 1.42; 95%CI 0.99, 2.04) were individually associated with mental well-being. When food insecurity was included in the model with water security and mental well-being, food security had a mediating effect (ACME 0.05; 95%CI 0.02, 0.07; ADE 0.56; 95%CI -0.04, 0.13).

Conclusion:
Associations between drinking water access and water security had been previously demonstrated in rural areas, contrary to our results. This may be due to the relatively ubiquitous distribution of public water taps and neighborhood water sharing in low-income, urban Beira. Our mediation findings support growing literature that water and food insecurity likely impact the prenatal population's mental well-being through a mediated pathway. Further research is needed to confirm causality along these pathways and determine the specific mechanisms through which these interactions take place, but it is suggested that interventions aimed at reducing poverty-related, adverse mental well-being should focus on improving food security, potentially through improving water security.

Key learning objectives:
-Understand the quantitative relationships between water and food security and mental well-being among prenatal women in a low-income, urban area
-Understand the potential practical implications of food security's mediation between water security and mental well-being
-Understand the viability of using drinking water access on-premise as an indicator in some urban contexts

Are mechanization solutions enough to eliminate sanitation workers' contact with human faecal matter?
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Additional Authors: Manvita Baradi

The objectives of the study are as following:
● To document initiatives taken by select urban local bodies (ULBs) in India to improve working environment for sanitation workers involved in manual cleaning of septic tanks and sewer lines
● To understand the issues and challenges the ULBs face in setting up Emergency Response Sanitation Unit

Sanitation workers in India who clean confined spaces such as sewer lines and septic tanks work are

subjected to unsafe working conditions, lacking proper training and safety equipment. Despite the Government of India (GOI) having introduced laws and guidelines and banning manual scavenging since 1993, there is little compliance due to a lack of regulatory oversight. According to the National Commission for Safai Karamcharis (NCSK), more than 1060 workers died since 1993 while cleaning confined spaces, but the actual number of deaths and injuries could be higher than what is officially documented.

With increased emphasis on mechanizing sanitation services, it is not always viable. Acknowledging this, the GOI released an advisory in 2019 to establish Emergency Response Sanitation Unit (ERSU) in urban local bodies (ULBs) spelling out protocols for safe confined space entry. This study examines the implementation of ERSU and evaluates actions taken by ULBs and was undertaken in five cities with sewerage coverage ranging from 33% to over 99%. A qualitative methodology was adopted, with primary data gathered through key informant interviews of stakeholders, including ULB staff and private contractors and open-ended interviews of sanitation workers who clean confined spaces. The aim was to collect information on various initiatives including system strengthening, capacity-building of stakeholders, and monitoring and reporting systems put in place by the ULBs to ensure compliance with laws. Relevant official documents were also collected to supplement the analysis of secondary data. A framework including factors like governance, regulation and enforcement, health and safety, livelihood opportunity, entitlements and behaviour change was developed to analyse the data.

Findings:
All ULBs have procured variety of vehicles that are being used to provide mechanised services. While ULBs have issued orders to set up ERSU and nominated officials for handling the day-to-day operations of the ERSU, standard operating protocols to be followed lack in 4 out of 5 cities. In these cities, most ULB field staff and contractors are unaware of ERSU and their responsibilities, nor have they received training on confined space entry. The ULBs have imparted trainings to sanitation workers, however 3 out of 5 cities provided short theoretical trainings. Modality adopted for empanelment of private contractors also has significant impact on monitoring and compliance. The city of Bhubaneswar stands out in establishing systems, including capacity building and monitoring of confined space entry, to comprehensively improve the working environment. Since the establishment of ERSU, except Bhubaneswar, no city has officially recorded any manual entry in septic tank or sewer line. However, the sanitation workers shared that unsafe manual entry in confined space still exists.
Most ULBs have taken initiatives on factors that are being monitored annually by GOI, with a focus on quantity rather than actual impact on making sanitation work safer. The extent of manual entry has significantly reduced, albeit it has not been eliminated. Bhubaneswar establishes a strong example of how ULBs can take initiatives that can be implemented to improve safety, enforce regulations and strengthening systems to ensure no worker engages in manual scavenging.

The inclusion of ageing in hygiene interventions during Covid-19: lesson learnt from 5 countries
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Background:
Globally, one in every 11 people is over 65 years old. Due to the heightened vulnerability of this age group to infection from COVID-19, Hygiene & Behaviour Change Coalition (HBCC) programme from the UK Government and Unilever (implemented in 37 LMICs) targeted this group to raise awareness on hand hygiene practices, coughing-sneezing etiquettes, and mask use through mass media, interpersonal communication, community campaigning, and installing handwashing stations. We explored the inclusion of older adults in that intervention.

Methods:
We conducted a mixed-method process evaluation in Indonesia, Kenya, and Zambia and qualitative exploration in Sierra Leone and Bangladesh. We randomly selected 3 intervention counties from Kenya

and Zambia and 2 from Indonesia, and from each of those counties, we randomly selected six smallest administrative units. From each of those units, we randomly selected a cluster of 30 households in Kenya and Zambia and a cluster of 40 households in Indonesia for survey. We conducted surveys with 510 older people (Indonesia: 162, Kenya: 246, Zambia: 102), in-depth interviews with 35 older people and their caregivers (Indonesia: 12; Kenya: 11, Zambia: 12), and Key informant interviews with 73 (Indonesia: 16, Kenya: 28, Zambia: 18, Sierra Leone: 2, Bangladesh: 9) implementation officials, school teachers, older people's organization, and healthcare providers. We collected demographic data, accessibility of intervention components, and challenges in hygiene practices. We used self-reported age and considered 60 or more years as older people. Descriptive statistics were used for quantitative, and thematic analysis was used for qualitative data.

Results:
More than 85% of older people reported receiving hygiene messages across three countries. However, around 40% in all three countries considered the messages challenging to remember while 29% in Zambia, and around 15% in Kenya and Indonesia found it challenging to maintain. Additionally, many of them in Kenya (33%) and Zambia (21%) reported financial burden as a barrier to maintain the hygiene measures. Access to household handwashing stations/places was hindered due to the lack of assistance reported by around 5% older people in all three countries. Additionally, in Kenya and Zambia, around 15% reported difficulties accessing water for handwashing while around 10% were unable to reach cleaning agents independently. Use of public handwashing stations among older people in Kenya and Zambia were high (around 85%). However, in Indonesia, 37% didn't use public handwashing stations and 84% of them reported distance as a key barrier. Additionally, in all three countries inaccessible structure of public handwashing stations (obstruction on the path, lacking wheelchair access, and no guidance rope/railing) increased their challenges. Key informants mentioned insufficient resources, lack of suitable places to establish facilities, inadequate staff training, low involvement of older people organizations in planning and implementations, short program time, and strong religious beliefs as key barriers to include the aged population in the intervention.

Conclusion:
Sustainable interventions need to be co-designed and implemented with the involvement of older people's organizations all along, and administered for relatively longer periods to sustain a change in people's behaviour.

Access or Behavior? Which WASH factors contribute to a child's nutritional status?
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Additional Authors: Asi Lusia, Sherly Vantono

Background:
Aligned with the government of Indonesia's target to reduce stunting prevalence to 14% by 2024, Wahana Visi Indonesia (WVI) has also set a priority on improving the nutritional status of children under 5 years old (U5) by implementing Children are Well Nourished Technical Program. It integrates Nutrition, Livelihood, Water, Sanitation & Hygiene (WASH) and Community Voice and Action. Since WVI has implemented a stunting reduction program since 2016, the objective of the study was to gain situational analysis for setting up priority intervention. The study is deployed for further analysis to look for WASH access and behavior factors that contribute to improving the nutritional status of U5 children in 15 of WVI's assisted district areas.

Methods:
The study employed 30 clusters x 7 households (HHs) survey using cross sectional design study with U5 children's caregivers as respondents. It used the probability proportional to size (PPS) sampling method to determine the 30 clusters. The total samples were 5,250, of which 210 samples were taken from each area program. The data was collected using a structured questionnaire with KOBO Collect for data entry and analyzed descriptively using SPSS, Microsoft Excel, and Power BI.

Results:
The result shows a total of 2.956 children U5 involved in this study (girls=49.83%; boys=50.17%). The prevalence of stunted was very high at 43.2% (CI: 41.32% - 45.2%); wasted at 16.40% (CI: 15.01% - 17.9%) and underweight at 28.30% (26.56% - 30.06%), with higher number of boys than girls. The prevalence of diarrhea was 8.3% (CI: 7.36% - 9.51%) with 55% were boys. The proportion of households using a basic sanitation facility is 42.7% and using a basic drinking water facility is 57%. The percentage of households practicing proper handwashing is 46%. The proportion of HH practicing safe household drinking water is 49.57% (CI: 47.69% -51.45%). Bivariate analysis shows that HHs practicing safe drinking water management is associated with diarrhea (p=0.015; OR 1.7), (CI 1.1-2.6)), but there is no association with WASH access factors. There are no factors associated with underweight. Interestingly, it is found between stunting with boiling water for drinking water (p=-0.001 OR 2.1), and with hand washing with soap (p=0.002 OR 0.7). Also, between open defecation with wasting (P=0.005) and underweight (P=0.014). Multivariate analysis shows factors that most contribute to diarrhea is WASH behaviors - HHs practicing safe drinking water. Nevertheless, the factor that most contributes to nutritional status (stunting) is WASH behaviors - HHs practicing proper hand washing with soap.

Conclusion:
The study shows that WASH behaviors, particularly defecating in the toilet, handwashing with soap and practicing safe drinking water at home, such as boiling, are associated with diarrhea, wasting and stunting, but WASH access, such as having toilet, water and handwashing facilities are not.
It is known that access has a key role in WASH behavior change, and this study shows the importance of behavior change intervention. Providing WASH access is not enough to be able to achieve a better health outcome for U5 children and a healthier environment for all.

Five-year evaluation of a multi-country initiative to improve water, sanitation, and hygiene in healthcare facilities
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Background:
Access to water, sanitation, hygiene (WASH), waste management, and environmental cleaning services in healthcare facilities (HCFs) in Sub-Saharan Africa lags global averages. Limited services in these five domains in HCFs hinder the ability to implement adequate infection prevention and control, prepare for public health emergencies (e.g., Ebola, COVID-19), and provide quality care. Starting in 2018, the Safe Water Program of the Conrad N. Hilton Foundation developed district-wide initiatives to improve WASH services in HCFs in rural districts in five countries. The U.S. Centers for Disease Control and Prevention (CDC) evaluated the initiative's impact.

Methods:
The Safe Water Program identified target districts and funded partners to implement comprehensive WASH interventions to improve WASH services in 17 HCFs in Burkina Faso, 8 in Ghana, 25 in Ethiopia, 12 in Niger, and 40 in Uganda. CDC developed assessment tools using Joint Monitoring Programme (JMP) guidance and conducted baseline and follow-up assessments of WASH services in all program HCFs. Tools included, 1) assessments of WASH services according to JMP WASH service ladders (basic, limited, and no service), 2) assessments of hand hygiene resources at all patient care areas, and 3) direct observations of healthcare worker hand hygiene practices before and after patient contact. Baseline assessment occurred during 2018–2020 and follow-up assessments occurred in 2022. Interventions to improve WASH services were informed by baseline data and occurred between assessments.

Results:
Overall, WASH services in HCFs were sustained or improved across all five domains. In Burkina Faso and Ghana, the proportion of HCFs with basic water services remained near 100% at follow-up while in Uganda it stayed around 58%; in Niger it increased from 19% at baseline to 58% at follow-up and in Ethiopia it increased from 44% to 56%. HCFs with basic hand hygiene services increased by 22–75

percentage points across all countries. Basic sanitation services were below 5% at baseline and follow-up in all countries except Ghana, where they increased from 0% to 50%. Basic waste management service remained low in all countries at follow-up (range = 0%–13%). In Ghana, basic environmental cleaning services increased from 0% to 50%; elsewhere, they remained low at follow-up (range = 0%–18%). Coverage of hand hygiene resources (alcohol-based hand rub (ABHR) or water and soap) across all patient care areas increased by 29–71 percentage points from baseline to follow-up across all countries. Use of ABHR or handwashing with water and soap before and after patient contact increased in Burkina Faso (37% to 60%) and Niger (2% to 18%) and decreased in Ghana (20% to 10%) (Ethiopia and Uganda data incomplete).

Conclusions:
CDC's evaluation of the Conrad N. Hilton Foundation Safe Water Program found substantial improvements in HCFs meeting the JMP basic level for water and hand hygiene services while improvements in sanitation, waste management, and environmental cleaning services were low to moderate. To meet the Sustainable Development Goals of 100% coverage of WASH services for HCFs by 2030, continued investments in WASH infrastructure, particularly sanitation, waste management, and environmental cleaning, are needed.

Legionellosis on the rise: A scoping review of sporadic, community-acquired incidence in the United States
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Background:
Legionella bacteria are frequently present in drinking water distribution systems and within building plumbing. Over the past two decades, the incidence of legionellosis (predominantly Legionnaires' disease and Pontiac fever), has been steadily increasing in the U.S. though there is no clear explanation for the main factors driving the increase. While legionellosis is the leading cause of drinking water-associated outbreaks in the U.S., most cases are considered sporadic and acquired in community settings where the water source is never identified. There is a need to understand the epidemiology of community-acquired legionellosis in the U.S. and the main factors that may be driving up incidence to better inform preventive interventions.

Objective:
The objective of this scoping literature review was to synthesize evidence regarding drivers of community-acquired legionellosis in the U.S. since the early 2000s. We aimed to determine the magnitude of impact and strength of evidence for each driver as it relates to increasing incidence. We searched for evidence to understand whether the rise in legionellosis cases represents a true increase in disease or clinical improvements in the diagnostic, testing, and reporting landscape.

Methods:
We screened 1,738 titles resulting from a PubMed search using keywords around legionellosis and identified 18 peer-reviewed articles that met inclusion criteria.

Results: The potential drivers of increasing legionellosis incidence were categorized into five areas: 1) improved clinical case capture; 2) racial and socioeconomic inequities; 3) population susceptibility; 4) climate and hydrometeorological factors; and 5) built environment, including water and housing infrastructure. Strong evidence was found for precipitation patterns as a major driver and both temperature and relative humidity as moderate drivers of incidence. Interestingly, the aging population in the U.S. and improved clinical case capture due to increased testing and improved diagnostic methods – two factors frequently hypothesized as the primary drivers of increasing case counts – were determined to have only minor and moderate impacts on the year-on-year increases, respectively. Legionellosis in the U.S. is a clear health equity issue as it disproportionately affects Black communities and impoverished populations; however, racial and socioeconomic inequities and the impact of water and housing infrastructure characteristics were largely understudied in the context of community-acquired infections.

Conclusion: This scoping review found an overall lack of strong evidence to clearly explain the increasing incidence of community-acquired legionellosis in the U.S. Further investigation is needed to understand how climate factors, such as extreme precipitation, interact with *Legionella* exposures in the built environment to increase drinking water-associated infections. Understanding the complex relationships between environmental, infrastructural, and population factors driving legionellosis incidence will be an important step in developing mitigation strategies and public policy on local and national scales to reduce waterborne infection morbidity and mortality in the U.S.

Learning objectives:
(1) Review epidemiological trends in community-acquired legionellosis incidence in the U.S., including racial and social disparities
(2) Discuss clinical, environmental, and population-based drivers of increasing legionellosis incidence and their respective magnitudes of impact
(3) Understand the need for further research about the interactions between climate and drinking water exposures resulting in sporadic legionellosis

Role of Urban Local Governance in Improving Sanitation Outcomes
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Background:
Tiruchirappalli, is the fourth largest corporation in Tamil Nadu, India. The city is partially sewered, covering 30 per cent of households. On-site sanitation systems (OSS) such as septic tanks, holding tanks, and single pits are the predominant arrangement in urban households in the city. Regardless of settlement characteristics, wastewater is often discharged into open drains, water sources, or adjacent lands, leading to unsanitary conditions. This study aimed to understand the approval and construction process of OSS as prescribed in the Tamil Nadu Combined Development Building Rules (TNCDBR) and on-ground practices, to identify reasons for such practices.

Methods:
The TNCDBR rules for building plan approval were studied, and a representative sample of 40 households that received plan approval one year prior to the study was selected based on Urban Local Body (ULB) records. Approved plans in these households were compared against Indian Standards (IS) standards for the construction of OSS and actual structures to identify the deviations. Additionally, surveyors, engineers, government officers, and households were interviewed to understand their practices and perspectives. The study was conducted between October 2021 and January 2022.

Key Findings:
The TNCDBR mandates the submission of OSS design and dimensions as defined by the IS, but in practice, the urban local body (ULB) uses a software that merely checks the provision of a sanitation structure in the plan, and specifications vis-à-vis standards and disposal arrangements are not reviewed at the plan approval stage.

TNCDBR requires the corporation to be notified during specified stages of construction, and a building completion certificate is issued upon compliance with the approved plan during site inspection. However, in practice, ULB officers are not notified during construction progress, and most site inspection occur when two thirds of the construction is complete. At this stage, ULB officers review the built-up area vis-à-vis the approved plan and issue deviation notices if any and impose fines, which clients choose to pay off because addressing deviation at this stage is difficult. During inspection, OSS is often not yet constructed and even if it is, deviations are not reflected in the deviation notice. Typically, OSS is constructed based on available offset and as per Vaastu, a traditional Indian practice for building design and architecture.

In the sampled households, many deviations in actual OSS from IS standards and the approved plan were noted. Ninety per cent of OSS do not comply with IS standards. Further, deviations from the

approved plan in terms of designs variations (80 per cent), location deviations (50 per cent), disposal arrangements (40 per cent) were noted. Stakeholders point to the high cost of land as a reason for deviations.

Conclusion:
This study highlights gaps in the implementation of TNCDBR at the approval and inspection stages. It calls for bridging the gap between TNCDBR and actual approval and inspection practices and strengthening urban local governance structures to effect improved sanitation outcomes. Additionally, all stakeholders in the building plan approval process need to be sensitised on the importance of constructing OSS as per standards and its environmental and health benefits.

Willingness to Pay to Enforce Fines to Prevent Open Defecation
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The elimination of open defecation (OD) offers numerous welfare benefits to individuals and communities. To reduce OD, public health officials and workers around the world use Community-Led Total Sanitation (CLTS). CLTS is designed to "trigger" communities to initiate a cultural shift that discourages OD and encourages using latrines. Overall, studies have found that while CLTS tends to increase latrine access and use, it does not eliminate OD. Furthermore, a growing body of evidence suggests that the impacts of CLTS may not be sustainably without additional interventions or programming. One approach for sustaining the gains from CLTS interventions is to use sanctions that increase the costs for deviating from the norm of using a latrine. The Handbook on Community-Led Total Sanitation specifically highlights the use of sanctions against people who practice OD in ODF communities as a possible indicator of sustainability. While CLTS aims to generate new norms regarding OD, it is unclear whether community members in places where CLTS successfully generated a change in sanitation behavior support the use of fines. To examine support for fines we surveyed a random subset of 624 respondents as part of the endline survey of a randomized controlled trial testing the impact of a CLTS follow-up program that offered pro-poor sanitation subsidies. The trial covered 109 communities that has been verified open defecation free in northern Ghana. The module included a stated preference experiment using contingent valuation to examine how respondent's willingness to pay for a hypothetical system that would employ professional enforcers to monitor communities and fine people if they are found practicing OD. Additionally, we asked follow questions regarding support for fines and appropriate fine amounts. The results from the stated preference experiment suggest that households had a positive willingness to pay to prevent OD and supported the use of fines to prevent open defecation.

WinS Impact on Caregiver-reported Kindergarteners' Health and Attendance in a Randomised Trial – Addis Ababa, Ethiopia.
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Water, sanitation and hygiene (WASH) interventions in schools (WinS) have been proposed to reduce morbidity in schoolchildren, including gastrointestinal and respiratory infection, and improve school attendance. However, evidence of the impact of WinS interventions on pupil health and educational outcomes has been mixed. We evaluated the WASH in Schools for Everyone (WISE) programme implemented by US-based NGO Splash in partnership with the Government of Ethiopia, which aims to achieve universal WASH coverage in schools in Addis Ababa, Ethiopia over a five-year period. Within the context of a cluster-randomised trial assessing intervention impacts on primary school-aged children (WISE evaluation), we conducted a sub-study to specifically assess impacts on kindergarten (KG) pupils. We included schools enrolled in the main trial with KG classes and randomly selected and allocated additional schools with KG classes until 20 schools each were enrolled in the intervention and control arms. Schools were randomly assigned 1:1 to receive the intervention during the 2021/22 academic year

or the following year (waitlist control). The intervention comprised WASH infrastructure improvements, including water storage and filtration, drinking water / handwashing stations and upgraded sanitation facilities, and behaviour change promotion. Within each participating school, we randomly selected 20 KG pupils (ages 3 - 6), and recorded caregiver-reported diarrhoea, respiratory illness and school absence over four consecutive weekly telephone interviews with caregivers of selected pupils between April and June 2022.

We found consistent reductions in caregiver-reported diarrhoea, respiratory illness and absence, although only reduction in absence was significant at the 5% level (OR: 0.67, 95% CI: 0.46, 0.99). Dropout of three schools and the considerable challenges of telephone-based data collection resulted in large losses to follow-up, impacting statistical power. Further research should examine how the use of mobile health technology can be improved to obtain sufficient follow-up data for evaluating school-based interventions

The Influence of Weather Patterns on Water Collection Labor in Senegal, 1992-2019.
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Background:
Given shifts in temperature and rainfall patterns globally with climate change, increased rates of evaporation and decreased rainfall could impact water availability and increase the burden of collecting water. Two previous studies have used Demographic and Health Surveys (DHS) to assess water collection labor. Pickering and Davis (2012) found that an increase in freshwater availability was negatively correlated with distance traveled to a water source. Graham et al. (2016) found that across the 24 countries, adult women were predominantly responsible for the water collection and female children were more likely than male children to collect water. This study uses DHS surveys from Senegal to assess associations between precipitation and evaporation on water collection labor.

Methods:
Nine surveys from Senegal between 1992 and 2019 were included. All surveys included GPS coordinates for each cluster of households. Weather data were included from the Modern-Era Retrospective analysis for Research and Applications, Version 2 (MERRA-2) from NASA. Each household cluster was assigned a specific Köppen-Geiger climate classification zone. Data from MERRA-2 were downloaded from the nasapower package, climate zones were assigned using the kgc package, and associations were estimated in R 4.2.3.

Results:
The source population included 53,649 households within 380 clusters (primary sampling units) between 1992 and 2019. We excluded households in urban settings (21,508), households that had piped water nearby (13,769), and households that received water from trucks or bottles (989). We also excluded households without water collection times (3,269). We included 14,408 households in this study, and 8,807 households had data for the person who collects water.

The average water collection time across all households was 32.2 minutes. The person responsible for collecting water included 7805 adult women (88.6%), 588 adult men (6.7%), 286 female children (3.2%), and 128 male children (1.5%). The average walk time for adult women was 27.8 minutes, female children was 38.5 minutes, adult men was 69.6 minutes and male children was 50.0 minutes.

The average walk time was 22.2 minutes in the tropical climate zone and 38.0 minutes in the dry climate zone (p < 0.001). There were weak correlations between walk time and 30-day total precipitation for the tropical climate zone (r = 0.01) and the dry climate zone (r = 0.02). Additionally, there were weak correlations between walk time and 30-day total evaporation for the tropical climate zone (r = -0.03) and the dry climate zone (r = -0.04).

Discussion:
This study shows that climate zone, but not precipitation and evaporation in the prior 30 days, are associated with the amount of time needed to collect water in Senegal. Additionally, men and male children walk further to collect water; however, women and female children are more likely to collect water. This study is limited in that it included only 27% of households in Senegal and that only 9 surveys were performed across the 27 year range. Future directions include modeling the relationship between

water collection time, precipitation, evaporation, and temperature, in addition to including surveys from other sub-Saharan nations.

Cleaning and disinfection practices of alcohol-based handrub containers at healthcare facilities in rural Uganda

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Introduction:
In healthcare settings in low- and middle-income countries, local production of alcohol-based hand rub (ABHR) provides a practicable alternative to commercial ABHR, which is typically more expensive or may be in short supply. Due to limited resources, containers used for storing and dispensing ABHR often must be reused, potentially becoming contaminated if not cleaned and disinfected properly before refilling. As part of an initiative to support local production of ABHR among healthcare facilities (HCFs) in rural districts in Uganda, we developed a standard operating procedure (SOP) on cleaning and disinfection (C/D) of ABHR containers following WHO guidance and provided on-site training to infection prevention and control personnel on the SOP.

Objectives:
This study intended to 1) assess the availability of C/D supplies and equipment to evaluate the feasibility of the ABHR container C/D SOP, 2) document baseline ABHR container C/D practices, and 3) assess changes in C/D practices following training.

Methodology:
We conducted a baseline survey during on-site trainings held between June 2022 and April 2023 and a follow-up survey between July and September of 2023. We collected information on the availability of supplies and equipment (e.g. brushes/sponges/cloth, soap, personal protective equipment (PPE), chlorine) for cleaning and two methods of disinfection—chlorine and thermal (boiling or autoclaving)—and ABHR container C/D practices at 91 HCFs in five districts that receive locally-produced ABHR..

Results:
All but one HCF reported reusing ABHR containers. At baseline, most HCFs had access to clean water (61%), soap (63%), chlorine (66%), and an autoclave or boiler (67%); fewer HCFs had brushes/sponges/ cloth (26%), at least one bucket (47%), and all necessary PPE (42%). Only 8% and 12% of HCFs routinely had all the key C/D supplies and equipment needed for adequately cleaning and disinfecting containers using chlorine and thermal disinfection methods, respectively. These percentages increased to 14 and 18 following the training. HCFs that adequately cleaned containers (e.g. using soap and water, brushing or scrubbing to mechanically remove organic matter) increased from 3% at baseline to 17% at follow-up. HCFs reporting disinfecting containers increased from 2% to 27%. All used chlorine for disinfection and none of the HCFs reported using thermal disinfection at baseline or follow-up. Of the 25 HCFs reporting disinfecting containers at follow-up, 19% adequately applied the chlorine disinfection method (e.g. wearing PPE, using a 0.1% chlorine solution, ensuring 15 minutes of contact time). The most frequently mentioned reason for not implementing C/D was "didn't think it was necessary" at baseline and "lack of C/D supplies or equipment" at follow-up.

Conclusion:
Although HCFs commonly re-use containers for locally-produced ABHR, few perform C/D necessary for preventing contamination and most lack critical C/D materials and equipment. Training HCF personnel on a C/D SOP improved C/D practices; however, practices remained sub-optimal due to both poor adherence to all key C/D steps and continued lack of required supplies and equipment. Future efforts should be aimed at routine mentorship and monitoring of ABHR container C/D as well as improving access to C/D supplies.

Novelty:
The need for cleaning and disinfection (C/D) of reusable ABHR containers is not well understood and the documentation of existing C/D practices is scarce.

Do workplace policies predict PPE-related knowledge and ownership among desludging operators? A Ugandan case
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Implementation of workplace policies and procedures has been suggested to reduce exposure to occupation hazards by promoting knowledge of personal protective equipment (PPE)-related knowledge and ownership. However, few studies provide evidence of the relationship between workplace policies and procedures and PPE-related knowledge and ownership among desludging operators in low-and-middle-income countries. This study, therefore, hypothesized that workplace policies and procedures predict knowledge and ownership of PPE. Data analysed in this study were part of a larger study that aimed to use the sanitation safety planning tool to improve the occupational health and safety of desludging operators in 11 cities in Uganda. Data were collected using an electronic structured questionnaire and analysed using STATA version 16.0.

Our findings indicated that 52.8% of the respondents worked in places with health and safety policies, 40.9% had health and safety manuals and procedures and 42.6% had received compulsory health and safety training. About 50.8% had a health and safety focal person, and 39.9% had a system to identify and deal with hazards. About 20.8% of the respondents strongly agreed that if they noticed a workplace hazard, they were obligated to report it and 23.8% strongly agreed that they helped their teammates understand the importance of health and safety.

The face and head protection equipment known and owned by the respondents were: safety spectacles (known by 24.1% but owned by 1.7%), goggles (known by 37.6% but owned by 15.5%), welding shields (known by 12.2% but owned by 1.0%), laser safety goggles (known by 13.9% but owned by 0.3%), face shields (known by 36.6% but owned by 9.2%), hard hats (known by 49.5% but owned by 24.4%), and helmet (known by 71.9% but owned by 40.6%). Ear protection equipment known and owned by the respondents were: single-use earplugs (known by 9.6 but owned by 0.3%), and earmuffs (known by 10.2% but owned by 1.0%). Hand and arm protection PPE known and owned by the respondents were; gloves (known by 92.7% but owned by 84.2%), finger guards (known by 20.8% but owned by 0.0%), and armlets (known by 15.5% but owned by 0.0%).

Only 20.5% satisfactorily owned PPE and 38.6% had good knowledge of PPE used for face and head protection, foot and leg protection, hand and arm protection, and ear protection. PPE-related knowledge was associated with having a health and safety policy (PR 0.55, 95% CI: 0.40-0.74), the existence of health and safety manuals, and procedures (PR 1.51, 95% CI:1.01-2.26), compulsory health and safety training (PR 1.75, 95% CI: 1.03-2.98), having an appointed person in charge of health and safety (PR 0.53, 95% CI: 0.34-0.84), considering worker safety extremely important (PR 1.74, 95% CI: 1.11-2.70), and having an active health and safety committee (PR 0.71, 95% CI: 0.51-0.99). None of the workplace policies and procedures were associated with PPE ownership.
In this study, we concluded that workplace policies and procedures predicted PPE-related knowledge and not ownership. There is a need for workplace managers to accompany workplace policies and procedures with the provision of enforcement of PPE use.

Assessing household animal-sourced fecal contamination via microbial source tracking in northwestern coastal Ecuador.
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The presence of animals and their feces in the domestic environment represents a potential source of exposure to enteropathogens, contributing to the disease burden of children living in close contact with animals. This is particularly important for low and middle-income countries, where domestic animals are common, water and sanitation conditions are often poor, and 8% of infant deaths are attributed to enteric diseases. To assess sources of household environmental fecal contamination, we measured microbial source tracking (MST) markers in households with infants under two years old from communities across an urban-rural gradient in northwestern coastal Ecuador. After an initial piloting phase to validate MST markers in the study region and determine the sampling locations most appropriate for MST marker detection, we conducted environmental sampling in 147 households from August to October 2022. We collected swabs of floor samples (n=146) and rinses of child (n=147) and adult (n=146) hands. Samples were analyzed using quantitative PCR for the GenBac3 MST marker for general fecal contamination, HF183 for contamination attributable to humans (to distinguish human vs. animal fecal contamination), Rum2Bac for ruminants, Pig2Bac for swine, DG37 for dogs, and GFD for birds. GenBac3 and HF183 were detected in more than 90% and 50% of all analyzed samples and across all sample types, respectively. Of the animal markers, the avian-associated marker GFD was most prevalent, detected in 23% of all samples and 38% of floor samples, followed by the dog-associated marker DG37 (detected in 10% of all samples) and swine- and ruminant-associated Pig2Bac (3.9%) and Rum2Bac (1%). Among positive samples, mean log10 concentrations for HF183, the human fecal marker, ranged from 2.4 to 6.3 gene copies (GC)/sample, while animal markers ranged from 2.4 to 4.5 GC/sample. Markers from animal sources were more prevalent in areas of intermediate rurality (44%) compared to the rural (35%) and urban (32%) areas. These results suggest that both general- and human-associated fecal contamination is prominent in households from the study setting. The prevalence of animal markers was lower but had relatively high concentrations when detected (mean log10 concentration of 3.0 GC/sample for any MST animal marker). Differences in animal-associated fecal contamination across the rural-urban gradient suggest that geographic and lifestyle factors impact household exposures to animals and their feces. This work will be used to generate a quantitative index for animal-associated fecal contamination that will be used in conjunction with a survey-based metric to understand early childhood exposures to animals in this and other LMIC settings. These metrics will allow us to improve the definition of at-risk groups and to incorporate this information within an exposure science conceptual framework to account for animal, environmental, and human behavior components of child animal exposures.

Pathogen exposure risk associated with household water storage in Beira, Mozambique.

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Background:
Water supply infrastructure and household water management can influence enteric pathogen exposures and risk of gastrointestinal infections. Household water storage is a common practice when water access is outside the household or available intermittently, even in communities that have access to treated and piped water, and can significantly impact water quality at the point-of-use. As a first step in estimating infection risk attributable to unsafe water storage, we characterized pathogen hazards in household stored water and associated household taps or community collection points in urban Beira, Mozambique. We hypothesized that pathogen densities would be greater in household stored water compared with household and community sources, due to additional contamination opportunities at the household level.

Methods:
We collected samples during the rainy and dry seasons, as a nested study of a water supply intervention health impact study in Beira, encompassing neighborhoods with access to the city's improved water supply network and those without. We collected and concentrated large-volume water samples from public community taps (n=49), using dead-end-ultrafiltration (DEUF), and household source (n=38) and stored drinking water (n=76), using membrane filtration (MF) techniques. We analyzed all samples using RT-qPCR via a TaqMan Array card for 29 unique enteric pathogens, including bacterial, viral, protozoan and helminthic targets. We also tested matched samples for presence and quantity of total coliform and

E. coli to determine pathogen viability via IDEXX Colilert-18. Statistical analyses will be conducted comparing pathogen densities across the three water types.

Results:
We detected at least one enteric pathogen in 28% of samples and culturable E. coli was detected in 29% of samples from the preliminary sample analysis. Pathogens were detected most often in household stored water (35% of samples with at least one pathogen present), compared to household source water (23%) and community source water (14%). Similarly, approximately 41% of household stored water samples were positive for culturable E. coli., compared with 19% of household source water and 9.5% of community source water samples. Furthermore, 20% of household stored water had both culturable E. coli and enteric pathogens present, compared to 4% at the household source level and zero samples at the community source. The most prevalent pathogen across all water sources was Cryptosporidium spp. In household stored water, additional pathogens present included Giardia spp., Vibrio cholerae, Entamoeba histolytica, Trichuris trichuria, Campylobacter jejuni/coli, and various types of E. coli.

Conclusion:
Initial results suggest a detectable percentage difference in drinking water quality at the household stored level compared to household source and community source, with greater pathogen density in the household stored water than either source waters. As these samples are taken across neighborhoods with access to the improved water supply network and those without, there could be evidence to suggest that the source of drinking water and quality of supply network are not the only factors for water quality at the point-of-use. These results could provide additional support for water quality and behavioral interventions at the household level in urban areas.

An exploration of self-supply and functionality through private water source mapping in Western Kenya
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Background:
In Sub-Saharan Africa, self-supply water sources are often a primary means of accessing water in rural areas, where government or institutional support for water supply is limited. These sources are developed and maintained by individuals or households without external support and have advantages in their affordability, accessibility, and responsiveness to household needs. However, the quality of the water from these sources can vary, and there are concerns about the potential for contamination. To address these concerns and improve water access in the region, there is a growing emphasis on integrating self-supply sources into broader water sector planning and development.

Objective:
The Water Project (TWP) aims to achieve 100% coverage of basic water access in Hamisi, Lurambi, Malava, and Mumias East sub-counties in Western Kenya. Like in many rural areas, however, the location and functionality of existing water infrastructure are largely undocumented. In 2022, TWP launched a water point mapping (WPM) project to inventory and assess all water sources in the target area. The aim of this analysis is to describe the self-supply water sources identified during mapping and assess their functionality, in order to better incorporate self-supply into regional water development plans and ultimately improve health outcomes.

Methods:
The WPM activity was conducted April-August 2022 and is a comprehensive assessment inventory of all improved and unimproved, private and public, non-surface water sources in the four target sub-counties. The activity comprised two data collection tools, a Participatory Map and Water Point Survey. The Participatory Map was conducted with community health volunteers, local chiefs, and community elders upon entry into each sub-location and provided an overview of the communities, schools, healthcare facilities, and water infrastructure. Enumerators then conducted the Water Point Survey at all sources.

This survey included basic management questions, an infrastructure assessment, and sanitary inspection. Descriptive analysis was conducted in Excel, and multinomial logistic regression will be conducted in R.

Results:
A total of 16,021 water sources were mapped, including 10,583 (66%) privately owned, 4,081 public, and 740 institutional (school, HCF, etc.) sources. Of the privately owned water sources, 49% were also used by other community members. Protected dug well without handpump was the most common self-supply system type (67%), followed by piped systems (12%) and rainwater harvesting (9%). Of the self-supply systems, piped water systems had the highest rate of non-functionality (25%) and were most likely to be non-functional if the source was a municipal water system (54%). Protected dug wells had the lowest rate of non-functionality (13%).

Conclusion:
Self-supply protected dug wells are the most common form of water access and are more likely to be functional than any other system type in the study area. Government and NGO stakeholders invested in improving health in Western Kenya should therefore consider WASH programs that target the users of private wells. Programs that distribute resources for or provide education in household water treatment and storage, for example, may provide health benefits beyond those achieved through the expansion of access to public point sources.

Persistence of respiratory, enteric, and fecal indicator viruses in fecal sludge from onsite sanitation
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Wastewater-based epidemiology (WBE) has been used to effectively track COVID-19 in communities of various sizes, identify the spread of emerging variants, and guide the deployment of testing resources. The utility of WBE has encouraged a shift in the application of WBE from COVID-19 to other waterborne, foodborne, and fecal-oral viruses. WBE method development has been almost exclusively constrained to sanitation systems that rely on a network of sewers conveying wastewater to a centralized treatment facility. This dependency limits the applicability of WBE in low and middle-income countries, where 2.7 billion people rely on non-sewered, onsite sanitation. Specifically, Senegal's Ministry of Health and Social Action has expressed interest in establishing and strengthening surveillance systems for priority diseases. However, the transition to centralized sanitation will not be immediate, and WBE requires adaptation for use in non-networked sanitation. For on-site sanitation technologies, excreta may remain in the system anywhere from weeks to years before it is emptied. Therefore, it is important to understand the persistence of pathogen RNA in waste streams from onsite sanitation to organize waste emptying campaigns and contextualize detection results.

In this work, we leveraged a fecal sludge treatment plant in Dakar, Senegal as a centralized location that receives excreta from many onsite sanitation systems. We evaluated the persistence of respiratory, enteric, and fecal indicator viruses in fecal sludge at various temperatures. For brevity, this presentation will focus on results for SARS-CoV-2 and Pepper Mild Mottle Virus (PMMoV). Fecal sludge samples were spiked with heat inactivated SARS-CoV-2 and subjected to temperature controlled rooms placed at 4 oC, 15 oC, and 30 oC. The experiment was conducted over 70 days total, and targets were quantified at 12 timepoints throughout those 70 days. Aliquots were taken in duplicate, concentrated via centrifugation, and subjected to RNA extraction and droplet digital PCR (ddPCR) to quantify viral RNA for SARS-CoV-2 nucleocapsid targets N1, N2 and PMMoV.

Exogenous SARS-CoV-2 was found to be highly persistent in fecal sludge with stable concentrations at 4 and 15 oC, and slight decay at 30 oC (k = 0.009 day-1 for N1, and k = 0.016 day-1 for N2), with corresponding T90 values of 255 and 144 days for N1 and N2, respectively. PMMoV was also demonstrated to be relatively persistent in fecal sludge (k = 0.04 day-1 at 4 oC) with T90 value of 56

days. High RNA persistence suggests that onsite sanitation systems with emptying frequencies of 1-8 months may in fact be suitable candidates for environmental surveillance programs. The findings of this study suggest feasibility for disease monitoring among communities who rely on onsite sanitation infrastructure, and sampling from fecal sludge treatment plants shows promise for capturing representative data from a larger population than sampling individual onsite systems.

Understanding the Enablers and Barriers for Improved Menstrual Hygiene Management (MHM) in Western Kenya
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Additional Authors: Neville Okwaro

Background:
In March 2023, the USAID Western Kenya Sanitation Project (WKSP) completed an assessment of MHM barriers and enablers in eight western Kenya counties, covering scale of menstrual education and information dissemination, availability and access to menstrual products and facilities, menstrual waste management options, and the political economy underpinning MHM.

Methodology:
The assessment utilized a cross-sectional design with a mixed-methods approach, concurrently applying both quantitative and qualitative data to corroborate and triangulate. The quantitative approach targeted 800 girls (unmarried) 10–19 years and 835 women (15–49 years) who were married or heading their households. WKSP used two sets of questionnaires for each group via an open data kit application. The study engaged 57 Key Informant Interviews with county government officials; organized 65 focus group discussions with men, boys, girls, and women from rural, urban, and peri-urban settings; and completed 17 in-depth interviews with social enterprises.

Analysis and Results:
Findings identified barriers to MHM that entailed negative cultural practices and attitudes; exclusion of men and boys from meaningful involvement; and limited MHM information sources. In nearly all counties, negative beliefs about menstruation and its management prohibited women and girls from participating in societal activities and thus stigmatizing menstruation. For instance, the belief that exposure of used sanitary towels would lead to witchcraft and infertility among girls and woman was common. Access to MHM information was limited, with 41% of women and 35% of girls being unaware of menstruation before their first menstruation; only 35% of the respondents confirmed receiving education on MHM primarily through schools (53%), mothers/caregivers (20%), and sisters (12%). Menstrual products variability included single use pads (88%), clothes (6%), and washable pads (3%). In waste management, pit latrines were dominant waste disposal locations for used pads, with a majority of girls throwing them into the latrine or toilet when both at home (97%) and away (81%).

However, findings also pointed to enablers. First, political goodwill was present for MHM programming supported by the Governor's Office and County First Lady's Office including the purchase and distribution of sanitary towels to schools, MHM awareness and sensitization, and the Busia Governor serving as the MHM champion in the region. Some counties have supported health systems through methods including the construction of sanitation facilities in school through the Constituency Development Fund in Busia and a Unified Payments Interface number linked to the National Hospital Insurance Fund and National Education Management Information System for students to access health services. All counties also had nascent drafts on MHM policies based on the 2019 National MHM Policy framework.

Conclusions:
Informed by the assessment and its recommendations, WKSP seeks to implement a 3-prong approach on breaking the MHM silence through strategic communications and behavior change campaigns including community dialogue days and dedicated MHM laboratories; engaging and expanding enterprises to scale user-friendly and different user-preferred MHM products and services; launching innovation calls for improved waste management; and collaborating with county governments to include specific MHM provision in their current revision of county development plans.

Financing complexity: Public-Private Partnerships in reaching universal access in Rwanda
Olivier Tuyishimire, Water For People

Rwanda faces a daunting WASH finance gap estimated at US $134 million per year to reach SDG 6 by 2030. However, in Gicumbi District, 442,000 people, including every community, school and healthcare facility will soon be reached with universal access to basic water and sanitation services, on time for the national goal of universal basic access by 2024 and safely managed by 2030. How did this happen? In 2016, Water For People began working with the government of Rwanda in Gicumbi District to share the capital expenditure costs for water supply systems in a complex co-financing arrangement. How did we get District officials, national officials, and regulators to agree? This presentation will cover the process to get local ownership and financial buy-in for a complex program with many different sources of funds, different availability timelines, and with tough targets and deadlines. The session will also illustrate the pivotal role of political will, community engagement to foster citizen demand for improved services and complex contract management. Relationship management to maintain strong commitments and day-to-day alignment between all stakeholders of the program was also crucial. There are still problems with sustainability. Currently, tariffs make up a small portion of funding, and as the program matures, we need to make sure maintenance and capital maintenance costs are adequately covered. To close the gap for 2 billion people worldwide to access clean water and sanitation, we all need to work together to increase the funding available for WASH – from wherever we can find it.

What is unique, new or novel about this research?

We present a novel approach to financing WASH: a co-financed District-Wide approach that includes local and national system strengthening to support sustainable service delivery. The investment plan for Gicumbi District began with a full asset lifecycle analysis of existing infrastructure, its value, existing coverage with basic services, and the resulting budget gap of life cycle costs to cover every household, school, and healthcare facility. This data informed negotiations with the government and regulator, WASAC, to come to an agreement to co-finance implementation in a 2016 MoU. Also unique is the ownership by the District, which is expected to manage all contracts, hire private sector operators to perform O&M, purchase land, own and maintain all infrastructure, and plan and finance all future capital maintenance after 2028 when Water For People plans to exit.

Addressing lead in purportedly "lead-free" water supply systems using XRF verification and supply chain improvements: Case study from Ghana
Siddhartha Roy, University of North Carolina
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Lead (Pb) is a colorless, odorless and tasteless chemical contaminant present in water supply systems worldwide and a toxin that can impact neurological and cognitive development. The primary source of lead in drinking water is lead-containing pipes and plumbing that leach lead into the water. Previous work by our team in 3 West African countries found 9% of water samples in exceedance of the WHO guidance value for lead (10 ug/L) and over 80% systems with at least one part containing lead above the international "lead-free" standard (0.25% Pb by weight).

The multi-year "Ghana Water Quality Study" was recently launched to generate evidence and validate strategies for progressively improving water safety by reducing water lead occurrence in and exposure from drinking water. As part of this study, our team screened 100 rural water systems (83 boreholes and 17 mechanized piped systems) installed in seven districts, primarily between 2019-22, using parts specified as lead-free (i.e., <0.25% Pb by weight), based on manufacturer and supplier assurances. In each system, rods, cylinders, riser pipes, foot valves, spouts, and tanks (boreholes) or taps (mechanized systems) were analyzed for lead and other toxic metals by handheld X-Ray Fluorescence (XRF; model: Oxford X-MET 7000 Handheld XRF).

The study revealed that most tanks (57%; 47/83) and taps (100%; 17/17) exceeded the international lead standard (0.25% wt/wt). Few if any of the other components exceeded international lead standards. There were no significant differences in lead content of handpump tanks by district (Garu, Builsa South, Bawku West, Fanteakwa, Sekyere East, Zabzugu, and West Gonja) and installation year (2019-22) (one-way ANOVA; $p>0.05$). The maximum lead content measured in tanks was 2.29% and in taps was 3.13%. XRF data suggest that screened tanks were galvanized steel and screened taps were brass.

Based on these findings, our team conducted outreach to identify manufacturers capable of supplying truly "lead-free" parts to be independently verified by XRF assay prior to acceptance. At least two manufacturers confirmed that lead is routinely used in construction of water system parts, especially handpump tanks, and claimed that truly lead-free systems would be prohibitively expensive. One manufacturer agreed to custom-fabricate lead-free stainless steel tanks to desired specifications and another agreed to supply lead-free stainless steel taps. The cost of the custom-fabricated SS tank increased overall cost for a borehole by 2%, while lead-free taps represented a negligible increase in the cost of mechanized systems. These items have been received, will be characterized by XRF and those components that are verified as lead-free will be installed in new water systems.

The study demonstrated the vulnerability of global supply chains for water system components to contamination by lead-containing materials, and found that lead-free items can feasibly be procured at somewhat increased cost. The results further suggest that organizations procuring and/or installing such systems for drinking water supply may benefit from traceable third-party verification that the components to be used are lead-free and safe for drinking water. Such actions can support efforts to progressively achieve lead-free drinking water systems.

Barriers and facilitators to fecal sludge treatment in humanitarian camps: a systematic review of experiences
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Additional Authors: Christine Kelly, Aoife Schmitt and Daniele Lantagne, Tufts University

Key Learning Objectives
• The same number of barriers and facilitators emerged from the systematic review. Barriers could often be mitigated by facilitators, by selecting the appropriate treatment system or adapting the design.
• Interventions were implemented mainly in Bangladesh, meaning many humanitarian contexts were not covered, and the overall evidence was weak, so there was a lack of high quality data.

Introduction:
People affected by humanitarian crises are particularly vulnerable to waterborne disease outbreaks. Camps are a common context of humanitarian settings, where safe treatment of human excreta remains rare. Untreated fecal sludge is directly disposed of into the environment, leading to environmental and public health risks. Implementer internal reports on programs are seldom disseminated externally, and evaluations of programs are rarely published in peer-reviewed manuscripts. Accessing knowledge regarding FSM interventions, to draw upon experience and build sectoral capacity, is challenging. Thus, it is necessary to synthetize experience (including grey literature) from humanitarian camps on fecal sludge treatment, in order to understand successes and lessons learned from previous programs. The objective of this research was to summarize existing information to identify barriers and facilitators to fecal sludge treatment in humanitarian camps.

Methods:
We completed a systematic review of manuscripts and reports that: 1) had an assessment of the implementation of FSM activities; 2) were implemented in a humanitarian context; 3) completed primary data collection; and 4) had output level data. We searched eight journal databases and 39 international organization websites from January to November 2020, and further completed reference screening of included documents. Two authors completed title, abstract and full text screening, and excluded documents not matching inclusion criteria. As more than 200 documents were included, we narrowed the

selection criteria on intervention and setting to fecal sludge treatment activities in humanitarian camps. Two authors completed data extraction, and graded interventions using the Bond Evidence checklist. Any discrepancies in data recording and categorization were discussed between authors.

Results:
We searched 18,377 publications and included 49 documents. Overall, evidence was weak or of minimum standard. The documents included 70 interventions from 12 countries, with 22 treatment modules. We identified 403 barriers and 402 facilitators, divided into 11 categories: performance (186), operation (146), technical (108), economic (78), environmental (59), spatial (55), social-cultural (47), temporal (44), safety (34), supply (29), and political-institutional (19). The main barrier of the performance category was unmet limit values for effluents, and the main facilitator was high removal values of treatment systems. The main barrier of the operation category was systems needing strong supervision for operation, and the main facilitator was systems being easy to operate and maintain. Most barriers and facilitators were collected from Bangladesh (75%), and during the stabilization-recovery phase of a humanitarian crisis (61%). Lime treatment was the most implemented treatment module (21%). We found that the barriers and facilitators were mostly linked to the treatment system itself, and less to local context. We found that many barriers can be mitigated by facilitators before implementation of the system.

Conclusion:
Proper decisions on the selection and design of the treatment systems can be taken to avoid barriers before implementation, with facilitators used to mitigate them. Additional implementation and improved reporting of fecal sludge treatment in humanitarian camps is necessary to remedy the overall lack of high quality data. Further research is needed to evaluate the outcomes and impacts of appropriately selected and implemented treatment systems in camps.

An analysis of menstrual health and hygiene-friendly aspects of public toilets in Rio de Janeiro and Manila
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Additional Authors: Marian Fe Theresa Lomboy, University of the Philippines Manila; Ernesto R. Gregorio, Jr., University of the Philippines Manila

Background:
Rio de Janeiro (BR) and Manila (PH) are two of the cities included in a multi-city study, conducted in partnership with academic institutions in six cities around the world which assessed the menstrual-friendly characteristics of public toilets in comparable neighborhoods of each city. In Brazil there is no federal law or regulation that makes the provision of public toilets compulsory, and public toilets in Rio de Janeiro are generally perceived to be insufficient, with most of them not meeting the menstrual health and hygiene (MHH) needs of the population. In Manila, there are policies and initiatives for the provision of public toilets but evidence has shown that these public toilets are still inadequate in number, unclean, and with unreliable access to water supply. The purpose of this presentation is to answer the following questions with respect to these two differing social, economic, and geographic urban contexts: 1) Are these cities providing MHM resources in public toilets? and 2) What are the specific barriers and enablers to the provision of MHM resources and public toilets, and how do they differ by city context?

Methods:
We conducted a mixed-methods study that included: 1) menstrual-friendly public toilet audits in four comparable neighborhoods within Manila and Rio (business area, tourist area, transit hub, and residential park or plaza); 2) key informant interviews with toilet or menstruation advocates, and former or current government officials. Audits were conducted by trained research assistants (April - May 2023), and key informant interviews are being conducted by the principal investigators in each city (May 2023; analysis in June - July 2023).

Results:

The two cities had an unsatisfactory number of public toilets in the audited areas. The quality of toilets and their menstrual-friendly characteristics varied enormously across neighborhoods. In the case of Rio de Janeiro, the tourist and transit areas had the highest concentration and number of audited toilets, however, the quality of toilets in the tourist area was significantly better. In Manila, the most public toilets were identified in the business area, followed by the transit station and the residential area. Thematic analysis of the key informant interviews expected to reinforce initial observations regarding the enablers and barriers to improving MHH-friendly public toilets in Rio and Manila. Preliminary findings suggest that menstrual friendly and public toilet-related inequalities of each city were reflected in local government's priorities and attention to each neighborhood. Activists and non-governmental organizations also emerged as having an important role in supporting actions and public debate.

Conclusion:

In middle- and low-income countries such as Brazil and the Philippines, the quantity and maintenance of public toilets are unsatisfactory especially in peripheral neighborhoods. The importance given to the issue of menstruation in these contexts seems to be secondary considering the enormous challenges faced by the population in terms of access to water, hygiene, and sanitation in general. Further research is needed to understand the extent of these challenges, and how they can best be addressed.

Construction of large-scale primary drainage infrastructure reduced flooding in residential properties in Lusaka, Zambia
Nathan Chesterman, Mathematica
Additional Authors: Grant Anapolle, Nathan Tembo, Hellen Sikeemba, Rodgers Musonda, Muleya Sonde, Grace Mschili, Gelson Tembo, Anthony D'Agostino, Clair Null

Background:

Seasonal rainfall in Lusaka, Zambia, routinely causes widespread household flooding and is associated with public health problems such as cholera outbreaks. Between 2013-2020, the Millennium Challenge Corporation (MCC) and the Government of Zambia invested more than $75M to design and construct 23 km of concrete-lined primary drainage and provide technical assistance to the municipal authority responsible for maintaining the infrastructure as part of the Lusaka Water Supply, Sanitation, and Drainage (LWSSD) Project. This study contributes to the sparse literature on the impacts of large urban stormwater infrastructure projects.

Objective:

We investigated two research questions to support MCC learning and advance the evidence on addressing urban stormwater in low-income contexts: (1) How was household-level flooding affected by the new drainage, or otherwise mediated by other factors? (2) What are the prospects for the future functionality of the drainage infrastructure?

Methods:

For (1), we used population-weighted regression models to analyze household-level flooding outcomes before and after the drainage was constructed, controlling for rainfall and household characteristics and clustering standard errors at the neighborhood level. For (2), we combined household survey data on garbage disposal behavior with direct observations of the drainage infrastructure. We relied on household surveys collected in 2022 (n = 1,019 households) to form a repeated cross-section with data collected by the CDC in 2016 (n = 3,140).

Results:

(1) Compared to 60 percent of households in 2016 that experienced flooding in the 30 days prior to being surveyed, households surveyed in 2022 were 22 percentage points less likely to report flooding (p <= 0.001). Among households surveyed in 2022, over 10 percent of those that reported flooding had their latrine or toilet overflow as a result. Households were equally likely to report flooding before and after the construction of the drainage if it had rained more than 208mm in the 30 days prior to being surveyed. Besides rain, the most important factors mediating household flooding were proximity to impermeable

surfaces (22 percentage points higher likelihood of flooding, p <= 0.001), and the presence of well-maintained drainage in household plots (nearly 90 percent lower rate of flood days, p = 0.04).
(2) Several sections of the drainage were clogged by garbage or silt in 2022. Garbage dumping (including in the drainage) is rampant in Lusaka because the cost of formal garbage collection services regulated by the city was relatively expensive: several times higher than what the average poor household spent on water. Sixteen and 45 percent of households (in more affluent low-density neighborhoods and poorer high-density neighborhoods, respectively) did not use the city's official garbage collection services.

Conclusions:

Our findings indicate that large-scale gray infrastructure projects are effective at reducing, but not eradicating flooding, with implications for public health. Rainfall is projected to become increasingly erratic due to climate change. This demonstrates the need for multimodal solutions, such as complementing gray infrastructure with green infrastructure aimed at improving water infiltration, and allocating sufficient resources towards addressing root factors that threaten infrastructure, which are exacerbated by urbanization.

Use of vacuum and non-vacuum emptying technologies in informal settlements of Kampala city
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Additional Authors: Gilbert Bamuhimbise, Sheilla C. Apio, Joel R. Kinobe, Allan Nkurunziza, Najib Lukooya, Robinah Kulabako

Key learning objectives:
- Identify functional emptying technologies in informal settlements,
- Determine time required for various emptying events, FS characteristics and cost-benefit analysis of different emptying technologies.
- Relate emptying technologies to health of sanitation workers

Background:
Over 90% of the population in Kampala (capital of Uganda) Informal settlements is served by onsite sanitation facilities (septic tanks and pit latrines). These fill up fast, leaving emptying as the most viable option for their sustained reuse. This study fills the gap for the limited information about different emptying technologies suitable/used in informal settlements and limitations sanitation workers face while carrying out emptying operations. The study compared adequacy of vacuum and non-vacuum emptying technologies used in informal settlements of Kampala. This study was relevant in identifying critical events during the emptying and transportation to aid the process of optimizing and planning emptying services in informal settlements and at a city level.

Methods:
111 questionnaires (78 for vacuum and 33 for non-vacuum) were administered to obtain data about faecal sludge (FS) source and time estimates, while 37 faecal sludge (FS) samples were characterized. A total of 37 emptying events in 7 different informal settlements were recorded and used in the FS characterization study over a period of 16 weeks. A hand-held GPS (Garmin Montana model 650) was used to measure the distance travelled, maximum speed, average moving speed and time spent by moving trucks. Benefit Cost Ratio (BCR) and Net Present Value (NPV) methods were carried basing on economic data obtained through questionnaires.

Results:
FS emptied by vacuum trucks was 43.6% from lined pits, of which 28.2% are from informal settlements. 56.4% is emptied from septic tanks by vacuum technology, where informal settlements contribute 12.8%. FS emptied by non-vacuum technologies was 9.1% from lined pit latrines, 30.3% septic tanks and 60.6% unlined pit latrines (42.4% from informal settlements). Vacuum trucks of capacity 3.6 m3 were the most commonly used in informal settlements, while large vacuum trucks (7.2 to 14 m3) exclusively operated outside informal settlements. Many vacuum truck operators rarely wore overalls, nose masks, gumboots or gloves while emptying but mainly adhered to them during discharge due to the strictness of the treatment plant administrators. The non-vacuum technology operators wore overalls, gloves and

gumboots while emptying the latrines but missed nose masks.

Conclusion:
Kampala city needs to consider both vacuum and non-vacuum technologies in their FSM systems and planning due to the nature of settlements, toilet types and the differences in FS characteristics. The most critical event is the time spent during containment emptying, where non-vacuum can take up to 3 hours and less than an hour for vacuum technologies. Such longer emptying times by non-vacuum technologies can be reduced through enforcing minimum standards of containment facilities and preventing dumping of solid wastes in pits. In addition, there is a need to sanction non-compliant operators in observation of PPEs and SOPs in order to improve their health and safety.

Alternative Indicators for Handpump Functionality and Water Service Level
Catherine McManus, University of North Carolina

Introduction:
Handpump surveys estimate that at any moment, one in four handpumps in Sub-Saharan Africa are not functioning. Functionality as a binary indicator (functional or non-functional on the day of survey) is widely recognized as inadequate. Binary functionality measures if a handpump is operational, and does not measure level of service. However, there is no agreed-upon alternative standard and judgments of handpump management systems (often, community water committees) are made using this simple indicator, often by identifying statistical associations between "functionality" and sociotechnical factors, such as management behaviors and characteristics of water committees. This work explores how these statistical relationships (and the management conclusions they often imply) change with alternative indicators of handpump functionality.

Methods:
This ongoing work uses a dataset of handpump characteristics and performance collected in ten countries in Sub-Saharan Africa. Regression analysis was used to identify and compare changes in significance and strength of statistical relationships between handpump management factors and different indicators of handpump functionality. The functionality indicators used as outcome variables include: duration (in days) of the most recent breakdown, number of strokes required to produce the first drop of water, and the number of subsequent strokes required to produce 20L of water. We compare the results of these regression analyses to the results obtained using the traditional binary functionality outcome.

Preliminary Results:
Determinants of the alternative indicators differ depending on the outcome variable of interest. For example, we find that the existence and response of an external support system has a statistically significant association with breakdown duration, but not either indicator related to water production (number of strokes to get first water, or strokes to produce 20L). That a caretaker was trained had higher strength of associations with all indicators than that the same caretaker was paid. Distance to the closest urban center (often a proxy for availability of and access to supply chains) had a significant relationship with breakdown duration (downtime) and with the number of strokes required to produce water. Committee characteristics and behaviors (such as women committee members, that the committee holds committee and community meetings, and that the committee collects fees, and separately collects fees on a regular schedule) were generally not statistically associated with any of the functionality outcome indicators. Factors related to maintenance have stronger statistical relationships with breakdown duration and handpump water production.

Discussion:
As handpump functionality moves beyond binary metrics of operationality, alternative indicators and conclusions drawn using them should consider how users of handpumps experience their water point: in days of service and in strokes of the pump handle. These different functionality indicators have different relationships with management and maintenance factors. Recommendations or best practices for handpump management may differ depending on the priorities of the committee – minimizing breakdown duration and maximizing stroke-based productivity may be achieved differently. This work can be used by

handpump managers to design a handpump functionality monitoring program and maximize the functionality of their handpump.

A pilot study on design, implementation and evaluation of greywater soil infiltration systems in Odisha
Prasanta Mohapatra, Odisha Water Supply and Sewerage Board
Additional Authors: G. Mathi Vathanan; S. Majhi

Background:
Odisha State in India has implemented non sewered solution for faecal sludge management on saturation basis in all its 115 towns and cities. Having addressed it, the State is focussing on grey water management. On pilot basis two towns were taken up. Conventional sewerage system is costly, long implementation time and requires skilled personnel to operate. Hence, there is a need for cost-effective decentralized solutions for managing greywater and preventing environmental pollution. Soil infiltration systems (SIS) such as household soak pits and lane level absorption trenches have potential for managing greywater for local reuse such as groundwater recharge. This study is an evaluation of effectiveness of SIS for managing greywater piloted in two towns of Odisha. The study aimed to establish design, feasibility of construction, implementation, performance and cost-effectiveness of SIS for greywater management.

Methods:
The pilot project was implemented during October 2021 to December 2022 in Jatni and Dhenkanal towns of Odisha. Four geographical areas (GAs) were selected inside each town such that each GA covers the catchment of a major storm water drain including the secondary and tertiary drains. Households survey (Jatani, n=676, Dhenkanal, n=1155) was conducted in year 2021 involving the community to assess family size, on-site sanitation containment details, availability of space inside household premises and owner's willingness to allow soak pit construction. Street level surveys focused on road and drain type, dimensions, feasibility of construction of trench structure along the drain and measurement of flow in drains. Soil infiltration capacity was assessed at each GA and drain water and nearby handpump water samples were analysed for physicochemical and microbiological parameters. The infiltration structures were designed as per the Greywater Manual for rural areas in India and were constructed by the local Self-Help Groups. The trench structures are 1.5 m wide,1.5 m deep, filled with gravels and constructed in modules of 15 m length to serve several households on the street. The per capita cost of the SIS was compared with the conventional sewerage systems implemented in other towns of Odisha.

Results:
Households have onsite sanitation systems for black water and greywater is discharged to the storm water drains. Significant number of households (Jatani=15.9% & Dhenkanal=13.8%) were found discharging blackwater directly to the drains. The soak pits constructed (Jatani, n=30 & Dhenkanal, n=40) are efficient for small household family size of six. The flow measurement data show trench structures (Jatani=420m & Dhenkanal=350m) have full absorption capacity. Drain water quality exhibit low strength wastewater with faecal contamination whereas water from handpump tube well didn't show presence of faecal coliform. The per capita cost of SIS is $61 compared to per capita of $301 for conventional sewerage system.

Conclusions:
The study suggests that local SIS is cost-effective for greywater management. It can be a substitute for conventional sewerage system in towns where onsite sanitation system exist and are serviced by efficient city-wide faecal sludge management system. For SIS to be more effective in managing contaminants, households should be prevented from discharging faecal waste to the drainage system.

Lived Experiences of Menstrual Health and Hygiene among Transgender and Non-Binary Populations in Urban India: A Qualitative Approach
Priyanka Dubey, University of Iowa

Additional Authors: Muthusamy Sivakami, PhD; Shannon Lea Watkins, PhD; Kelly K Baker, PhD; William T Story, PhD, MPH; Rima Afifi, PhD, MPH

Significance:
Most research on menstrual hygiene management (MHM) remains focused on women and girls, with limited evidence on how transgender and non-binary (TNB) persons manage their menstruation. This research aims to document the lived experiences of menstrual health and hygiene among TNB people in urban India.

Methods:
Using a qualitative approach, we conducted 13 semi-structured telephonic interviews with TNB adults aged 19-40 years, in three major Indian metropolitan cities, with the help of trusted community organizations. Eleven participants identified as trans-male, one non-binary, and one male/ intersex. Participants were asked to share their experiences of managing their menstruation in multiple spaces of life, such as at home, school, workplace, and other public spaces. Interviews were audio recorded, transcribed, de-identified, and cleaned. We developed a codebook using an iterative process starting with the literature and interview guide and adding new codes that arose based on the transcripts. We applied thematic analysis to the transcripts.

Results:
Three major themes have emerged. First, 'gendering of menstruation' shapes overall experiences of menstrual health and hygiene among participants. Participants reported having little to no knowledge about menarche and menstruation which rendered them in a state of confusion, shame, and dysphoria. Participants faced dual burden of meeting gendered expectations without having any prior knowledge about menstruation which spiraled their dysphoria manifolds. Managing dysphoria was one of the biggest challenges of managing periods. Second, 'navigating physical aspects of menstruation' was less challenging in familiar, private surroundings, however, accessing public spaces and bathrooms remains a major challenge and stressor. Though many reported undergoing hormonal replacement therapy to suppress menstruation (and elevate gender euphoria), they continued experiencing menstrual symptoms, triggering dysphoria. Third, participants reported facing 'challenges beyond bleeding' which included burden of multiple diseases, lack of access to healthcare services that is binary in nature and lack of social support.

Discussion:
Documenting lived experiences of menstrual health and MHM among TNB people supports the effort to 'de-gender' menstruation. The study highlights the challenges and compromises that TNB population groups make in their day to day lives in accessing and navigating spaces that weren't designed and created for them. Thus, magnifying the voices and lived experiences of TNB people can bolster the development of effective interventions to enhance their wellbeing.

Exploring Gender and Social Dynamics of Water Management Committees in the Democratic Republic of Congo
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Additional Authors: MacArthur, J., Yakalo, T. and Ngeleka, J.

Women's engagement in water governance is crucial for sustainable health and development. However, many initiatives focus only on the number of female participants, ignoring power dynamics that may affect women's participation and decision-making. This study documents gender dynamics of elected water management committees (WMCs) in the Kasai region of the Democratic Republic of Congo. WMCs carry out water governance functions such as fee collection and maintenance. Women were encouraged to participate in the WMCs, but it was unclear to what extent this engagement was meaningful. We conducted a participatory rapid appraisal study to assess the gender dynamics including the interactions and relationships between women and men on the committees and the power-based dynamics that underpin these interactions. The study examined the inclusivity and effectiveness of WMCs, drawing on the literature to use a three-part framework of functionality, participation, and engagement.

Methods:
We purposively selected four WMCs to reflect different geographic locations and types of water infrastructure. In October 2022, a total of 26 individuals from these WMCs participated in eight focus groups (disaggregated by gender) and used pocket voting to rate different aspects of the committee's functionality. Responses were recorded in French and translated to English for analysis. Content analysis and descriptive statistics were conducted and compared between men's and women's groups for each committee. The results were compiled into the functionality-participation-engagement framework. Finally, the team classified the participation and engagement of women in each of the WMCs.

Analysis and Results:
WMCs in this study face challenges with fee collection, community trust of fund management, and management of water points. Women were less likely than men to agree on the functionality and effectiveness of the committee, and gender differences were seen in engagement aspects such as communication, meeting time, location, and seating arrangements; however, these were sometimes worse for men than women. Men and women described poor community relationships, with women providing more detail on the challenges in fund collection and community relationships. Women in leadership roles were less likely to agree that women could do these roles well, indicating a potential lack of confidence and/or capacity. However, none of the committees had nominal or passive engagement of women. Women tend to be more stable participants than men, but often in non-decision-making roles. Men described that women are often underestimated, and women described household work as a limiting factor to active participation.

Conclusions and Recommendations:
We recommend communicating the value of the committee and fee system to communities, identifying opportunities to build women's confidence in leadership positions, and exploring ways to increase young women's participation. We also suggest that committees structure meetings to ensure good time management and consider rebranding the organizational structure to give each member a substantive role. Overall, our study highlights the need for greater attention to gender dynamics in water governance initiatives to improve the inclusivity and effectiveness of WMCs. Future research could explore the barriers women face in participating in WMCs, incentives for being a committee member, and opportunities for enabling women's leadership.

Acceptability of container-based sanitation facilities in healthcare facilities in Kenya
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Key Learning Objectives:
1. Compare acceptability of Container-based toilets with standard toilets in health care facilities.
2. Assess cleanliness conditions of healthcare facility toilets.

Background:
Container-based sanitation (CBS) may provide a sustainable fecal sludge management option for some healthcare facilities (HCF) in low-income countries. CBS has been acceptable in household and other institutional settings; however, little is known about its acceptability in HCFs. We piloted CBS in HCFs in Kenya and assessed their acceptability compared with standard toilets in neighboring HCFs.

Methods:
From 2019-2022, CBS was piloted in a primary care facility in the Rift Valley region and in a large hospital in northern Kenya that serves a refugee camp (both of which make up the CBS arm). Comparison HCFs with standard pit and flush- toilets (control arm) were purposively sampled based on comparable monthly patient volume, proximity to CBS HCFs, and variability in waste management practices. A survey to collect participants' (patient, non-patient visitor, and staff) opinions and recent experiences using HCF toilets was administered. Participants were asked if they considered toilets acceptable for use and the

usual state of cleanliness for toilets, and responses were compared between arms using multivariable logistic regression with generalized estimating equations to account for clustering by HCF. Additionally, we observed all toilets in the HCFs for the presence of feces, urine, odor, rubbish, and insects.

Results:
Of 210 participants interviewed, 149 (71%) reported using either CBS or standard toilets in the past week (43 (60%) CBS arm, 106 (77%) control arm). Overall, 95% of participants in the CBS arm and 88% control arm found the toilets acceptable for use. However, when adjusting for sex and participant category (patient/non-patient visitor/staff), acceptability was higher in the CBS arm (OR 3.73, 95% CI 1.66-8.37). Moreover, CBS users found specific features acceptable (cover material application, 90%; urine diversion, 90%; regular waste collection, 86%), and, among CBS users who had also used standard toilets in the CBS arm, 19/24 preferred CBS over standard toilets. A total of 8 CBS toilets, 20 flush toilets, and 52 pit latrines were observed across all HCFs. Poor conditions were common in pit latrines: 58% had odor present, 40% had insects present, 31% had urine/water puddling present, and 15% had intact feces on the floor. These poor conditions were altogether absent from flush and CBS toilets except 5% of flush toilets that had intact feces on the floor. While CBS were available for outpatients and visitor in the CBS arm, all outpatient/visitor toilets in the control arm were pit latrines (34/34), and all flush toilets were reserved for staff and inpatients.

Conclusion:
In a small number of HCFs, CBS had higher acceptability than standard toilets and may be a suitable sanitation option for some HCFs, especially as an alternative to outpatient pit latrines. However, good management and regular cleaning are essential to acceptability, and regular waste collection may require specific CBS health and safety training for infection prevention control.

Decolonizing development: a practical approach applied within a Rwandan sanitation social enterprise
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Additional Authors: Nicholas Kuria

Background and Motivation:
Decolonizing development has been a priority for many international development practitioners and researchers. Decolonization efforts have aimed to shift power structures between western interests and community beneficiaries through concepts such as "Self-reliance," "resilience," and "increasing country voice". However, there are few good examples of moving beyond decolonization concepts to on-the-ground implementation within international development organizations. In this work we outline our approach that has been put into action by a sanitation organization in Kigali, Rwanda.

Pit Vidura, originally launched by an American expatriate founder in Rwanda, delivers safe and affordable fecal waste emptying services for low-income households in Rwanda. After three years of operation, an effort was launched to transition the leadership, operation, and ownership of the company to the local team.

Process:
This work has been taking place over a 3.5 year period and within the context of a social enterprise that provides waste collection and transportation services for low-income households in Kigali, Rwanda. The following events have constituted the organization's efforts to transition the leadership, operation, and ownership of the social enterprise:

1. Leadership training for Rwandan general manager
2. American CEO stepping down and moving to an advisory board role
3. Rwandan general manager and R&D team seeking out and applying for grants
4. Launch of Rwandan led research and development team
5. Shareholding for senior employees

Results and Key Insights:
Increased service coverage and revenue generation since transition to local leadership
Since the leadership transition in 2020, the service has successfully expanded its reach to more households than ever which has lead to a total revenue increase and less reliance on grants.

Table 1. Revenue and Grant Consumption Before and After Leadership Transition

	Year 2018	Year 2019	Year 2020	Year 2021	Year 2022
Total Revenue	$ 50,554	$ 175,234	$ 229,131	$ 227,980	$ 162,658
Consumed grant	$ 18,046	$ 135,280	$ 117,599	$ 131,275	$ 7,661

Non-leadership advisory roles for westerners:
The western advisory board members have been seen as supporters and enablers of the local team's mission, as opposed to driving the vision of the local team's efforts. Since the transition, the advisory board which includes five members from the global north, has successfully done work to further the work and vision of the local team such as proofreading grants, proofreading papers for submission in peer reviewed journals, alerting the team about funding opportunities, and supporting the R&D efforts with specific domain expertise. The advisory board has no financial interest in the organization but provides support as needed to the local team.

Challenges accessing resources from non-elite circles:
One of the main challenges for the local team remains garnering grant funding without the same personal relationships and qualifications as those in "elite" western circles. Furthermore, applying for grant opportunities in English and adhering to stringent reporting requirements are barriers for the Rwandan team accessing support to grow their operations and reach in their communities.

Microplastics exposure in young children in Mali
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Micro- and nanoplastics (MnP) are omnipresent in the natural and built environment. Existing research has identified MnP pollution sources, as well as its presence in environmental water, drinking water, food and soils, and the accumulation and exposure by people. Evidence indicates a correlation between the ingestion of MnP by adults, gut inflammation and its relation to MnP concentration in stool. Common conditions such as diarrhoea will therefore exacerbate the potential harms of MnPs, increasing inequalities.
We have established analytical methods and libraries for MnP characterization and conducted two sets of pioneering preliminary studies in Mali:

1. Mapping of plastic use/garbage in households in Urban and Rural Mali: How are plastic items used in the household e.g. utensils or containers related to eating or drinking, and the extent of plastic waste in the household compounds?

Methods:
Study-1: Explored the above research questions in 280 randomly selected houses in 3 villages and 2 urban Bamako communities. A questionnaire collected data on use of common plastic items in the household. Observation of the waste areas (rubbish pile/container) and deposits around the compound in the household was done to estimate the presence of plastic in their rubbish/household waste. The questionnaire and observational data are coded to enable a comparison between urban and rural households, or by other characteristics such as the education level.
Study-2: Nested in a large RCT MaaCiwara study similar observations are being made about plastics disposal; data collection in progress and results available in July 2023.

Preliminary results: Study-1: 100% of the surveyed families used plastic items for kitchen or eating as well

as other household use in both urban and rural areas.
Studies-1 and 2: All households had plastic waste around their compounds; the measure of waste around the compound and in the waste pile/bin is currently being coded for quantification.

2. Identification of MnP in stools and child's drinking water: What are the overall MnP particle concentrations, total mass burden, and polymer types in drinking water and stool of children aged 6-36 months across aforementioned cohort of infants in Mali?

Methods:
Cross-sectional random samples were taken from children's drinking water and stools chosen from the 27 children (6-36month) who were sampled in 60 urban and 60 rural communities during the baseline data collection of MaaCiwara study. Florescent microscopy was conducted for 127 stool samples and 72 water samples to identify and quantify MnP, including characterisation of their particle properties (size, form and shape). Raman spectroscopy was conducted on 116 stool and 19 water samples to identify the types of MnP polymers (e.g. Polyethylene (PE) or polyvinyl chloride (PVC) or Polypropylene (PP), etc).

Preliminary results:
• MnP were detected in over 90% of the stool samples and most of them were classified as 'fibres' and some were 'fragments.
• Approximately 80% of the water samples were positive for MnP; both fibres and fragments were found.
• Several types of polymers were identified, the most abundant being Polyvinyl Chloride (PVC), Polyethylene (PE), respectively.

Detailed findings will be presented at the conference.

Occupational Health Risks Among Sanitation Workers During Faecal Sludge Emptying in Tanzania
Raphael Mginga, University of Dar es Salaam

Background:
Sanitation workers aspire to achieve safely managed sanitation (SDG 6.2) by 2030 through bridging the gap between sanitation facilities and faecal sludge emptying services. However, these workers execute this vulnerable work at the cost of their dignity, safety, and health as they often expose them to asphyxiating gases, faecal contact, and detritus objects which risking them to debilitating infections, injuries, social stigma and even death. Sanitation workers provide a vital role for public health and SDG 6.2 achievement, but the occupational health risks posed by emptying service to this workforce is inadequately documented or is lacking at all. Thus, this study aiming to assess and prioritizing the health risks and to propose the health safety measures to protect sanitation workers and dignifying the occupation.

Sanitation workers: Sanitation workers in this study are manual and mechanical workforce that emptying faecal sludge from onsite sanitation facilities and transport to treatment or disposal site.
Research questions:
1. What are the existing emptying practices and critical safety measures undertaken by sanitation workers?
2. What are health risks posed during faecal sludge emptying to sanitation workers?
3. To what extent the health risks as a result of emptying are severe to the health of sanitation workers?

Data collection tools and methods:
This study is a cross-sectional comprises both qualitative and quantitative data collection methods conducted in Dar es Salaam Tanzania. Qualitative data were collected through focus group discussions (FGDs), in-depth interviews (IDIs) and Key informative interviews (KIIs). 30 FGDs were applied only to sanitation workers, 24 in-depth interviews (IDIs) administered to local and sanitation workers leaders' and 9 key informative interviews (KIIs) from government institutions and NGOs trade in sanitation, health and occupational safety and NGOs where conducted. However quantitative data were collected through physical observations of 36 emptying events to analyise practices and health risks posed to sanitation

workers and its associated factors and safety measures undertaken by sanitation workers.

Data analysis:
Quantitative data was analyzed by using bivariate analysis using x2-test while qualitative data was analyzed by using integrated behavioral modal for WASH (IBM-WASH) to describe the existing emptying practices and its associated factors. '5 Why' analysis was used to understand the ins and outs of health risks during FS emptying instead of relying on apparent and too 'Risk Exposure and Tolerance Assessment Tool' (RETA Tool) was used to assess risk exposure-tolerance. Finally, the health risks among sanitation workers were prioritized and ranked by using 'Risk Matrix'.

Key findings:
Tables, graphs, charts and figures were generated to describe the results in simple sense of understanding. Asphyxiants gases through inhalation and bioaerosols were found to be the most serious problem facing emptiers, most of workers are informal and several emptiers are not using PPE on job, few of them are taking tetanus injection and majority of sanitation workers do not have medical insurance.

Significance of the findings:
The prioritization of the risks to the highest risks is to inform stakeholders in sanitation sectors to improve the system through a combination of controls in sanitation chain. Mixture of control could take in emptying guidelines development, behaviour change, technology upgrades and improved standard operating procedures.

Discussion and recommendation:
Sanitation workers are often exposed to health risks whereas majority of them go through unfortunate health conditions related to their occupational and unappropriated of stakeholders linked to health, safety and lack of PPE. Additional, emptying can be used as a solution to reduce employment problem for many youths in urban residents, therefore, considering it as an employment opportunity, professionalize and institutionalize it will bring a positive change in dignifying and formalize the occupation of emptying.

Effects of Climate Vulnerability on Household Sanitation Access, Functionality and Practices in Rural Cambodia
Rana Abdel Sattar, iDE
Additional Authors: Jennifer Roglà, PhD Toeur Veasna Tyler Kozole Chris Nicoletti James Harper, PhD, PE

Background/Problem Statement:
In Cambodia, climate vulnerability often takes the form of flooding. Seasonal flooding is common and widespread. Flooding typically occurs for more than three months every year across approximately 80 percent of Cambodian territory (ADPC & UNDRR, 2019), and approximately 2.5 million people live in flood-prone regions (Bukauskas et al., 2017). This population must regularly manage threats, temporary dysfunction, or damage to their sanitation systems.

Objective:
In this study, iDE explores the link between climate vulnerability, toilet functionality, and fecal sludge management (FSM) intentions and practices of rural households. The study seeks to answer the following research questions: 1) how does living in a climate-vulnerable region affect toilet abandonment? and 2) how does living in a flood-prone region affect toilet functionality and households' sanitation practices and perceptions?

Methods:
Data is collected through two household surveys, a latrine sales database, two flood-extent maps, and a composite climate vulnerability index (CVI) and analyzed through multiple linear regression and measures of association.

Results:
Both higher climate vulnerability and rates of poverty increased toilet abandonment: for every one point increase in CVI, toilet abandonment increased by 4%, and for every percent increase in poverty at the district level, toilet abandonment increased by 1.2%. Additionally, linear regression showed that toilet dysfunction was affected by various factors, including living in a flood prone region and more people living in the household.

Compared to households in non-flood-prone areas, flood-prone households had increased understanding that putting untreated fecal sludge into a body of water was unsafe (6%), increased feeling that the safe disposal of fecal sludge was important (7%), and decreased social acceptance of resuming open defecation during toilet dysfunction (5%). Conversely, flood-proneness did not impact awareness of the practice of "flooding out" (opening a pit's lid during a flood to drain its contents), feeling that the treatment of fecal sludge before disposal was important, or households' sanitation practices, including having more than one pit, pit piercing, and the choice of practice when a pit fills (with the exception that deeper pits were more common in flood-prone regions).

Conclusions:
The link between climate vulnerability and sanitation is clear: climate vulnerability negatively impacts toilet functionality and encourages unsafe sanitation practices, such as latrine abandonment. Because climate change increases the frequency and irregularity of heavy storms and floods, increased toilet abandonment and dysfunction are likely to increase in climate-vulnerable regions. These issues will be magnified for the poorest households in rural communities. Rural households living in flood prone areas are also more likely to face challenges with latrine functionality and more frequent occurrences of pit fillings.

Based on these findings, we make the following suggestions: 1) further investigation is needed on the impacts of climate hazards on rural sanitation infrastructure and household sanitation practices to encourage practical implementations of climate-resilient sanitation; 2) access to affordable sanitation products and FSM services must consider both uptake and maintenance, particularly in climate-vulnerable regions; and 3) sanitation development programs' focus must broaden and become more holistic to include climate vulnerability.

Adoption of Point-of-Use Chlorination for Household Drinking Water Treatment
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Background:
Centralized chlorination of urban piped water supplies has historically contributed to major reductions in waterborne illness. In locations without effective centralized water treatment, point-of-use (POU) chlorination for households is widely promoted to improve drinking water quality and health. Realizing these health benefits requires correct, consistent, and sustained product use, but real-world evaluations have often observed low levels of use. To our knowledge, no prior reviews exist on adoption of chlorine POU products.

Objectives:
Our objectives were to identify which indicators of adoption are most often used in chlorine POU studies, summarize levels of adoption observed, understand how adoption changes over time, and determine how adoption is affected by frequency of contact between participants and study staff.

Methods:
We conducted a systematic review of household POU chlorination interventions or programs from 1990 through 2021 that reported a quantitative measure of adoption, were conducted in low- and middle-income countries, included data collection at households, and reported the intervention start date.

Results:
We identified 36 studies of household drinking water chlorination products that met prespecified eligibility criteria and extracted data from 46 chlorine intervention groups with a variety of chlorine POU products and locations. There was no consensus definition of adoption of household water treatment; the most common indicator was the proportion of household stored water samples with free chlorine residual above 0.1 or 0.2 milligram per liter>0.1 or 0.2mg/L. Among studies that reported either free or total chlorine–confirmed adoption of chlorine POU products, use was highly variable (across all chlorine intervention groups at the last time point measured in each study; range: 1.5%–100%; sample size-weighted median=47%; unweighted median=58%). The median follow-up duration among intervention groups was 3 months. On average, adoption declined over time and was positively associated with frequency of contact between respondents and study staff.

Discussion:
Although prior research has shown that POU chlorine products improve health when correctly and consistently used, a reliance on individual adoption for effective treatment is unlikely to lead to the widespread public health benefits historically associated with pressurized, centralized treatment of piped water supplies.

Engaging the Informal Private Water Sector to Respond to Water Supply Needs in Urban Areas
Rolando Wallusche Saul, Catholic Relief Services
Additional Authors: Jennifer Weatherall

Purpose and Study Design:
CRS, with funding from USAID, completed a comparative study in Maiduguri, Nigeria that sought to identify the most effective and sustainable way of meeting water needs of urban populations affected by a protracted humanitarian crisis. The research question was: 'Is it more effective to directly support an existing informal private water sector rather than rehabilitating existing boreholes and handing over management to a community managed water committee?'.

Experience in protracted crises points to little to no engagement with the informal private water sector to meet humanitarian water supply needs. Instead, humanitarian actors continue to employ traditional ways of working that rehabilitate existing water points, and hand these over to community committees to manage. This common practice is fraught with challenges, and inherently unsustainable, as most community-managed water points lack effective cost recovery methods, and when breakdowns occur communities lack the resources and motivation to address repairs and restart services. Instead, CRS sought to pilot interventions that worked with informal private water vendors and their intermediary distributors "pushcart sellers", to see if this proved to be a more cost-effective approach to addressing the emergency water needs of displaced and host community members.

The research began with a market and technical assessment of the water sector and its infrastructure, followed by pilot activities that supported and incentivized informal private water vendors and water pushcart sellers to improve their practices and service delivery. The improved practices and service delivery, based on the result of pilot activities, were monitored against those of community-managed water supplies to generate evidence on the effectiveness of both intervention types and answer the research question.

To capture the effectiveness of the different interventions and enable comparative analysis, CRS implemented both market-based and non-market-based water supply activities followed by regular monitoring using mixed methods between 2020 to 2022.

Key Findings:
1. CRS invests less in private boreholes, but their water output is higher than that of community-managed systems. 2. The difference in water quality between private and community boreholes is minimal. 3. Post project, there was no significant difference in safety and cleanliness between community and private borehole compounds. 4. Private borehole owners invested more in the operation and maintenance of

their boreholes than communities did, resulting in more reliable services and fewer breakdowns. 5. Promotion of safe water-handling practices among intermediaries (i.e., pushcart sellers) resulted in continuation of these practices.

Informing Policy and Practice:
The study found there is substantial untapped potential to engage and partner with the private water sector in protracted crises, requiring WASH actors to rethink their traditional approaches towards community-managed water structures and to explore ways to increase local government investment in regulating these informal private water actors. Mapping of the water sector, both public and private, should form the foundation of any humanitarian WASH response in order to identify potential partners and explore opportunities to extend support.

Garbage In, Garbage Out: Building the Urban Sanitation Cost Database
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Additional Authors: Ruthie Rosenberg, Grant Mackintosh, Andrew Sleigh, Tristano Sainati

Rapid urbanization and population growth necessitate increased, and increasingly effective, investment in urban sanitation services. Ideally, new investment decisions would be informed by relevant cost data from existing systems. Unfortunately, the empirical data on the real costs of urban sanitation are sparse, and the little available data cannot be meaningfully analyzed due to wide variation in technologies, inconsistencies in classification of costs, and the rarity of actual systems encompassing the full sanitation value chain. Even the most sophisticated modeling tool requires high-quality data to generate actionable insights, and to date, such high-quality data on the real costs of urban sanitation are unavailable.

Climate and Costs in Urban Sanitation (CACTUS) offers a standard framework for collecting, analyzing, and reporting the highly complex and variable costing data that exists for current sanitation systems based on clear cost categories and distinct clusters of sanitation technologies that facilitate comparisons. Drawing on a robust foundation of empirical data collected to date, CACTUS generates standard cost reporting metrics - total annualized cost per household (TACH) and total annualized cost per capita (TACC), which incorporate total capital and operating costs over the full lifetime of the sanitation system.

Reliable and comparable benchmark estimates for costs of safely managed urban sanitation are a critical input for service providers and decision makers to plan and implement citywide inclusive sanitation. In the absence of such estimates, opportunities to share and apply learning are lost, and the pace toward SDG6 remains slow. CACTUS offers a codified approach for collecting, categorizing, and documenting empirical cost data and generates standard reporting metrics. These metrics - TACH and TACC - enable meaningful comparison across factors such as technology type, geographic location and population size, which has so far been impossible in the sanitation sector.

CACTUS generates benchmark cost ranges based on selection of up to three combinations of technologies across the sanitation value chain. Anyone with empirical data from delivery of sanitation services anywhere along the value chain can strengthen the TACH and TACC estimates CACTUS generates by reporting cost data according to the CACTUS framework; the utility of the tool will increase as the database grows. By familiarizing participants with the CACTUS framework, the free, user-friendly, Excel-based data collection tools and the benchmark cost estimates that are already available, this session will motivate service providers, government and funders to use and contribute to this valuable resource. Through widespread adoption of CACTUS, real costs for urban sanitation can be compiled and analyzed to harness lessons learned and accelerate progress toward safely managed sanitation for all.

Exposing the unexposed: a strategic approach towards ensuring safe sanitation in Dhaka city
Adnan Hakim, UNICEF, Bangladesh
Additional Authors: Atiqul Islam, Dr. Md. Mujibur Rahman, Mehedi Hasan, Neelima Thota, Dr. Roshan Shrestha

Dhaka, the capital of Bangladesh, around 30,093 residents live per km. According to Dhaka Water Supply and Sewerage Authority (DWASA) only 20% of city population are connected to sewerage system. The remaining areas are supposed to be covered by on-site system (ideally, consisting of septic tank and soakage pit). The reality, however, is that most of the old sewer network system elements are dysfunctional, and hence unable to convey sewage to treatment plant; on the other hand, inadequately designed and built septic tanks (mostly without soakage-pits) are also not serving the purpose in absence of planned fecal sludge management systems. The waterbodies of the city are grossly polluted with untreated domestic sewage.

With the goal of restoring the water quality of lakes and canals, the Dhaka North City Corporation (DNCC) took an initiative of 'sanitation compliance assessment' in the catchment area of Banani-Gulshan-Baridhara lake. The assessed areas are considered the wealthiest areas of the country. The assessment was planned for 4358 buildings/lots (33% of all lots) with a pre-checked questionnaire along with physical checking of sanitation facilities. Compliance criteria were developed considering aspects of septic tank design, existence of functioning soakage pit, and discharge of sewage into storm drains and lakes. Among the areas, Banani and Gulshan that have seen planned development since early 1960s, are mostly under the old sanitary sewer network, while Baridhara and Niketon developed in 1980s and 1990s are not covered with sewer network, and as per building regulation, septic tank along with soakage pit system must be built.

The study findings reflected an awfully bad sanitation situation in wealthiest areas of the city. In Baridhara, out of 550 buildings surveyed, septic tank exists in only 56% of buildings and an astoundingly less than one percent (1%) passed the compliance criteria. The remaining 44% of the buildings discharge sewage into storm drains and into the lakes. The situation is even worse in Niketon. In Banani (1166 house lots surveyed) 47% claimed to have connection to sanitary sewer network but only 32% could confirm by showing sewerage bill, 16% have septic tanks but only 2% complied. The situation is even worse in Gulshan. In both Banani and Gulshan areas, it could not however, be ascertained whether sewer connections are with the sanitary sewer network or sub-surface storm drainage network.

The study findings are immediately got concerned authorities' attention. As an immediate reaction, the Mayor of DNCC visited the areas and symbolically, blocked the discharge outlets of a few buildings using stem of banana trees. This caused a huge media attention and residents of these areas immediately turned to address the issue. In response, the DNCC took few immediate actions to improve cities sanitation systems: (i) set up a monitoring cell to track the correction for compliance (ii) strengthen law enforcement to dislodge illegal discharge points (iii) organized transformative 'sanitation technology Trade fair' connecting private sector with potential market (iv) initiated "schedule desludging" program and (v) launched communication campaign for a positive outcome towards safe sanitation practices.

Community Led Total Sanitation (CLTS) brings positive change to Ethnic Minority Communities in Northern Vietnam
Silvana Faillace, Church World Service
Additional Authors: Ngo Quoc Dung, Pham Thanh Hai

Background:
Since 2015, and continuing now, Church World Service (CWS) - in Vietnam is coordinating with partners to implement "New Integrated Development and Essential Action (New IDEA) for ethnic minority communities in Vietnam". This is a community development project with activities primarily focused on information sharing, knowledge growth and skills development (capacity building) for awareness-raising and community mobilization leading to behavior change to help families and communities improve environmental sanitation and hygiene at home and in public better than in earlier times. The project locations are Dai Tu district, Thai Nguyen province; Muong Te and Than Uyen districts, Lai Chau province; and Chiem Hoa district, Tuyen Quang province.

Objectives:
The evaluation assessed CWS contributions to improve (i) the personal hygiene and environmental

sanitation of the families and communities to improve the well-being of the people; (ii) the quality, safety and friendliness of learning environment at schools, and (iii) the quality, safety and friendly environment for patient care in health facilities. The evaluation provided evidence of achievements and impact of the New IDEA project (2015-2019) and it draws conclusions and shares lessons learned. This work was done in all project locations.

Methods:
This evaluation used a cross-sectional descriptive method combined with comparison and analyzes, including document review, data collection, information collection, quantitative interviews, in-depth interviews, observation, group discussion, KAP interview of households and school children, household, school, and commune health station checklists. The evaluation was conducted in 4 districts of 3 provinces. In each district, 67% of New IDEA communes and one control commune, were surveyed. In total, 13 communes, 22 villages, 12 schools, and 13 commune health stations were surveyed.
The total number of people providing information in focus group discussions (FGD), in-depth interviews (IDI), Knowledge, Attitude and Practice (KAP) questionnaires was 1,086, (male 443, female 553, ethnic minority 1,009; boy students 115, girl students 106, and students' parents 99).

Results:

The evaluation concluded that the project had 1) Improved household (family) / community environment, i.e., with better hygiene and sanitation; 2) Safer and friendlier learning environment for school children, and 3) Safe and friendlier environments for health examination and treatment.

In the surveyed New IDEA villages and communes, all respondents said that the community environment was improved: 92.89% of residents, officials, teachers and students were "satisfied" when asked about household and community environmental sanitation. This exceeds by 27% the 65% target and it is 23.5% higher than the 69.33% satisfaction in control communes with no New IDEA activities. The things people in New IDEA communes were most happy and satisfied with were these: 96% of households (95% of which are of ethnic minority households) having and using sanitary latrines; plus 92% of households were using clean water. Families also noted satisfaction with biosand water filters; collecting and sorting household waste; having clean village lanes and having more frequent community activities. Also, all surveyed villages have achieved and maintained Open-Defecation Free (ODF) status.

Conclusion:
The New IDEA project has contributed to improving household and community sanitation. Achieved results help ensure sustainability, largely due to (i) effective use of participatory approaches with adult/student consideration, and (ii) integrated interventions such as Community-Led Total Sanitation (CLTS); promotion of low-cost and innovative technologies appropriate in the specific situations in New IDEA impact areas. These lessons could be learned for Vietnam WASH program expansion to animal waste management, home trash/community garbage promotion, etc.

Assessing Water System Strengthening Interventions: A Building Blocks and Qualitative Information System Approach in Amhara, Ethiopia
Mussie Tezazu, Millennium Water Alliance
Additional Authors: Jason Lopez; Tamene Chaka; Zeynu Essa

Background:
Monitoring water system strengthening interventions is vital for enhancing transparency, accountability, effectiveness, and sustainability of achievements. A comprehensive monitoring system is necessary for understanding the various actors and factors influencing water service delivery. The Millennium Water Alliance (MWA), in collaboration with IRC WASH, designed a monitoring, evaluation, and learning (MEL) framework for its Sustainable WASH Program (SWP) in Ethiopia's Amhara region.

Methods:
The MEL framework employs a systems approach, using building blocks analysis and qualitative information system (QIS) scoring to assess water service delivery improvement over time. Building blocks are essential components of a strong WASH system, providing a manageable way to analyze critical elements. These building blocks are assessed using key statements representing core elements in an ideal scenario for sustainable water service delivery. The QIS methodology uses ordinal scoring scales to quantify qualitative process and outcome indicators.

Results:
MWA has used the building blocks analysis and QIS scoring to capture baselines, measure annual progress, and plan for end line evaluations of the five-year SWP. This approach has allowed prioritization of actions and measuring progress over time, ultimately aimed at improving service delivery. In addition, it has facilitated the evaluation of relationships between system aspects and water service delivery.

Conclusion:
The MEL framework, which combines building blocks analysis and QIS scoring, provides a comprehensive and contextualized understanding of WASH systems. This approach allows for the identification of strategic priorities, enhancing the sustainability of program benefits and improving health outcomes in collaboration with implementing partners and stakeholders. MWA aims to share its learnings and results with WASH actors globally, promoting effective monitoring of water system strengthening interventions.

(Waitlisted for poster presentation)
Reviewing a transformative model for empowering and dignifying sanitation workers' lives in regional Bangladesh
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Introduction:
Sanitation workers are central for the promotion of safely managed sanitation, and the achievement of SDG6.2. Unfortunately most initiatives on safely managed sanitation system focus on infrastructure (treatment plant) and logistics (desludging vehicles), with limited attention on sanitation workers. Training courses addressing occupational health and PPE, mostly offered as one off events, are regularly provided to sanitation workers. However, these attempts are neither effective nor adequate for improving the lives of sanitation workers.

So the question remains – what approach can most effectively protect sanitation workers and improve their livelihoods and dignity? It would need to address skills and education, confidence, collective platform and agency, access to technology, finance and business development services, social security, networking, and partnership development.

Action Research Methodology:
This paper presents the outcomes of 9 years (2014-2023) of practice-based action research. Initially working with 2 cooperatives of septic tank and pit-latrine emptier in 2014, this approach has utilised an "ideate-trial-review" cycle approach for constant learning and improvements - enabling the "Transformative Model" to emerge and be refined.
Over the past 9 years frequent FGDs, KIIs, Government meetings, learning harvesting workshops, project reviews, and external academic reviews resulting in peer-reviewed publications have all been utilised to learn, adapt and improve the approach - ensuring that the views and voices of the sanitation workers remain at the center of this approach.

Result – the Transformative Model:
The presentation will cover the learning, adaptations and impacts of the past 9 years of Transformative Model activities. It will review the programs current strengths and weaknesses, and particularly, the

sanitation workers' views and feedback.

The the current status of the "Transformative Model" for Sanitation Workers is as follows.
The model organizers sanitation worker communities, setting vision for changes (decent work and dignified lives), forming cooperatives, and prioritising female participation and leadership.
The cooperatives members collaboratively prioritize problems using participatory tools , with solutions identified , with required actions agreed and documented.
Necessary trainings, on job coaching, and mentoring support sanitation workers' development. New knowledge and skills subsequently enables cooperatives to apply for Government registration, thus formalising a previously informal sector.
Following registration, the model focusses on entrepreneurship development using externally respected tools (eg ILO toolkits) and approaches (participatory market system development).
Both male and female members are supported access and use locally developed, ingenious technologies to replace manual work.
Considering the high-risk nature of sanitation work, cooperative members are supported (often funded through municipality contracts) with social security schemes incorporating insurance for health and life from accidents and illness.
Finally, networking sessions are organized with employers to build partnerships and provide contracts for delivering faecal sludge management and solid waste management services. Thus completing the formalisation of cooperatives into legal, institutions with contracts for service delivery, improving working conditions, economic resilience and social standing.

Implication for practice and policy:
The "Transformative Model" is now being implemented as part of national Government and international development bank funded projects across Bangladesh. In addition to 56 cooperative Practical Action is supporting across 13 cities and the formation of national and city-level sanitation worker networks.
Furthermore, it is being incorporated into national level training for CWIS in Bangladesh.
It is applicable, with contextualisation, across contexts to transform the livelihoods and dignity of sanitation workers into the future.