Verbal Presentations
Improving the Lives of Children with Disabilities through WaSH Monitoring in Schools

Korydon Smith, University of Buffalo, SUNY

According to UNICEF, 94% of children with disabilities in Uganda do not advance to secondary school. While numerous factors are at play, a lack of safe and accessible water, sanitation, and hygiene (WaSH) facilities at schools is a major problem. Moreover, it is a global challenge. Worldwide, 190 million adults and 93 million children have some form of disability—80% of whom live in low- and middle-income countries and face a multitude of environmental, attitudinal, and institutional barriers while seeking access to education, employment, and healthcare. This presentation, therefore, focuses on achieving SDG4, particularly regarding the design of inclusive WaSH facilities in schools for children with disabilities. Special emphasis will be on the WHO/UNICEF Joint Monitoring Programme (JMP) for WaSH indicators in schools, which, in 2016, added accessibility criteria to a list of "expanded" indicators. While new indicators will provide a clearer picture of the accessibility of school facilities and advance the inclusion of children with disabilities, challenges remain in both data collection and implementation. In order to deepen the understanding of WaSH accessibility in schools, a team of researchers, practitioners, and students collected primary data on 30 Ugandan schools in March 2017 (to our knowledge, the first data collected using the new indicators). Results of the study will be presented. The discussion aims to (a) explain the concepts and implications of the JMP accessibility criteria, (b) discuss the state of facilities in Ugandan schools, (c) explore practical and innovative options for accessible WaSH in schools, and, ultimately, (d) frame areas for improving future monitoring tools, such as the JMP standards.

How Does Intervention Fidelity Affect the Impact of a WASH in School's Intervention on Absence, Diarrhea, Respiratory Infection, and Soil-Transmitted Helminths? Results from a Longitudinal Randomized-Controlled Trial in Laos.

Anna Chard, Emory University

Additional Authors: Matthew Freeman

Background: Evidence for the impact of WASH in schools (WinS) interventions on pupil absence and health is mixed; studies have reported null results and reductions for some sub-populations in absence, diarrhea, and respiratory and soil-transmitted helminth (STH) infections. However, most studies report results from intention-to-treat (ITT) analyses only, despite varied fidelity to the WinS intervention and important contextual implications. Policy and programmatic guidance requires a more nuanced approach to assessing program impact. We compare ITT and treated of the treated (ToT) results from a longitudinal randomized-
controlled trial (RCT) to assess the role of fidelity to a WinS program on pupil absence, diarrhea, respiratory infection, and STH infections. Methods: We randomly selected 100 primary schools lacking functional WASH facilities in Saravane Province, Laos and randomly assigned them to the intervention (n=50) or comparison (n=50) arm. The intervention delivered 3 toilets, handwashing facilities, an improved water source, and hygiene education. Schools were followed over 3 school years. At each unannounced visit we conducted a roll-call of all pupils; surveyed 40 pupils on recent absence, illness, and school and household WASH access and behaviors; and observed WASH facilities. Stool samples were collected each year prior to annual de-worming and analyzed for STH. We evaluated program fidelity based on 20 criteria for 6 WinS outputs (water supply, toilets, individual handwashing facilities, group hygiene activity promotion, group handwashing facilities, and drinking water filters). Results: In the ITT analysis, we found no evidence of an effect of the intervention on absence (roll-call or self-reported), nor did we find an impact on respiratory or STH infection. There was some evidence that the intervention reduced diarrhea in the dry season (OR: 0.56, p<0.01), though not in the rainy season or overall. The ToT analysis revealed lower odds of absence among pupils attending schools that met 76-100% of output criteria (OR: 0.76, p=0.02) compared to comparison schools, but higher odds of absence among pupils attending intervention schools that met few (26-50%) of these criteria (OR: 1.28, p<0.01). Compared to pupils attending comparison schools, odds of STH infection were higher among pupils attending intervention schools that met 0-25% (OR: 1.41, p<0.01) and 26-50% of output criteria (OR: 1.26, p<0.01).

Conclusion: This is the largest RCT of a WinS program on pupil absence and illness ever conducted in Asia, and the second largest globally. We found no overall impact of the intervention on absence or health. Results were dependent on fidelity to the intervention—where fidelity was high, we saw a positive impact on some outcomes. Incomplete adherence negatively impacted outcomes in pupils. Results are similar to ToT analyses in Kenya and Mali, and warrant greater monitoring of program fidelity to avoid adverse outcomes.

**Beyond CHAST: Investing in School WaSH**

Sarah Aguti, The Water Trust

Additional Authors: Angelique Dioguardi; Chris Prottas

The Child Hygiene and Sanitation Training (CHAST) methodology provides a foundation for leveraging schools to build stronger hygiene and sanitation habits and norms in children and their communities. This presentation will focus on the additional infrastructure investments and coaching needed to create an effective enabling environment for sustainably improved WaSH in schools in rural Uganda. The presentation will begin with a needs assessment of Mutunda sub-county in the Kiryandongo district of Uganda. This needs assessment will include an assessment of the cost to address the gaps and the resources available to the schools from government and student fee contributions. The presentation will proceed with an overview of the school WaSH program implemented by The Water Trust across all 18 schools in the sub-county. This section will summarize the construction and training support provided to ensure access to a functional water point, separate latrines for boys and girls, handwashing facilities, as well as effective facility management and financial planning, and effective hygiene education. Additional attention will be paid to: (a) human-centered design of the handwashing facilities (b) coaching of teachers
to integrate daily nudges for handwashing into their classroom management (c) financial training and coaching of the school management committee and parents and teachers' association. The presentation will proceed to summarize the results of the program on self-reported hygiene and sanitation behaviors, observed handwashing behaviors, and the presence and quality of school budget lines for maintenance and repairs. This discussion will include a review of the program’s lessons learned, with a focus on the following themes: shifting from conceptual hygiene knowledge to habit formation, the economics of school maintenance and repairs, and the role of menstrual hygiene management vs. parent beliefs on the role of girls in girls' dropping out of school.

4:00 – 5:00 PM

Redbud

Costing and Financing the Operation and Maintenance WASH in Schools (WinS) to meet targets under SDG 4 and 6

Bella Monse, GIZ

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WinS is highlighted in the Sustainable Development Goals (SDGs) under goal four on inclusive and equitable quality education, as well as goal six on available and sustainable management of water and sanitation for all. Target 4a is to build and upgrade facilities that are child, disability and gender sensitive; while targets 6.1 and 6.2 speak of achieving universal and equitable access to safe water, and adequate and equitable sanitation for all by 2030. Meeting these ambitious targets requires hardware investments in schools that are inclusive and child, and gender sensitive as well as concerted inputs towards promoting proper use and maintenance of constructed facilities to ensure they are sustained. A school’s access to resources to operate and maintain their WASH facilities is a necessary condition for well-managed WinS. These resources may be government funds or community support and needs involvement of parents and community members through an active School Management Committee (SMC). In 2014-15, UNICEF and Save the Children conducted an exploratory study to understand financing mechanisms for O&M of WinS facilities, and to identify good practices and areas for improvement. The study was conducted in 10 countries, namely Indonesia, Philippines, Armenia and Tajikistan; Kenya, Ethiopia and South Africa; and Bolivia, Honduras and Guatemala. The study confirmed that in all countries schools receive annual funding for school maintenance, either from their local or national government. There are national budgets for maintenance in Armenia, Indonesia, Tajikistan, Philippines, Egypt, Kenya and South Africa. Annual maintenance amounts ranged from as little as 0.86 US$ per child per year to 78 US$ per child per year; these figures depended on the activities covered by the funds. In a few countries, such as in Kenya this funding already has a dedicated budget line and recommended amount for maintenance of WASH facilities. However, no guidelines were found to orient principals and SMC to cost, budget and spend for O&M of WinS. Thus, in practice, schools often did not use these funds for their intended purpose. In 2016, GIZ embarked on the development of guidance for school level to a) define their WinS O&M needs, b) calculate the costs for those needs and
c) use that information to plan, budget and mobilize resources to improve their WinS status. This framework provides schools with the practical tools to determine the cost of consumables and labor for regular use, cleaning and simple maintenance of WinS facilities. The maintenance cost figures are on a per toilet facility and per-child basis which can therefore be used to determine the annual WASH maintenance requirement for an entire school. This tool has the scope to be user-defined and relevant to different WinS facilities and contexts. It is ready to be piloted with governments as practical tools are much needed to move forward meeting the 2030 goals for education and WASH.

A Systematic Review of Costing and Financing of WASH in Schools

Shannon McGinnis, Temple University

Additional Authors: Heather Murphy; Thomas McKeon; Richa Desai; Akudo Ejelonu; Stanley Laskowski

Background: Despite the success of recent efforts to increase access to improved water, sanitation, and hygiene (WASH) globally, approximately one-third of schools around the world still lack adequate WASH services. Inadequate WASH is still an issue in many countries due to a lack of awareness and government policies, insufficient budget allocations, and financial resources. As a result, in 2014, 80% of countries reported their current levels of financing are insufficient to meet their targets for drinking water and sanitation. This is especially an issue in rural areas that receive less than 10% of WASH financing globally. In order to improve budgeting and decision-making, it is important to understand the costs to implement and maintain WASH programs and infrastructure in developing countries. For these reasons, improving knowledge around cost components and potential methods of financing for future WASH programs may help to support the planning and designing of interventions at the school level. The purpose of this systematic review is to understand what costing data is available on WASH in schools globally, identify financing mechanisms that may help to support funding of WASH in schools, and address key considerations or barriers to take into account when designing budgets or financing models for WASH in school’s programs. Methods in an effort to recover all existing costing and financing data relevant to WASH in schools in a developing country context, two research questions were addressed in this systematic review: 1. What are the elements, and associated costs, that could apply to a WASH in school’s programs in a developing country context? 2. How can or how is WASH in schools financed in a developing country context? A systematic review protocol was developed using the "Cochrane Handbook for Systematic Reviews of Interventions" Results/Conclusions A total of 48 articles were included in this review. Sources referenced both rural and urban settings and included journal articles, government documents, graduate theses, NGO reports, and books. Only 12 of 48 articles made some reference to WASH in schools. Of these articles, one focused on hygiene education and latrine cleaning, one listed support tools that could be used for WASH in school programs, one discussed the benefits of funding school WASH, and nine discussed comprehensive WASH (including water supply, sanitation, and hygiene) in schools through case studies in Kenya, the Asian-Pacific region, Ethiopia, India, Uganda, Bangladesh, and Latin American Countries. Results show a lack of information around WASH costing, particularly around software elements as well as a lack of data overall for WASH in school settings as
compared to community WASH. This review also identifies several key considerations when
designing WASH budgets or selecting financing mechanisms. Findings may be used for advising
and planning future WASH in school programs.

**Blue Schools: Linking Wash in Schools with other SDG 6 Targets**

John Brogan, Terre des Hommes

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Water sanitation and hygiene (WASH) in institutions is an integral part of Sustainable
Development Goal #6. The Wash in Schools (WINS) community of practice has been highly
successful in developing and promoting methods and resources to provide students with access
to drinking water, sanitation facilities and hygiene education. Blue Schools is a promising
approach to raise awareness about the link between water, waste, food and environment
among children. Pioneered by the International Rainwater Harvesting Alliance and the Swiss
Agency for Development and Cooperation, Blue Schools complements standard WINS
activities with a school garden as practical place to show relationships between food production
and an efficient management of water, and demonstration of watershed management practices.
To contribute to the WINS community of practice, the verbal presentation / poster will
summarize the efforts in 2017 of Swiss Water and Sanitation Consortium experts from seven
countries to develop "Blue Schools 2.0", to include: 1) Best practices from based on lessons
learned in in more than 250 schools since 2011. 2) School demonstration of technologies that
enhance watershed management practices (per various Eco Regions); 3) Information and
inspiration for youth about career and business opportunities related to SDG6 topics. 4)
Guidance and materials for teachers to train pupils on the different topics.

**Dogwood**

**Utilizing Human Centered Methodologies to Retrofit an EcoSan Toilet in A Peri-
Urban Community of Lusaka, Zambia**

Jasmine Burton, Wish for WASH

At the beginning of 2016, the Zambian branch of Water and Sanitation for the Urban Poor
(WSUP) and Lusaka Water and Sewerage Company (LWSC) worked with Wish for WASH
(W4W), a Georgia Tech founded student startup, to retrofit one of the three-hundred
Ecological Sanitation (EcoSan) toilets in a Lusaka's peri-urban compound. The EcoSan toilets,
originally constructed in 2010 as "improved sanitation" through a project co-sponsored by SIDA
and CARE Zambia, were found to be largely misused (i.e. unsustainable composting practices)
or unused altogether. A pilot, therefore, was conducted to test new design of a functional and
desirable toilet facility that restored the superstructure of the EcoSan system. The W4W-
WSUP team's objectives were to design a toilet facility that was: “Recognized internationally as
an improved sanitation system in its functionality”. Used correctly and consistently by
individuals “Compatible and sustainable with the capacities of the local waste-management
service: Safe and accessible for children, handicap, elderly, and pregnant women” Scalable The
2016 pilot was hosted on a single plot of land with five permanent residents of the Chipata Compound who had previously received an EcoSan toilet; a team of W4W and WSUP engineers, designers, and analysts conducted logistics. Methodology for the pilot was rooted in human-centered design (HCD) practices. W4W's previously-developed SafiChoo sit-squat seat entered into HCD cycle, comprised of the three stages: hear, create, and deliver. "Hear" steps involved a baseline needs assessment and monitoring of the pilot household. "Create" stages were characterized by rapid product iteration while the "deliver" stage was the new product or service offering. The resulting pilot system included changes made to the front-end toilet interface offered by the SafiChoo toilet seat and the back-end collection capacity of an EcoSan superstructure in order to best address the needs and desires of users and waste management team. These iterations came in two stages that both included improved ways of moving the solid-liquid waste filtration to the back end of the system, minimizing the facility's odor while providing a sit-squat seat on the front of the system. Overall, interviews reflected a generally positive public perception regarding the W4W-WSUP combined design, although the team noted that there was likely some social desirability bias in interview responses. Many potential users commented on the durability and cleanliness of the toilet, as well as the comfort of the design. Moving forward, the team hopes to conduct a larger scale market viability pilot to test the concepts sustainability and scalability.

Quality Construction and Appropriate Toilet Technologies: Learnings for Improving the Sanitation Mission in India

Andrés Hueso, WaterAid India

Additional Authors: Arundati Muralidharan; Raman VR; Puneet Srivastava; Aakanksha Pathania; Nidhi Pasi; Chandra Ganapathy

While nationwide construction of toilets is underway on a massive scale promoted by the Swachh Bharat (Clean India) Mission in India, quality of construction and the use of appropriate technologies has emerged as a concern. In this context, WaterAid India, in response to a request from the Ministry of Drinking Water and Sanitation, Government of India, undertook a rapid assessment of toilet technologies covering eight Indian states, through a cross sectional survey of 1,204 households. Regarding prevailing toilet designs, over half (52%) had twin leach pits, 26% had a single leach pit, and one-fifth (21%) had some sort of containment structure though often reported as a septic tank. While the most suitable technological choice for most parts of the country probably is the leach pit, we found a growing preference for septic tanks with improvements in socio-economic status of households studied. Our findings suggest that among the households having a fully constructed and functional toilet, only a third of those toilets is safe and sustainable, that is, reliably preventing faecal-oral contamination for the foreseeable future. Another one-third is safe but will require major upgrades to remain so in the long term; mostly single leach pits or twin-pits that did not maintain sufficient distance between the pits. The remaining third are unsafe, in terms of not being protective of public health. This is related with lack of technological appropriateness for the geographies, such as leach pits in areas with very shallow water tables and/or not keeping a safe distance from water points. These problems might be related to the lack of information: only 47% of the households with constructed toilets, and 30% of households with toilets under construction received any
technical information about construction. Whenever information was provided, the Panchayats (local bodies) were the primary source. While promotion of twin leach pits has already been taken up by the mission, we recommend further prioritisation of: 1) Massive and multi-pronged communication efforts for (a) identification and mitigation of barriers to opting for twin leach pits for suitable conditions; (b) ensuring adherence to standards while constructing septic tanks; (c) promotion of suitable toilet technologies for different geographical conditions; and (d) building awareness on the safe distance between the leach pits and from water sources, 2) Ensuring safe technical services for emptying septic tanks as necessary, 3) Systemic improvements in transferring incentives in time in order to support quality construction, and 4) strengthening program monitoring including key technological and health aspects.

An Environmental Evaluation of Urine-diverting Dry Toilets (UDDT) in Hiloweyn Camp, Dollo Ado, Ethiopia

Travis Brown, CDC

Additional Authors: Patricia Akers; Jennifer Murphy; Molly Patrick; Yegerem Tsige; Ahmed Adow; Mohamed Abdirashid; Mohamed Nur Mohamed; David Githiri; Vincent Hill; Thomas Handzel

Background: Alternative sanitation technologies, such as urine-diverting dry toilets (UDDTs), could ensure safe and hygienic management of human waste in humanitarian settings, when pit latrines are impractical. Beginning in 2012, over 900 double vault UDDTs were installed in Hiloweyn Refugee camp in southern Ethiopia. We conducted a longitudinal environmental evaluation to determine the performance of UDDTs in order to provide guidance on their operation and to document factors (i.e., temperature, pH, moisture content, and storage time) influencing microbial inactivation within UDDTs. Methods: Environmental conditions and microbial inactivation were monitored over 12 months in 20 closed, shared-family UDDTs in Hiloweyn camp. Sealed nylon mesh bags, containing 3 g of representative UDDT waste and approximately 15,400 viable Ascaris suum ova, were embedded into the middle layer of existing waste inside vaults. In addition, bags containing 60 g of unaltered UDDT waste were embedded adjacent to Ascaris bags for analysis of pH, moisture content, and naturally-occurring E. coli concentration. After 0, 6, 9, and 12 months of storage, bags were removed and analyzed for pH, moisture content, E. coli concentration, and Ascaris viability. Performance of UDDTs was assessed using the World Health Organization guideline for safe use of excreta for agricultural use (<1000 E. coli / g total solids) and measuring log10 inactivation of viable Ascaris ova.

Results: Over 12 months of storage, average temperature of waste ranged from 32-36 °C; average moisture content of waste decreased from 9% to 3%; and average pH remained relatively constant at ~9. UDDTs that met the E. coli WHO guideline for agricultural use (<1000 E. coli / g total solids) increased from 30% to 95% from baseline to 12 months. After 6 months of storage, there was a >2.8-log10 reduction (>99.8%) in Ascaris viability. Conclusions: Data indicate substantial inactivation of Ascaris suum ova and E. coli in waste stored for 6 and 12 months, respectively, in UDDTs under hot, dry, alkaline conditions. Additional studies are needed to determine if waste stored in UDDTs meets WHO recommendations for Ascaris (<1 ova per gram total solids). Based on the results, 12-month storage of waste and the use of appropriate personal protective equipment are recommended to ensure a hygienic approach to
human waste management. Additionally, studies evaluating UDDT performance under different climate conditions are needed to better understand effectiveness of UDDTs in other low-resource settings.

**Bellflower**

**A Test of Ecological Sanitation as a Solution to Local Public Health and Global Climate Change Problems**

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Ensuring access to clean, safe sanitation for the world’s population remains a challenging, yet critical, global sustainability goal. Ecological-based sanitation (EcoSan) technology is a strategy for improving sanitation, particularly in areas where financial resources and infrastructure are limiting. EcoSan technology captures and composts human feces to transform pathogenic organics into nutrient and organic matter resources. EcoSan may therefore solve three important ecological challenges spanning local to global scales by (1) providing improved sanitation for vulnerable communities and reducing the spread of intestinal-borne pathogens, (2) returning nutrients and organic matter to degraded agricultural soils, and (3) reducing greenhouse gas (GHG) emissions compared alternative waste treatment technologies (particularly waste stabilization ponds). Quantitative data are however required to critically evaluate the potential of EcoSan to address these public health and climate goals. We quantified human health and climate mitigation potential of EcoSan in partnership with Sustainable Organic Integrated Livelihoods (SOIL), a Haitian NGO that uses EcoSan to produce sellable compost from human organics. We established replicated, controlled compost management experiments at SOIL’s composting operation. Compost management options included rainfall exclusion, cement floor linings, leachate recycling, and a sugarcane bagasse biofilter. We also compared EcoSan composting GHG emissions with those from a government-operated waste treatment pond and grassland where waste has been illegally dumped. We monitored GHG emissions (methane, carbon dioxide, and nitrous oxide) from SOIL’s static compost piles weekly for the duration of compost management. We regularly screened compost piles for pathogen presence and abundance from both solid compost and leachate samples. Leachate was also analyzed for mineral nitrogen and phosphorous nutrient content. Pilot field experiments were established to determine the effect of compost land application to yields of lima beans and spinach. The results suggested that EcoSan systems are effective at achieving dual sustainability goals including the provision of sanitation and mitigating climate change. Preliminary field application experiments also indicate that compost is effective at increasing crop yields, suggesting its importance in building resilience agroecosystems by closing nutrient cycles. Bacterial pathogens were eliminated in compost piles and leachate regardless of the type of EcoSan pile management approach. Higher moisture content in compost piles drove the highest GHG emissions, and moisture varied with cover, pile lining, leachate management. Emissions from unlined, uncovered, compost piles were 8x lower than lined and covered compost piles, and all composting approach emissions were lower than the dump and waste pond, respectively.
A Comparative Sanitation Infrastructure Analysis Evaluating Resilience, Community Priorities, and Sustainability Tradeoffs

Katherine Chambers, University of Colorado

Additional Authors: Sherri Cook

The number and impact of natural hazards has steadily increased globally, demanding the development and implementation of resilient sanitation systems. The ability to resist and accommodate future hazards must be prioritized in system selection, though these decisions cannot be made in isolation from community priorities and sustainability factors (e.g., socio-cultural, economic, environmental) that influence a project's long-term functionality. Resilience is defined as the ability of systems exposed to hazards to resist, absorb, accommodate, and recover from the effects of a hazard in a timely and efficient manner (UNISDR); while sustainability is defined as a system's ability to meet community priorities and function properly over time. The overall goal of this work is to identify characteristics of resilient and sustainable sanitation systems to improve responses to natural hazards and ensure long-term functionality by (1) developing and ranking metrics to evaluate resilience and sustainability; (2) identifying and ranking community priorities to identify systems that are resilient and in alignment with these priorities; and (3) evaluating the social, economic, and environmental tradeoffs made when prioritizing resilience. There is limited data on natural hazards and their effects on sanitation systems, and few studies have explored how to enhance system resilience in alignment with community priorities. A phased, mixed-methods approach will be used to collect and analyze data on sanitation infrastructure in Ethiopia. In April 2016, the country suffered from torrential rains and corresponding flash floods that left nearly 240,000 people displaced. Most people displaced by floods (91 percent) returned to their area of origin, but seasonal displacement remains a problem. The research will be in partnership with the Red Cross (IFRC) and will take place with communities affected by flooding in Ethiopia's Awash River Basin. The first phase of research will take place this summer and targets community members, system operators, and implementing organizations through the use of interviews, observations, online questionnaires, and focus groups. Sanitation system resilience will be quantified and compared based on metrics including (but not limited to) repair cost, time, and frequency. Community priorities will be ranked using Analytic Hierarchy Process, a method that uses pairwise comparison to develop an ordered list of an individual's priorities in the context of a decision. The results of this summer's work will include an evaluation of sanitation infrastructure resilience and alignment with community priorities. This information will guide organizations in selecting systems that are resilient and meet community needs, increasing the likelihood of buy-in and long-term functionality. Future work will determine the socio-cultural, economic, and environmental tradeoffs made when prioritizing resilience in system selection.

Intervention Pathways Towards Improving the Resilience of Pastoralists in Climate Vulnerable Communities of Ethiopia

Argaw Ambelu, Jimma University
Building resilient communities towards recurrent droughts is increasingly becoming an important element in development endeavours, particularly among communities vulnerable to shocks and stresses. Despite decades of remarkable efforts made by governmental and non-governmental organization, the resilience capacity of pastoralists in Ethiopia remains poor. The aim of this study is to test the statistical relationships among the resilience dimensions that emerged through community consultations, and to identify the intervention pathways for effective resilience building efforts. Data were collected from 1058 randomly sampled households in Arero and Dhas districts of Borana Zone, Southern Ethiopia. The data were collected through interviewer administered structured questionnaire and observational checklist. Principal component analyses were done to develop composite scores of the different resilience dimensions. Structural equation model (SEM) verified the theoretical model developed during the community consultations. The SEM model indicated that the environment dimension mainly the availability of water resources is the basis for climate resilience in drought affect communities of Borana. The SEM also revealed that resilience towards impact of recurrent droughts was multi-dimensional and showed statistically significant (p<0.05) relationships. Consequently, household food insecurity manifested as ultimate outcome of poor resilience. Infrastructure and social services (β = -0.24), livestock dimension (β = -0.21), human capital (β = -0.12), psychosocial distress (β = -0.1) dimensions significantly (p<0.05) affected the status of household food insecurity. Furthermore, livestock and wealth (β = 0.16), wealth and infrastructure (β = 0.06), infrastructure and human capital (β = 0.18), livestock and psychosocial distress (β = -0.09) dimensions have structural relationships and significantly influence each other. Environment and peace and security are found to be major underlying resilience factors and significantly associated with pastoralists’ resilience which affect other resilience dimensions. The intervention pathway indicated that intervention on the livestock and infrastructure dimensions could help to improve the resilience of these communities.

Mountain Laurel

Acceptability and Effectiveness of Household Membrane Filters Distributed in Internally Displaced Persons Settlements in South Sudan

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Additional Authors: Ilia Sadeghi; Trevor White; Anna Murray; Ayse Asatekin; Shannon Holding

Introduction. The Sawyer PointONE filter, a hollow membrane fiber filter with 0.1 μm pores, is a widely promoted household water treatment (HWT) option. In the laboratory, the PointONE removes >6-log of bacteria; however, in the field, lower log reductions, slow flow, and highly fouled membranes have been documented. As a compact, portable HWT option, the PointONE was selected for distribution to conflict-affected unstable populations in South Sudan. Due to the concerns detailed above, the distribution included a comprehensive monitoring program. Herein, the acceptability, effectiveness, and fouling results from 13 months of PointONE use are presented. Methods. A total of 773 filters were distributed in South Sudan from November
2015-January 2016. Beginning in January 2016, a quarterly survey of 95 households was conducted to evaluate acceptance, use, and maintenance of filters. Beginning December 2015, monthly water quality testing of stored household water for thermotolerant coliforms (TTC) was conducted at 60 households; if the result was positive, a new sample was collected directly from the filter. Two poorly performing filters were shipped to the United States, cut open at the inlet side and visually examined. One membrane fiber from each filter was removed, scanning electron microscope (SEM) images were collected, and energy dispersive spectroscopy (EDS) was used to characterize elemental composition. Results. Over 13 months, 68-91% of households reporting using the filter in the previous 24 hours. While 56-90% of households reported no problems, reported problems included slow flow; bad taste; water still dirty; and broken filters, syringes, or buckets. The majority could demonstrate correct use (97-100%) and correct backflushing (96-100%). Flow rate varied over time, from a starting average of 0.12 L/min to 0.05 L/min. In stored drinking water samples, 46% had detectable TTC (range 12-75% by month). Upon resampling, 0-40% of direct-from-filter samples were contaminated. Contamination increased over time and with surface water use. Backwashing and cleaning improved results. Visual inspection of used filters showed discolored membrane surfaces covered by a brown fouling layer, SEM results showed cake fouling layers on the inner and outer fiber surfaces, which were sufficiently thick that the membrane was not detectable in EDS analysis. Conclusions. In South Sudan, PointONE filters were found acceptable, with high rates of correct and consistent use. The filters effectively removed bacteria for a time, but effectiveness fluctuated with time, influent water quality, and cleaning. Fluctuations were attributed, in part, to membrane fouling. In general, PointONEs have the potential to improve household water quality in emergencies; however, as with other available filters, there are risks that should be addressed through appropriately designed programming, including use and cleaning instructions, household visits, and periodic monitoring.

Assessment of Synthetic Hydroxyapatite (Fluorolith) filter material for the removal of Fluoride in Kenya

Nancy Githugo, Nakuru Defluoridation Co.

Nakuru Defluoridation Company Limited has over a decade of experience in production of bone char (BC) and Di Calcium Phosphate (DCP) Pellets fluoride removal materials in water. However, the use of these materials has over time been limited by several factors such as very high Fluoride concentrations in some water sources, hence frequent replacement of filter material resulting to sustainability concerns. A major challenge was that it was not easy to regenerate Bonechar, and also pellets could not be regenerated hence shorter filter lifespan. The above shortcomings triggered the need to have a better and affordable fluoride removal material hence the espousal and development of a locally made synthetic Hydroxyapatite material called Fluorolith®. Fluorolith® is a whitely granulate, insoluble in water and is made of CaO, P2O5 and H2O. Water filtration with Fluorolith® is selective for fluoride ion. It is the same mechanism that allows for fluoride uptake on Bonechar. Nonetheless, the uptake capacity of synthetic Hydroxyapatite is more than three times higher than Bonechar and Pellets. Unlike Bonechar and pellets, synthetic Hydroxyapatite can be easily regenerated a property with the potential to reduce water treatment costs, and no undesired by-products are generated. A study was done to assess the achievability of Fluorolith® as an affordable filter material in low-
income areas, in particular rural communities in the Kenya rift valley and the results showed that water treatment with synthetic Hydroxyapatite has the potential of affordability than Bone char and Pellets due to its high uptake capacity and regeneration was possible. Fluoride uptake as well as regeneration with Sodium Hydroxide was assessed in column experiments. Results from column experiments in the laboratory indicated that the fluoride uptake capacity of synthetic Hydroxyapatite is 7.0mgF-/g, further regeneration results indicated that on the three regenerations done there was considerable fluoride uptake. The average fluoride uptake after regeneration was 4.5mgF-/g in the second and 4mgF-/g in the third. Using the Laboratory findings a prototype filter using synthetic Hydroxyapatite was installed and monitored all through with three regenerations, fluoride monitoring showed an uptake capacity of 8.2mgF-/g with second regeneration uptake capacity of 5.7mgF-/g and third regeneration uptake capacity of 5.1mgF-/g. The difference between laboratory findings and field experiences most probably was due to slower flow rates in the field.

Priorities of Emergency WASH Practitioners when Selecting Household Water Filters

Candice Young-Rojanschi, CAWST

Additional Authors: Laura McDonald

Household water filters are widely used in international development. However, their use is less common in emergency contexts. This study aimed to understand the key parameters that contribute to selection of household water filters by WASH professionals in the emergency sector. This work supported the identification of filters for field testing within the Humanitarian Innovation Fund's (HIF) Emergency Household Water Filter Challenge (the Challenge). As such, the parameters selected for testing were based on those established by HIF for the Challenge. The study consisted of 19 interviews, in two phases: scoping and weighting. Interviewees were recruited through HIF’s Technical Working Group and through the Global WASH Cluster. They had a range of experience with filters - some had never implemented them, while others had extensive experience with multiple filter types. The nine scoping interviews shaped the methodology and led to the development of four emergency scenarios: 1) earthquake followed by cholera, 2) flooding, 3) complex emergency with a stationary population, and 4) complex emergency with a moving population. For the ten weighting interviews, respondents were first asked to divide 100 points between the three broad parameter categories of ease of use, performance, and logistics for each scenario. Next, again for each scenario, respondents divided 60 points between the six sub-parameters within each category. This process made it possible to determine each interviewee's prioritization of parameters for a given emergency scenario and compare this prioritization between emergency scenarios for a given interviewee as well as between interviewees. Variability between respondents was generally higher than variability between emergency scenarios. The two parameters with the highest overall variability were: 1) whether the filter required consumables, and 2) microbiological performance. Several interviewees stated that filters must be capable of viral removal for any application, while others stated that the removal achieved by most common filters was satisfactory, so they did not prioritize achieving greater microbiological performance. The parameter with the lowest overall variability was environmental impact of disposal, for which most respondents gave a low weight
in all emergency scenarios. They commented that although this parameter is important, in emergency contexts other factors are more important. The specific weightings and explanations provided by interviewees shed light onto the decision making process for selection, procurement and implementation of household water filters in emergencies. In comparing the variability between respondents and between emergency scenarios for a given respondent, it was found that there is not consensus among emergency WASH professionals as to which parameters are most important. Therefore, household water filter selection is not only context-specific but also practitioner-specific.

Azalea

A Rapid Assessment of Municipal Water Systems Following Hurricane Matthew? Haiti, 2016

Andrea Martinsen, CDC

Additional Authors: Richard Gelting; Jean Allain Darius; Othale Blanc; Myriame Dorfeuille

On October 4, 2016, southwestern Haiti was struck by category 4 Hurricane Matthew, affecting over two million Haitians, including 175,000 forced into temporary shelters. The large displaced population, coupled with damage to existing water infrastructure and limited municipal and household chlorination, led to heightened risk for waterborne disease such as cholera in the affected areas. This represented a risk for global health security because of the potential for emergence and spread of waterborne diseases. The National Directorate of Potable Water and Sanitation (French acronym DINEPA) began the Communal Water and Sanitation Technician (French acronym TEPAC) program in early 2013, which maintains two technicians in each of Haiti’s communes outside of Port-au-Prince. As of 2016, there were 258 TEPACs nationwide. Hurricane Matthew was the first major natural disaster following the initiation of the program. One TEPAC role is the implementation of water, sanitation and hygiene (WASH) activities in emergencies. During this emergency, the central DINEPA office, as well as UN and NGO partners, relied heavily on the TEPACs to identify areas of need and to facilitate response activities. With CDC support, TEPACs rapidly assessed the functionality and chlorination of community water systems following the hurricane, in addition to asking about the status of the system immediately beforehand. A functionality index was then calculated based on the number of functioning separate components, including intake structures, storage tanks, and supply and distribution pipelines, plus the proportion of kiosks and fountains that were functioning. This rapid assessment provided a snapshot of damage incurred during the storm using the existing DINEPA workforce. While just under a third of the water systems in the four main affected departments - Grand Anse, Sud, Nippes, and Nord Ouest - were damaged due to the storm, many were already functioning at suboptimal levels prior to October 4th. In the affected areas, a total of 48 water systems out of 151 incurred damage, with 82 systems rated as poorly functioning post-hurricane with a score of two or less (out of a total possible score of 7). Grand Anse was the most affected department with 11 systems out of 26 incurring damage. These data were used by DINEPA to direct WASH partners who are working on rehabilitation of systems to those most in need. Following the hurricane, TEPACs began routine monitoring of free chlorine residual for a subset of water systems. Additionally,
follow-up assessments are underway to continue to monitor the functionality of the damaged water systems. Having DINEPA technical staff on the ground facilitated timely data collection and improved coordination. Their utilization following Hurricane Matthew can serve as a model for other emergencies.

**Water, Sanitation, and Hygiene Access in Southern Syria: Analysis of Survey Data and Recommendations for Response**

Mustafa Sikder, Tufts University

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Introduction. In March 2011, armed conflict began in Syria; since that time 13.5 million Syrians are estimated to be in need of humanitarian assistance and 6.1 million are internally displaced within Syria. Before the conflict, >90% of Syrians had access to infrastructure water. The UNICEF WASH Cluster has been collecting data on WASH access within Syria. The goal of this work is to analyze data collected by the WASH sector in South Syria, to identify the most effective WASH response interventions. Methods. The WASH sector conducted a household survey in 17 sub-districts of Dar’a and Quneitra governorates of South Syria; permanent residents and internally displaced persons of urban and rural areas were randomly selected for survey inclusion. A 24-question survey was administered to gather information on household demographics, water collection, storage and consumption practices, sanitation and waste management status, and hygiene behaviors; drinking water samples were collected and tested for free chlorine residual (FCR) during the survey. Data from households with children under five were tabulated and univariate, multivariate and mixed-effect regression analysis were used to evaluate associations between diarrhea and WASH indicators (regression ongoing). Results. The dataset included 1,281 responses, with average household size of 7.6 persons, and 31.1% IDPs. Overall, 19.4% of households were headed by women, the average head of household age was 42.3 years, and 46.5% reported living in damaged or shared shelters. Water trucking was reported as the "most used source in the last 30 days" by 77.0% of respondents, ranging from 36.1-100% by sub-district. Network water was reported as the most used source of water by 22.0% of respondents (range 0-61.4%). Overall, 32.2% reported a secondary source of water, 41.5% of respondents reported spending two or more days without water, 34.0% of respondents reported they did not have enough water sometime in the last 30 days, and 26.1% of respondents reported they modified hygiene practices to adjust for lack of water. Respondents reported paying, on average, 20.5% of their income for water. The average FCR was 0.03 mg/Liter, with the majority of households (77.0%) having 0.00 mg/L FCR in their water. Overall, 75.3% of respondents reported having access to clean and functional toilet for all members (ranging 43.9-100.0%), and 49.5% of respondents were able to show a handwashing facility with soap and water to the enumerator. When asked about availability of hygiene items, 75.2% of respondents reported not being able to find or afford necessary hygiene items in the market. Discussion. To our knowledge, this is the first report of WASH indicators and diarrheal prevalence in children in the Syrian context. Since the conflict, centralized WASH services have significantly declined, and access to water is insufficient, haphazard, and costly. Further analysis is ongoing and will inform recommendations.
Redbud

**Women Sanitation Sales Agents in Cambodia: Barriers, Enablers and Potential Solutions**

Janita Bartell, WaterSHED

Additional Authors: Melita Grant; Sreyleak Chhin; Caitlin Leahy

Women are key stakeholders in water, sanitation and hygiene (WASH). They disproportionately benefit from improvements in household WASH and often drive household decision-making regarding WASH products and services. Yet, through monitoring data from its large-scale sanitation marketing program in Cambodia, WaterSHED observed that women are severely underrepresented and often underperform as latrine entrepreneurs in the rural WASH market. 16% of all latrine businesses are women-owned generating 13% of all latrine sales to program records. In that way, women not only lose out on income generation opportunities, but also have a very limited ability to drive innovation in sanitation products, processes and services. Existing literature on the role of women in business in Cambodia indicates that women face regulative barriers; restrictive cultural values; barriers to networking; lower levels of education and training; and limited access to finance and to business development services. NGOs, donors and government employ a range of strategies to support women entrepreneurs. This presentation outlines key findings from a comprehensive literature review on women in business in Cambodia and illustrates the findings using the case of women entrepreneurs in the WASH sector in order to identify gender-specific barriers and opportunities for women WASH entrepreneurs in rural Cambodia. Currently women’s limited participation as WASH entrepreneurs is a serious limitation for the sustainability, inclusiveness and effectiveness of the rural WASH market. Findings of the case study are based on 30 in-depth interviews with male and female latrine business owners across eight provinces of rural Cambodia. The results of this study demonstrate the strong influence of gender norms on women’s opportunities and ability to become successful WASH entrepreneurs. The data revealed that restrictive gender norms are at the root of most inequalities such as women’s very small professional networks, their limited mobility and lower levels of education. Rural households do not recognize these norms as underlying driver of inequalities nor do they question these norms. In sum, this presentation will provide an important contribution to the discussion how to understand and capture gender inequalities in the WASH market taken the example of Cambodia.

**The Last Taboo: Formative Research to Inform Menstrual Hygiene Management Interventions in the Pacific**

Chelsea Huggett, WaterAid
The impact of poor menstrual hygiene management (MHM) on women's and girls' participation in education and income generation in the Pacific, a sub-region with the world's lowest water, sanitation and hygiene (WASH) coverage, is poorly understood. Globally and regionally there is limited research on MHM beyond school settings, particularly among marginalized women. In 2016 the Australian Department of Foreign Affairs and Trade commissioned research in three Pacific nations to inform regional MHM programming. A multi-country mixed-methods study was undertaken in rural and urban sites in Papua New Guinea (PNG), Solomon Islands (SI) and Fiji, to examine barriers to women's and girls' effective MHM and impacts on their participation in education and income generation. 293 women, men and adolescent girls, including women working in informal economies and women with disabilities, participated in focus group discussions and interviews. Structured observations of WASH facilities were undertaken in schools and workplaces alongside an analysis of the availability, cost and quality of sanitary products. Menstruation-related beliefs differed across the three settings and were perceived to be a barrier to effective MHM, particularly in PNG and SI. As an upper-middle income country, Fiji has made greater progress in addressing MHM. Women working in informal economies in rural and urban areas in all three countries faced the greatest challenges managing MHM due to lack of access and affordability of quality sanitary products, the poor functionality of WASH facilities and associated user fees (where applicable). MHM challenges were compounded for those living in rural and remote areas and for those with a disability, and were related to accessibility/affordability of quality sanitary products, adequate information and functional WASH facilities. These challenges contribute to absenteeism from school and work. Across all countries, most adolescent girls aspired to use disposable sanitary products. This study informs approaches to improving MHM in the Pacific. It highlights the need for MHM solutions to address disparities between urban and rural populations, among women and girls working in informal settings and those experiencing disability. The preference by some women and most girls to use disposable products, despite widespread affordability and quality issues in rural and some urban areas, and a lack of effective, at-scale solid waste management systems make the issue of product alone a critical one. Meanwhile cultural beliefs that menstrual blood is ‘dirty’ remain a barrier to effective MHM for many women and girls. Poor MHM in SI, PNG and Fiji will remain a barrier to gender equality in each country without context-appropriate, cross-sectoral collaboration, that addresses areas of unmet need and focusses attention on the most marginalised. Most importantly the research findings call for women and girls to be at the centre of all solutions.

The Role of Gender in Community-Level Social Organization and Reduced Enteric Infection in Rural, Coastal Ecuador

Sonia Hedge, University of Michigan

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Despite dramatic reductions in childhood mortality in the past decade, diarrhea remains a major cause of preventable childhood deaths worldwide. Well known measures to prevent
diarrheal infection include good water, sanitation, and hygiene (WASH) practices. These behavioral practices, however, are influenced by a multitude of factors, including social organization. Women experience a continual tradeoff in daily tasks, particularly in low-resource settings, and play a unique role in influencing community-level social organization. Previous studies conducted on coastal Ecuadorian population have identified that a greater density of social ties between individuals in remote communities may lead to the spread of WASH practices, both individual and collective, and reduced diarrheal disease, however the role of gender was not examined. This study identifies how gender roles at the individual- and community-level are related to social organization in the context of WASH in 18 communities in rural, coastal Ecuador. From August to November 2016, we conducted in-depth interviews with men and women (5 per gender), and 4 focus groups in each community. Focus groups were purposively conducted with community leaders, adult men, adult women, and youth (13-18 years of age). The study team transcribed, coded, and discussed interviews for a thematic analysis by comparing existing theories on power dynamics with themes found in the data. We found that women experience a distinct set of stressors, largely, environmental, social, and sexual, that inhibit the role they play in social organization and the collection and treatment of water. Communities with higher agency amongst women experienced high social organization, with men playing a critical role in creating gender equity and enhancing agency among women. Both men and women, however, identified water insecurity as a primary stress and deterrent to social organization. The intensity of the stressors experienced by women were modified by ethnicity, living environment, and access to a natural water source. The indigenous populations in the region experienced more severe gender inequity than other ethnicities. This study has the potential to inform context-specific and gender-sensitive interventions.

**Dogwood**

**Water Scarcity in the Middle East**

Marielle Snel, World Vision

The Middle East has experienced many environmental concerns lately. Water resources are becoming increasingly scarce, especially for the millions there who already lack access to sanitary water. Some of these countries, including Jordan, Lebanon and Iraq are facing unique problems that require global and immediate attention. Beside their neighboring location, one shared factor of all these countries is their lack of water resources and poor water management. Water shortage has become an increasingly difficult problem to manage. More than 10% of the world's population live in a region where the demand for water exceeds its supply. The imbalance between supply and demand, along with persisting issues such as climate change and exponential population growth, has made reflecting on water reuse a necessary method for conserving water. Ironically, the Middle East has some of the largest oil reserves in the world, which produces most of the area's wealth. Even so, the region's climate and environment make living harsh. The Middle East requires water resources for its people as well as to maintain the suitable land for agriculture. Water conservation through WASH (Water, sanitation and hygiene) schemes is a critical element which includes policies, strategies and activities that are made to sustainably manage the natural resource fresh water, to protect the water environment, and to meet the current and future human demand. Population, household
size, and growth and affluence all affect how much water is used. Factors such as climate change have increased pressures on natural water resources especially in manufacturing and agricultural irrigation. This poster will reflect the goals and activities around water conservation undertaken by World Vision within the context of the Middle East specifically Jordan, Lebanon, and Iraq. A number of key water conservation schemes such as rain water harvesting, water conservation in groundwater resources, utilizing groundwater resources will also be reflected on in the poster with demonstrative pictures from the field.

The Economic Impacts of Large-Scale Water Infrastructure Improvements in Urban Zarqa, Jordan

Daniel Hudner, Social Impact

Additional Authors: Marc Jeuland; Matuesz Pucilowski

Jordan is a highly water scarce country facing acute sectoral tradeoffs in water use. Consumers in Zarqa, the country’s second most populous urban area, typically receive water from the municipal piped network for fewer than 48 hours each week, and engage in a variety of costly coping strategies to mitigate the effects of water scarcity. Farmers in the Jordan River Valley use potable fresh water for irrigation, drawing on the same water sources as urban centers. The high demand for fresh water has been exacerbated by high population growth and an influx of refugees from the Syrian conflict. Against this backdrop, the Millennium Challenge Corporation entered into a $275 million compact with the government of Jordan, to improve the technical performance of piped water infrastructure, and increase the collection, treatment and reuse of wastewater, with the ultimate goal of increasing water efficiency and reducing poverty. This paper presents early evidence on the effects of the Compact, based on data collected towards the end of the implementation period. We find evidence of several changes in areas subjected to the different infrastructure improvements, including reporting of improved water pressure, increased connection to the sewer network and reduced sewage backups, and substitution of the source of irrigation water in the Jordan Valley. We also find evidence of spillovers within Zarqa, compared to neighboring areas in Amman that are supplied by a separate utility. A key category of anticipated impacts - reduced spending on expensive alternatives to utility water - however does not appear to materialize, possibly due to low confidence in the safety of this network water. Though these results only correspond to short-term effects of this infrastructure improvement, they add to a scant body of rigorous evidence on the benefits of capital-intensive water infrastructure.

Bellflower

Decentralized Sanitation as a Solution to Growing Tourism in El Salvador

Adam Keough, Catholic Relief Services

Additional Author: Paul Hicks
The coastal area of El Tunco, El Salvador, is comprised of several small towns with a population of roughly 3,000 permanent residences. Since 2010, thirty hotels, bars, restaurants and shops have been built or expanded in Tunco, and expansion is continuing at a rapid pace. Most of the small and medium businesses are located next to the Tunco River or along the beach. There are also various new development projects underway along the Gran River. On any given day, there are approximately 300 to 500 local and international tourists visiting the lively beach town. On weekends during the peak season, upwards of 3,500 people visit the bars and restaurants. The economic growth brought on by the boom in tourism has been positive for the community. However, the local infrastructure has not been able to keep up with the expansion, creating serious health and environmental consequences. To improve the sanitation system in El Tunco and the surrounding communities, an integrated approach is underway to address the different issues faced by the diverse communities along the Tunco river, as the contamination of the river is likely to affect the burgeoning tourist trade at the mouth of the river, where the contamination is most concentrated. By working together with the local business community, municipal officials, the ministry of tourism, and local non-profit organizations the community has decided to move to a decentralized and mixed systems approach to waste-water management. Decentralization will minimize operational costs and reduce the possibility of a major collapse in the system that could result in massive point source contamination of the coastal area. For all on-site septic systems, best practice guidelines are being established and supported by investment in correct sanitation infrastructure, to help existing residents improve their facilities and to provide information for new developers in line with improved standards. The replacement of current on-site sanitation systems with more appropriate designs will significantly help the communities in both the short and long term. On the main tourist strip, where space for individual septic tanks is not available, a large communal septic tank (or tanks in series) under the main street is to be constructed. Implementing a fecal sludge management program, comprising emptying services and treatment, will result in lower costs and discourage dumping of sludge into watercourses. The liquid effluents will be connected to a liquid-only sewer, which provide significant cost savings over conventional sewers. Separating the solid and liquid wastes allows for more targeted treatment options, potentially at different locations. Decentralization and mixed-systems allow communities like Tunco to achieve improved sanitation coverage that is scalable with operations costs that are cost effective.

Public Health Risks Associated with Unsafe Fecal Sludge Management in Accra, Ghana

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The SaniPath tool (SaniPath.org) has been used to evaluate public health risks from unsafe fecal sludge management (FSM) in low resource urban neighborhoods of Accra, Ghana, Vellore, India and Maputo, Mozambique. Based on the results shared from these studies with development partners and local government decision makers, there was a demand for an assessment that could characterize a citywide sanitation condition. We set to evaluate whether the SaniPath
tool can be used to characterize city level exposure from unsafe fecal sludge management using a sub set of representative neighborhoods with varying sanitation coverage, population density and socio-economic status. Accra Metropolis is a city with poor fecal sludge management. Using publicly available data, we selected four representative neighborhoods from Accra of varying population density, sanitation coverage and socio-economic status. The four neighborhoods were classified using a score scale into "very poor", "poor", "moderate" and "good" sanitation neighborhoods. From April 2016 to August 2016, we collected behavior survey and environmental sampling data to understand public health risks from unsafe FSM associated with these neighborhoods. The behavior survey consisted of key informant interviews, transect walk with community leaders, surveys with community members and surveys with school children. The environmental samples were collected in public areas within the neighborhoods from the sea, beach sand, swabs from public latrines, soil, piped drinking water, open drains and produce. The data was analyzed using the SaniPath tool software. Overall, there was a general trend of fecal exposure that followed the classification of neighborhoods. However, produce had the greatest risk of exposure to fecal contamination regardless of the classification of the neighborhood. The proportion of the population exposed to produce across all four neighborhoods ranged from 93% to 96% and there was no significant difference in the high level (10^6.18 CFU per 100ml to 10^7.14 CFU per 100ml) of average E.coli concentration. Piped drinking water had the least risk of exposure to fecal contamination in all the neighborhoods and the trend of neighborhood classification was as hypothesized. Publicly available data available to decision makers may be used to characterize a citywide sanitation condition to advocate for action. Unsafe FSM can lead to exposure to fecal contamination irrespective of where you live.

**Onsite Treatment and Reuse of Blackwater**

Brian Hawkins, RTI International

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Our research is focused on the development and implementation of decentralized waste water treatment technologies that enable onsite water reuse, as part of a comprehensive strategy to sustainably address sanitation needs in water- and energy-scarce environments. Using an electrochemical process that oxidizes chloride from urine into chlorine, we have demonstrated the feasibility of disinfecting blackwater with affordable, off-the-shelf technology, making it safe for reuse as flush water in a prototype toilet system. With repeated recycling, the process liquid requiring treatment reaches a steady state with high conductivity, high turbidity, and a considerable chemical oxygen demand (COD), which are associated with an increase in the energy required to achieve complete disinfection. Moreover, the persistence of color, turbidity, and odor in the disinfected liquid negatively affects the user acceptance of recycled blackwater as flush water in field tests of the toilet. Here, we describe efforts to improve the efficiency of the disinfection process and the quality of the recycled liquid. Studies on the system at steady state revealed that running the electrochemical process at higher voltage improves energy efficiency, and established running parameters that reliably achieve disinfection at fixed run times, enabling automation. Further, we found that increasing the tortuosity of the liquid flow
path through the pre-process settling system achieved a persistent reduction in turbidity and the apparent steady-state accumulation of COD, likely due to the retention of COD associated with larger particles in the settling tanks. This was achieved without additional filtration or retention time, and without enlarging the overall footprint of the settling tanks. Interestingly, these improvements did not result in improved energy efficiency of the electrochemical disinfection process, as predicted. These observations, together with a particle size distribution analysis of COD in the process liquid, suggest that the dissolved components of COD represent the most significant energy demand on the electrochemical process. Thus, while improved settling does improve characteristics of the flush water important for user acceptance, improving the energy efficiency of electrochemical disinfection will require remediation of dissolved COD. Future efforts will investigate additional approaches to reducing COD in wastewater, and the potential of hybridized processes to improve the overall efficiency of onsite blackwater treatment and reuse.

Mountain Laurel

Characterizing the Biodegradation of Faecal Sludge in Pour-Flush Pit Latrines in South Africa

Francis de los Reyes, NC State University

Pit latrines receive an estimated 0.6 billion kg of faeces and 2.1 billion kg of urine from 1.77 billion people around the world every day. Once pits are full, the faecal sludge has to be removed, transported, and treated/reused. One of the biggest challenges in this sanitation chain is devising a hygienic, efficient, and modern way of emptying pit latrines. Previous workers have focused on devising the 'best' machine that can effectively and reliably empty any pit. The ideal machine is envisioned to be safe, hygienic, and economical, while being mobile and lightweight, allowing access pits located away from main roads. The machine should be robust, should be amenable to easy operation by a few personnel, and can be maintained using local expertise and supplies. However, because conditions and culture in different countries and regions vary, developing such a technology is difficult. To date, there is not a single machine that can be used to effectively remove faecal sludge from pit latrines of all types and with varying contents. We discuss these issues, and suggest that classifying pit emptying technologies according to the type of pit (e.g., wet pits with little trash, wet pits with lots of trash, and dry pits with lots of trash), should be the direction for machine design. We discuss criteria for ideal pit emptying devices deployed in a region: robust to handle trash, different strengths of sludge within pits, and a range of water content encountered in the same region. Optimizing pit emptying needs to include considerations of FS collection from the pit, to the road, and transport to a treatment facility, and not just pit emptying. A systems approach to pit emptying is discussed and should include analysis of other issues such as supporting small business owners and providing for proper safety and training.

Motivators and Barriers to Latrine Uptake in Rural Haiti

Candice Young-Rojanschi, CAWST
The coverage of improved sanitation facilities in rural Haiti remains very low, with only 19% of the rural population covered in 2015. After the emergency phase in response to the 2010 earthquake, the National Directorate for Drinking Water and Sanitation established a no-subsidy policy for the construction of household latrines as part of their strategy to improve coverage. This policy shift has led nongovernmental organizations (NGOs) to change their implementation models by eliminating subsidies. Helvetas, a Swiss NGO, is one such organization that is implementing sanitation projects in two rural areas of Haiti: Foret des Pins and Petit Goave. In Spring 2017, Helvetas and CAWST collaborated on a study to evaluate Helvetas-led sanitation projects. The study objective was to identify motivating factors and barriers that influenced the purchase and utilization of latrines by households in the two communities. Furthermore, the study explored the changes that happened after the no-subsidy policy was applied and after Helvetas exited. CAWST and Helvetas interviewed three key groups of stakeholders: households, masons, and community agents. Structured interviews allowed for comparison of responses within stakeholder groups and triangulation across groups. In total, 82 households, 16 masons, and 16 community agents were interviewed. Responses were coded and categorized. Based on this qualitative analysis, health and status were important motivators in both communities. In Petit Goave, social norms were another motivator, while in Foret des Pins, a key motivator was the hope of receiving a rainwater harvesting system if your household constructed a latrine. All three stakeholder groups reported that the main barrier to latrine purchase was lack of money. Masons and community agents, however, also mentioned lack of household understanding and willingness to pay as barriers. Foret de Pins provided an opportunity to explore the influence of subsidies on uptake, as some households had constructed latrines before the no-subsidy policy and some after. The main finding in this regard was that subsidies had not influenced the reasons for uptake - across groups, households provided the same reasons for getting a latrine. Petit Goave shed light on what happens after the implementing organization leaves the community, as this study took place a year after Helvetas exited. Capacity building of community agents and masons enabled them to play an important role during the project. When the project and its funding ended, however, community agents became less engaged, while the profits from sales kept the masons engaged and motivated. These findings have helped to improve Helvetas' understanding of the projects' successes and limitations, which will enable the them to: (1) capitalize on the experience, (2) replicate the approach in other areas of Haiti, and (3) share the approach.

Addressing the Barriers to Improve Latrine Use in Rural India

Sherin Daniel, World Vision India

Community led water security helps to develop a sustainable community water system. It is essential that the community feel responsible to manage, maintain and operate their own water access points. World Vision India considers that the establishment and training of a sustained community led water security system, as an integral part of every water project, in every community. World Vision India’s Unnnao area development program in Uttar Pradesh facilitated community led water security to equip the women SHG members with mechanisms, skills, tools and above all behaviour required for successful implementation and maintenance of
Water Security at community level. The community led water security established and allowed community residents to participate in a comprehensive training, which include extensive maintenance of water points including mainstreaming women and ensuring gender equality through skill development, hygiene and sanitation education, recording of financial flows, planning of weekly and monthly meetings about progress, and managing community use of the water system, including arbitration of any disputes and prevention against damage. The main function of the community led water security system is to manage the community water system: by overseeing day-to-day operations and setting policies, such as whether and how much to charge for usage to cover future maintenance costs, maintenance plan, regular servicing/overhaul of the facilities, change of fittings and (minor) repairs and cleaning the facilities. The CLWS also promoted health and sanitation education in the community. The role of CLWS extended beyond mere management and logistics. They also served to elevate the position of women within the community. Establishing leadership roles for women within project requirements and helping them to facilitate and shift attitudes on gender and traditional roles, allowing for greater social mobility. When women serve on water committees, it gave them more power and influence, which created continued change in a community. Further it ensured security of the facilities against vandalism, misuse, and damage from animals and ensured efficient use of the water system. Investing on the capacity of women SHG members to operate as private entrepreneurs, help women to mainstream as professional and business oriented personals who can proactively operate and maintain water sources within and outside their communities on a day to day basis. Ensuring that the local governing leadership are aware of their roles and proactively utilize their service to improve the functionality of existing water sources in a large scale manner.

Azalea

Data for Decision Making: Rural, Urban and Peri-Urban WASH Baseline Surveys in the Solomon Islands

Mamita Thakkar, UNICEF

Additional Authors: Kate Shields; Ryan Cronk; Waqa Tikoisuva

Title: Data for decision making: rural, urban and peri-urban WASH baseline surveys in the Solomon Islands Authors: Mamita Bora Thakkar, Katherine F. Shields, Ryan Cronk, Lydia Abebe, Waqairapoa Tikoisuva The economic and social well-being of Pacific Island Countries (PICs) is dependent upon the quality and quantity of their water, sanitation and hygiene (WASH), but these countries face unique challenges in water management. The ability of island countries to effectively manage the water sector is constrained by their small size, environmental fragility, vulnerability to a range of natural and anthropogenic hazards, and limited human and financial resource base. The PICs have shown the lowest increase in access to improved drinking water and sanitation since 1990 in the world and did not achieve the Millennium Development Goals (MDGs). However, the Solomon Islands did not have any nationally representative data to serve as a baseline for the MDGs. In 2015, survey data were collected from over 1600 households in randomly selected rural enumeration areas across all nine provinces of the Solomon Islands as a baseline for Sustainable Development Goal targets
6.1 and 6.2. While 55% of households had access to a basic drinking water source, only 14% had access to a basic sanitation facility, with 79% practicing open defecation. Seventeen percent of households had access to a basic hygiene facility. On the other hand, while the Solomon Islands Government adopted the Solomon Islands Rural WASH Policy in 2014, there is no policy document for WASH in urban and peri-urban areas of the country, which are growing at an annual rate of 3.5% - the highest in the Pacific. Informal settlements, which often lack basic services, now make up an estimated 40% of the population of the capital city of Honiara and are growing at a rate up to 12% per year. However, data about access to WaSH services in urban and peri-urban areas is not available. In an effort to start a conversation on policy for urban and peri-urban WASH, UNICEF Pacific and the Water Institute at UNC are currently collaborating on an urban and peri-urban WASH baseline survey. This presentation will explore the determinants of water availability, and sanitation and hygiene access in the rural Solomon Islands, in addition to sharing preliminary findings on WaSH access from the urban and peri-urban baseline. In addition, we will share insights on how multi-lateral and academic organizations can support data-driven decision making at the national level.

**Concepts of Hygiene in Islamic Faith: Qualitative Findings from Muslim Communities in Sylhet, Bangladesh**

Farzana Yeasmin, icddrb

Additional Authors: Mahbub Ul Alam; Khobair Hossain; Tania Jahir; Tarique Md. Nurul Huda; Adrian Bucher; Aleena Khan; Abu Mohd. Naser; Md. Mahbubur Rahman; Leanne Unicomb

Introduction: Although faith-based messages have potential for attitudinal change among members of the low-income communities, this approach has been largely underutilized in contemporary water, sanitation and hygiene (WASH) programs. Innate religious views can be used to encourage positive WASH behaviors among people particularly where religious influence is prominent. To understand religious views and beliefs related to WASH, this study was conducted among Muslim residents who share mosques. Methods: We selected four villages from three districts in Sylhet division and selected one Islamic school (madrasa) and the associated mosque in each of four areas. The field team used a list of names of adult males who attended Friday prayer and religious lectures regularly from the mosques' Imams (religious leaders) and randomly selected male participants. Adult female participants were selected from the same households. The field team conducted eight focus group discussions (four each with males and females) to understand the religious views on hygiene, existing WASH behaviors and barriers. We developed coding guides based on our research objectives. After coding, major themes were summarized and analyzed. Result: Some male respondents mentioned that they learned cleanliness when attending the Madrasa. They said that as part of Iman (personal loyalty to Islamic beliefs) they must wash their hands after using the toilet to maintain cleanliness. They reported that the Imams described that cleanliness was part of Sunnah (practice of Muhammad Sm) during religious lectures at mosques during Friday prayers. Most female respondents mentioned that they washed hands during Wadu (washing process that occurs before prayers) and one said that Wadu is necessary before reciting the Quran, the religious book of Islamic faith. All male respondents from one village said that they must wash hands 'to be sacred'. Most female respondents said that during menstruation they need to keep their body and cloth used
for menstruation neat and clean as it is a matter of sacredness. Some female respondents said that they washed their drinking water storage container with detergent because hygiene is part of Iman. They also mentioned that if they maintain cleanliness as part of Iman they would not fall sick. One female respondent said that those who do not maintain hygiene (cleanliness) will not have his/her namaz (prayer) accepted. One female said namaz will not be perfect if they do not wash their hands after using the toilet. Poor WASH infrastructure, affordability of materials and prevailing social norms were reported as barriers to maintaining hygiene, as found elsewhere in Bangladesh. Conclusion: There is evidence that some WASH behaviors are supported by the teachings of Islam. There is potential for religious views to act as motivators of WASH behavior as positive emotional drivers for future WASH interventions.

Utilizing Data to Strategize Around the Challenge of Covering Long-Term Maintenance and Replacement Costs for Rural Community-Managed Projects

Michael Staub, Water Mission

Maintaining long-term financial sustainability is essential to ensuring the continued functionality and utilization of clean/safe water systems into the future. Long-term financial sustainability is achieved when revenue rates exceed the combined costs of operation as well as rates of depreciation. Water Mission analyzed the financial trends of several of its projects from around the world, finding that nearly all projects were successful at covering their operational expenses, thus making them financially sustainable in the short-term. However, only a fraction was able to confidently maintain revenues to also cover depreciation costs, thus making them financially unsustainable in the long-term. This analysis covers projects from differing regions particularly Central East Africa, Honduras, Haiti, Peru, and Indonesia, regions where Water Mission has had a sustained presence for at least three years. All of these projects adopt a community-managed model that requires ownership, operation, and maintenance of a localized committee. Furthermore, each of these projects requires advanced treatment, particularly chlorination and in many cases filtration. Population sizes range from 300-3,000 people, set primarily in rural contexts. Such analysis has determined that Water Mission needs to engage a strategy that will increase revenues and/or decrease expenses. Strategies for increasing revenue may involve a broad range of approaches for improving "tariffs, taxes, and transfers," therefore requiring the involvement of numerous different stakeholders. On the other hand, strategies for expense management are more limited and can only address the issue in part.

4:00 – 5:00 PM

Redbud

Holistic Programming to Improve Girls’ Education: USAID’s ASPIRE Program in Malawi

Sarah Bramley, Save the Children

Save the Children is implementing the USAID-funded Girls’ Empowerment through Education and Health Activity (ASPIRE). This four-year, $18.2 million program (Basic Education $7 million,
PEPFAR $2 million, DREAMS $7.3 million, WASH $1.9 million) addresses girls' achievement and retention in Malawi. These indicators are alarmingly low and suggest that despite the commitment of the Government of Malawi (GOM) to improve the situation, Malawi is not meeting girls’ right to education. For girls to achieve academic success, they must enter and stay in school, be learning while in school, and be healthy and supported by their community at all times. Through partnership with USAID, Save the Children is addressing girls' needs holistically, by including interventions on literacy and curriculum development, teacher training and support, gender and life skills education, sexual and reproductive health, HIV/AIDS and water, sanitation, and hygiene (WASH), menstrual hygiene management (MHM), and community mobilization. This design aims to keep girls in school and learning. ASPIRE delivers improved educational achievement for girls in upper primary and secondary schools through an approach that combines (a) evidence-based approaches for effective teaching of foundational academic skills in the context of gender-sensitive learning environments, and (b) proven, socially-driven approaches to change positively social norms and behaviors influencing girls' retention. Our conceptual approach recognizes girls as actors in their own personal development, but contends that girls' development cannot be considered outside their social web of relationships, norms and systems. Our theory of change therefore posits three essential elements for sustainable impact: (i) If evidence-based approaches to develop girls' foundational literacy skills and a gender-sensitive learning environment - inclusive of adequate WASH - leading to improved learning outcomes; and (ii) If collective community dialogue and action positively change attitudes and behaviors directly affecting the causes of girls’ dropout to increase retention; and (iii) If girls are empowered with the knowledge, motivation and skills to be effective agents in their personal development; Then girls in upper primary and secondary school will demonstrate improved academic achievement. ASPIRE will benefit girl learners in all 315 primary and 40 secondary schools in Balaka and Machinga districts with the following key outputs: Output 1: Reading skills for girls in upper primary school improved. Output 2: Adoption of positive sexual and health-care seeking behaviors among youth ages 10-19 increased. Output 3: Key structural and cultural barriers for girls ages 10-19 decreased. Key activities to achieve those outputs include: “1,500 trained upper primary level teachers provide advance reading and writing skills to learners”. Primary schools receive over 390,000 textbooks, supplementary reading books and other reading.

**Adverse Pregnancy Outcomes Associated with Household Water, Sanitation and Hygiene in Indonesia**

Claire Chase, World Bank

Using panel data from the Indonesia Family Life Survey (IFLS) a sample of 456 pregnant women at the time of the survey were tracked to a subsequent wave, and their pregnancy outcomes (livebirth or miscarriage) observed. After controlling for other confounding factors, results suggest that having access to improved water at the time of pregnancy is associated with a 7 percentage point increase in the probability of a livebirth. This result is particularly driven by women living in rural areas where access to clean water is lower. Access to improved water also reduces the probability of miscarriage by 2 percentage points. Having an improved toilet in the home or living in a community with high coverage of toilets during pregnancy was not associated with pregnancy outcomes.
**Evaluation of Integration of Environmental Health Policies in Health Care Facilities in Malawi**

Ryan McCord, UNC Chapel Hill

Additional Authors: Lydia Abebe; Benjamin Meier; Irving Hoffman; Jamie Bartram

Malawi is one of many countries on the African continent to have transitioned to a decentralized governance system. This system, despite its potential benefits, often presents major challenges related to intra-governmental coordination and inconsistencies in practice. Given that health care facilities have only recently become a priority for WaSH interventions both worldwide and in Malawi, the environmental health policy structure is in its early stages of development and still faces many challenges. As a result, Malawi has faced barriers in connecting policies related to environmental health in health care facilities to the practices within the facilities themselves. As a part of the first comprehensive assessment of environmental health within health care facilities, we analyze the mediating mechanisms among environmental health policy stakeholders in Malawi, given their decentralized governance system. Through interviews with government officials at the national, district, and facility levels, we gathered information on the barriers and opportunities that have arisen as the government builds a stronger system to promote environmental health in Malawi’s public health care facilities. Preliminary results show support for the provision of environmental health infrastructure and services within health care facilities in Malawi’s existing policies. However, these policies are often not carried out at the facility level. Officials at higher levels cite challenges related to designation and coordination of responsibilities within the decentralized system in order to adequately respond to the needs of facilities. Officials at the facility level cite challenges of lack of access to resources as well as untimely response to the needs of the facility from higher levels of government. Further analysis of the results of this study will highlight specific opportunities for Malawi’s health officials to strengthen the coordination and integration mechanisms from the central government down to the individual facility in order to better enable the provision of environmental health within health care facilities.

**Exposing Key Benefits and Challenges of Environmental Sanitation Interventions in Health Care Facilities in Ségou, Mali**

Lydia Abebe, The Water Institute

Additional Authors: Edema Ojomo; John Brogan; John Tomaro

Inadequate environmental conditions in health care facilities lead to nosocomial infections. A recent series of rapid assessments of health care facilities in Mali found that water quality was insufficient in 61% of the facilities surveyed; water storage was inadequate in 50% of the facilities; triage of medical waste was incorrect in 75%; maintenance and disinfection of walls and horizontal surfaces was deficient in 69% of the centres; and patients attending 70% of the
facilities did not receive correct information on appropriate and effective hygiene practices. Since 2012, Terre des hommes (Tdh) has been implementing a project to improve access to adequate WASH measures in health centres in the Macina and Markala districts of the Ségou Region of Mali. The objective of the project was to improve WASH services in 35 health care facilities (HCF) visited by approximately 20,000 patients each year. This study exposes key benefits and challenges of Tdh’s health care facility environmental sanitation intervention in Ségou, Mali. Thirty-nine (39) interviews were carried out with participants who were involved in Tdh’s program in both of the intervention districts in Ségou: Markala and Macina. The study identified eight (8) key recommendations for improving training and eight (8) key recommendations for improving monitoring. Our findings can assist NGOs working with governments involved in health care facility improvement of environmental sanitation status to improve their approach to developing and implementing programs.

Establishing a National Baseline for WASH in HCF: Contextualizing the Joint Monitoring Programme’s WASH in HCF Indicators

Channa Sam Ol, WaterAid

Additional Authors: Por Ir; Srun Sok; Sophary Phan

Birth practices are rapidly changing in Cambodia. Fewer mothers are choosing to deliver their babies at home with traditional birth attendants, opting instead to give birth in healthcare facilities (HCF); since 2000, the percentage of facility-births has increased from 10% to 83% in 2015. Therefore, it is important that the HCF is a safe place for delivery. Ensuring safety requires sufficient clean water, accessible toilets, proper management of medical waste and good hygiene practices. Similar to many developing countries, Cambodia lacks coordination mechanisms and reliable national monitoring and evaluation mechanisms to ensure sustained improvements of WASH in public HCF throughout the country. The direction of the new National Health Strategic Plan (2016-2020) focuses on quality of care and universal health coverage. To track progress, the Ministry of Health (MoH) requested a baseline assessment on WASH in HCF. Building on pilot assessments, The National Institute of Public Health, with support from the MoH and the Ministry of Rural Development (MRD), developed an assessment tool based on the WASH in HCF indicators from the WHO/UNICEF Joint Monitoring Programme (JMP), focusing on the maternity ward and outpatient department (OPD). The assessment, which included interviews with HCF staff and facility checklists, was rolled out in 117 public HCF in five selected provinces between September and October 2016. The findings showed that 91% of assessed HCF had a basic water service (improved/on the premises), yet only half (49%) reported that the water source provided sufficient water year-round for all purposes. All assessed HCF had improved toilets, however when accounting for all of the JMP requirements, only 2% percent met the sanitation indicator. The figures for hand hygiene at selected points of care (OPD and delivery room/area and toilet), and healthcare waste management were relatively poor (15% and 14% respectively) when compared to national and international standards. The effort of the alignment of this assessment tool with the JMP indicators met several limitations including: the challenge of aligning basic service definitions with current building standards in Cambodia; the lack of national norms and standards for WASH in HCF in Cambodia to benchmark the assessment; the possible seasonal
bias that cannot be addressed by this cross-sectional study; the attention to measuring means or facilities rather than practices. These learnings are driving MoH and partners to develop the standard and norm for WASH in HCFs and consider the JMP tools. This is the first large scale, comprehensive assessment of WASH in HCFs in Cambodia. The findings and recommendations are being translated to initiate an MoH-led WASH improvement plan which is embedded within the national quality of care framework.

**Bellflower**

**Strong Heart Water Study: Designing a Multi-Level Participatory Intervention to Reduce Arsenic Exposure in American Indian Communities**

Elizabeth Thomas, Johns Hopkins University

Additional Authors: Joseph Yracheta; Martha Powers; Marcia O'Leary; Reno Red Cloud; Lyle Best; David Harvey; Joel Gittelsohn; Ana Navas-Acien; Christine George

**Background:** In the United States, arsenic contamination of groundwater supplies disproportionately affects rural populations using private wells. The Strong Heart Study, a prospective cohort study identifying risk factors for cardiovascular diseases in American Indian (AI) communities, demonstrated that chronic arsenic exposure was associated with an increased risk of cardiovascular disease, diabetes, kidney disease, and cancer. In response to these findings, the Strong Heart Water Study (SHWS) was initiated to design, implement, and evaluate a multi-level participatory intervention to reduce arsenic exposure. The intervention promotes point of use removal of arsenic in drinking and cooking water and health promotion for private well users in AI communities in North and South Dakota. The SHWS intervention package is being tailored through formative research to consider the individual, household, community, and tribal-level factors that may influence adoption, use, and maintenance of an arsenic removal device. **Methods:** In-depth interviews (n=34) were conducted across three Nations from 2015-2016 with private well users, Indian Health Service staff, community members, and other key stakeholders. Interviews were audio-recorded and transcribed for emergent thematic analysis. A community workshop (n=27) held in 2016 used listing and ranking to explore priorities regarding water and preferred communication channels for intervention delivery. A pilot trial of the intervention package began in February 2017. Results: Participants prioritized aesthetic qualities of water (e.g. temperature), safety, and other situational factors (e.g. cost) when considering their drinking and cooking water. Workshop participants emphasized the desire for communication of water test results, home visits for intervention delivery, and reminders to use filtered water. Interview and workshop findings informed intervention design, including health promotion messages and household items to facilitate use of filtered water for drinking and cooking (e.g. tankards to store and cool filtered water). Participants of the household trials reported positive experiences with the arsenic removal device and items supporting filtered water use. Household trials identified logistical and technological modifications needed for intervention hardware and software. Conclusions: The SHWS is the first study to develop a multi-level participatory intervention to reduce arsenic exposure among private well users in AI communities. Through formative research we identified personal, social, and situational factors that are influential in the adoption of risk-
modifying behaviors related to arsenic exposure in AI communities. This research provides critical insight into the design and implementation of drinking water interventions in AI communities. The SHWS intervention will be evaluated in a randomized controlled trial beginning in the summer of 2017.

**Arsenic Primer 2.0 - Updating a Resource**

Rick Johnston, WHO

Additional Authors: Jennifer DeFrance; Peter Ravenscroft; Fiorella Polo; Cecilia Scharp

In 2008, UNICEF published an Arsenic "Primer" - a brief document summarizing different aspects of programming to mitigate arsenic exposure and adverse health outcomes, targeting UNICEF WASH staff. In the nearly ten years that have followed, exposure to arsenic in drinking water has decreased substantially, but too many people still drink unsafe water with elevated levels of arsenic. Many experiences have been gained in this period, and the (WHO) Framework for Safe Drinking Water, comprising target setting, water safety planning and surveillance risk management framework of Water Safety Planning has become firmly entrenched in water safety programming. In 2015, a new 2030 Agenda for Sustainable Development was set and explicitly includes not only consideration of the preeminent public health threat from microbiological contamination but also requires tracking of arsenic and fluoride contamination. The 2030 Agenda aims for universal access to safe water for all, and therefore prioritizes those who do not yet have sustainable access to safe drinking water, including those consuming unacceptable levels of arsenic. It is therefore timely for the Arsenic Primer to be reviewed. UNICEF and WHO have collaborated to refresh and update this resource. The target audience has been expanded to include WHO as well as UNICEF staff, but also WASH practitioners in government and civil society. The content has been re-arranged to match the risk management paradigm, and updated with recent research and programmatic experiences, as well as to emphasize the risk management paradigm. The Primer contains three main sections: 1) Understanding the problem a. Arsenic impact on health b. Arsenic occurrence in groundwater and surface water c. Food and other sources of exposure 2) Bringing about solutions - reducing exposure to arsenic in drinking water a. Hazard mapping and preliminary investigations b. Measuring arsenic in drinking water c. Frameworks for safe water and target setting d. Water safety planning and risk prioritisation e. Provision of safe water f. Monitoring barriers g. Surveillance and measuring effectiveness h. Water resources management and sustainability 3) Multi-sectoral responses to arsenic contamination a. Health sector b. Agriculture sector c. Food and nutrition The presentation will introduce the updated primer and advocate for WASH programmers to consider arsenic in their work.

**Piloting School-Led Arsenic Testing in Sherpur District, Bangladesh**

Firoj Alam, UNICEF

Additional Author: Onabolu Boluwaji
Bangladesh has made significant progress towards achieving its goal of universal access to improved water supply. However, progress in improved water coverage has not been matched by progress in access to arsenic safe water. Although 97.9% of the population has access to improved water sources, about 19.7 million people are exposed to arsenic concentrations in drinking water above the Government of Bangladesh (GoB) standard (0.05mg/l) (MICS 2012-2013). A key challenge to scaling up arsenic mitigation is the large number of tubewells, an estimated 10 million, the majority of which are untested for arsenic safety. Though the sector has identified screening of tubewells, as the first step towards arsenic mitigation, most of these wells remain untested for reasons related to the absence of a water quality monitoring system, low access to laboratory services, lack of human and other resources and poor sustainability of interventions. Consequently, in collaboration with the local government and education ministries, UNICEF piloted the school led arsenic strategy in 4 schools in Sherpur District, Bangladesh between 2016 and 2017. Total 24 students were trained in arsenic testing and provided with field test kits for practical chemistry lessons and community members encouraged to come to the school for water quality testing. To date 600 wells have been tested and the data is being used by and the Department of Public Health Engineering for action. Households whose water showed high concentrations of arsenic were advised of alternative safe water options such as switching to reduce exposure. The preliminary findings indicate that school led water quality testing is a low cost sustainable approach for screening water sources; reducing exposure to arsenic and building the children (including girls) skills in science. It is a no cost/low cost arrangement within the reach of the arsenic affected people in the community.

Mountain Laurel

The Impact of Septic Systems and Rainfall Events on Groundwater Quality in Private Wells in Rural Pennsylvania, USA

Heather Murphy, Temple University

Additional Authors: Jingwei Wu; Susan Spencer; Aaron Firnstahl; Joel Stokdyk; Mark Borchardt

Background Pennsylvania (PA) has the second highest number of private wells in the US, with approximately 3 million people relying on well water. Private wells are not regulated by the USEPA or any other authority, and thus the burden is on the homeowner to test and treat their water accordingly. Between 1971 and 2008, 30% of all waterborne outbreaks in the US were associated with the consumption of untreated groundwater. PA had the second highest number of outbreaks during this time-period. Based on previous research, we estimate that there could be 81,000 cases of acute gastrointestinal illnesses (AGI) per year in PA due to private well water. This research investigated whether septic systems could be impacting the water quality in private wells in rural PA. In addition, we explored the impact rainfall events had on the occurrence of enteric pathogens and indicators in private groundwater supplies. This research will help State and Federal regulators establish guidelines to support households in the protection of their well water. Methods Five private wells were selected for preliminary study in rural PA. The wells were all located in fractured rock aquifers in Bucks and Montgomery Counties, two counties that have the highest density of private wells and septic systems in the state. Samples were collected every two weeks between May-August 2016 (n=34). Samples
were collected for general water quality analysis and for the analysis of E.coli and total coliforms using culture based techniques. At the time of sampling, large volumes (~800L) of water were filtered using dead-end ultrafiltration. Ultrafilters were sealed in sterile plastic bags and shipped on ice for analysis at the USDA-USGS laboratory in Marshfield, Wisconsin where they were eluted and concentrated using established methods. Concentrated samples were frozen at -80°C until analyzed using RT-qPCR for the following targets: human Bacteroides, human polyomavirus, pepper mild mottle virus, Campylobacter jejuni, Salmonella, enterohemorrhagic E.coli, norovirus GI & GII, adenovirus and enterovirus. Results/Conclusions The wells ranged in depth from 15 to 690 feet deep. All wells were positive for total coliforms (n=27) and 3 wells were positive for E.coli (n= 9), each on at least 2 occasions. All wells were positive for human Bacteroides on two or more sampling events (n=13). Four out of five wells were positive on one sampling event for the pepper mild mottle virus and one well was positive for human polyomavirus. Cumulative rainfall 7-14 days prior to sampling had a statistically significant relationship with the concentration of human Bacteroides. The results suggest that rainfall events and septic systems are contributing to contamination in these groundwater wells. Research is on-going to understand the temporal variability and confirm the source of contamination in these wells.

**Examining Well Water Quality and Emergency Resource Needs After a Flooding Event**

Adrienne Katner, Louisiana State University Health Sciences Center

Additional Authors: Kelsey Pieper; Komal Brown; Dongjuan Dai; Lauren O’Rear; Marc Edwards

Background: The summer 2016 flooding in Louisiana has been considered the worst U.S. natural disaster since Hurricane Sandy four years ago - 6.9 trillion gallons of rain between August 8 and 14, 2016. In addition to the extensive structural damage, private drinking water wells were submerged under several feet of contaminated surface water for multiple days. Previous research has shown that microbial contamination is often associated with systems that have a higher probability of surface-groundwater interactions. Thus, well owners should be encouraged to take precautionary measures prior to floods (i.e., seal the top of the well) and shock chlorinate flood-affected wells before resuming use. This research explores weakness in dissemination of emergency information for private well users and examines its link to well water quality following the flood. Methods: In October 2016, 150 free water sampling kits were provided to well users in Livingston Parish - one of the worst impacted regions. Basic well water sampling kits were given to 100 participants, which included 250 mL first draw metals sample, and two additional 250 mL samples after a 1-minute flush for metals and microbial analysis. The remaining 50 participants received basic well water sampling kits along with three additional bottles for quantification of opportunistic pathogens (OPs). OPs samples were collected from within the hot- and cold-water premise plumbing and within the well. Metals were analyzed via ICP-MS and genetic markers for Legionella spp., L. pneumophila, and Mycobacteria were enumerated by qPCR. In addition to water samples, well users were asked to complete a questionnaire regarding 1) resident socio-demographics; 2) well construction; 3) well water use patterns; and 4) response behaviors and attitudes related to flooding. Results/Discussion: Only 25% of samples tested positive for total coliform bacteria and 4% for
E. coli. However, testing revealed non-flood related water quality concerns. Specifically, 48% of samples contained manganese above the EPA threshold of 0.05 mg/L and Legionella spp. DNA was detected in 57% of samples. Before the flood, 83% and 94% of well users indicated consuming and cooking with their well water, and this reduced to 41% and 59% after the flood. Despite this reduction, only 7% of well users sought well water testing after the flood, which was primarily because they did not know how or where to test (54%). Participants indicated a need for information about testing (92%) and treatment (79%). Most well owners reported that they were not provided with assistance or information about their wells before or after the flood (95%). During this flood, 68% of residents had to evacuate their homes (average of 8 days) and 55% of residents indicated that they had no power and 45% had no internet access when returning home. This sampling provides insight on the impediments to well stewardship, and well water conditions during a natural disaster.

Racial Disparities in Access to Municipal Water Supplies in the American South: Impacts on Children’s Health

Frank Stillo, UNC Chapel Hill

Additional Author: Jacqueline MacDonald Gibson

Background: Throughout the American South, African-American neighborhoods on the fringes of cities and towns were systematically excluded from access to municipal services, including water and sewer service, paved roads, and police and fire protection. More than five decades after the Civil Rights Act, many such neighborhoods still lack municipal services, instead obtaining their drinking water from private wells, which they must manage on their own. Due to a lack of monitoring data, little is known about water quality and associated health impacts of these exclusionary zoning practices. Objective: This presentation reports on an assessment of the prevalence of lead and associated impacts on children’s blood lead and IQ in peri-urban African American neighborhoods excluded from municipal water service in Wake County, North Carolina. Methods: Two first-flush water samples were collected and tested for lead in 29 households in peri-urban Wake County neighborhoods excluded from nearby municipal water service. Lead concentrations were used with the Integrated Exposure Uptake Biokinetic Model to estimate blood lead concentrations for a hypothetical child in each household. Potential child IQ decrements from elevated blood lead levels were then estimated using a previous study of associations between blood lead and IQ. Results: Among the households studied, 28% exceeded the health-based U.S. Environmental Protection Agency action level of 15 ppb. Children at 18 months are predicted to have the highest blood lead levels (mean: 1.3 µg/dL, st. dev.: 0.95 µg/dL) with the highest exposure resulting in a mean of 4.5 µg/dL attributable to water lead alone. In turn, expected IQ loss attributable to water lead alone is estimated to have a mean value of 1.3 points, with a maximum of 3.4 points in the most-exposed household. These results suggest that racial disparities in access to municipal water service may increase the risk of exposure to lead in drinking water in excluded African-American neighborhoods. In turn, increased exposure to lead in drinking water could increase blood lead levels and decrease children’s IQ.

Azalea
Multi-Stakeholder Optimization Strategies for Household Chlorination Programs: A Randomized Evaluation of the Impact of Bucket Subsidies and Household Visits

Michael Ritter, Tufts University

Additional Authors: Kristen Lueck; Eveline Camille; Christophe Velcine; Rose-Kerline Guillaume; Daniele Lantagne

Background: Despite demonstrated health benefits of household water treatment, demand remains low in developing countries. One strategy to promote other preventive health products is to offer conditional incentives to users. In a prior experiment in Haiti, we found that offering free water storage buckets to households that made monthly chlorine purchases increased the proportion of monthly purchasers from 6% to 49%. However, costs were greater than the increase in sales revenue, and this strategy was less cost-effective than others tested. In this experiment, we tested conditional bucket subsidies (instead of free buckets) and aimed to measure the impact of bucket subsidy level and household visits on chlorine purchases, cost recovery, and cost-effectiveness. Methods: We conducted a randomized experiment within the context of a program in rural Haiti that distributes branded sodium hypochlorite solution through community sales agents. Agents informed households that they would be eligible to receive a bucket at a subsidized price if they purchased at least three bottles of chlorine during a three-month period. Households were assigned by raffle to six groups with bucket prices ranging from $0 to $2.34 (slightly below the market price). We randomly assigned 38% of households to receive one visit from a sales agent. Results: Of 5,096 households that were randomized, 3,584 signed forms to indicate awareness of the offer. Using treatment on treated analysis, 38% of households purchased at least three bottles. Among households who received a free bucket offer, 60.4% purchased at least three bottles, compared to 25.0% of those who received the highest price. In multivariate models, the probability of purchasing at least three bottles decreased by 35.1 percentage points (p<0.001) for every $1 increase in bucket price. Households who received visits purchased more than those who didn’t, but neither the difference in total purchases, nor the proportion that purchased at least three bottles was statistically significant when controlling for sales agent fixed effects. At all prices, the cost of visits exceeded increased revenue, and cost recovery increased with increasing bucket prices. The most cost-effective strategy was to offer no visits and a mid-range bucket price ($0.94). Discussion: Optimal strategies for household chlorination depend on which program goal is prioritized. We found that a different bucket price was optimal for each of three different program objectives (the lowest price maximized chlorine purchases, the highest price maximized cost recovery, and a mid-range price maximized cost-effectiveness). Stakeholders seeking to maximize an objective can select the optimal incentive strategy. Additionally, in a context with high prior product exposure, household visits did not effectively increase demand, however heterogeneity in purchase rates suggests agents play an important role in purchase behavior, which should be further researched.

Effect of Drinking Water Chlorination at the Point-of-Collection on Child Diarrhea in Dhaka, Bangladesh: A Double-Blind Cluster-Randomized Controlled Trial
In cities of low-income countries, few utilities are able to maintain fully pressurized systems that deliver water 24 hours a day. As a result, even if water is clean at the source, it becomes contaminated by the time it reaches the point-of-collection. Whereas the majority of urban residents in the developing world are considered to have access to "improved" water sources, it is estimated that roughly one billion receive water that does not meet international standards for safety. We evaluated the effect of a decentralized urban water chlorination intervention on child health through a double-blind cluster-randomized controlled trial among 100 shared water points in Dhaka, Bangladesh. The treatment group received drinking water automatically chlorinated just prior to the point-of-collection by a solid tablet chlorine doser (the Aquatabs Flo). The control group received water treated by a doser identical in appearance that supplied vitamin C. Drinking water at the point-of-collection at treatment taps had detectable chlorine residual 81% of the time (compared to 0% at control taps). The mean total chlorine residual at taps in the treatment group was 0.4 ppm, which is above the World Health Organization minimum guidelines but well below the average dose of typical point-of-use chlorine treatment products. When asked to guess their treatment status, 30% of respondents in the treatment group and 20% in the control group thought the device was dosing chlorine. Children in the treatment group had 23% less caregiver reported diarrhea (World Health Organization definition) than children in the control group (Treatment: 10%, Control: 7.5%; PR: 0.77, 95% CI 0.65-0.91; N=4227). A similar reduction was estimated for caregiver-defined diarrhea (PR: 0.77, 95%CI 0.66-0.90, N=6205). Reported illness-related expenditures in the past two months per child was significantly lower in the treatment group than the control group. Caregivers in the treatment group were also slightly less likely to report that their child had consumed antibiotics in the past 2 months (40% in treatment compared to 44% in control, PR: 0.93, 95% CI 0.88-0.98). Respiratory illness and negative control outcomes (e.g. bruising) were very similar between groups, and there were no significant differences between groups in weight-for-age z-scores. Whereas many previous water intervention trials have focused on household-level water treatment, our findings demonstrated that an automatic point-of-collection water treatment intervention can increase consumption of safe water and improve child health in a low-income densely populated setting. While previous blinded trials have failed to detect health impacts, our trial estimated a significant reduction in child diarrhea in a low-income setting. Finally, our results suggest targeting a low chlorine residual dose (0.3-0.5ppm) in an effort to increase acceptability of chlorinated water can still improve water quality and reduce the risk of diarrhea.

**Improving Water Safety at the Household Level: Chlorine Dispensers in Ethiopia**

Laura Brunson, Millenium Water Alliance

Additional Authors: Peter Lochery; Richard Kibuuka; Mussie Tezazu; Abebaw Kebede
Drinking water quality is a key issue in Ethiopia, despite achievement of the Millennium Development goal on water. An estimated 42.2 million Ethiopians live without access to safe water, with household water quality being a key issue (WaterAid, 2016). In rural areas, less than 2% of households have piped water coming to the household, and less than 6% use an appropriate water treatment method (Central Statistical Agency Ethiopia and ICF, 2016). A 2015 study of Millennium Water Alliance (MWA) program sites in Ethiopia showed that over 75% of household stored water had >10 CFU/100 mL, which is consistent with global data for developing countries (Shields et al., 2016). To respond to this data, MWA and CARE Ethiopia are collaborating with Evidence Action to implement chlorine dispensers at 49 community water points and then assess results and sustainability. A program feasibility study showed 54% of households were aware of chlorine as a treatment method but only 5% used chlorine with the reported reason being lack of availability. Though chlorine dispensers have been utilized successfully in a few other countries, this pilot offers a unique service delivery model and evaluation of early implementation of dispensers in Ethiopia. Key study questions include whether communities are amenable to using liquid chlorine, viability of having community members serve as promoters for chlorine dispenser use, and whether local institutional structures will continually provide chlorine and community support for this service delivery model. This presentation will share details on the service delivery model, why MWA decided chlorine dispensers were the right-fit solution, per capita costs, piloted methods, community uptake, and resulting residual household chlorine levels. Discussion will focus on strengths and weaknesses of this approach, challenges of implementation, potential for scale up and ability to effectively address issues of sustainability and water quality at the household level.

Wednesday, October 18th

2:30 – 3:30 PM

Redbud


John Trimmer, University of Illinois

Additional Authors: Diana Byrne; Valerie Bauza; Amanda Lardizabal; Philip Atiim; Jeremy Guest

Inadequate food security represents a major health concern across sub-Saharan Africa, contributing to elevated rates of malnutrition. Efforts to increase agricultural productivity of the smallholder farms on which many rural households rely are ongoing and include practices such as increased application of synthetic fertilizers and pesticides. However, use of these chemicals, along with limited sanitation access and open defecation, may give rise to environmental and human health risks through various exposure pathways that include contamination of drinking water sources. These risks have the potential to undercut prospective nutritional gains from increased crop productivity, and they must be considered when promoting the application of agricultural chemical inputs. Accordingly, this study leverages a combination of household
surveys and recurring water source testing to elucidate potential connections and seasonal trends between contaminant exposure and local agricultural and household practices in rural villages in northern Ghana. Surveys were conducted in over 300 households across six villages spanning two districts and focused on demographics, decision-making, child health, water, sanitation, and agriculture. E. coli and total coliform were also enumerated from drinking water, hand rinse, and soil samples collected from a subset of 31 households to characterize fecal contamination in and around the home. Finally, boreholes, shallow dug wells, and surface water reservoirs in these communities were sampled monthly over one year and analyzed for chemical (total ammonia, nitrate) and fecal (E. coli, total coliform) contamination. Of respondents indicating participation in agriculture (99%), over 60% apply fertilizer (mainly NPK, Ammonia) and over 80% apply pesticides (mainly glyphosate, atrazine), increasing potential for chemical exposure through inhalation or skin and eye contact during mixing and application. Approximately 60% of respondents indicated no drinking water treatment, posing a health risk as climatic influences such as infrequent but heavy rainfall can result in runoff carrying chemical and fecal (including manure) contaminants to water sources. In terms of child health, 28% of children under five were reported to have had diarrhea in the past week. Household survey and sampling data will be presented to identify major exposure routes and their connections to factors such as chemical application method and water source type. Furthermore, time-series water source sampling data will be presented to compare one district relying primarily on surface water (susceptible to runoff of local agricultural inputs) and one served predominantly by groundwater (potentially more protected from contamination). The ultimate findings from these data will assist in identifying critical risk pathways and guiding future agricultural interventions, ensuring that food security is enhanced without jeopardizing environmental and human health.

Rethinking Tap Water in Rural Communities: A Hybrid Centralized-POU Drinking Water Treatment System in Chiapas, Mexico

Simon Mostafa, Fundacion Cantaro Azul

Additional Authors: Heather Reese; Parimita Routray; Belen Torondel; Howard Chang; Thomas Clasen

Background: Inadequate dietary diversity increases individuals’ risk of micronutrient deficiencies and reduces the body’s defenses against infection. Improved household-level water access may lead to improved dietary diversity by facilitating household food production (e.g. on-plot gardening and livestock rearing). Improved water access may also reduce the time that mothers spend collecting water, thereby freeing them for caregiving, including child feeding. One study has observed a positive association between water availability and child nutrition in sub-Saharan Africa, but evidence is lacking for South Asia. Methods: We assessed the effect of the Gram Vikas MANTRA program, which combined household-level piped water, bathing areas, and latrines, on household food production and child dietary diversity. We conducted a matched cohort study among 45 villages that received the MANTRA intervention compared with 45 control villages in two districts of Odisha, India. We surveyed households with a child under age 5 and asked about farming activities in the previous 12 months, poultry and livestock ownership, and socio-demographic characteristics. We collected data on dietary intake in the
previous day for infants and young children ages 6-23 months (N=2792) using a standard World Health Organization survey module, then categorized foods into seven food groups and calculated the number of food groups consumed (range: 0-7). We used linear regression to analyze dietary diversity and logistic regression to analyze variables related to household food production. All analyses were adjusted for household wealth and village-level clustering. Results: Diets in our sample population were extremely poor, with children consuming a mean of 0.68 of 7 food groups (SD: 1.39) and only 8% of children achieving minimum dietary diversity (≥4 of 7 food groups) in the previous day. There was no association between the intervention and dietary diversity (©¬ = 0.027, 95% CI: -0.089,0.14). We observed no association between the intervention and crop production (OR: 0.76, 95% CI: 0.57,1.02), poultry ownership (OR: 1.01, 95% CI:0.57,1.81), or livestock ownership (OR: 1.17, 95% CI:0.81,1.68). Conclusions: Access to piped water at the household level was not associated with increased household food production or improved dietary diversity for children ages 6-23 months old. Dietary diversity is extremely poor in our study population, but households do not appear to be using the increased water access for food production. This may be due to several reasons, including male migration resulting in lack of agricultural labor, interruptions in water supply affecting water availability, and/or prioritization of other uses for household-level piped water over agricultural purposes. Multi-sectoral interventions, potentially including agricultural inputs and training alongside nutrition education, are needed to further improve child nutrition in this population.

More Than Drinking Fountains: An Integral Approach to Increasing Access and Sustainability of Safe Drinking Water Services in Rural Schools

Fermin Reygadas, Fundacion Cantaro Azul

Additional Authors: Robles Gil, Barbara Salazar Narvaez

Many schools in Mexico lack access to safe drinking water sources, which contributes in part to the great burden of gastrointestinal diseases observed in children. This situation is heightened in rural areas, where many households and schools do not have access to piped water. Government attempts to solve this complex problem have typically been insufficient, mainly focusing on building infrastructure, such as drinking fountains in schools. We propose a different approach where access to drinking water in schools is understood within a wider context requiring systemic changes to increase service sustainability and the creation of healthy environments. Our program, Cántaro Azul's Agua Segura en Escuelas (Safe Water in Schools), has developed a multi-faceted approach to addressing this issue. Such model creatively integrates the infrastructure, pedagogy, and participatory processes surrounding water and health in rural schools. The infrastructure consists of a kiosk that catches and treat rainwater; an excellent alternative source of water in schools without piped water or with highly contaminated sources. This expands the range of schools that can be supplied with safe drinking water compared to conventional interventions. A pedagogical strategy based on a behavioral change model is also implemented with the intent of generating healthy habits related to drinking safe water in the school and beyond. This includes an educational guide for teachers and the implementation of a jug of safe water and drinking bottles for every student as a manner to modify the physical environment and encourage the consumption of safe water. In order to generate a sense of ownership and enhance the sustainability of a safe water service
for the school, the program is implemented as part of a participatory process. To this end, a School Safe Water Network is formed by students, teachers, and parents that takes responsibility for ensuring access and encouraging the use of safe drinking water within the school. This shift in approach recognizes the school children as subjects of law who are able to effect change within the social spaces they inhabit: their family, their school, and their community. In this presentation we share the fundamental aspects of our model as well as the results obtained during the evaluation of 68 safe water projects implemented in schools in the states of Chiapas and Oaxaca. The impact of this novel approach can be measured in terms of increased access to safe water, reduction in the consumption of sugar-sweetened beverages and improved hygiene and sanitation habits in school children. Based on this information, we will share our perspective on how this model can be replicated to maximize the impact of school water projects in rural communities through collaboration with other organizations as well as government agencies.

**Dogwood**

**Risk Governance of Emerging Contaminants in Drinking Water Resources: Analyzing Practices in the Netherlands, Germany, Switzerland and the State of Minnesota**

Julia Hartmann, National Institute for Public Health and the Environment

Additional Authors: Susanne Wuijts; Ana Maria de Roda Husman; Jan Peter van der Hoek

The presence of emerging contaminants in the aquatic environment can have an impact on human health through the consumption of drinking water. And, even if some of these emerging contaminants are not of concern from a public health point of view, their presence might still influence public perception of drinking water quality (e.g. trace levels of pharmaceuticals). During the last decades, a great amount of research has been done on emerging contaminants in the aquatic environment, mainly focusing on screening and characterizing emerging contaminants. However, limited information is available on if and how the scientific information is implemented in current policy frameworks and what the knowledge gaps are. This study analyzes the risk governance of emerging contaminants in drinking water resources with the objective to identify areas for improvement. Based on the identified areas for improvement, suggestions for future research are made. A qualitative analysis of the practices used in the Netherlands, Germany, Switzerland and the state of Minnesota was performed. The International Risk Governance Council (IRGC)-framework was used as a normative concept. Furthermore, four quality indicators were selected based on recent literature, namely: the integration of science into policy making, the involvement of all relevant stakeholders, the accountability of the decisions made, and the consideration of other factors next to public health risk-reduction in the choice for remediation strategies. Scientific literature, policy documents, and newspaper articles were used as data sources for the analysis. This study shows that one of the elements of the IRGC-framework is missing in all four analyzed policy frameworks, namely the concern assessment (i.e. the assessment of associations and perceived consequences that stakeholders might associate with the contaminant). In addition, the identification process of emerging contaminants in most policy frameworks was found to be
nontransparent since data and decisions made are not shared with stakeholders (e.g. sharing of monitoring data). Furthermore, not all available information sources for the identification of emerging contaminants are being used, which is mainly due to the lack of a systematic approach for the analysis of these information sources. Recommendations for future research are therefore to study possibilities for the systematic analysis of all relevant information sources and include that into the decision making process, to improve transparency of the risk governance process, and to investigate the possibility and added value of implementing the concern assessment in the risk governance process.

Sanitation and LGBTI: Review of Issues Faced and Efforts to Overcome Them

Andres Hueso, WaterAid

Additional Author: Connie Benjamin

Discussions on gender and WASH typically ignore non-normative gender identities. To address this, we reviewed the existing literature on the interrelation of LGBTI and sanitation. The evidence is scanty, and mostly focused on developed countries, although there is a growing body of evidence looking at South and South-East Asia. Most of the publications focus on the challenges transgender people face when accessing public toilets or other communal facilities, which include verbal abuse, physical and sexual assault, denial of access, arrest and expulsion. Almost nothing was found on LGBI people (not including transgender). Solutions range from 'gender-neutral' public toilets, to 'third gender' ones, as well as ensuring transgender people can access toilets matching their gender identity. But there is no clear consensus. Overwhelmingly, the review reinforced how little is known about the challenges LGBTI face in relation to sanitation, a gap academics and practitioners alike could help address.


Gregory Pierce, UCLA Luskin Center

This study proposes that quality concerns from any U.S. drinking water source can be assessed and classified using three broad but comprehensive dimensions: the presence of health-related contamination, accurate detection of this contamination, and the perception of quality among those served by the source. Despite enhanced research interest in drinking water quality post-Flint, the parameters of contamination, detection and perception have largely been studied and classified on a standalone, or at best, paired basis. By contrast, this study defines the complete set of combinations of these three quality parameters. Out of twelve possible scenarios, seven represent a concern for public health agencies. The study also suggests an order of prioritization among the seven scenarios of concern and suggests the feasible corrective policies which interested and responsible parties can pursue to address the relevant quality deficiencies. Using available data, an optimistic back of the envelope calculation of the proportion of households in the United States with assurance on each of these dimensions stands around two-thirds, while more pessimistic assumptions would put the proportion closer to one-half. This holistic assessment framework can aid researchers, drinking water agencies and
communities in taking corrective action to raise the level of quality assurance from any drinking water source in the U.S.

Bellflower

Improving Hygiene during the Perinatal Period: Assessing the Evidence and Groundtruthing in Nigeria

Robert Dreibelbis, London School of Hygiene and Tropical Medicine

Additional Authors: Erin Flynn; Helen Buxton; Olutunde Yinka; Stephen Sara; Tess Shiras

Background: Infections account for approximately 15% of all neonatal deaths globally (Blencowe et al., 2011). This is also the highest risk period for maternal deaths (Li, Fortney, Kotelchuck, & Glover, 1996), with an estimated 10% of all maternal deaths attributable to sepsis. USAID’s Maternal and Child Survival Program (MCSP) and the London School of Hygiene and Tropical Medicine are currently conducting a multi-phase study investigating the behavioral determinants of poor WASH practices during the time period from the onset of labor through the first 2 days of life. Phase 1 of this activity included a literature review and scoping visit. Phase 2 (ongoing) includes an intensive direct observation period at critical moments at health care facilities and the home environment. Methods: A two-stage systematic literature review explored current evidence of the effectiveness of interventions to improve hygiene practices by health care staff, mothers, and other caregivers during the perinatal period. This review identified a total of 19 systematic reviews and meta-analyses examining intervention effectiveness. An additional 212 studies were included in a structured mapping of literature to identify barriers and enablers to effective hygiene. Scoping visits and key informant interviews in Nigeria explored the literature review findings in context. Both literature and scoping visits informed the protocol of a mixed-methods observational study of hand hygiene and infection prevention and control in labor, delivery, and newborn/maternity wards and the household environment for 30 births in rural Nigeria (data collection: July 2017). Findings: Literature review identified the impact of interventions ranged from a 93% reduction in neonatal tetanus associated with clean birthing surfaces to a 15% reduction in neonatal sepsis mortality associated with generic "clean birth practices". Generally, health impacts were based on limited and/or low-quality evidence and for several practices, including those in the WHO Six Cleans list, there was insufficient data to produce pooled effect estimates. Scoping visit identified a lack of standardized infection prevention and control (IPC) strategies compounded by inadequate essential supplies. Chlorhexidine gel - the WHO recommended method for clean cord care - was given to a small percentage of neonates due to lack of supplies and health care worker preferences. All facilities operated within the context of severe manpower shortages and limited IPC training. Interventions to improve hygiene during the perinatal period must be understood within the context of under-resourced, overly-burdened health care systems in low-income countries. More robust data on the impact of intervention is required in order to inform policy priorities for reducing maternal and neonatal survival. Forthcoming structured observations of labor, birth, and the transition to the home environment will identify possible intervention points.
Assessing Environmental Contamination in the Maternity Wards of Two National Hospitals in Phnom Penh, Cambodia

Xinyue Wang, Emory University

Additional Authors: Lindsay Denny; Christine Moe

Cambodia has a high neonatal mortality rate (18 deaths per 1,000 live births), and approximately 40% of neonatal deaths might be linked to healthcare-associated infections (HAI). Some of these deaths may be due to inadequate WASH provisions and poor infection prevention practices in the maternity ward during birth. Improved understanding of WASH conditions and contamination in healthcare facilities (HCF) can enhance our ability to reduce the risk of infections by designing targeted interventions. The goal of the study was to examine the association between inadequate WASH infrastructure and practices and environmental contamination in the maternity wards of two national hospitals in Cambodia. Over an eight-week period between June and August 2016, two sets of observations and two key informant interviews were conducted to evaluate the accessibility and quality of WASH infrastructure and hygiene behaviors of healthcare workers (HCW). A total of 207 environmental samples (66 hand rinses of HCW, 58 water samples, 74 surface swabs, and 9 equipment rinses) were collected and analyzed for Escherichia coli, Total Coliforms, and Staphylococcus aureus by the membrane filtration method with Compact Dry Plates. Hospital A was observed to have better access to, and quality of, WASH infrastructure and disinfection practices compared to Hospital B. Both hospitals received water from the municipal water utility and had piped water. Hospital A further chlorinated the municipal water supply on site, while Hospital B did not treat the tap water and used a storage tank that reportedly had not been cleaned in decades. The odds of a tap water sample meeting the WHO microbial drinking water guideline was significantly higher for Hospital A than Hospital B (p<0.05). There were 24 functional sinks and alcohol hand rub in the maternity ward of Hospital A. In Hospital B, 5 out of 6 maternity ward sinks were functional, and soap and alcohol hand rub were not provided. Hand rinses collected in Hospital B had a higher incidence and magnitude of microbial contamination compared to samples collected in Hospital A (S. aureus OR: 21.4, 95%CI: 4.3-104.6). We observed routine, twice daily cleaning of the maternity ward in Hospital A and irregular cleaning in Hospital B. The odds of detecting target microorganisms on any of the high-touch surfaces was 1.9 times higher in Hospital B compared to Hospital A (p<0.05). Inadequate WASH infrastructure and unhygienic behaviors may increase the likelihood of environmental contamination in the maternity ward. Lack of functional sinks, soap, and hand rub were associated with greater hand contamination. Inadequate cleaning protocols were associated with increased microbial contamination on frequently touched surfaces. To achieve a clean hospital environment requires adequate WASH infrastructure and good practices. Future investigation is needed to assess the burden of HAI caused by poor WASH in HCF and identify affordable, effective solutions.


Kelly Baker, University of Iowa
Women with unimproved water and sanitation access may be at higher risk for adverse birth outcomes than women with improved water or sanitation access. Adverse birth outcomes may be caused by increased exposure to fecal pathogens or to physical stress or injury while fetching water or navigating challenging terrain to find a safe, private place to defecate or bathe. Addressing biological needs in public areas also exposes women to socially stressful environments. However, living in a community with strong social capital may buffer the impact of WASH on birth outcomes. This retrospective cohort study examined whether social capital and social environment affect the association between water and sanitation access and birth outcomes for 6,453 women who gave birth to a child between 2005 and 2011 during the India Human Development Survey. Preterm birth and low birth weight infants occurred in 14.9% and 15.5% of women, respectively. Final models with WASH and Social variables were adjusted for maternal age, parity, wealth, education, number of antenatal visits, use of iron or folic supplements, religion, and cooking location. Unimproved versus improved water access was associated with an increased risk of preterm birth (Odds ratio (OR)=1.29; 95% Confidence Interval (CI)= 1.04, 1.61) and low birth weight (OR=1.41; CI=1.14, 1.73). Spending >2 versus <2 hours per day fetching water was associated with low birth weight (OR=1.31; CI=1.03, 1.66), but not preterm birth. Preterm birth was associated with sharing an in-building latrine (OR=1.56; CI=1.02) and sharing a community/public latrine (OR=0.39; CI=0.26, 0.58), versus private latrine access, but not with open defecation. Latrine access was not associated with low birth weight. Reported harassment of women and girls in the community versus no harassment was associated with preterm birth (OR=1.68; CI=1.38, 2.04) and low birth weight (OR=1.26; CI=1.03, 1.55). High versus low crime rates, social cohesion (conflict in the community versus everyone gets along), and collective efficacy (community works together to solve problems versus problems solved as individual families) were not associated with either outcome, and did not mitigate WASH associations. Further adjustment for fatigue and anemia during pregnancy (indicators of stress or infection) revealed that associations between in-building latrine access and preterm birth were mediated by these biological conditions. This provides the most comprehensive evidence to date that WASH and gender-specific social stress adversely impact birth outcomes in low-income settings, in some cases through unsafe biological conditions. The counter-intuitive protective relationship of community/public shared sanitation on preterm birth is unclear, but may be due to much higher levels of wealth and education among participants in this group. Interventions targeting WASH and harassment of women may reduce rates of preterm and low birth weight infants in low-income settings.

Mountain Laurel

Urban Health and Disparities: A Comparison of 57 Cities

Christine Stauber, Georgia State University

Additional Authors: Ellis Adams; Dajun Dai; Richard Rothenberg; John Heath
We performed an analysis of 57 (mostly capital) cities in 54 countries using data available from the Demographic and Health Surveys between 2003 and 2013. Using the approach of the Urban Health Index (UHI), we computed UHI scores using 9 indicators from three domains (environment, women's education, and childhood immunizations) to characterize the urban health and range of health disparities across the 57 cities; the majority from Africa. We examined correlation among the indicators and compared the UHI scores with GNI and GINI. The city with the highest UHI score was Tirana, Albania and the two with the lowest UHI score were Port Au Prince, Haiti and Monrovia, Liberia. Cities in countries from the European Region had the overall highest UHI scores whereas cities in countries from the African Region had the lowest. Despite overall lower UHI scores, cities from countries in the African Region presented a wide range of values suggesting noteworthy regional variation that deserves more exploration. We examined how the city level UHI score was associated with a country's Gross National Income (GNI) and Gini Index. As one might expect, a higher GNI is associated with a higher UHI score. However, more importantly, deviations from this trend suggest that some cities are capable of achieving a higher urban health score with fewer resources. Conversely, there are cities that have access to substantially more financial resources (as suggested by a higher GNI) yet struggle to improve urban health. Inequality, when measured as Gini index, presents a slightly more complicated picture. Cities in the European Region are achieving a higher urban health score with lower city or country level inequality while cities in the Americas Region are still combating high country level income inequality despite achieving higher urban health. As might be expected, the variability was great in the African Region although some trend suggests that as cities in this region improve UHI score, the Gini index increases suggesting an increase in inequality. Our work here suggests that in addition to documenting important global or regional trends in urban health associated with environmental and socio-economic indicators deviation from these trends (both positive and negative) are important to identify and understand. The influence of national, regional and local policies regarding health and inequality need to be more fully explored and documented to identify how deviations from these trends can serve as learning tools.

Commonalities in Sanitation Issues in High and Low Income Countries

Susan Merther, WEFTEC

Additional Author: Barry Liner

We often think the problems facing high and low income countries face distinctly different problems with respect to sanitation. However, many themes that high income countries are dealing with could be informed by advances in low income countries. For example, as we look at sanitation as a business and challenges with faecal sludge management, high income countries can gain insight as they move towards resource recovery (nutrients from faecal sludge or biosolids are the same nutrients). In addition, FSM issues are similar to decentralized solutions in high income applications. As wastewater utilities increase their public profiles to build legitimacy for resource recovery programs, they could learn from the capacity building efforts used in low income countries. This paper will highlight and discuss the commonalities in these, and other, issues between high and low income countries.
Assessing Conflict in Water Resources Projects

Chris Seremet, Catholic Relief Services

Additional Authors: Jean Baptiste Talla; Dennis Warner; Tom Bamat

Catholic Relief Services (CRS) has developed an operational guidance document intended to provide guidance for assessing conflicts in water resources development and emergency projects. It is directed at program managers and field personnel who have responsibility for the planning, design and implementation of water resources projects. The approach presented in this report is broad, rather than detailed, and intended to provide a pattern, or template, for assessing the presence of existing conflict in communities that could interfere with water projects, or assessing whether a new water project could create conflict. General guidance for resolving conflict is also provided. The document is based on CRS peacebuilding principles and approaches and through a series of activities: a desk review of current literature, interviewing CRS country programs, developing a conflict classification system, and field testing the approach which included the use of questionnaires. The field testing used key informant interviews, focus group discussions and community meetings with regional and district-level government officials, and individual men, women, and young girl groups in WASH in development, WASH in emergencies, and water for irrigation, community marker gardens, and livestock watering contexts in Cameroon, Niger, and Zimbabwe. The use of the questionnaires during the field tests proved to be useful in understanding the water development and conflict dynamic. In Niger, farmers, pastoralists and nomads both identified competition over access to water resources for crop production and for livestock watering as the main issue dividing the communities. In Cameroon, the questionnaires were used with representatives from the host community and refugees in a town and one small village, both having received refugees from Central Africa Republic. In the town, tension exists between the two groups, mainly due to the large number of refugees settling in the town, a limited number of water access points (boreholes with handpumps), the rules governing the use of the water points, and the national and international emergency response. In the village, the feeling was more harmonious as both communities are of the same people and have received equal support from the emergency response. In Zimbabwe, the only conflict mentioned was non-water related and was due to cattle grazing in the gardens before the community erected fencing. The main problem facing the farmers is the lack of reliable sources of water for irrigation. Several recommendations for using the document are to: conduct joint assessments with water and peacebuilding staff to allow for a complementary use of skills and a mutual learning; use the 3B4D approach (binding, bonding bridging) (discover, dream, design, deliver) to understand community social cohesion as it likely plays an important role in the presence of conflict around water resources; pay attention to the equitable access to water as this can lead

Azalea

WASH Facility Evaluation Tool (FACET) for Health Facilities and Schools

John Brogan, Terre des Hommes
Water sanitation and hygiene (WASH) in institutions is an integral part of Sustainable Development Goal #6. The WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation (JMP) has convened a set of consultations around monitoring WASH in Schools and Health Care Facilities, leading to the finalization in 2016 of core questions and indicators for WASH in these settings. These revised sets of indicators have been widely circulated and are gradually being incorporated into new facility assessments and MIS data collection initiatives. Mobile data collection (MDC) applications are increasingly used for collection of comparable data per national and international standards. The efficiency of MDC enables government ministries, UN agencies and civil society members to visualize incoming data in real time for strategic decision taking (e.g. resource allocation for training, equipment and risk management). There has been strong growth in the use of new technologies for data collection and analysis of WASH in both humanitarian and development settings, including schools and health care facilities. A number of platforms and tools are used by different partners, with some of the most commonly used systems including systems drawing on Open Data Kit (ODK - https://opendatakit.org/), a free and open-source collection of tools used widely in the humanitarian field. With support from the JMP and the Swiss Water and Sanitation Consortium, the Swiss Federal Institute of Aquatic Science and Technology (Eawag), CartONG and Terre des hommes (TdH) have adapted the core questions and associated checklists for WASH in Schools and WASH in Health Care Facilities to the ODK compatible mobile platform supported by UNOCHA: KoBo Toolbox (https://www.humanitarianresponse.info/fr/applications/kobotoolbox). To support the WASH community of practice, the partners will share the Facility Evaluation Tool (FACET) materials to accompany agencies to measure WASH in institutions.

WASH in Non-Household Settings: Learnings for Scaling Up WASH in Schools

Anjan Sarkar, Splash International

Splash’s WASH in school’s program in Kolkata has a unique objective - 100% coverage of the 2000 odd government schools in the city. We chose to focus on Kolkata, the third largest city in India, due to its strained infrastructure, higher than average slum population and opportunity to prove our model works in one of the most difficult possible environments. The program is two years old, have so far been in little over 100 schools but has given some good learning and unique insight that helps us strengthen our model. The behavior change component of the program specifically targets at engaging the stakeholders in achieving the individual schools’ WASH goals. A key component is to identify focal teacher(s) from each of the schools and train them to take lead in creating enabling environment in their schools. Inculcate hygiene habits among the child cabinets (child club) who can then disseminate knowledge and practices to other students and also play a supervisory role in ensuring practices of hygiene habits. Our learning has been that: - Strong partnership with the government’s Department of Schools Education is crucial for ensuring government ownership and their involvement in designing context specific scalable interventions. - Behavior Change program design based on the existing pedagogy and curriculum ensure greater adoption by teachers who otherwise consider these as additional workloads. - Good WASH practices exist in many schools, early identification of these good practices and building upon them can enable impact and sustainability at faster rate. - Reaching out to more parents, beyond those who are in the Parent Teacher Committees,
makes operation and maintenance far more participative and hence sustainable. Events or orientation programs on hygiene alone will have limited recall or impact in a few months’ time. This needs to be coupled with a conducive environment facilitated by the school stakeholders.

**Can Autonomous Production of Sodium Hypochlorite in Health Facilities Resolve Disinfectant Cost and Quality Issues in Rural and Peri-Urban Health Facilities? Evidence from Zambia**

Gregoire Castella, Antenna Foundation

Additional Authors: Jérôme Voillat; Gabrial Thor Erismann; Chaitanya Sure

Many health centres in Africa do not have reliable access to disinfectants. Issues with quality and/or quantity of available disinfectants hinder a health centre's ability to ensure both a continuous supply of safe drinking water and the minimum hygiene protocols required in a health facility. Zambia is illustrative of this problem; as a landlocked country with a small industrial base, it is dependent on imports driven from ports in South Africa and Tanzania. The resulting high transportation costs and increased risk of degradation due to improper storage and handling during transport, are particularly problematic for health centres. A potential solution to this challenge is the local production of disinfectant by the health centres themselves. After a successful pilot project in 4 health facilities in 2015, the project partners - UNICEF, the Zambian Ministry of Health and Antenna Foundation - launched an intermediate scale up in 55 health centres in 2016. The technology (the WATA ® device) at the centre of the pilot project uses electrolysis to transform saline solution to sodium hypochlorite solution. It is very well adapted to this context since all the raw materials for production - water, salt and energy - are cheap and readily available locally. After installation, the health centres are thus totally autonomous for production of a multi-use disinfectant. Health centre staff have appropriated the technology and chlorine is being produced at a regular basis in all of the health facilities in which this technology has been installed. Indications are that costs for disinfectant supply are lower relative to previous sources of disinfectants and health facility cleanliness has improved since the implementation of this program. These results suggest that autonomous production of chlorine is a sustainable and enhanced strategy that responds adequately to the needs of rural and peri-urban health centres in Zambia.

4:00 – 5:00 PM

**Redbud**

**Identifying Opportunities to Improve Piped Water Continuity in Honduras, Nicaragua, and Panama Using Bayesian Networks and Regression**

Ryan Cronk, The Water Institute

Many piped water systems in rural areas of Latin America and the Caribbean (LAC) provide discontinuous service. In response, governments and external support actors developed SIASAR - the Rural Water and Sanitation Information System - to monitor water service levels,
infrastructure conditions, water committees, and technical assistance providers. After data collection, SIASAR actors combine these data into sustainability metrics to assess water service sustainability. There is little analysis of these SIASAR data to identify improvement opportunities and the sustainability metric has not been validated. We used multivariable regression and Bayesian Networks (BNs) to analyze variables associated with the availability of 24-hour water services using SIASAR data from 5,560 community-based piped water systems in Honduras, Nicaragua, and Panama and compared our regression models to the sustainability metric. In Honduras and Nicaragua, the proportion of systems providing 24-hour services spanned 71 percentage points among sub-national regions. Good condition infrastructure and year-round water availability were associated with higher 24-hour service. The availability of support for system rehabilitation in Honduras and for preventative maintenance in Nicaragua were associated with higher availability of 24-hour services. The BNs predicted that good condition infrastructure and year-round water availability were more influential on 24-hour service than management variables such as the availability of external technical support and funds to rehabilitate the system. In each country, insufficient household water tariffs were collected for 90% or more of systems to cover capital, operations, and maintenance costs. The $r^2$ values for our regression models ranged from 0.22 (Nicaragua) to 0.49 (Honduras) as compared to 0.05 (Nicaragua) to 0.03 (Honduras) for the sustainability metric - suggesting that our regression models better predict high service levels than the sustainability metric. Actors supporting rural water services can make better use of monitoring data to identify water service improvement opportunities and allocate technical and financial resources to systems with low service levels.

**Sustainability of USAID WA-WASH Drinking Water Investment in West Africa**

Lakdar Boukerrou, Florida International University

During the first Phase (2011-2015) of the USAID West Africa Water Supply, Sanitation, and Hygiene Program (USAID WA-WASH), the primary goal has been to increase sustainable access to safe water services for Burkina, Ghana, and Niger’s rural populations. The Program promoted innovative solutions like rope pumps, treadle pumps, sand dams, small scale piped distribution systems, and point of use treatment to provide reliable access to water for drinking and production uses. Thus, 376 drinking water points were constructed providing access to 65,691 people (USAID WA-WASH Phase I Final Report, 2016). In Phase II (2016-2017), the Program has been monitoring the quality of the drinking water points installed in the three target countries to ensure that water used by people meets national standards. The monitoring is bacteriological contaminants focused and between July and November 2016; 58 water samples were collected and analyzed in Burkina Faso, 28 in Ghana, and 24 in Niger. The analysis results showed that 92.7% of the water points were unsafe for consumption in Burkina Faso, 64.3% in Ghana, and 14.3% in Niger. In response to this challenge, the Program prepared an action plan to ensure good water quality at the USAID WASH-WASH constructed drinking water points. This action plan comprises focus groups to encourage municipal authorities to take ownership of Phase I achievements, training of water points repairers in chlorination, sensitizations of households on Aquatabs, and on-site treatment using chlorine. Water samples collection and analysis were performed to check on the quality of water at the point of use. This approach paid off as shown by the water samples analysis conducted between February

Leveling the Playing Field - Thinking and Working Differently to Reach the Poor

Luis Alberto Andres, World Bank

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In the era of the Sustainable Development Goals (SDGs), equity and inclusion are very much front and center on the agenda in striving for universal access to water supply, sanitation, and hygiene (WASH). These goals also raise the standard that define access to services, and with higher standards comes increased costs. Therefore, decision makers will need to be more efficient in how resources are allocated and spent, and how best to reach those who are more vulnerable. Over the last two years the World Bank's Water Global Practice has systematically analyzed inequities in service provision by poverty, location, social category, and time across 18 countries. This work has investigated how inequities in service provision contribute to inequities in outcomes such as childhood stunting and risk of mortality due to diarrhea, and also tries to understand 'binding constraint' to service delivery to the poor. Through this work we ask whether there a need to think more about how and where WASH funding is spent? To be more effective and have an impact on human development outcomes with WASH funding, is there a need to use additional filters in making spending decisions? Are the mental models of service delivery that have been around for the last 20 years or more generating the efficiencies required to achieve the SDGs? Are the politics of service delivery reform really understood by sector practitioners? Through this work we hint at possible answers, bring new insights through innovative methods, and challenge ourselves to push us outside our comfort zones to think differently about how to address what some would call "wicked hard" problems. We argue that to make progress toward the vision of the SDGs and reduce inequities in the provision of WASH services (and related outcomes) business needs to be done differently along three fronts: >Investments need to be rebalanced and better targeted; >Investments and interventions need to be coordinated across sectors to improve human development outcomes; and >Gaps in policy or between policy and implementation need to be addressed by shifting our thinking about "sectors" to focusing on the "service." Doing so opens up the ambit of reform efforts to help understand political and nontechnical factors that impede service delivery.

Dogwood

Epidemiologic Investigation of Municipal Drinking Water Treatment Practices and Nontuberculous Mycobacterial Infection

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Additional Authors: Nadine Kotlarz; Madalyn Zimbric; Lutgarde Raskin; John LiPuma; Lindsay Caverly
Each year, 16,000 hospitalizations and 3,000 deaths caused by infections due to nontuberculous mycobacteria (NTM) occur in the United States. NTM are primarily transmitted by water and frequently recovered from municipally treated drinking water. Higher levels of NTM have been reported in drinking water disinfected with chloramine compared to chlorine, raising the possibility that chloramine disinfection increases human exposure to NTM and risk of NTM infection. However, few studies have used an epidemiologic approach to examine a relationship between NTM infection and municipal water treatment practices. We obtained records of all NTM diagnostic tests performed from January 2000 through September 2015 at the University of Michigan's medical center. Data obtained included specimen source, NTM species, subject address at time of specimen collection, and diagnosis codes. Information on municipal water treatment practices for 140 Michigan cities was obtained from the US Environmental Protection Agency. Propensity score matching was used to match subjects with chloraminated drinking water to subjects with chlorinated water. Logistic regression modeling was used to examine relationships between NTM infection and municipal water treatment practices. There were 1,244 cases of NTM infection over the 15-year study period. As expected, subjects with a risk factor for NTM disease (e.g., immune deficiencies) and older age were significantly more likely to have an NTM positive specimen (p = 0.04 and 0.03, respectively). Annual prevalence of NTM infection among subjects ranged from 1.48 per 10,000 (2001) to 2.66 per 10,000 (2009) but did not increase significantly over the study period. In logistic regression modeling with the matched subjects, municipal water disinfectant type (chloramine) was not significantly associated with NTM infection (p = 0.93), contrary to expectations. However, the use of surface water as opposed to groundwater as the primary drinking water source was significantly associated with infection (p = 0.04). These findings suggest that use of chloramine for drinking water disinfection does not increase NTM disease burden. The impact of a surface water source on NTM infection points to the importance of source water quality and the greater potential for higher NTM abundance in surface water relative to groundwater. This finding is interesting in light of water scarcity pressures forcing water purveyors to consider alternative drinking water sources. Monitoring NTM in source waters used for drinking water production may be a proactive strategy that can be implemented by water treatment plants. NTM are an emerging public health challenge. Epidemiologic data provides useful information to inform monitoring and water treatment decisions. Gaps in data caused by limited reporting of NTM disease cases and municipal water treatment practices need to be addressed for continued evaluation of water treatment practices to improve drinking water safety.

Epidemiological Evidence of Groundwater Contribution to Global Enteric Disease, 1948-2015

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Approximately 2.2 billion people around the world rely on groundwater as their drinking water source. It is widely accepted that groundwater is more pristine than surface water. While this assumption is frequently the case, groundwater is not always free of contaminants; accordingly, this presumption can result in a potentially hazardous sense of security among owners, operators and users. The present research presents a review of published literature providing
epidemiological evidence of the contribution of groundwater to global human enteric infection. The focus of the review is enteric pathogens transmitted via the faecal-oral route, and specifically those associated with acute gastrointestinal illness (AGI). The review identified 649 published groundwater outbreaks globally between 1948 and 2013 and several epidemiological studies that show there is an increased risk of AGI associated with the consumption of untreated groundwater. The review identified that the following five pathogens were responsible for most outbreaks: norovirus, Campylobacter, Shigella, Hepatitis A and Giardia. Crudely, the authors estimate that between 35.2 and 59.4 million cases of AGI per year globally could be attributable to the consumption of groundwater. Although groundwater is frequently presumed to be a microbiologically safe source of water for consumption, this review demonstrates that consumers served by an untreated groundwater supply remain at risk to enteric disease. Collaboration between microbiologists, hydrogeologists and epidemiologists is needed to better understand pathogen occurrence, persistence, detection and transport in groundwater as well as build stronger epidemiological evidence documenting the true magnitude of disease associated with groundwater globally.

An Advanced Legionellosis Risk Model Accounting for Epidemiological Evidence of Disease Burden

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The overall disease burden of Legionellosis in the United States has been increasing in the past decade. This increase in national disease burden has made Legionella pneumophila (L. pneumophila) the leading waterborne etiological agent in the United States. Legionellosis is a disease outcome that incorporates two specific diseases, first is Pontiac Fever, a self-limiting febrile illness, and Legionnaire’s Disease, a potential lethal pulmonary disease. This research desired to account for more realistic water use patterns in showering, effects of flow rate on aerosol size, breathing rates of the population, and rates of disease incidence in the United States. The incorporation of these factors has developed a microbial risk model with the potential for higher accuracy and resolution to the population. Additionally, as the disease burden data were reported using age, sex and racial demographics, these demographics were modeled as well. The risks were modeled as daily risk of infection and illness, annual risk of infection and illness, moderate illness DALY, severe illness DALY and post-acute illness DALY. This research postulates three methods. First, that the method of incorporating incidence rate to model probability of illness given infection allows for a means of modeling this probability of illness given infection for specific populations. Second, that higher disease risk estimate resolution can be provided to use moderate DALY for Pontiac Fever, severe DALY for Legionnaire’s Disease and post-acute DALY for consequences of illness later in life. Third, a more accurate model of L. pneumophila exposure and pathogenesis develops a more accurate risk model. This model allows for the first steps in a deeper understanding of the population level risk of Legionellosis in the United States’ drinking water systems.

Bellflower
Marks of Failed and Successful Mechanized Borehole Systems: The Case of the Sinazongwe ADP

Emanuel Opong, WVI

World Vision Zambia's Sinazongwe Area Development Program (ADP) is located in the Southern Province of Zambia and is home to two of the first mechanized water systems (MWS) implemented by World Vision in Zambia to combat an outbreak of cholera in Malima in the Sinazongwe District. As part of a comprehensive and ongoing water, sanitation and hygiene (WASH) program that integrates the work of World Vision and local government partners, two communities in Malima, Siankwayi and Sinakambiri have received MWS in conjunction with sanitation and hygiene education. We were tasked with an informal evaluation of the health and social markers of these two communities and with the development of a checklist, or "recipe," for a establishing successful MWS throughout Zambia. We created and piloted a multilevel, qualitative survey administered to children, adults, focus groups of WASH Committees, and district government as well as NGO staff. Clinic data on waterborne illness was also gathered to assess the health impact of the MWS. Participants were randomly selected by household. The surveys revealed challenges pertaining to the financial sustainability of the MWS, dissonance between community members and WASH committees, oversaturation of sanitation education, and large gaps in community access to the MWS. Mechanization is complex and challenging for community to undertake and overtime, interest in payment for the system and zeal of WASH committees decreases. We recommend communities reexamine their WASH committee membership. Further studies should examine the feasibility/preference of alternative methods of payment and power sources for the MWS.

The Swiss Cheese Failure Mode of Self-Supply Hand-Dug Wells in a Developing Nation: Review and Implications for Water Safety Planning

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This paper considers the relevance of Water Safety Plans (WSP) in a developing urban city and reviewed the practicality of self-supply (SS) WSP implementation in such context. The paper is part of a wider research that assessed SS systems in Abeokuta, south west Nigeria, towards the development of an appropriate WSP for small systems. The assessment incorporated a mixed method approach. A total of 2,280 dug wells were located serving about 45% of the over 250,000 human population. Ninety-eight wells were visited for sanitary inspections, risks assessment and water quality analysis. The owners and users of the wells selected for water quality investigation were retained for semi-structured interviews. One hundred and five respondents were interviewed. Questions were asked to obtain respondents' perceptions on the water source, operations, management, maintenance, household usage and handling, and on individual health and safety. Outcomes show SS system practices in a growing urban city of a developing country where poverty, ignorance, denial, and institutional failures, among others, are characteristic features. Evidence from the research emphasises the need to safeguard the water quality of SS sources, and that first, appropriate targeted programs of enlightenment are required to aid user understanding of water quality issues and links to ill health. The World Health Organization (WHO) eleven steps WSP framework is not suited to the context of
Avoiding Failure: The Use of Qualitative Comparative Analysis to Identify Pathways to Successful Sanitation Interventions

Allie Davis, UC Boulder

The recovery of energy, nutrients, and water from wastewater continues to gain traction as a solution to reduce the costs and negative environmental impacts of sanitation systems. For example, resource recovery can address infrastructure gaps and resource limitations by producing biogas for cooking or lighting, by capturing urine or producing compost for organic fertilizer, or by recycling water for irrigation or toilet flushing. Despite these obvious benefits, the impact of resource recovery on the acceptance and success of a sanitation system is still not well understood. Especially for sanitation projects, community acceptance can be an extremely important determinant of success, and acceptance is less likely to occur if community needs and preferences are not addressed. Therefore, there is a need to understand how resource recovery aligns with community priorities or if it can reduce the high failure rates of sanitation systems, especially in resource-limited communities. To this end, this research developed and applied a methodology to determine to what extent community priorities for sanitation have been addressed by sanitation interventions and compares the ability of different sanitation technologies (resource recovery and non-resource recovery) to meet these priorities. Data will be presented from 20 case studies from communities in Karnataka and Tamil Nadu, India. First, sanitation priorities for each community were identified using semi-structured interviews, photovoice, and focus groups. Next, data from researcher observations, document analysis, and interviews were triangulated to determine which priorities were addressed, partially addressed, or unaddressed by the current sanitation system. Finally, a cross-case comparative analysis was performed to understand (i) how well different technologies addressed contextualized community priorities and (ii) if an increased percentage of addressed priorities correlates to improved sanitation success (i.e., the system had continuous use and maintenance and met environmental regulations). Results show that resource recovery...
technologies can meet more sanitation priorities and also address general community infrastructure needs such as electricity, cooking fuel, and water scarcity. On average, systems with resource recovery addressed 83 percent of sanitation priorities and systems without resource recovery addressed 65 percent of sanitation priorities. Furthermore, findings suggest that systems that address more sanitation priorities had a positive influence on success, but priorities alone are not sufficient to achieve success. In successful cases, more than 80 percent of sanitation priorities were fully or partially addressed, compared to 60 percent for failed cases.

Mountain Laurel

Impact Evaluation of Large-Scale WASH Infrastructure Improvement Project: Baseline Water Quality Testing Results

Lauren Cunningham, CDC

INTRODUCTION: Due to substantial unplanned growth in peri-urban areas (PUAs) in Lusaka, Zambia, water and sanitation utilities encounter challenges in providing adequate services and populations can experience a high risk of water- and sanitation-related disease. The US Millennium Challenge Corporation and the Government of Zambia are partnering to improve the water and sanitation infrastructure in Lusaka. CDC is conducting a yearlong independent impact evaluation to estimate the effects of interventions on drinking water quality and ultimately the incidence of disease. METHODS: As part of the evaluation, this study aims to assess changes in water quality through measurement of microbial, chemical, and physicochemical water quality parameters in approximately 3100 stored household drinking water samples, 775 point-of-consumption (POC) water samples, and 775 source water samples in intervention and control PUA households both prior to interventions (baseline) and after interventions are complete (follow-up). Samples are being analyzed for total coliforms, Escherichia coli (E. coli), nitrate, free chlorine residual, and turbidity (source water only). World Health Organization (WHO) recommendations are being used to assess water quality. RESULTS: In the first half of baseline sampling (October 2016 - May 2017), a total of 2567 stored, POC, and source water samples were tested. E. coli was detected in 75% of samples, nitrate exceeded 50 mg/L in 60% of samples, and free chlorine residuals were below 0.2 mg/L in 91% of samples. In source water samples (n=438), total coliforms were detected in 85% of samples, E. coli were detected in 51% of samples, nitrate exceeded 50 mg/L in 63% of samples, free chlorine residuals were below 0.2 mg/L in 85% of samples, and turbidity exceeded 1 nephelometric turbidity unit (NTU) in 40% of samples. In stored water samples (n=1684), E. coli was detected in 80% of samples, nitrate exceeded 50 mg/L in 63% of samples, free chlorine residuals were below 0.2 mg/L in 92% of samples. In POC water samples (n=445), E. coli was detected in 83% of samples, nitrate exceeded 50 mg/L in 61% of samples, and free chlorine residuals were below 0.2 mg/L in 89% of samples. CONCLUSION: Based on baseline analyses to date, most source, stored, and POC water samples do not meet WHO recommendations for drinking water, suggesting that the water could a potential health risk if consumed. To better assess risk, water testing results will be analyzed in conjunction with responses to select household survey questions to allow for predictive modeling of water quality parameters and diarrheal disease. Furthermore, the baseline data will be compared with
data collected after the completion of the infrastructure interventions to support conclusions about the effect of these improvements on public health and, specifically, on the reliability of quality municipal drinking water.

**How Much Will It Cost to Monitor Microbial Drinking Water Quality in Sub-Saharan Africa?**

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Additional Authors: Rachel Peletz; Emily Kumpel; Joyce Kisiangani; Robert Bain; Ranjiv Khush

Microbial water quality monitoring is crucial for managing water resources and protecting public health. However, institutional testing activities in sub-Saharan Africa are currently limited. Because the economics of water quality testing are poorly understood, the extent to which cost may be a barrier to monitoring in different settings is unclear. This study used cost data from 18 African monitoring institutions (piped water suppliers and health surveillance agencies in six countries) and estimates of water supply type coverage from 15 countries to assess the annual financial requirements for microbial water testing at both national and regional levels, using World Health Organization recommendations for sampling frequency. We found that a microbial water quality test costs 21.0 ± 11.3 USD, on average, including consumables, equipment, labor, and logistics, which is higher than previously calculated. Our annual cost estimates for microbial monitoring of piped supplies and improved point sources ranged between 8,000 USD for Equatorial Guinea and 1.9 million USD for Ethiopia, depending primarily on the population served but also on the distribution of piped water system sizes. A comparison with current national water and sanitation budgets showed that the cost of implementing prescribed testing levels represents a relatively modest proportion of existing budgets (<2%). At the regional level, we estimated that monitoring the microbial quality of all improved water sources in sub-Saharan Africa would cost 16.0 million USD per year, which is minimal in comparison to the projected annual capital costs of achieving Sustainable Development Goal 6.1 of safe water for all (14.8 billion USD).

**Evaluation of A Low-Cost Compartment Bag Test to Quantify Hydrogen Sulfide Producing Bacteria in Drinking Water**

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Tests for detecting hydrogen sulfide (H2S) producing bacteria as fecal indicators have been proposed to assess drinking water safety in low-resource settings. This study compared a semi-quantitative compartment bag test (CBT) to the EPA- and FDA-approved multiple test tube (MTT) method to quantify H2S-producing bacteria in drinking water sources. Both methods used PathoScreen? medium to detect target bacteria in 60 surface water samples collected from North Carolina drinking water reservoirs. Samples were subjected to paired levels of incubation temperatures (25°C, 35°C) and numbers of incubation days (1, 2, 3). Results indicated there was a significant positive correlation between methods, particularly at 25°C and
2 days incubation ($r=0.78$). However, the CBT tended to underestimate H2S-producing bacteria concentrations in samples. The CBT shows promise as a microbiological drinking water test for low-resource environments, particularly where quantitative information is preferable to presence/absence results. However, further calibration is recommended to improve test performance.

Azalea

Integrated WaSH and Community Based Nutrition (CBN) programs: Insights from a Five-Year UNICEF Program in Ethiopia

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The integrated Water, Sanitation and Hygiene (WaSH), Multiple Use Services (MUS) and Community Based Nutrition (CBN) program is a large scale five-year rural program jointly implemented by the Government of Ethiopia (GoE) and UNICEF between 2012 and 2016 in the four highland regions of Amhara, Tigray, Oromia and SNNPR. This program is financially supported by the Government of the Netherlands (GoN), the Government of Canada (DFATD) and UNICEF. Baseline survey data were collected from 3200 households and schools in 80 kebeles (the smallest administrative unit in Ethiopia) between June and August 2013 from 3223 households. Repeat measurements were undertaken in a midline survey between January and March 2017. At baseline, incidence of diarrhea was reported for 3% of children under the age of five for the past week. 45% of children in the study population were found to be stunted and 24% were found to be underweight. Differences between stunting of males and females appeared to be minimal. There was a dramatic drop in height-for-age z-scores comparing children at birth to children at six months of age. Protected wells were the most commonly used primary drinking water source, used by 26% of households. However, children most commonly practiced open defecation. Hand hygiene behaviors were frequently reported among women in a household, but less frequently reported amongst children. Timely initiation of breastfeeding was high, with 82% of children less than two years of age breastfed within an hour of birth. However, only 40% of children had appropriate introduction of complementary foods, and 7% met the standards for minimum dietary diversity. The household hunger scale indicated that for 97% of households, there was little to no hunger in the household. Using difference-in-difference analysis, we compare these baseline results to the midline data to provide insight into the impacts of large programs which integrate WaSH and Community Based Nutrition (CBN) interventions. In addition, we explore the determinants of diarrheal disease and stunting in the context of the intervention communities in Ethiopia. Results have been disaggregated by region and the impact of the 2014/5 El Nino and 2016 La Nina droughts on stunting reduction have been analysed.

Improving Water, Sanitation, and Hygiene in Healthcare Facilities in Mali --- Results of a Multi-Sectoral Collaboration
Inadequate water, sanitation, and hygiene (WASH) infrastructure in healthcare facilities (HCFs) in the developing world poses significant health risks to patients, HCF workers, and surrounding communities, and compromises the dignity of vulnerable populations. The risk of health facility-acquired infections in developing countries has been estimated to be 2-20 times higher than in developed countries. The World Health Organization (WHO) and UNICEF reported in 2015 that only 58% of HCFs in sub-Saharan Africa have access to an improved water source. In 2015, WaterAid, WHO, and the Centers for Disease Control and Prevention (CDC) began a collaboration with the Malian Ministry of Health to implement and evaluate a WASH program in HCFs in 2 districts in Mali. CDC and WaterAid conducted a baseline WASH assessment in 21 HCFs in Bla and Koro districts in April 2015. Inexpensive, portable water stations were installed for handwashing and drinking in patient care areas of all 21 HCFs on Global Handwashing Day in October 2015. During the subsequent year, WaterAid and partners installed and rehabilitated waterpoints in targeted HCFs, implemented water treatment practices, and encouraged HCF staff to develop WASH and infection control plans. A follow-up assessment was conducted in March 2017. From baseline to follow-up, there was an increase in the percentage of HCFs reporting an improved water source (90% to 100%, p<0.001), an adequate water supply to meet daily needs (61% to 100%, p<0.001), and a decrease in reliance on off-site water sources (43% to 24%, p=0.22). Additionally, there was an increase in the percentage of HCFs with infection control (32% to 48%, p=0.45), WASH (16% to 57%, p=0.04), and waste disposal plans (21% to 76%, p=0.01). At baseline, we observed that 15 (47%) of 32 handwashing stations were improved (including a water container, cover, and tap), compared to 105 (99%) of 106 at follow-up (p<0.001). We observed increases from baseline to follow-up in availability of water (72% to 96%, p<0.001) and soap (66% to 91%, p<0.001) at handwashing stations. We also found the percentage of HCFs with a handwashing station within 5 meters of latrines increased from 16% to 95% (p<0.001). Drinking water availability at HCFs increased from 43% to 100%(p<0.001), with reported water treatment increasing from 26% to 71% (p=0.01). Water testing conducted at water sources at 20 HCFs and 25 drinking water stations at follow-up revealed that 100% had free chlorine residuals >0.2 mg/L and all were negative for Escherichia coli. Within 2 years, targeted HCFs in Mali achieved substantial improvements in reliable access to a water supply, infection control policies, handwashing stations, and safe drinking water. This program demonstrates that deficient WASH services in HCFs can be addressed effectively through a comprehensive approach including local engagement and partnership with governments, donors, and non-governmental organizations.
**One Size Fits Most - Assessing the Compatibility of Ethidium Monoazide and Propidium Monoazide Pretreatment with Two Widely Used Human Adenovirus qPCR Protocols to Estimate Viral Infectivity**

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Recreational and source drinking waters are under increasing pressure from human activities in Europe and North America, but particularly so in rapidly developing regions. It is well known that these waters contain waterborne bacterial-, protozoan- and viral pathogens (all of which may cause gastrointestinal infections) due to non-point source fecal contamination or insufficient sewage treatment. Numerous studies have shown that quantitative polymerase chain reaction (qPCR) is very sensitive and specific in detecting waterborne enteric viruses, however it does not distinguish between infectious and inactivated viral particles, therefore limiting its value for quantitative microbial risk assessment (QMRA) or disinfection studies. Recently, capsid integrity (ci-) qPCR has been described utilizing the virus capsid impermeable and genome intercalating substances ethidium monoazide (EMA) and propidium monoazide (PMA), which may remove false negative results for viral infectivity testing. In the presented study, we assessed the compatibility of two widely used human adenovirus (HAdV) qPCR protocols (HAdV1/HAdV2) with a robust and inexpensive PMA-/EMA pretreatment step to improve the distinction between infectious and non-infectious viruses. HAdV virions (one of the most persistent human enteric viruses in the environment) were inactivated partially and completely using heat, UV and chlorine before being quantified with long established cell culture, conventional qPCR and a novel ci-qPCR method. Apparent inactivation of virions was detected for heat (- log 2.92 and - log 4.34 for HAdV1; - log 1.72 and - log 2.36 for HAdV2) and chlorine inactivated HAdV (- log 1.32 and - log 2.51 for HAdV1; - log 1.27 and - log 2.87 for HAdV2), but there was little to no difference between ci-qPCR and qPCR protocols when virions were disinfected by UV (- log 0.61 and log 0.74 for HAdV1; - log 0.64 - log 0.81 for HAdV2). Hence, for non-UV inactivated scenarios, the implementation of azo-dye pretreatment appears to vastly improve the ability of established and running qPCR assays to remove positive signals from non-infectious HAdV and increase - by being cost-effective and easy to implement - the significance of qPCR results for public health purposes in low and middle-income settings.

**Evaluation of an Emergency Bulk Chlorination Program Targeting Drinking Water Vendors in Cholera-affected Wards of Dar es Salaam and Morogoro, Tanzania**

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In August 2015, the Tanzanian Ministry of Health, Community Development, Gender, Elderly and Children (MOHCDGEC) reported an outbreak of cholera. By February 2016, the outbreak had affected 22 of 25 regions and resulted in 16,521 cases and 251 deaths. During a cholera
outbreak, access to safe drinking water is critical and chlorination of drinking water supplies is a priority. At the onset of the outbreak, only a small proportion of households in urban Dar es Salaam and Morogoro had direct connections to piped water. Many households obtained drinking water from water vendors, who sold water from multiple sources from tanks ranging in volume from 1,000-20,000 liters. Water supplied by vendors in cholera affected areas of Dar es Salaam and Morogoro, was not adequately chlorinated. The United Nations Children's Fund Tanzania, MOHCDGEC, and the US Centers for Disease Control and Prevention, collaborated to enroll and train vendors to treat stored water with large, 8.68g, sodium dichloroisocyanurate tablets. Eight hundred ninety-seven vendors in highly affected wards in Dar es Salaam and Morogoro were enrolled and provided with a three-month supply of tablets. A baseline assessment and routine monitoring was conducted by ward environmental health officers. An evaluation was conducted three months after program initiation. In total, 88.9% of vendors were interviewed. Free residual chlorine (FRC) was detected in 12.0% of vendor tanks at baseline and 68.8% of tanks at end line; however, FRC levels were low due to prolonged storage times in the tanks. Vendors (89.5%) felt it was easy to treat with tablets. The results, suggest high acceptability and use of the tablets. Bulk chlorination offers a cost-effective community-level approach to chlorinating water close to the point-of-use.

A Systematic Review and Meta-Analysis of Water, Sanitation, and Hygiene Exposures in Cholera Case-Control Studies

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Introduction. Water is an important transmission route for cholera, and water, sanitation, and hygiene (WASH) interventions are commonly implemented to prevent or control cholera transmission. During outbreaks, case control studies are commonly conducted to assess risk factors and protective factors for disease transmission. To our knowledge, the evidence from case control studies on the impact of WASH risk and protective factors on cholera transmission has not been summarized. Methods. To close this evidence gap, we conducted a systematic review of published literature by describing the theory of change, developing inclusion criteria, searching and selecting studies, assessing the quality of evidence, and summarizing the impact of WASH factors predicted to be risk factors or protective factors for cholera transmission. Case-control studies published in English and conducted in populations experiencing a cholera outbreak that reported an association between a WASH factor and cholera using odds ratios were eligible for inclusion. Using the theory of change model, WASH factors were divided into risk or protective factors within the categories of water source, water treatment, water management, sanitation, and hygiene. Summary odds ratio were generated for each WASH factor category using Mantel-Haenszel fixed-effects analysis, I² tests were used to quantify heterogeneity, and five sensitivity analyses were conducted. Results. Overall, 111 manuscripts were identified, and 47 manuscripts describing 51 individual case control studies met inclusion criteria. Studies from 30 countries were included; most had high risk of bias (62%). All seven predicted risk factors for cholera transmission increased the odds of cholera (OR 1.9-5.6), with heterogeneity ranging from 0.0-76.1%. Six of seven predicted protective factors reduced the odds of cholera transmission (OR 0.4-1.4), with I² values from
56.8-90.6%. The exception was sanitation; all sanitation exposures increased the odds of cholera. In sensitivity analyses, three associations of 70 (4.3%) changed directionality or significance, all among protective factors. Discussion. As expected, all predicted risk factors identified in the theory of change increased the odds of cholera. However, not all predicted protective factors reduced the odds of cholera, and the heterogeneity and sensitivity for predicted protective factors was higher than for predicted risk factors. Although the WASH programmatic data was insufficiently described in the manuscripts to ascertain why this was so, we postulate the reason predictive protective factors may not be protective is that they are not effectively implemented such that risks are reduced. It is recommended that cholera response activities focus on reducing transmission risks, that WASH programming is monitored to ensure risks are effectively reduced, and that case control study manuscripts include information on the design and implementation of interventions.

**Dogwood**

**Unfinished Business: Water, Sanitation and Hygiene in Remote Indigenous Communities in Australia’s Northern Territory**

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Additional Authors: Brieana Dance; Juliet Willetts

Improving water, sanitation and hygiene (WASH) outcomes for the ~60,000 Indigenous people living in remote communities in Australia’s Northern Territory (NT) remains an important but unresolved policy challenge. Despite major national reforms aimed at bolstering Australia’s water security over the last decade, the WASH situation in remote Indigenous communities (RICs) has attracted little attention. This study sheds new light on this issue by assessing the status of WASH indicators (access, behaviours, health outcomes) and identifying obstacles that constrain progress. Up-to-date information on access to WASH services in RICs in NT is scant. We piece together historical data to deduce that there is now almost universal access to improved water sources and sanitation facilities. At least 90% of dwellings currently have a piped water supply and a private sanitation facility. In the 72 largest communities, the quantity of water used by households is far greater than the Australian average, and regular testing reveals the water supplied is of good microbiological quality. The main infrastructure shortfalls - in terms of access, reliability and safety - can be found in the more than 400 small homeland communities, most of which have a population of less than 50. Notwithstanding nearly universal access to services, the burden of WASH-related diseases remains substantial. Indigenous children in remote communities are twice as likely to be hospitalised for intestinal infection as non-Indigenous children. Environmental enteropathy and prevalence of intestinal parasitic infestation (e.g. Strongyloides) provide further markers of excreta-related disease transmission. Trachoma remains endemic in many RICs despite repeated mass drug administrations. Skin infections are also prevalent, and these are thought to underlie disproportionately high rates of acute glomerulonephritis and acute rheumatic fever, both of which lead to chronic and life-threatening kidney and heart diseases. The WASH landscape in RICs therefore presents a paradox: widespread access to WASH infrastructure but a continued high burden of WASH-related diseases. The underlying reasons for the situation are complex and inseparable from the
entrenched socio-economic disadvantage that characterise many households in RICs. However, evidence points to several proximate causes that contribute to the high burden of WASH-related diseases: (i) problematic hygiene practices; (ii) non-functional health hardware within the home (taps, toilets); and (iii) high household occupancy rates. We conclude that past and current service delivery investments have helped to reduce WASH access disparities between Indigenous and non-Indigenous Australians, but they have failed to close the WASH-related disease gap. If future WASH investments in RICs are to yield optimal health dividends, the broader ecosystem must also be tackled, namely hygiene practices, maintenance of household-level hardware, and overcrowding.

**Relocatable Sanitation Systems for Climate Displaced Communities**

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The first human solid waste bioreactor to be deployed in North America will soon arrive in Kivalina, Alaska, over 80 miles above the Arctic Circle. Over one hundred years ago, Kivalina—a coastal Inupiaq whaling community living on the Chukchi Sea—began discussing plans to relocate their village. The Kivaliñgmiut people were forcibly settled onto a 27-acre barrier island at the edge of their 2,200-square-mile traditional estate in 1905. As early as 1911, people began discussing relocating to a new site in anticipation of erosion, and to provide more space for homes, access to clean water and sanitation, and economic opportunities for young people. Today, there is still no running water or toilets in Kivalina homes, and agencies are reluctant or unwilling to invest in expensive infrastructure for a village pursuing relocation. Kivalina’s ongoing water, sanitation, and housing issues are now severely compounded by the effects of an Arctic that is warming twice as fast as the rest of the world. Relocatable, biochar sanitation technologies like the Kivalina Biochar Reactor could be transformational in climate affected communities like Kivalina where the infrastructural, environmental, and funding challenges to deploying centralized sewered sanitation systems are well documented. The pioneering Kivalina Biochar Reactor is a pipeless and fully containerized mobile solution that can be easily relocated to a new village site when the community moves. It processes solid human waste separated at the home by Urine Diverting Dry Toilets and transforms the waste into biochar—a carbon-rich, pathogen-free, value-added byproduct. Relocatable technologies like the Kivalina Biochar Reactor can benefit climate displaced communities in Alaska and beyond offering a more affordable and resilient alternative to piped infrastructure in zones subject to climate risk.

**Missing School in Australia due to Gaps in Menstrual Health Management**

Nina Hall, University of Queensland

A recent scan of water, sanitation and hygiene (WaSH) status in remote Australian Aboriginal communities identified a range of issues arising from a lack Menstrual Health Management (MHM) options for young girls. These include logistical challenges in feminine hygiene supplies to a lack of appropriate health education tools delivered through culturally-sensitive channels. The impacts of this lack of MHM has caused regular school absences, an inherent sense of
shame, and negative health issues. This presentation examines the current challenges, and then
details several case studies that have sought to improve MHM opportunities for young rural
girls and women in these indigenous communities. This is presented within the context of the
UN Sustainable Development Goals (SDGs), which relate to WaSH and MHM though the Goals
for water, sanitation and hygiene (SDG 6), gender equality (SDG 5), quality education (SDG 4)
and good health and wellbeing (SDG 3). Australia is a signatory to the UN SDGs, and is thus
committed to attaining these Goals both at home and abroad. The results of this scan and
identified MHM solutions are crucial for ensuring that no one is 'left behind' under the
sustainable development agenda towards 2030.

Bellflower

**Drinking Water Quality, Diarrhea, and Enteropathogen Infections in Peruvian Households with Infants**

Miranda Delahoy, Emory University

We compared the association between water quality and diarrhea in Peruvian infants using
cross-sectional measures (water quality measured on the day of diarrhea survey) versus
prospective measures (water quality measured 4-7 days before diarrhea survey). We examined
the relationship between microbiological water quality and child infection with a panel of
enteropathogens. From June-July 2016 we collected water and stool specimens from 96
households with infants enrolled in a cohort study in Piura, Peru. At visit 1 we administered an
exposure questionnaire, collected a 20L water sample from the household’s primary drinking
water source using dead-end ultrafiltration, and collected a 100 ml grab sample from this
source and from 1-2 other containers of drinking water. At visit 2 (4-7 days later), 100 ml
water samples were taken from the visit 1 sources, a stool sample was collected from the study
infant, and diarrhea symptoms were recorded. The 100 ml samples were tested for E. coli on
the day of collection using the IDEXX Colilert method. Stool samples were assayed for a panel
of bacterial, viral, and parasitic enteropathogens using the Luminex multiplex Gastrointestinal
Pathogen Panel, and work is in progress to assay the concentrated 20L water samples using this
method. 36% of the 351 water samples were positive for E. coli. Significant differences in E. coli
concentrations were observed by water source, with concentrations highest in water from an
outdoor or neighbor’s tap. E. coli concentrations were significantly higher in stored samples,
especially when water was uncovered, stored on the ground, or stored for multiple days. Self-
reported water treatment was not associated with E. coli. Of the 94 children who provided a
stool sample, 68% had an enteropathogen detected in their stool and 14% had diarrhea at visit
2. Presence of E. coli in any household drinking water source at visit 1 was not associated with
a child having diarrhea 4-7 days later; however, children from households where a water sample
was positive for E. coli at visit 2 had significantly higher odds of diarrhea at that time (OR = 9.6;
95% CI: 1.1-81.1). Concentrations of E. coli were significantly higher in water samples from
houses in which a child had diarrhea (p = 0.02) or was shedding any enteropathogen (p = 0.04)
or E. coli (p < 0.01) in their stool at the time of water collection. Also associated with higher
concentrations of E. coli in water were having any animal, a chicken/bird, or a cat in the house,
or having 2 young children in the house. Water samples from houses with a flush toilet and
sewer connection had significantly lower concentration of E. coli. A possible explanation for the
cross-sectional, but not prospective association between diarrhea and E. coli in drinking water is that children with diarrhea are contaminating household water. These results give insight into the relationship between water quality, infant enteropathogen infections, and diarrhea.

**Effects of a Piped Water and Sanitation Intervention in Rural Odisha, India on Child Dietary Diversity: A Matched Cohort Study**

Sheela Sinharoy, Emory University

Additional Authors: Heather Reese; Parimita Routray; Belen Torondel; Howard Chang; Thomas Clasen

**Background:** Inadequate dietary diversity increases individuals' risk of micronutrient deficiencies and reduces the body's defenses against infection. Improved household-level water access may lead to improved dietary diversity by facilitating household food production (e.g., on-plot gardening and livestock rearing). Improved water access may also reduce the time that mothers spend collecting water, thereby freeing them for caregiving, including child feeding. One study has observed a positive association between water availability and child nutrition in sub-Saharan Africa, but evidence is lacking for South Asia. Methods: We assessed the effect of the Gram Vikas MANTRA program, which combined household-level piped water, bathing areas, and latrines, on household food production and child dietary diversity. We conducted a matched cohort study among 45 villages that received the MANTRA intervention compared with 45 control villages in two districts of Odisha, India. We surveyed households with a child under age 5 and asked about farming activities in the previous 12 months, poultry and livestock ownership, and socio-demographic characteristics. We collected data on dietary intake in the previous day for infants and young children ages 6-23 months (N=2792) using a standard World Health Organization survey module, then categorized foods into seven food groups and calculated the number of food groups consumed (range: 0-7). We used linear regression to analyze dietary diversity and logistic regression to analyze variables related to household food production. All analyses were adjusted for household wealth and village-level clustering. Results: Diets in our sample population were extremely poor, with children consuming a mean of 0.68 of 7 food groups (SD: 1.39) and only 8% of children achieving minimum dietary diversity (4 of 7 food groups) in the previous day. There was no association between the intervention and dietary diversity ($\beta = 0.027$, 95% CI: -0.089,0.14). We observed no association between the intervention and crop production (OR: 0.76, 95% CI: 0.57,1.02), poultry ownership (OR: 1.01, 95% CI:0.57,1.81), or livestock ownership (OR: 1.17, 95% CI:0.81,1.68). Conclusions: Access to piped water at the household level was not associated with increased household food production or improved dietary diversity for children ages 6-23 months old. Dietary diversity is extremely poor in our study population, but households do not appear to be using the increased water access for food production. This may be due to several reasons, including male migration resulting in lack of agricultural labor, interruptions in water supply affecting water availability, and/or prioritization of other uses for household-level piped water over agricultural purposes. Multi-sectoral interventions, potentially including agricultural inputs and training alongside nutrition education, are needed to further improve child nutrition in this population.
Effectiveness of a Combined Household-Level Piped Water and Sanitation Intervention in Rural Odisha, India on Diarrhea, Respiratory Infection, Soil-Transmitted Helminth Infection and Nutritional Outcomes: A Matched Cohort Study

Heather Reese, Emory University

Additional Authors: Parimita Routray; Sheela Sinharoy; Belen Torondel; Howard Chang; Thomas Clasen

Background. Open defecation is widespread in rural India, and few households have piped water connections. While government campaigns have increased toilet coverage in India, recent studies found limited impact on health, possibly due to sub-optimal toilet use or household water access. Although coverage of community-level improved water sources is high even in rural India, household-level water access may be critical to the use of pour-flush toilets in this context. Methods. We conducted a matched cohort study to assess a combined water and sanitation intervention implemented by Gram Vikas, an Indian NGO, in rural Ganjam and Gajapati districts in Odisha, India. Their approach includes household-level piped water connections contingent on full community-level coverage of household toilets. Surveys were administered four times between June 2015-Oct 2016 to eligible households (N=2384) with a child under 5 in 45 randomly selected intervention and 45 matched control villages. We assayed >4000 environmental samples, collected across the study duration, for contamination with E. coli, Shigella spp. and Vibrio cholera. Health surveillance included diarrhea (primary outcome), acute respiratory infection, soil-transmitted helminthiasis, and anthropometry to assess nutritional outcomes. All regressions were adjusted for an a priori determined set of sociodemographic variables, and for clustering at the village and household levels, as relevant.

Results. The intervention was associated with increased access to improved toilets (85% v. 18%), as well as increased toilet use by adults (74% v. 13%) and for child feces disposal (35% v. 6%) (all p< 0.001). The intervention was also associated with increased access to piped water (73% v. 8%, p<0.001). However, almost all households in both study arms stored drinking water--a source of continued exposure to fecal contamination (46% v. 50%, >10 E. coli CFU/100mL). The intervention was not associated with reduced diarrheal disease in children under 5 (OR: 0.94, 95% CI: 0.74-1.20); however, there was some evidence the intervention may be protective against soil-transmitted helminth infection in children under 5 (OR: 0.44, 95% CI: 0.18, 1.00). The intervention was also associated with increased height-for-age (HAZ) (+0.17 HAZ, 95% CI: 0.03-0.31), though over a third of children in both arms were moderately stunted (33% v. 40%). Conclusion. Given previous evidence that increasing sanitation use, even with high coverage, is especially difficult in rural India, this study offers evidence that combining household piped water with sanitation access can substantially decrease open defecation, and improve child nutritional outcomes in rural India. The intervention was associated with increased HAZ for children under 5 years; but was not protective against diarrhea. The heterogeneous effects on health may be due to continued exposure to fecal environmental contamination.

Mountain Laurel
Impact of Different Irrigation Systems on Domestic Drinking Water Quality in Peri-Urban Areas of Gujarat, India

Ruchi Vangani, IIPHG

Additional Authors: Deepak Saxena; Nicolas Gerber; Dilleep Mavalankar; Joachim von Braun

In the rural and peri-urban settings, where agriculture is one of the main sources of livelihood, the multi-purpose character of irrigation and drainage infrastructure creates several interlinks between water, sanitation (WATSAN), agriculture, health & nutrition. Rapid urbanization of peri-urban rural settings has added further stress to the inadequate water supply and sanitation from increased human activity and has led to an increase in water-borne infectious diseases and malnutrition. The study used a holistic approach with the inclusion of agricultural, WATSAN, hygiene and community characteristics to understand the environmental-health-economic linkages in a peri-urban rural setting. The study found that the microbiological water quality in the peri-urban rural settings is very poor, water at the household point of use and storage (80% and 73% samples contaminated respectively) had poor microbiological quality and could not be considered potable as per the WHO standards. Community open defecation (had significantly higher levels of E. coli contamination in their drinking water 76%) and high village-household density (105% E. coli count) deteriorated the household storage water quality. Drinking water quality was positively impacted by size of the storage container and water treatment practice such as reverse osmosis. The mean longitudinal prevalence of diarrhea in the community was 1.6 per person years. Among the variables having a significant impact on diarrhea were wastewater irrigation farming, water household storage quality, and sanitation infrastructure. The under 5 children of farmers using wastewater in irrigation have a statistically significant higher (120%) incidence risk ratio of diarrheal incidence. Household improved toilet lead to an 8% reduction in diarrheal incidence significantly. Stunted kids had a significantly higher incidence of diarrhea, vice versa being true, increased longitudinal prevalence of diarrhea increases stunting of under 5 children marginal effect of 7% at a significance level of p<0.05. On the other hand, stunting is also affected by household improved toilet and open defaecation in the community. Other community variables as garbage collection and drainage variables showed impact in the unadjusted model but were dropped in the adjusted model due to collinearity effect. The study concludes that proper wastewater management, improvements in household sanitation infrastructure as well as community sanitation and sewerage connections, hygiene intervention - are all of the significant intrinsic importance and need co-investments for better health outcomes in peri-urban rural settings. (The study is financed by the Bill and Melinda Gates Foundation under the broader project of Agriculture-WATSAN Nexus Project undertaken by the Center for Development Research (ZEF) of the University of Bonn, Germany in collaboration with the Indian Institute of Public Health Gandhinaga).

User Perspectives on Water Reuse: Insights from Urban India

Myles Elledge, RTI

Additional Authors: Sonia Grego; Laura Morrison; Michael Luettgen; Sumeet Patil; Varsha Thakkar
For the first time, more people live in cities than in rural communities. By 2050, 70 percent of the world's population, some 6.4 billion people, are expected to live in towns and cities. Cities of the future will experience difficulties in managing scarce and unreliable water supplies. New solutions are needed that increase the efficiency of urban water systems, and deploy new sustainable solutions. Future water systems will need to apply technologies for water reuse and recycling, and advance use of technologies to generate energy and nutrients from wastewater. Given water constraints and the water stress found in many locations, solutions for recycling wastewater for reuse are gaining attention. As water recycling technologies become increasingly available, the question of end-user attitudes towards and acceptance of reused waste water remains. This question is particularly important because understanding the acceptance of waste water for different reuse applications provides feedback for the development of technologies and helps inform social marketing strategies, which target users' most prevalent barriers to adoption. This presentation draws upon projects under the Reinvent the Toilet program, aimed at onsite human waste treatment. Drawing on a series of RTI, NEERMAN, and SEWA focus group discussions and a 1,200 household survey in low-income areas of Ahmedabad, India the presentation will share findings on knowledge, attitudes, beliefs and preferences surrounding reused water. The session will also present insights from Coimbatore, India and RTI's testing of a Kohler prototype system for wastewater treatment with water reuse for toilet flush in middle income apartment blocks. Observations from varied demographics and social groups are broadly positive about the practice of treated and recycled water for flush water, and are more nuanced for other body wash or household use purposes. This presentation adds important field insights to what is a limited literature related to acceptance of reused water.

**Understanding Sources of Contamination in Stormwater Ponds to Promote Water Reuse in Alberta**

Megan Beaudry, University of Alberta

Background: Harvesting stormwater provides Alberta with a strategy to address the growing demands on water resources due to climate change and projected population growth. However, stormwater reuse poses a variety of challenges due to the potential of this source to be contaminated with human and animal feces, and thus microbial pathogens such as Campylobacter spp., Salmonella spp., and pathogenic E. coli. Storm events are correlated with an increased prevalence of disease, likely due to the mobilization of pathogens in the environment leading to increased exposure and transmission risks. The contamination of water with human and/or animal excreta possesses significant risks to human health - albeit the risks associated with pathogens found in human wastes are greater than those associated with animal wastes. Several recent studies have demonstrated that human feces are commonly found in urban stormwater systems, and therefore, urban stormwater risks associated with its use must be better understood in terms of contamination sources. Objective: To identify sources of contamination and bacterial pathogens present in various stormwater ponds located in Calgary, Airdrie, and Edmonton. Methods: Throughout the summer 2017 stormwater season (May-September) over 500 samples will be collected from various stormwater ponds in Edmonton, Calgary, and Airdrie. DNA will be extracted from various samples from inlets and outlets of the
ponds. Bacteriodes specific markers will be used to identify potential sources of contamination (Human, Dog, Muskrat, Ruminant, Birds, Canadian Goose) and pathogens present (Arcobacter, Campylobacter, Salmonella) through quantitative PCR. Additional culture based methods for Campylobacter spp. and Salmonella spp. will be used on select stormwater pond samples to further determine the risks. Routine testing of fecal indicator bacteria using culture-based (coliforms, thermotolerant coliforms, E. coli and Enterococcus) and molecular-based methods (qPCR Enterococcus) will be done to assess overall microbial water quality and for comparing stormwater quality against existing water quality standards (e.g., recreational water quality). Expected Outcomes: This research will help to better understand the pathogen risks in stormwater within Alberta and contribute to ongoing risk models that will aid in the development of government regulations for water reuse.

Azalea

**Progress on the Sanitation Ladder: Looking back at the MDGs and Projecting to 2030**

Mark Elliott, University of Alabama

Additional Authors: Charlotte Sheridan; Julia Zimmerman; Alycia Overbo; Oliver Cumming; Jamie Bartram

The Millennium Development Goal (MDG) target for sanitation used a binary (pass-fail) indicator: proportion of the population using "improved" sanitation not shared between households. Pass-fail targets are simple but provide no credit for many efforts like installation of shared latrines to eliminate open defecation (OD). The WaSH community has long called for an approach to sanitation progress that gives credit for improving service levels. Typically termed "ladder" approaches, progress of a population up from the bottom "rung" (OD) and all shifts to higher rungs (e.g., from unimproved facility to improved shared) contribute to progress. Ladder visualization is common, but changes in the population on the middle rungs of the ladder (e.g., improved shared) are ambiguous. A method was needed to quantify ladder progress clearly and concisely. We will present: (1) the first global analysis of sanitation ladder progress from 1990-2015; (2) ladder progress vs. progress using the MDG criterion; and (3) ladder progress projected through 2030 and the outlook for two specific SDG targets (elimination of OD and adequate sanitation for all). We used public JMP data and gap-filling methods to estimate missing values and maximize the included population (as in Cumming et al., 2014) for this analysis. We used a four "rung" ladder and developed a simple "ladder score" metric with a multiplier for each ladder rung: OD (bottom rung; multiplier 0.0), Unimproved sanitation facilities (next rung; 0.33), Improved shared facilities (third rung; 0.67), and Improved facilities not shared (top rung; 1.0). Ladder score is calculated by multiplying the % population on each rung by the multiplier for that rung, then summing those four values. A country with all persons on the top rung would score 100%. Using public JMP data and filling gaps, we built a database for 190 countries with 99.8% of global population. We found no evidence that pass-fail MDG targets discouraged progress lower down the ladder. In fact, progress was greatest further down the ladder. Using a standard "proportion of population without X" formulation: global progress toward elimination of OD (45% of gap closed) exceeded Ladder Progress (38%) which exceeded MDG
progress (30%) from 1990-2015. In Urban areas, the differences were larger: OD (58% of gap closed), Ladder (33%) and MDG (18%). Country-level results and projections varied widely. Some countries that made "limited or no progress" on the MDGs made ladder progress through diverse means, including shared sanitation (e.g., Ghana) or OD reduction (e.g., Haiti). The SDGs on OD and universal coverage are far off track, though many countries are on-track to eliminate OD by 2030 (91 of 190 countries). Most regions are held back by one or a few countries where progress has stalled. We propose that a quantitative ladder-based approach can yield simple and understandable targets while also providing credit for diverse approaches to sanitation.

Research Priorities under Sustainable Development Goal 6 and Research and Learning Challenges among Global Partners of Sanitation and Water for All (SWA)

Karen Setty, The Water Institute

Additional Authors: Jamie Bartram; Mats Leifels

Background and Methods: The Research and Learning (R&L) constituency of Sanitation and Water for All (SWA) conducted a survey to identify high priority research, information access, and learning needs applicable to the provision of water, sanitation, and hygiene (WaSH) services under Sustainable Development Goal 6. The main survey technique was a web questionnaire targeting SWA members from the (1) country, (2) R&L, and (3) external support, civil society, and private sector constituencies. Quantitative and qualitative data analysis was conducted by question, participant, and constituency sub-groupings to identify patterns and inductively generate themes. About 76 respondents shared their views on WaSH research and learning needs from approximately 36 countries across six world regions. Using collective rankings and qualitative suggestions, a recommended research agenda was constructed for use by the R&L constituency, and learning, funding, and stakeholder interactions were characterized. A second phase of the research will involve follow-up interviews around the role of evidence in recent decision-making experiences. Findings Overall, untreated wastewater and fecal sludge management were of highest concern among the targets of Goal 6, followed by ending open defecation. Priority knowledge areas differed among constituencies in some cases, suggesting that research agenda development processes should account for the viewpoints of multiple parties. For example, menstrual hygiene management and gender equality ranked much higher as a recent decision area or information need among respondents from the external support, civil society, and private sector constituencies when compared to countries and R&L. Because funding availability was a prime factor in decision making, research on WaSH recommendations might co-prioritize elicitation of costs and potential financing avenues. The responses also suggested some learning challenges. Interestingly, lengthy or technical information was a less frequent complaint than information that was too brief or general. The value placed on executive summaries, though, suggests both brief and technical information should be packaged together, along with accessible interpersonal support. Regarding barriers to participation in training and educational events, responses were constituency-specific, indicating that subgroups of WaSH actors differ in their current states of knowledge access and ongoing needs. Further, those in the country constituency conveyed more concern about discordant or unreliable
information, and all except the R&L constituency desired greater access to learning and training opportunities, especially through seminars and discussion.

**Sanitation Progress Index: Measuring Progressive Realisation of SDG 6**

Stuart Kempster, WaterAid

The ambition of SDG 6 to deliver universal access to water and sanitation will be measured by the proportion of the population using 'safely managed services'. While the increased attention to service quality is a very positive development, having single 'top-of-the-ladder' indicators may create perverse incentives for WASH actors to focus attention on that rung only. For example, decision makers may prioritise providing treatment services for better-off neighbourhoods that have access to basic sanitation, as this would be reflected as progress towards the core indicator (safely managed sanitation). On the contrary, providing limited or basic services in dense slums - where safely managed sanitation might be unfeasible - will not count as progress and could end up being neglected. Reducing inequalities and ensuring progressive realisation of the human rights to water and sanitation are of paramount importance to achieving the ambition of the SDGs. There is therefore a need to prioritise those that do not have access to WASH and to drive changes that move people up through the rungs of the ladder, in line with public health and equity considerations and taking into account the local context. To this end, we suggest a Sanitation Progress Index; an index which combines progress across each rung of the ladder into one composite measure of national progress. Within this index, the different levels of the UNICEF/WHO Joint Monitoring Programme service ladder are afforded different weights - based on a survey of global civil society and sector experts - in order to capture the relative benefits of moving from one rung to the next. Presenting progress through this index will facilitate better monitoring of the progressive realisation of the human right to sanitation, and will allow for more nuanced comparisons of progress between countries and across different points in time.

4:00 – 5:00 PM

Redbud

**Effectively Promoting Hand Washing Frequency Through Improving Technique: A Cluster-Randomized Trial in Rural Zimbabwe**

Jennifer Inauen, EAWAG

Additional Authors: Jonathan Lilje; Hans-Joachim Mosler

Diarrheal disease is a major cause of mortality in young children globally. Consistent hand washing with soap (HWWS) can reduce the risk of diarrhea by almost fifty percent, but changing hand-washing behavior is difficult. Systematic behavior change approaches that use theory and evidence to promote behavior change promise to enhance HWWS effectively, and allow for a better understanding of the active ingredients of behavior change interventions. In this study, we aim to present the effects and mechanisms of a behavior change intervention to
promote HWWS based on the RANAS approach (risk, attitudes, norms, ability, and self-regulation). Sixteen wards of Masvingo province in Zimbabwe were randomly allocated to the intervention or a wait-list control group. The intervention targeted several RANAS factors to increase the frequency and improve the technique of HWWS. 448 randomly selected caregivers of young children participated in quantitative face-to-face interviews at baseline and follow-up assessing the RANAS factors. HWWS was observed in a sub-sample of 224 randomly selected participants. At baseline, the frequency of HWWS was very low. Observed households washed hands in 0.9% and 4.4% of all observed food-related (e.g. before eating) and stool-related (e.g. after defecation) situations respectively. There were no baseline differences between the intervention and the control group. At follow-up, intervention household members (vs. the control group) washed hands in 25.0% (vs. 7.0%) and 32.8% (vs. 11.5%) of all observed food-related and of all stool-related situations respectively. The increases in HWWS frequencies were significant compared to the control group (all p<001). Mediation analyses revealed that while the intervention enhanced several of the targeted psycho-social factors (e.g. disgust), the intervention effects were significantly mediated through increased action knowledge (36% explained variance in the intervention effect), the perception of others’ behavior (descriptive norm, 16%), and increased confidence in being able to continuously perform hand washing in the face of barriers (maintenance self-efficacy, 8%). In conclusion, this study supports the efficacy of a systematic approach to behavior change to promote HWWS. The analyses of the mechanisms revealed interesting insights into the active ingredients of the intervention, such as the importance to promote action knowledge (e.g. through improving hand washing technique). This underlines the value of mediation analysis for evaluating behavior change interventions.

**Applied Research on Disinfection of Surfaces and Hands to Prevent Ongoing Transmission of Ebola**

Daniele Lantagne, Tufts University

Additional Authors: Marlene Wolfe; Karin Gallandat; Melissa Opryszko

Introduction The West African Ebola Virus Disease (EVD) outbreak was the largest to date, resulting in 28,638 cases and 11,316 deaths. As such, new guidance documents were developed, including recommendations for surface cleaning and handwashing. The research questions investigated were based on these recommendations, which all used 0.05% and 0.5% chlorine solutions to disinfect living things (hands) and non-living things (surfaces), respectively, in treatment units, but varied substantially between agencies and were not evidence-based.

Methods Chlorine solutions used in EVD response are made from powdered calcium hypochlorite (HTH), granulated sodium dichloroisocyanurate, and liquid sodium hypochlorite; pH varies from 6-12. Three research themes were investigated. For chlorine chemistry research, shelf-life was determined by storing solutions at 25, 30, and 35°C, and testing chlorine daily for 30 days; and test kits were identified and assessed for accuracy, precision, ease-of-use, and cost. For surface cleaning research, an appropriate surrogate was selected by replicating an Ebola surface disinfection experiment using four potential surrogates, and then surface cleaning efficacy was tested across a matrix of samples, varying exposure time, surface type, pre-treatment, chlorine type, and soil load. For handwashing efficacy, volunteers' hands were spiked
with surrogate, handwashing was completed using seven methods, and surrogates were assayed from hands and rinsewater. For handwashing safety, volunteers washed their hands 10 times a day for 28 days, and daily surveys and hand examinations were completed. Results Chemistry. At 25-40°C, shelf-life varied from 4 hours - >30 days and accuracy was greatest in titration methods, yet test strips were easier-to-use and less costly. Results depended on pH, with HTH most stable. Surface cleaning. Phi6 was the most appropriate Ebola surrogate; during surface cleaning there was a minimum 3.1 log reduction. Surface type most strongly influenced efficacy; rough heavy-duty tarp was most resistant. Handwashing efficacy and safety. Log reductions varied from 1.94-3.69 across all tests, with HTH consistently performing statistically significantly better on hands; and chlorinated solutions maintaining rinsewater safety. Signs of irritation related to transmission risk were observed least frequently in those using sanitizer and HTH. Conclusions This research answered questions responders asked about how to prevent transmission in EVD settings. Overall: 1) HTH performed best for disinfection, although HTH is explosive and can clog pipes, so proper handling is needed; and, 2) Doctors without Borders recommendations were most often efficacious. A strength of this work was dedicated research funding, a limitation of this work is results did not inform the current outbreak, but will inform the next outbreak. Future work is needed to proactively assess disinfection chemistry, efficacy, and safety for emerging diseases.

Comparison of Analytical Techniques to Explain Variability in Stored Drinking Water Quality and Microbial Hand Contamination of Female Caregivers in Tanzania

Angela Harris, Stanford University

Additional Authors: Amy Pickering; Alexandria Boehm; Mwifadhi Mrisho; Jenna Davis

Exposure to fecal contamination continues to be a major public health concern for low-income households in sub-Saharan Africa. Drinking water and hands are known transmission routes for fecal pathogens in household environments. Much effort has been given to identify correlates of water and hand contamination; however, the WASH sector has not been successful in developing statistical models of fecal contamination that have accurate predictive power. Linear regression techniques with continuous outcomes, such as ordinary least squares regression and general estimating equations, are often used in these contexts. Alternative modeling schemes may be better suited to the phenomena under study (e.g., non-linear relationships). For this study, three different modeling techniques — ordinary least squares regression, logistic regression, and classification tree — were used on the same set of primary data collected from 1217 household in Bagamoyo, Tanzania, to model variation in E. coli contamination as a function of household and behavioral characteristics. Variation in hand and water contamination was poorly explained by all modeling approaches. For household drinking water quality, the ordinary least squares regression model correctly predicted the drinking water quality categories (i.e., low, medium, and high) for 36% of cases overall, statistically no different from chance. Multinomial logistic regression predicted 44% of cases correctly, and classification tree modeling predicted 45% of cases correctly; both models predicted cases better than would be expected by chance. For the hand rinse samples, the ordinary least squares regression model, the binary logistic regression model, and the classification tree model correctly predicted the
classification of 0%, 3%, and 14% of cases negative for E. coli, respectively. The poor prediction accuracy of all model types suggest that variation in hand and water contamination is difficult to capture using modeling techniques of one-time water and hand rinse samples. For improved prediction using correlates to contamination, future studies could explore modeling of repeat measures of household stored water quality and female caregiver hand contamination.

Dogwood


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INTRODUCTION: Provision of safe drinking water was a critical public health intervention of the 20th Century, yet bottled water consumption has risen dramatically in the US in the last 40 years. Recent water crises have increased distrust in public water infrastructure, particularly among non-Hispanic (NH) black, Hispanic, and foreign born adults. It is unclear whether similar differences in water intake patterns mirror disparities in perception of tap water safety. This paper examines disparities in tap and bottled water consumption patterns among US adults by race and Hispanic origin, nativity status, and socio-economic status. METHODS: We used 24-hour dietary recall data for 9,666 adults aged 20 and over from the National Health and Nutrition Examination Survey, 2011?2014. We tested differences in mean intakes and percent consuming plain, tap, and bottled water between groups using Wald tests and covariate-adjusted intakes and odds ratios using multiple linear and logistic regression models. RESULTS: In 2011?2014, the mean total plain water intake (the sum of tap and bottled) on a given day for US adults was 1,166 ml (SE = 26), with 725 ml (62.2%) coming from tap water and 441 ml (37.8%) coming from bottled water. 81.4% (SE=0.6) of adults drank any plain water, 55.2% (SE=1.4) drank tap water and 33.4% (SE=1.4) drank bottled water (tap and bottled are not mutually exclusive). Adjusting for covariates, the results suggest that NH black and Hispanic adults consumed B=330 ml (SE=45) and B=180 ml (SE=45) less tap water and had 0.44 (95% CI: 0.37, 0.53), 0.55 (95% CI: 0.45, 0.66) times the odds of consuming tap water than NH white adults, respectively. Adults with a college education consumed B=329 ml (SE=58) more tap water and had 2.7 times (95% CI: 2.26, 3.28) the odds of consuming tap water than adults with less than a high school education. Additionally, NH black, Hispanic, and foreign born adults consumed B=212 ml (SE=40), B=243 ml (SE=42), and B=188 ml (SE=41) more bottled water and had 2.2 (95% CI: 1.79, 2.69), 2.37 (95% CI: 1.91, 2.94), and 1.46 (95% CI: 1.19, 1.79) times the odds of consuming bottled water than their NH white and US born counterparts, respectively. Sensitivity analyses adjusting for household water filtration use did not modify results. CONCLUSIONS: While the majority of US adults consumed plain water on a given day, the source of plain water, i.e. tap or bottled, and amount of each plain water source differed by race/Hispanic origin, nativity status, and education for adults. Our results of plain water consumption patterns suggest that the same populations that rate higher distrust of tap water are less likely to actually consume tap water, indicating that these perceptions may factor in their decision to use bottled water over tap. Knowledge of these disparities may inform public
health interventions designed to increase plain tap water consumption and address distrust of tap water sources among specific populations.

**Examining the Effectiveness of Household Water Lead Remediation Strategies during the Flint Water Crisis**

Kelsey Pieper, Virginia Tech

Additional Authors: Adrienne Katner; Min Tang; Marc Edwards

Background: The pervasiveness of lead in drinking water continues to pose a significant public health threat. Exposure to water lead can be minimized or prevented through implementation of preventive measures. However, weaknesses in monitoring, regulation, and remediation of water lead have long been misunderstood and miscommunicated due to the complexity of plumbing corrosion science. Objectives: This presentation compares the efficacy of various household-level water lead remediation strategies through the lens of the Flint Water Crisis.

Discussion: When public health officials or residents are concerned about water lead, four household-level remediation strategies are commonly implemented: (1) flushing water prior to consumption; (2) providing bottled water; (3) using a NSF certified lead filter; and (4) removing partial or full lead service lines. During the Flint Water Crisis, all four strategies reduced water lead, but some proved to be more consistent and effective. For example, there was an 86% reduction in the first draw 90th percentile water lead levels after three minutes of flushing (22.4 to 3.2 µg/L; n=156). However, several homes experienced spikes in lead (max of 69 µg/L), which was likely linked to the disruption of the previously formed leaded scale layers. The U.S. EPA demonstrated lead filters were capable of removing high water lead levels (reduced 4,080 µg/L to 0.9 µg/L), with most homes having undetectable levels after filtration (<0.5 µg/L; 85% were non-detect after filtration). However, there were substantial financial burdens, maintenance needs, and water conservation implications associated with the four strategies, which should be considered in future application. Conclusion: While the Flint Water Crisis has heightened national concerns about water lead exposure, Flint was not the first lead in water contamination event that caused serious water-childhood lead exposure - the most notable was the 2001-2004 Washington, DC Lead Crisis. Despite the duration and magnitude of the DC Lead Crisis, and its documented and projected public health outcomes, lessons were not learned as plumbing corrosion science was miscommunicated and misrepresented. Accurate and concise information that aids public health practitioners, governmental officials, utility personnel, and residents in understanding water lead risk factors is imperative to implementing and effectively communicating remediation strategies that protect public health.

**Contamination, Detection and Perception: Classifying and Correcting Drinking Water Quality Parameters of Concern Post-Flint**

Gregory Pierce, UCLA Luskin Center

Additional Authors: Kelsey Pieper
This study proposes that quality concerns from any U.S. drinking water source can be assessed and classified using three broad but comprehensive dimensions: the presence of health-related contamination, accurate detection of this contamination, and the perception of quality among those served by the source. Despite enhanced research interest in drinking water quality post-Flint, the parameters of contamination, detection and perception have largely been studied and classified on a standalone, or at best, paired basis. By contrast, this study defines the complete set of combinations of these three quality parameters. Out of twelve possible scenarios, seven represent a concern for public health agencies. The study also suggests an order of prioritization among the seven scenarios of concern and suggests the feasible corrective policies which interested and responsible parties can pursue to address the relevant quality deficiencies. Using available data, an optimistic back of the envelope calculation of the proportion of households in the United States with assurance on each of these dimensions stands around two-thirds, while more pessimistic assumptions would put the proportion closer to one-half. This holistic assessment framework can aid researchers, drinking water agencies and communities in taking corrective action to raise the level of quality assurance from any drinking water source in the U.S.

Bellflower

**Sustainability Assessment of Rural Water Service Delivery Models: Findings of a Multi Country Review**

Luis Andres, World Bank

Additional Author: Craig Kullmann

In the era of the Sustainable Development Goals (SDGs), equity and inclusion are very much front and center on the agenda in striving for universal access to water supply, sanitation, and hygiene (WASH). These goals also raise the standard that define access to services, and with higher standards comes increased costs. Therefore, decision makers will need to be more efficient in how resources are allocated and spent, and how best to reach those who are more vulnerable. Over the last two years the World Bank's Water Global Practice has systematically analyzed inequities in service provision by poverty, location, social category, and time across 18 countries. This work has investigated how inequities in service provision contribute to inequities in outcomes such as childhood stunting and risk of mortality due to diarrhea, and also tries to understand 'binding constraint' to service delivery to the poor. Through this work we ask whether there a need to think more about how and where WASH funding is spent? To be more effective and have an impact on human development outcomes with WASH funding, is there a need to use additional filters in making spending decisions? Are the mental models of service delivery that have been around for the last 20 years or more generating the efficiencies required to achieve the SDGs? Are the politics of service delivery reform really understood by sector practitioners? Through this work we hint at possible answers, bring new insights through innovative methods, and challenge ourselves to push us outside our comfort zones to think differently about how to address what some would call "wicked hard" problems. We argue that to make progress toward the vision of the SDGs and reduce inequities in the provision of WASH services (and related outcomes) business needs to be done differently along three
fronts: >Investments need to be rebalanced and better targeted; >Investments and interventions need to be coordinated across sectors to improve human development outcomes; and >Gaps in policy or between policy and implementation need to be addressed by shifting our thinking about "sectors" to focusing on the "service." Doing so opens up the ambit of reform efforts to help understand political and nontechnical factors that impede service delivery.

**What Does It Take to Have a Fully Functional Service Authority? Evidence from Honduras**

Andres Gil, IRC

Additional Authors: Stef Smits; Maricela Rodríguez; Azucena Serrano

In Honduras, municipalities are charged with being a service authority. They are responsible for ensuring water and sanitation services provision by performing functions such as planning and financing of capital works, monitoring of services provision and providing technical assistance to service providers. They are also expected to establish platforms such as the COMAS (municipal WASH council where representatives of municipalities and civil society meet) and the USCL (local delegated regulator). The national policy for financing WASH indicates that municipalities must cover the costs of fulfilling these functions. It does not, however, provide guidance on the amount of resources that municipalities need to dedicate to these. This paper presents the findings of an assessment in 14 municipalities of the financial and human resources that these currently dedicate to the service authority function. The data were obtained through interviews with municipal staff and budgets reviews, and processed in a dedicated Excel tool. The study finds an average staff dedication of 2.2 Full Time Equivalents per 10,000 inhabitants for fulfilling the service authority role. About half of this time is spent on monitoring and technical assistance. The financial value of this staff time as well as related expenses on travel and meetings is about 1 USD/person/year. Despite this investment, not all service authority functions are adequately carried out. Some of the required platforms only exist on paper, and monitoring of all water systems in the municipal area often does not take place even on an annual basis. The study estimates that in order to fulfil all required functions adequately staff time and expenditure in cash would need to increase by approximately 70%. This increase should go mainly to the functions of monitoring, technical assistance, planning, and coordination.

**Water Supply and Sanitation Service Provision in Urban Slums of Dhaka, Bangladesh**

Sabrina Haque, World Bank

We sought to examine whether in Bangladesh, exposure to poor sanitary environments during early childhood has an impact on the late enrollment of children in primary schools. Children living in communities with a large proportion of households who have unimproved sanitation facilities or practice open defecation tend to be more exposed to bacteriological or fecal pathogens, which in turn lead to poor nutritional outcomes and poor cognitive and early
childhood development. For the purposes of the analysis, we utilized DHS data from 2014, 2011, 2007 and 2004, for which the location of the primary sampling units (PSU) is available with some random error. We then conducted a probit regression, for which we found that an increase in the proportion of households with no toilets in the community during infancy reduces the likelihood of primary school enrolment among six year olds by about 11 percentage points. On the other hand, an increase in the proportion of households with no toilets and unimproved toilets reduces the likelihood of late enrolment by about 33 percentage points. Current sanitation conditions of the household and communities have only a limited effect on the late enrollment of children in primary schools. As expected, mothers’ educational status and household wealth have a positive and significant effect on increasing the likelihood of enrollment. For further verification, PSUs in 2014 and 2011 were ranked based on the share of households with no toilets and the share of households with unimproved toilets in 2007 and 2004. Twenty percent of PSUs were chosen from the top and bottom of the distribution, and a subset of households was chosen using matching techniques such that the matched households are similar in the other observable characteristics except for the level of sanitation at the community level in 2004. PSUs that had a high share of no toilets or unimproved toilets tend to have low enrollment rates among the six-year-old group. Specifically, for PSUs with a high share of no toilets in 2004, enrollment rates in 2001 were 15 percentage points lower among the six-year-old children when compared to PSUs with a low share of no toilets. Similarly, for PSUs with high share of unimproved toilets in 2004, enrolment rates in 2011 were 12 percentage points lower among the six-year-old children as compared to PSUs with a low share of no toilets. This analysis further highlights the influence of improved sanitation at the community level in the early years of childhood on educational outcomes in later years. These findings reinforce the focus on ensuring access to toilets in the poorest households, considering the fact that household wealth has a significant impact on the likelihood of primary school enrollment. As results also demonstrate the impact of poor community level sanitation, a more holistic approach to area-wide sanitation is needed to bolster enrollment rates.

Mountain Laurel

Can Bulking Agent Types Influence Ascaris Eggs Inactivation Efficiency During Faecal Sludge Treatment via Co-Composting?

Musa Manga, The Water Institute

Faecal Sludge (FS) contains high concentrations of helminth eggs especially Ascaris eggs that are 10-100 times higher than those in domestic wastewater. Proper and sustainable treatment is required to inactivate these eggs if FS is to be recycled in agriculture, so as to minimise the public health and environmental risk. Composting is one of the common ways of sanitising FS in Urban Africa. However, it is associated with longer helminth eggs inactivation periods, which makes it commercially uneconomical. This study investigated the influence of bulking agent types on the inactivation efficiency of Ascaris eggs during FS composting. Dewatered FS was mixed with different bulking agent types i.e. SawDust (SD), Coffee Husks (CH) and Brewery waste (BW). Compost piles of FS:SD, FS:CH and FS:BW in volumetric ratio of 1:2 were set-up in duplicate, composted on a pilot scale and monitored weekly for Ascaris eggs survival for a period of 15 weeks. The results suggest that the bulking agent types had a statistically significant
(p < 0.001) effect onto the composting temperatures evolution and Ascaris eggs inactivation efficiency. Compost piles containing CH achieved the shortest pathogen survival period of 6 weeks compared to 8 weeks for SD and BW composting piles. The investigation suggests that apart from the temperature-time relationship, there were other mechanisms responsible for enhancing pathogen inactivation efficiency within the composting piles. All the composting piles attained 100% pathogen inactivation from FS and therefore, the compost was safe for use in agriculture. The findings of this study suggest that composting of FS with CH can reduce pathogen inactivation periods by 25%, which may thus reduce the operational costs of FS treatment facility.

A Landlord’s Journey to Improved Sanitation: Compound Sanitation in Cote D'Ivoire

John Saure, PSI

Additional Author: Serge Seiba

Compound housing is a common form of habitation for low-income residents in urban Cote d'Ivoire. In Abidjan, Cote D'Ivoire compounds represent 55% of housing. In compound housing, tenants live in rented family units, often sharing living space and facilities with upwards of 60 other people. When compounds have sanitation facilities they are usually shared, are often poorly maintained and a major source of conflict between tenants. Landlords are reluctant to invest in improved sanitation because of the high up-front cost. As such, efforts to increase access to basic sanitation in similar low-income, urban environments throughout the region must take into account compound environments and, more specifically, the role of landlords. The Sanitation Service Delivery (SSD) project is a USAID/West Africa regional urban sanitation project implemented in Benin, Côte d'Ivoire, and Ghana by PSI in collaboration with PATH and Water and Sanitation for the Urban Poor (WSUP). The goal of SSD is to improve urban sanitation outcomes by developing and testing scalable, market-based models that contribute to structural change within the region's sanitation sector. Recognizing the importance of compound sanitation, SSD has developed potential business models to respond to the needs and preferences of landlords, and ultimately households living in compound settings. In Cote D'Ivoire, SSD is testing a model among landlords based on prefabricated septic tanks, which can be installed quickly and easily and sized according to the number of users within a compound. SSD sales agents have met with a total of 69 landlords and have documented preliminary insights. Approximately 10% of these landlords expressed an interest in the septic tanks system, and requested a quotation for the work. Feedback from landlords has highlighted cost as a barrier to purchase. Some landlords noted a preference for traditional toilets without septic tanks in order to avoid the added expense of septic tank emptying. Others noted a desire to purchase toilets but wish to pay in installments, whilst some were confused by the notion of having to pay for a toilet when other NGOs give them for free. Over the coming months, the project’s sales agents will contact hundreds of landlords, capturing further insights as the project iterates on the design of the product and opens access to finance. SSD will present the consumer insights from landlords, including the preferences and needs for compound environments, the perceptions of product offerings, limitations in purchasing and upgrading sanitation products, and motivational factors impacting their decision to purchase the products.
A Case for Pit Latrines: A Conceptual Model of Pathogen – Specific Hazards Over Time

Lisa Fleming, the Water Institute

A conceptual model of pathogen-specific hazards in pit latrines over time is presented. The model's development, limitations, and results of a simulated case study are reviewed. The major methodological conclusions are that estimating the magnitude of viable pathogens (i.e. hazard) and potential burden of disease in a pit latrine waste stream given simple inputs is possible; deterministic models are useful despite their limitations for assessing hazards. Specific results of the simulated case study indicate a great potential for pit latrines to reduce the magnitude of hazard discharged into the environment. Additionally, findings suggest treated wastewater may be no more effective than properly managed pit latrines at reducing hazards and specific practices including infrequent pit emptying can have substantial public health benefits. Overall, accounting for variations in hazard by tracking pathogens over time is possible and can aid in assessing and comparing relative sanitation public health threats for planners and engineers.

Azalea

Effectiveness Evaluation of a Two-Step Water Filter Using Flocculation and Bio-Filtration in Rural Dominican Republic

Nikhil Patil, Tufts University

BACKGROUND: When developing new household water treatment and safe storage (HWTS) technologies, field trials are a critical step to document that the product is acceptable to users, and can be used effectively to reduce contamination of household drinking water. We evaluated the acceptability and microbiological effectiveness of a new gravity fed two-step water filtration system that uses flocculation and bio-filtration to treat household drinking water. The filter was tested in two rural communities in the Dominican Republic over a nine-week period. METHODS: We enrolled 60 households and conducted a baseline survey on current water treatment practices. Community health workers distributed the water filters, trained households on how to use and maintain the filter, and conducted monthly visits. Between January and March 2017 two follow-up surveys were conducted at six and nine-weeks post-distribution. A focus group discussion with a sample of users was conducted at the end of the study in each community. To evaluate microbiological effectiveness, untreated, direct-from-filter, and stored, filtered water samples were collected and tested for E. coli using membrane filtration and turbidity. A household had "confirmed use" if water treated with the filter (self-reported) was available at the unannounced survey visit. RESULTS: Reported use of the water filters was high (>85%) across both communities; however, confirmed use varied from 59% to 44% at six and nine weeks in Tierra Prieta and from 60% to 80% in La Jagua. At the second follow-up, respondents reported the filter was easy to use (69% in Tierra Prieta, 76% in La Jagua); they liked the taste of the filtered water (85% and 96%); they would recommend it to
others (96% and 100%); and, they planned to use it in the future (100% in both communities). In the second follow-up, 86% of direct-from-filter samples complied with WHO guidelines (<1 CFU/100mL E. coli) or were low-risk (1-10 CFU/100mL E. coli). For stored, filtered water, no samples complied with guidelines, and 55% were low-risk. Overall, 71% of all water samples from the second follow-up had turbidity <1 NTU. CONCLUSION: Overall, the water filters were reportedly acceptable to users, but confirmed use was lower than anticipated. Microbiological effectiveness results were mixed as there was some remaining microbiological contamination after filter use, and there was recontamination during storage post-filtration. These identified challenges will be addressed in future product design modifications. Our results highlight the importance of conducting field trials of new HWTS products before large-scale manufacturing and distribution.

Effects of a Behavior Change Campaign on Household Drinking Water Disinfection in the Lake Chad Basin Using the RANAS Approach

Jonathan Lilje, EAWGA

Additional Author: Hans-Joachim Mosler

Worldwide, an estimated 700 million people rely on unimproved drinking water sources and even more consume water that is not safe to drink. Inadequate drinking water quality still constitutes a major risk factor for cholera and other diarrheal diseases around the globe, especially for young children in developing countries. Household water treatment and safe storage systems represent an intermediate off-the-grid solution for settings which do not supply safe drinking via adequate infrastructure. However, the application and consistent usage of treatment products and technologies almost exclusively rely on the consumer's behavior. This study set out to evaluate the effects of a behavior change campaign promoting the uptake of household drinking water chlorination in several communities along the Chari and Logone rivers in Chad which was based on formative research using on health psychological theory targeting several behavioral factors. 220 primary caregivers in intervention communities were interviewed concerning current household water treatment practices and their mindset related to water treatment using the Risk, Attitudes, Norms, Abilities, and Self-regulation (RANAS) model six months after the intervention ended. Results show a more than two-fold increase in drinking water treatment over time in households after participation in the intervention. Significant differences compared to a control group were identified regarding several behavioral factors. Mediation analysis revealed that the intervention positively affected participants' individual risk estimation for diarrheal disease and their health knowledge, also their perceived efforts and benefits of water treatment, social support strategies, and knowledge on how to perform chlorination as well as their perceived ability to do so. The promotion's effect on self-reported water treatment is mainly mediated through differences in health knowledge and self-efficacy convictions. The findings imply that water treatment behavior can successfully be promoted using health psychological theory, but also show that there are opportunities for improvement in the campaign design and its implementation.

Effects of a Large-Scale Distribution of Water Filters on Water Quality and Diarrhea: A Cluster Randomized Controlled Trial in Western Province, Rwanda
Unsafe drinking water is a major cause of death and disease in low-income countries, and interventions to improve water quality within the household can reduce the risks associated with high exposures. However, little is known about the effectiveness of these interventions delivered programatically at scale. In late 2014, the Rwanda Ministry of Health and DelAgua Health, a private social enterprise, distributed and promoted the use of tabletop Lifestraw Family 2.0 water filters in Western Province. Filters were delivered free to the poorest 25% of households (N=101,000) within 72 randomly allocated sectors, with the remaining 24 sectors serving as controls. Using two-stage random sampling, we enrolled 1582 households from 87 interventions and 87 control village-based clusters to assess filter uptake, water quality and diarrhea in children under 5 years of age and the primary cook. Households were visited every 4 months over a 12-month period following intervention delivery. At visits 1, 2, and 3, 94.0%, 93.6%, and 91.9% of households had the filter (observed), and of these, 70.4%, 68.2%, and 59.2% had water in the filter, respectively. Additionally, at visits 1, 2 and 3, 80.6%, 75.6%, and 68.4% of households with the filter reported last filling them within the previous 2 days. In cluster-adjusted analyses using generalized estimating equations, the intervention arm was associated with a 36.4% reduction in the prevalence of detectable TTC contamination (prevalence ratio (PR) 0.64, p<0.001, 95% CI 0.58-0.70), a 44.9% reduction in the prevalence of moderate contamination >10 TTC/100mL (PR 0.55, p<0.001, 95% CI 0.47-0.64), and a 47.0% reduction in the prevalence of high contamination >100 TTC/100mL (PR 0.53, p<0.001, 95% CI 0.42-0.67). Adjusting for age and sex, the intervention arm had a 30% reduction in prevalence of caretaker-reported diarrhea for children under 5 in the previous week (PR 0.70, 95% CI 0.59-0.85, p<0.001, n=2352 children contributing 5936 observations). There was also a significant reduction in the one-week prevalence of a reported child diarrhea-related visit to a community health worker (CHW) (PR 0.60, 95% CI 0.39-0.93, p=0.022), health facility (PR 0.56, 95% CI 0.34-0.92, p=0.022), and CHW or health facility (PR 0.58, 95% CI 0.40-0.83, p=0.003). Reported diarrhea (adjusted for age) was also lower among primary cooks in intervention households (PR 0.58, 95% CI 0.46-0.72, p<0.001) (n=1592 cooks contributing 4337 observations). The results of this trial, the first of a large-scale programmatic household water filter intervention, indicate positive effects on drinking water quality and diarrhea for both children under 5 and adults that are consistent with smaller-scale efficacy trials of water filter interventions. However, declining filter usage over the study period suggests continued challenges in sustaining use that could threaten health benefits.
Poster Presentations
To achieve universal and equitable access to safe and affordable drinking water for all, there is a need for sustainable water management which ensures daily functionality of improved sources in rural Uganda. Currently, the access to water remains low in rural Uganda with 68 per cent and the functionality of water sources is estimated between 50 and 70 per cent. Although aid agencies are doing essential work in installing water sources, breakdowns will typically occur within the first year. With no money available for repairs, the source typically stays non-functional for weeks causing reversion to contaminated sources. Moreover, the growing population of Uganda will also increase the water demand by almost ten-fold by 2050. In combination with the increased occurrence of droughts, the availability of water will reduce and result in a severer shortage of water. Therefore, it’s important to ensure daily functionality of the existing water sources and rehabilitate the non-functional water sources. Whave developed a system approach for sustainable water management incorporating social, technical, financial, and institutional components in a framework rooted in local economy and governance. Public-private partnerships for effective and cost efficient operations and maintenance are developed with Whave acting as a benchmark for a local utility. Preventive maintenance service agreements are signed with the communities, and the communities pay an annual service fee. These agreements act as insurance, after paying the annual fee, the local utility will cover the costs for preventive maintenance and repairs. Preventive maintenance and repairs will be carried out by local technicians, hired by the local utility, with performance-payment contracts to incentivizes preventive maintenance and rapid repairs. Over the last four years, Whave achieved a daily operational reliability of 99 per cent within 200 communities and learned that the global challenge of non-functional water sources can be solved with the adoption of sustainable water management. Whave aims to establish two operational service utilities in two districts that are financially viable and afterward, roll out to all districts in Uganda.

Designing and Implementing National Monitoring Systems with Appropriate Sectoral Indicators for Heavy Precipitation and Flooding on Drinking-Water Supply and Drainage Systems: A Key Necessity for Adaptation to Climate Change.

Anthony Akpan, Pan African Vision for the Environment (PAVE)

Adaptation interventions have now become an integral part of plans and policies to deal with changing climate, but they are often also integrated into general development efforts. However, little evidence exists as yet on the success of these measures in reaching their intended objectives, and/or contributing to development, and/or mitigation efforts. One important step in making adaptation count is to design appropriate monitoring and evaluating mechanisms for adaptation investments that can contribute to evidence-based decision-making in the future. Whether an adaptation measure has produced desirable results or not, or if, the measure is in
progress, whether it is on a desirable path or not are issues that can be tackled by M&E processes. In contrast to mitigation investments, each adaptation investment is unique, not easily replicable, often bottom-up, very site-specific and difficult to quantify. While the secondary and tertiary benefits of adaptation may cut across various sectors, the design, implementation and immediate benefits are specific to a location. Hence appropriate sectorial indicators should be used which could be process, outcome or impact-based for heavy precipitation and flooding on drinking-water supply and drainage systems. There are many reasons why M&E should be incorporated as an integral part of adaptation intervention, some of which are as follows: Projections on climate change have a varying level of uncertainty, and adjustments may need to be made as more reliable information becomes available. M&E indicators help track the progress of the intervention as well as measure its effectiveness in achieving the desired objective. Critical success factors for an adaptation programme can be identified through M&E processes. When working within a limited pool of resources, M&E mechanisms can help efficiently allocate resources among various processes to bring about maximum returns. Sometimes efficient utilisation of a critical resource is a key success factor for measuring, in which case M&E mechanisms can be useful in ensuring that the resource utilisation follows the planned path. M&E indicators can be helpful in designing a good mix of mitigation and adaptation interventions so that they complement each other in the best possible manner. M&E indicators can help identify the target groups and other vulnerable groups, as well as the direct and indirect beneficiaries of the adaptation intervention. M&E indicators enable comparison with respect to a baseline for different time periods, as well as comparisons across interventions. M&E indicators focussing on the process and intermediate targets help identify unanticipated problems. This means that corrective action is possible while the programme is ongoing, instead of realising that the actual output is far away from the desired output at the end of the programme. Adaptation is a continuous process, and often one intervention is followed by the other.

**Enhancing Climate Resilience of WaSH Systems and Activities Through Water Security**

Elizabeth Kendall, Winrock International

WaSH projects aim to improve public health as the first step toward poverty alleviation and economic development. To do so, they focus on the construction or rehabilitation of water and wastewater systems (from simple rural schemes to large urban networks) and on the promotion of healthier sanitation and hygiene practices. WaSH programs continue to save lives, but they are increasingly sensitive to climate change. Once a simple issue of supply, communities are facing a variety of WaSH related risks, such as the pollution or depletion of water resources. The community-level scale of WaSH interventions makes it easy to overlook the cumulative effects of multiple water withdrawals and externalities from upstream and for downstream communities. There is a sector wide apathy towards the effects that WaSH projects can have on demand, especially with respect to the consequences of increasing rural water supplies, which attract human and livestock populations, causing extreme strain on local resources (equally water resources as well as croplands and grazing lands). From a public health perspective, the outcome of improved quantity and quality of community water supplies is almost immediate; however, WaSH projects lack the system-based approach to anticipate that
providing drinking water is only the first step in human development and soon leads to larger water demands for economic activities. The Sustainable Water Partnership (SWP) is a five-year, Leader with Associates cooperative agreement that supports U.S. Agency for International Development's (USAID) thought leadership, innovation and action in global water security by integrating water security issues into WaSH programming through relevant, project-specific initiatives. Together with its partners Tetra Tech, the International Union for Conservation of Nature (IUCN), World Resources Institute (WRI), Stockholm Environment Institute (SEI) and its resource partners' CEO Water Mandate and mWater, Winrock International has developed the Water Security Improvement (WSI) Process and accompanying toolkits to advice water users on how to create comprehensive water security intervention strategies using locally owned solutions at the river basin, sub-basin and local catchment scales. Building resilience into current and future WaSH projects requires the observance of SWP's five principals of water security: Apply a "systems-thinking" approach to the water related problem, identifying and addressing causes (not just symptoms), impacts, and externalities, use community participation to elevate water users from beneficiaries to empowered actors, consider the multiple uses of water (from subsistence agriculture to sanitation), Perform assessment and safety planning of water sources (quantity and quality), for now and in the near future, utilize watershed management, awareness raising, and institutional improvements to strengthen construction activities Communities need WaSH, but they deserve water security.

Building Climate Resilience in the Health Sector in Developing Countries: Experience from Tanzania

Hussein Mohamed, Muhimbili University, School of Public Health

Introduction: Public health has always been influenced by climate and weather. Changes in climate and climate variability, particularly changes in weather extremes affect the environment that provides people with clean air, food, water, shelter, and security. Tanzania is not an exception to the threats of climate change. Health sector is mostly affected due to emergence and proliferation of infectious diseases thereby affecting health of the population and thus impacting achievement of sustainable development goals. Methodology: desk review on documented issues pertaining to climate change and health in Tanzania was done using Google search engine. Key words included climate change, link, health, climate initiatives. Individuals working in Ministry of Health, Local Government, WHO, research and training institutions were physically approached to provide their views. Review of various documents from these institutions such as policy brief papers, field work activity reports and developed manuals and guidelines were done. Results: Six main climate resilience activities were identified in Tanzania. These include; Development of Climate Resilient Water Safety Plans Guidelines both for rural and urban water authorities; training of rural and urban water authorities on implementation of climate resilient water safety plans; training local environmental health practitioners on mainstreaming climate change and health into comprehensive council health plans; conducting vulnerability and adaptation assessment for the health sector; mainstreaming climate change in the National Health Policy; development of Risk communication strategy on climate and health; and development of Information, Education and Communication materials on climate change and to create awareness and sensitise people on climate change issues and its effect on public health Conclusion: Proper implementation of the these interventions will help the country
become resilient to many impacts of climate change in the health sector and become a good example for other least developed countries.

**Impact of Climate Change on Water and Health in the Coastal Megacities of India**

Shadananan Nair, Nansen Environmental Research Centre (India)

Maintaining water quality and public health under a changing climate has become a complicated issue in the coastal megacities - Mumbai, Chennai and Kolkata - of India. Millions of poor with limited adaptation capacity living in slums and coastal zones are highly vulnerable to climate change. Providing basic necessities such as reliable water and sanitation facilities become difficult. Increasing seasonality and intensity of rainfall creates floods during monsoons. Indiscriminate encroachment into wetlands, waterways and paddy fields, inadequate capacity of drains and improper maintenance of the drainage infrastructure worsens floods, resulting in casualties and outburst of epidemics. The cities face threat from the sea level rise, increased wave action and surges associated with increasing frequency and severity of tropical storms. Salinity intrusion in coastal aquifers increasingly affects water quality. Size and population of cities are fast expanding. Perhaps the most serious impact of climate change and population expansion on cities is the decreasing availability of reliable water. Decreasing availability of reliable water leads to internal migration and competition for water and conflicts. Current strategies for climate change impact mitigation and policy for adaptation are not efficient. Implementation often fails because of various administrative, social, political and economic reasons. This paper assesses the impact of climate change on water and associated health and socio-economic issues in the coastal megacities of India. Current policies and strategies related to climate change have been critically reviewed. Satellite cities with all basic facilities, well-planned to accommodate environmental changes and population inflow are to be developed. Measures to modernise the urban infrastructure to cope with the changing demographic and climate patterns are essential. India needs an appropriate and frequently updated climate change adaptation policy and an efficient strategy for the mitigation of impacts, with special consideration to the urban centres. Guidelines for this have been provided.

**Biosand Filter Performance After Periodic Abandonment in Honduran Schools**

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Biosand filters (BSFs) are slow water filtration systems that provide clean drinking water to homes in developing countries when paired with proper water, sanitation, and hygiene education (WASH). In order to maintain an active biolayer in the BSF, current recommendations suggest pouring water through the filter every 1-48 hours. This recommendation is not conducive to practical filter use during a school year schedule; therefore, BSFs have not been widely used or tested in schools. A nongovernment organization in Honduras has been pilot testing BSFs in rural Honduran schools since 2014. We investigated BSF performance in these schools on a schedule with varying breaks for weekends and
vacations. Thirty-six BSFs, installed between 2014-2016, were evaluated for microbiological contamination, turbidity, conductivity, flow rate, and sand depth. A monitoring survey was also used to investigate filter use and maintenance practices. Overall, BSFs demonstrated a 98% reduction of E. coli and a 97% reduction of total coliforms by IDEXX Colilert Quanti-Tray/2000 and quantification methods based on the Standard Methods Most Probable Number (MPN). Geometric mean E. coli in the source water was 326.4 MPN/100 mL, considered a "high" risk category by WHO guidelines, while the filtered water fell within the "low" risk category (6.5 MPN/100 mL). Source water in twenty-nine out of the thirty-five schools contained contamination in the "intermediate", "high", or "dangerous" risk categories; filtered water in all but one of the schools fell within the "no" or "low" risk categories. Twelve filters were installed in 2014 and had been reactivated twice, nine filters were installed in 2015 and had been reactivated once, and twelve filters were installed in 2016 and had not been reactivated. The values for E. coli reduction were similar in all three years (99.7% in 2016, 99.6% in 2015, 94% in 2014), but the turbidity reduction decreased from 88.3% in 2016, compared to 49.2% in 2015 and 54.3% in 2014. The difference in turbidity reduction was statistically significant using a one-way ANOVA (p<0.01); small sample size suggests that future research is needed to determine the impact of abandonment on turbidity removal over time. Flow rates for filters installed in all three years (2014, 2015, and 2016) were within the acceptable range; however, flow rates tended to be faster for older filters. According to the surveys, five of the filters tested were not being used due to the presence of one or more of the following obstacles: poor access to source water, internal contamination, and lack of community and/or teacher involvement. Preliminary results demonstrated successful reactivations of BSFs by consistent reduction of total coliforms and E. coli on filters ranging in age from one month to two years in age. Further research would be useful in determining the most efficacious reactivation techniques for filter performance in a school setting.

Baseline Assessment of Water, Sanitation, and Hygiene (WaSH) in Health Care Facilities in Malawi

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In spite of significant advances in clinical procedures and improvements in health outcomes, nosocomial infections continue to present serious challenges globally. While health care facilities (HCFs) have provisions in place to address the threat of infection, such as trainings in infection control and protocols for thoroughly cleaning the facility, health systems in low-income counties struggle to adequately cope with high rates of morbidity and mortality. Malawi's maternal mortality ratio is greater than 680 deaths per 100,000 live births, and neonatal mortality is 31 per 1,000 births. We conducted a countrywide assessment of WaSH and other aspects of environmental health in 45 HCFs in the central, northern, and southern regions of Malawi. Specifically, we assessed environmental health conditions in central hospitals, district hospitals, health centers, and health posts. Quantitative survey data were collected on water, sanitation, hygiene, ventilation, infection control, vector control, energy availability, and solid waste and wastewater management to establish baseline values of the current status of HCFs to serve as a basis for developing structural and behavioral interventions, as well as for
monitoring purposes and impact assessments. Preliminary findings suggest that responsibilities related to environmental health are generally carried out by mid- and lower-level staff and cleaners rather than top-level administrative staff. Additionally, in low-resource settings, environmental health concerns, such as ensuring sufficient access to hygienic handwashing materials and protective gear, become secondary priorities. Furthermore, there is a disparity in reliable water supply and energy access between central hospitals and smaller HCFs, impairing the ability to provide medical services to patients. Further analysis will result in recommendations to address the poor environmental conditions in Malawi, informing health care providers, environmental health officers and policy makers of specific steps towards improved outcomes in maternal and neonatal health.

Exploring the Relationship Between Sanitation and Wellbeing: A Best Fit Framework Synthesis

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The World Health Organization (WHO) defines health not as the absence of disease but as a "state of complete physical, mental and social well-being." In order to have a more comprehensive understanding of how sanitation impacts health, our research team was commissioned by the WHO to synthesize the evidence to date that explores how sanitation, both access and quality, impacts mental and social wellbeing. We conducted our search in English and utilized a generic search string where sanitation terms were combined with wellbeing terms. To prevent publication bias, we allowed for studies published in English, Spanish, Portuguese, French, German, or Italian with any publication status written between 1950 and December 2015. The search strategy yielded 5,909 titles and abstracts. After an initial screening followed by full-text review, 39 studies were deemed eligible. As the majority of eligible papers were qualitative, we used a best-fit framework synthesis approach to organize findings against a set of a priori themes based on current literature and conceptual models, including: assault, safety, privacy, shame, fear, anxiety, dignity, and economic well-being. We analyzed the relationship between these wellbeing themes across four distinct types of sanitation - open defecation (i.e. lack of sanitation) (N = 13 studies), shared/public sanitation (N = 11), school sanitation (N = 17), and private sanitation (N = 7). Our descriptive analyses found that individuals, especially women, experience a wide array of negative assaults to their personal wellbeing when they go out for open defecation (OD) in the absence of sanitation - verbal, physical and sexual harassment, injuries form unsafe OD sites, severe lack of privacy, social shame (often connected to issues of privacy) and more. However, similar negative impacts to wellbeing were present in the studies that explored participant's experiences with shared/public and school sanitation - fear of harassment from men and boys, lack of privacy, stress from lack of cleanliness, anxiety and withholding relief due to long lines, etc. Finally, while the experience of private sanitation was often positively described, poor and inadequate design of household sanitation still led to negative impacts on wellbeing. In sum, this review found that the ability for sanitation to improve a person's mental and social health primarily depends on the quality of
the sanitation facility - how well the facility meets the needs of the user which largely revolve around needs of privacy, safety and comfort.

**Water, Sanitation and Hygiene Conditions in 67 Healthcare Facilities in Uganda**

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Maternal and neonatal mortality and healthcare acquired infections has been linked with inadequate water, sanitation and hygiene (WASH) conditions in low and middle income countries. A 2015 WHO/UNICEF report states that about 38% of healthcare facilities in lower and middle income countries do not have safe supply of water and 19% lack adequate toilets. However, there is a dearth of primary knowledge and data on the functionality and quality of WASH services in health care facilities. We developed a WASH conditions assessment tool (WASHCon) to better characterize and provide this evidence in low and middle income countries. The WASHCon assessment was conducted from October 2015 to March 2017 in 67 healthcare facilities in Southwestern (n=6), Northeastern (n=9), and Western regions (n=52) of Uganda to identify priority areas for improvement, guide plans for interventions and advocate for action. The study was conducted in conjunction with the Ministry of Health Uganda, UNICEF Uganda and World Vision Uganda. The WASHCon consists of interviews with directors and administrative staff of the facilities, observation of WASH conditions, water quality sampling and analysis of key wards. The data was collected on a mobile device and analyzed in SAS software program. In the Western region, only 8% of the healthcare facilities met the basic standards for sanitation and 69% of the drinking water samples tested met the national standards for E.coli. In the Southwestern region, none of the healthcare facilities met the national drinking water standard for E.coli and only 22% of the hand washing stations were observed to have soap and water accessible to both patients and staff. In the Northeastern region, 21% of the toilets were non-functional and none of the functional toilets were hygienic. The results show that majority of the healthcare facilities have inadequate WASH services that do not meet the Sustainable Development Goal 6. These results are being used by UNICEF and World Vision to identify priority areas for improvement, implement interventions to mitigate morbidity and mortality from healthcare acquired infections associated with poor WASH conditions.

**A Systematic Review of Costing and Financing of WASH in Schools**

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Background: Despite the success of recent efforts to increase access to improved water, sanitation, and hygiene (WASH) globally, approximately one-third of schools around the world still lack adequate WASH services. Inadequate WASH is still an issue in many countries due to
a lack of awareness and government policies, insufficient budget allocations, and financial resources. As a result, in 2014, 80% of countries reported their current levels of financing are insufficient to meet their targets for drinking water and sanitation. This is especially an issue in rural areas that receive less than 10% of WASH financing globally. In order to improve budgeting and decision-making, it is important to understand the costs to implement and maintain WASH programs and infrastructure in developing countries. For these reasons, improving knowledge around cost components and potential methods of financing for future WASH programs may help to support the planning and designing of interventions at the school level. The purpose of this systematic review is to understand what costing data is available on WASH in schools globally, identify financing mechanisms that may help to support funding of WASH in schools, and address key considerations or barriers to take into account when designing budgets or financing models for WASH in school’s programs. Methods In an effort to recover all existing costing and financing data relevant to WASH in schools in a developing country context, two research questions were addressed in this systematic review: 1. What are the elements, and associated costs, that could apply to a WASH in school’s programs in a developing country context? 2. How can or how is WASH in schools financed in a developing country context? A systematic review protocol was developed using the “Cochrane Handbook for Systematic Reviews of Interventions” Results/Conclusions A total of 48 articles were included in this review. Sources referenced both rural and urban settings and included journal articles, government documents, graduate theses, NGO reports, and books. Only 12 of 48 articles made some reference to WASH in schools. Of these articles, one focused on hygiene education and latrine cleaning, one listed support tools that could be used for WASH in school programs, one discussed the benefits of funding school WASH, and nine discussed comprehensive WASH (including water supply, sanitation, and hygiene) in schools through case studies in Kenya, the Asian-Pacific region, Ethiopia, India, Uganda, Bangladesh, and Latin American Countries. Results show a lack of information around WASH costing, particularly around software elements as well as a lack of data overall for WASH in school settings as compared to community WASH. This review also identifies several key considerations when designing WASH budgets or selecting financing mechanisms. Findings may be used for advising and planning future WASH in school programs.

Clean and Safe Health Facilities Initiative: Implementation and Lessons in Ethiopia

Kebede Gela, WHO

The clean and safe health facilities initiative (CASH) was launched by the Ministry of health of Ethiopia in 2014, to improve the cleanliness and safety of health facilities and reducing healthcare-associated infections. Also to make the facilities are comfortable to the patients, staff and visitors. Main strategies of the CASH involve ensuring leadership commitment, bringing attitudinal change to the staff and leaders and make cleanliness is the responsibility of all in health care facilities. A case study was conducted in two secondary and tertiary health care facilities in Ethiopia during 20-25 February 2017. The purpose of the study was to understand how the CASH initiative has improved the facilities, identify lessons and the gaps. Interviews were conducted with facility staff and observation of water, sanitation and hygiene (WASH) infrastructure and infection prevention and control (IPC) practices at each facility. The CASH implementation approaches followed by the facilities included establishing a CASH team,
baseline assessment and problems identification using the developed national audit tool, engaging the facility and local leaders, dialogue and sensitization to the staff on cleanliness and hygiene practices, intensive waste collection and disposal campaigns. These resulted to have clean, organized and green hospitals with improved sanitation, and health care waste management as compared to the baseline. Moreover, it has enabled improved satisfaction and use of the facilities by the patients and other clients. The CASH initiative has resulted in varying level of success in different facilities while there remain gaps and challenges that need to be addressed. There is a need to further strengthen the CASH/IPC program and enable a mechanism for continuous improvement in the facilities through integration of recently developed WHO/UNICEF water and sanitation for health facility improvement tool (WASH-FIT).

**Social Microbes Haiti: The Impact of Deteriorating Latrines, Open Defecation, and Animals on Diarrheal Pathogen Environmental Contamination Patterns in a Peri-Urban Settlement of Corail, Haiti.**

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High rates of enteric pathogen co-infection in children under five years of age (<5) in low-income, disease endemic settings suggest that children are frequently exposed to diverse types of pathogens over space and time. However, it is unclear how children acquire infections over space and time. Multi-pathogen exposure of children may be particularly likely during play in non-domestic (public) settings. Discovery of variable risk of multi-pathogen exposure has important implications for prioritizing WaSH interventions. This Social Microbes analysis quantified pathogen doses and the probability of multi-pathogen exposure during play at public areas for <5 children living in a diarrheal disease-endemic setting. We then examined how doses and exposure to multiple pathogens was influenced by type and rate of child behaviors. A rapid observation survey assessed environmental sanitary conditions and young child behaviors in public areas in three communities in Kisumu, Kenya (Fall 2015). Children were playing at 54% of 120 public sites, and exhibited behaviors such as crawling on unpaved ground and geophagia. A qPCR Taqman Array Card was used to measure concentrations of 19 enteric pathogens in soil collected from these sites. A Bayesian framework drawing on the pathogen soil data was used to simulate the natural logarithm distribution of concentrations for a common virus, bacteria, and protozoan, while accounting for interdependencies between pathogens. Cryptosporidium spp. (geometric mean (gm) 5.5E+05; standard deviation (sd) 3.8 oocysts/gram), Enterotoxigenic Escherichia coli (gm 4.1E+05; sd 6.0 cfu/gram) and adenovirus 40/41 (gm 1.2E+07; sd 12.5 vpu/gram) were detected in 75%, 18% and 9% of soil samples, respectively. Simulated pathogen concentrations were adjusted for soil volume, adherence, hand size, and transfer efficiency to estimate the dose and probability of ingesting multi-pathogens during one soil-hand-mouth (SHM) or geophagia. Independent draws of SHM and geophagia doses were summed and compared by frequency of contact. Probability of ingesting all three pathogens increased additively with increased contact, while doses increased quadratically. The probability of ingesting three pathogens via one geophagia event (43%) was
equivalent to ~2.5 SHM contacts. Additional SHM events were required to equalize with doses from one geophagia event, and varied by pathogen type. Children <5 in disease endemic countries can be exposed to multiple pathogens during play in public settings, which suggests that public exposures contribute to co-infection burden in <5 children. We demonstrated that behavioral practices influence the magnitude and diversity of pathogen exposure. In-process analysis will further show how exposure patterns change as a consequence of spatial factors. Our results imply that interventions must reduce fecal contamination in non-domestic settings to prevent enteric infection in children in low-income, disease endemic settings.

**Economic and Energy Analysis of Novel Neighborhood Fecal Sludge Treatment Systems that Use Supercritical Water Oxidation**

Marc Deshusses, Duke University

Our team has designed and built a technical scale prototype supercritical water oxidation (SCWO) system to treat the fecal waste produced by roughly 1000-1200 persons daily. The unit is housed in a standard 20 ft. shipping container and has been undergoing testing at Duke since early 2015. The process, while high-tech is relatively simple. After moderate preheating, the waste slurry is mixed with supercritical water (~600 C) and air (which serves as oxidant), which rapidly brings the waste undergoing treatment to supercritical conditions (~400 C, 240 bars). Under these conditions, all organics are rapidly (i.e., few seconds) oxidized to CO2, with the corresponding heat of combustion released in the reaction medium. After the reaction, heat recovery follows in a 39 m long heat exchanger. Experiments were conducted with various fecal wastes and sludges and served to assess the economic and technical feasibility of this novel process. Typically, over 99.9% removal of COD, over 98% removal of total nitrogen and total phosphorous are observed and clean water is produced, as well as excess energy in the form of hot water. We recently conducted in-depth process optimization, including determining the sensitivity of the size of the unit, as well as optimizing the process for energy recovery. This led to the design of two systems, one that can handle the fecal waste of 3000 users per day, and one that can handle the fecal waste of 30,000 users per day. Detailed energy balances and process economics, as well as simplified business cases will be presented and discussed at the conference. The project is funded by the Bill & Melinda Gates Foundation.

**USAID/MCSP’s Clean Clinic Approach: Empowering the Haitian Health System to Improve WASH in Health Care Facilities**

Marie Maud Jean, Save the Children

With the recent spotlight on healthcare-associated infections (HCAIs) and recurring outbreak threats (e.g. Ebola, cholera), the need to improve Water, Sanitation and Hygiene (WASH) in Health Care Facilities (HCF) has emerged. In response, USAID’s Maternal and Child Survival Program (MCSP) and Save the Children developed the Clean Clinic Approach (CCA), a health system strengthening (HSS) and quality improvement (QI) approach that supports health facilities to identify WASH priorities, develop action plans, and implement incremental WASH improvements. In Haiti, initial program monitoring demonstrated WASH improvements in 20 pilot facilities, leading the government and donors to invest in scaling the approach to an
additional 49 facilities. In addition, the program’s WASH focus facilitated participating facilities’ ability to respond to Hurricane Matthew. This presentation will share the MCSP’s experience establishing WASH in HCF standards alongside the Ministry of Health, developing leadership within health facilities to tackle WASH priorities, and scaling to a total of 69 facilities in seven of Haiti’s ten Departments. The session will highlight how WASH in HCF work in Haiti contributes to improving quality of care and strengthening the health system by highlighting management needs and undertaking incremental WASH improvements.

Handwashing Stations in Health Care Facilities Lack Sufficient Conditions to Control Infections Across Ten Countries in Africa and Asia

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Many community-based studies that measure child diarrheal illness rely on a recall period of two weeks, which is problematic due to recall bias. Recent literature indicates that caregiver reported illness should be ascertained using a 7-day recall period. This study aimed to be the first large, multi-country analysis using the shorter 7-day recall period to identify the household level water, sanitation and hygiene (WASH) risk factors associated with diarrheal illness in children under five years old. As part of the 11 country Performance Monitoring and Accountability 2020 (PMA2020) WASH program, nationally representative household data were obtained between 2014 and 2016 from the Democratic Republic of the Congo, Ethiopia, Ghana, Kenya, and Uganda where diarrheal outcomes were ascertained. A total of 14,689 children from 10,754 unique households were analyzed. Logistic regression was used to examine the relationship between childhood diarrheal outcomes and household WASH and demographic factors. The overall prevalence of diarrhea in the five study countries was 22% (N = 14,689) with the lowest prevalence in Kenya (16%, N=2,655) and the highest in Uganda (32%, N=3,059). Maternal education, household wealth quintile, number of household members, sanitation classification, drinking water reliability, disposal of children’s feces in a latrine and presence of a hand washing location were found to be significantly associated with diarrhea in children under five, after adjusting for other variables (p<0.05). Children in homes with unimproved sanitation had significantly higher odds of diarrhea than those in homes with improved sanitation (AOR= 1.22, 95% CI 1.06-1.41), as did children in homes with intermittent, unpredictable water sources when compared to homes with predictable water sources (AOR=1.21, 95% CI 1.07-1.37). For child feces management, in households that reported children using the latrine, the odds of diarrhea were significantly lower (AOR=0.74, 95% CI 0.66-0.83). A significant difference in diarrhea prevalence was not seen between households with improved versus unimproved drinking water sources (OR=1.00, 95% CI 0.91-1.09, p = 0.99). Using an optimal 7-day recall period, this study confirms the need to prioritize adequate sanitation as a driver in reducing diarrheal disease in children under five. The PMA2020 WASH program which collects these data on a rapid, low-cost, and real-time basis is a robust monitoring tool to measure progress toward achieving targets set for water and sanitation under Sustainable Development Goal 6.
WaSH in School Premises: Key Findings from an Assessment Held in Nine States of India

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As mandated by the Right to Education Act (2010) in India, all schools must have separate toilets for boys and girls and adequate safe drinking water facilities. Government data from 2011-12 suggested that only about 80% of schools had separate toilets for boys and for girls, with 95% having drinking water facilities. Cognizant of these, Government of India launched Swachh Vidyalaya Abhiyaan (SVM) in 2014 aiming to provide separate toilets for boys and girls in all government schools by 2015. The GOI declared 100% sanitation coverage in all schools by 2015, yet experiences from the field suggest that while WASH facilities may exist, functionality and sustained use of these was questionable. In this context, WaterAid India undertook an assessment in select schools across nine Indian states covering 453 schools, using both quantitative and qualitative tools, aiming to comprehensively understand the school WASH situation, including the functionality of WASH infrastructure and enabling environment for hygiene behaviors. The assessment revealed that although drinking water was available in 84% schools surveyed throughout the year, it was not considered safe in almost 15% of schools. Gaps in maintaining cleanliness around the water sources and point of use were perceived to be leading to water contamination. In schools with hand pumps with shallow/deep wells, 57% had open drains and 40% had stagnant water with garbage nearby. Functional toilets were found in 95% of the schools assessed, with three fourth of the schools having separate toilets for male and female students. The toilet-student ratio was well below the norm of 1:40 (1:76 for boys and 1:66 for girls). Despite the availability of functional toilets, one fifth of the students reported defecating in the open during school hours. Running water in toilets was observed to be available only in a little over a third of the schools. Around a quarter of the toilets were cleaned daily. Lack of water and dirtiness were the top reported reasons for not using toilets. The presence of handwashing facilities was minimal, with one third of the schools having no running water and a little over half did not have soap near toilet facilities. It was reported that 95% of students washed their hands before eating while the figure for after using toilet was 82%. Just about one fifth of schools assessed had some facility for girls to manage their menses. Incinerators in 38% and dustbins in 62% schools were available as menstrual hygiene facilities. In half the schools lacking any MHM facility, girls reported throwing the used absorbents outside premises. The findings underscore the significant achievements by the SVM. However, it also points to the importance of further efforts needed on ensuring the availability of adequate number of functional toilets, safe drinking water throughout the year, handwashing stations with running water to enable hygiene practices, and support measures for menstrual hygiene.

Water is Everywhere, Not a drop to Drink: A Case of Floating Boat Fishers in Coastal Bangladesh

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Bangladesh is one of the most climate-vulnerable countries in the world and the main critical impacts of climate change are related to water. The evidence has been growing that both quantity and quality of water are already being affected across the diverse geographical regions including the coastal fishing communities. Floating boat fishers are the most vulnerable among the coastal fishing communities not only for the natural calamities but also because they are living close to the sea, do fishing in open waters, live on floating boats and unable to withstand the onslaught of hurricane-force winds and storm surge, limited socio-economic capitals and so on. Therefore, such fishing communities also lack of economic, social and political power for building resilience to these shocks and stress. Floating boat fishers are landless fishers from nomad group living in a floating boat. They became boat fishers due to river erosion and they are very poor, vulnerable, stigmatized, and deprived of all types of basic needs and exposed to different types of natural and humanitarian risks. They do not have any land for living and cultivation, no opportunity of education and medical treatment. They pass their whole life in a small boat with all the family members. Usually they live on boat in different small rivers where water current is quite low. All the household activities are performed inside the boats including cooking, eating, sleeping etc. They use the river water for drinking, cooking and other domestic purposes and frequently faced water-borne diseases. At early morning both men and women go to the rivers for fishing, which is their only source of income. As their life and livelihoods are on the floating boat and most of the time they are isolated from the main land, they are somehow out of government's social safety net program. Moreover, they are bound to oblige the fishing laws, like ban period and the hardship, as they do not have any other alternative livelihood opportunities. In addition, they cannot shift to other professions due to limited ecosystem services. Fishing is the only livelihood option and it's transmitted to generation after generation. Considering their vulnerability and disadvantaged situation, a USAID-funded “Enhanced Coastal Fisheries in Bangladesh (ECOFISH-Bangladesh)” project, which is jointly implemented by WorldFish and the Department of Fisheries (DoF), Bangladesh, extended its support to the boat fishers through different capacity building initiatives for improving livelihoods. However, their crucial needs are safe water, sanitation, medical facilities, children’s education, social recognition and inclusion among majority people, which are still challenging. A coordinated approach of government, development agencies and civil society is required to take them out from the vulnerable situation.

**Sustained Use of Portable Handwashing and Drinking Water Stations in Health Care Facilities --- Siaya County, Kenya, 2016**

William Davis, CDC

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Background: Data from 54 middle and low-income countries showed that 38% of health care facilities (HCFs) lacked improved water supplies and 35% lacked handwashing facilities, increasing the risk of healthcare-associated infections. To address this problem in Siaya County, Kenya, portable handwashing and drinking water stations were installed, along with a one-month supply of soap and sodium hypochlorite for water treatment, in 109 HCFs in 2005.
Water station upgrades and retraining were provided in 2012 and 2014. We evaluated this program in 2016 to assess acceptability, use, and sustainability of these interventions. Methods: We made surprise visits to a random sample of 28 HCFs that had been previously evaluated in 2012 to interview staff and conduct observations on: water sources, water treatment practices, and use and maintenance of handwashing and drinking water stations. At each HCF, we tested samples from the water source and one drinking water station for chlorine residual and Escherichia coli. Results: Water sources for the 28 HCFs included rainwater (54%), boreholes (36%), and public taps (11%). Twenty-seven HCFs (97%) had functioning drinking water stations, 26 (93%) had functioning handwashing stations, and 13 (46%) had soap at a handwashing station. Of respondents from 27 HCFs who reported that water station taps had broken, 17 (63%) said they replaced the taps. Respondents from 18 HCFs reported that water station containers had broken; 11 (61%) reported replacing the containers. Respondents from all 28 HCFs reported buying soap, while 19 (68%) reported buying water treatment products. Water testing revealed that no HCF water sources were chlorinated; 13 (46%) tested positive for E. coli. We detected free chlorine residual in drinking water samples from 2 (7%) of 27 HCFs and total chlorine residual in water samples from 8 (30%) HCFs, indicating previous water chlorination at the HCF. Samples from drinking water stations at 25 (93%) of 27 HCFs had no detectable E. coli, including all 15 from HCFs with uncontaminated sources and all 8 with detectable total chlorine residuals. Conclusions: Use of inexpensive handwashing and drinking water stations was sustained in all but two rural HCFs over a period of 12 years, indicating that these interventions are sustainable. None of the water samples from drinking water stations filled from uncontaminated sources yielded E. coli, highlighting the importance of safe water storage and the success of these containers in preventing contamination. No chlorinated drinking water samples yielded E. coli, underscoring the importance of water treatment. In most HCFs we did not observe soap at handwashing stations or evidence of chlorination in drinking water stations. These inexpensive and accessible commodities that can enhance the impact of water stations, and health worker training should stress their importance.

Systematic Literature Review of Surface Disinfection Efficacy to Inform Recommendations for Low-Resource Outbreak Settings

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Fomites are inanimate objects or surfaces, such as bedding, doorknobs, or medical equipment, that can transmit infectious organisms. Evidence-based guidelines for cleaning, disinfection, and sterilization have been developed for healthcare facilities in high-resource settings to break indirect disease transmission via fomites. A key gap in knowledge is for low-resource settings, where different fomites such as wood, concrete or heavy-duty tarp are of concern and disinfection with chlorine is currently the most common intervention. Additionally, in recent Ebola and cholera outbreaks, guidelines on how to disinfect fomites were inconsistent, with different chlorine concentrations, contact times, and pre-cleaning actions recommended. We are conducting a systematic review to answer three questions: (1) What do we know about the efficacy of chemical disinfection against pathogens and surrogate organisms on surfaces? (2) How can available data inform recommendations for low-resource outbreak settings? (3) What
are current knowledge gaps and research needs? The systematic review includes defining inclusion criteria, searching and selecting studies, assessing the quality of evidence and summarizing available data. Inclusion criteria were defined using the PICOS methodology; the population of interest are microorganisms on surfaces relevant to outbreak treatment centers/units or households, excluding biofilms; the intervention is chemical disinfection with the relevance of disinfectants to low-resource settings assessed based on transportability, affordability, and safety; comparisons will be made between different test organisms, surfaces, and disinfectants; only studies that provide a quantitative outcome for surface disinfection efficacy will be considered; and there are no a priori restrictions on study type. Scopus, Web of Science and PubMed were searched with relevant keywords; and field-specific textbooks, journals, and regulatory sources will be browsed manually. Five criteria specific to laboratory-based studies will be used for quality appraisal: (1) adequate controls, (2) methods clearly described, (3) appropriate detection method, (4) studies performed at least in duplicate, and (5) appropriate statistical analysis. After removing duplicates from online search results, 9,484 titles were screened. Of these, 1,903 appeared to be potentially relevant to chemical disinfection of surfaces. Abstract screening is ongoing at the time of submission. The systematic review will be completed by end summer. The outcomes of this work will include: (1) knowledge summary, incorporating results from different research fields such as environmental microbiology, food industry, and hospital infection control; (2) recommendations for disinfection of surfaces in low-resource outbreak settings; (3) recommendations for future research specific to low-resource outbreak settings.

Operational Research on Rural Water Safety Plans: Case Study Results from Implementations in India, DRC, Fiji, and Vanuatu

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Background and Methods Water Safety Plans (WSPs) are a comprehensive assessment and management tool promoted to ensure the safety of drinking water. While a framework for evaluating WSPs exists, evidence of WSP outcomes are minimal, particularly for rural, community-managed WSPs. We conducted a mixed-methods evaluation of WSP implementations to quantify the outcomes of, and develop recommendations for, implementing rural, community managed WSPs. Four countries were selected for inclusion in the study by UNICEF and Tufts; the level of WSP implementation was quantified in each country. The target was to survey 100 households (HHs) in WSP villages and 100 HHs in non-WSP villages per country. Household surveys included 57-60 questions on demographics; knowledge, attitudes, and practices (KAP) towards WASH; and, knowledge of water committees and WSP work. During each survey, a HH stored water sample and a HH source water sample were aseptically collected and processed with membrane filtration to quantify E. coli; counts were grouped by WHO risk classification. Key informant interviews (KII) and focus group discussions (FGD) contained 5-34 qualitative questions and were conducted with village chiefs, plumbers, water maintainers, water management committees, and village nurses as appropriate to the local context. All data was analyzed in R 3.3.2 using Fisher’s exact test of independence, with p<0.05 significant. Results and Recommendations Countries chosen for inclusion were India, the
Democratic Republic of Congo (DRC), Fiji, and Vanuatu: overall, 816 HH surveys, 1,113 water samples, 120 KII, and 136 FGD were conducted. WSP implementation was lowest in India and DRC, where not all elements of a WSP were included in the process. KAP surveys indicated: primary water sources differed between WSP and control HHs in DRC, Fiji, and Vanuatu. More WSP HHs paid for water in DRC and Vanuatu than control. More control HHs reported treatment in Fiji than WSP HHs; in Vanuatu more WSP HHs reported than control. Control village sources were more likely to have lower E. coli contamination at the source than in WSP villages in DRC and Fiji at the <1 E. coli CFU/100mL risk classification level and in Fiji and Vanuatu at the <10 CFU/100mL level. Control village HH stored water samples were more likely to have lower E. coli in Fiji and Vanuatu at both the <1 and <10 CFU/100mL levels. Interviews indicated improved capacity of local committees in understanding their water supply systems and in identifying key risks to the delivery of safe water. We found that there was: mixed interpretation of WSP implementations; no improvement in E. coli contamination; small improvements of water supply operations; and, non-centralized water supply situations that question the appropriateness of utilizing a WSP. If WSPs are implemented in rural supplies, we recommend: simplifying tools, promoting water treatment and monitoring, and creating financial and technical assistance programs.

Demonstration of Low Cost Handwashing at Scale - The Volta Region Tippy Tap Campaign

Paa Kwesi Woode, UNICEF Ghana

In Ghana 3,600 children die each year from diarrheal disease. Whilst handwashing with soap reduces the risk of diarrhea by 47%, only 21% of Ghanaian households have a designated place with soap and water for handwashing. A strategy to address this challenge in schools was developed to enable schools to build and use simple, low-cost handwashing facilities, complemented by behavior change messages and soap-making skills. This poster outlines a cost-effective, high-uptake approach to getting handwashing facilities in schools, initially in Mion District, then at scale across all of Volta Region. The strategy is based on the ‘Tippy Tap’ technology, requiring only locally available materials such as empty plastic containers (‘gallons’), ropes and sticks, operated by a foot lever to reduce the risk of disease transmission. The approach was initially trialed in 2015 in all 75 public schools of Mion District, resulting in 95% of schools using handwashing facilities, even following a period of school holidays. A follow-up survey over a year later identified 60% of schools with functional Tippy Taps, most significantly increasing their numbers. The remaining schools were restricted by water shortages and availability of soap. In 2016/7 UNICEF supported scale up of the tippy tap approach in the Volta Region, targeting over 3,900 schools and 540,000 children. The programme was delivered through Ghana Education Service staff and processes, including cascading training and an increased focus on local soap making to address challenges encountered in the Mion pilot. A spot check indicates that at least 90% of targeted schools are using Tippy Taps. Initial feedback indicates that tippy taps are well received as they are easy to make, low/no cost, and easy to operate and maintain, even in areas with water scarcity. This campaign is a promising combination to increase hand washing practice at scale within schools and homes.

Football for WASH: An Innovative Initiative for Scaling Up WinS in Kenya
Football for WASH (F4WASH) is an innovative public private partnership initiative aimed at scaling up WinS by improving and sustaining WASH services and behaviours in schools through football. The first phase (2012-2016) of FWASH initiative in Kenya was implemented 170 public primary schools, reaching 119,420 children in 7 counties. A qualitative assessment conducted in 2016 showed a number of benefits from F4WASH including improved sanitation and hygiene practices, increased enrolment in F4WASH intervention schools, improved academic performance of both boys and girls, increased self-confidence by adolescent girls influenced especially by sanitation and MHM facilities and increasing of girls’ involvement in sport. F4WASH also had positive influence on WASH practices and behaviours on the wider community while improving sporting - football facilities, football teams and training of world coaches. Maintaining of these facilities is done through ownership and active participation by children, teachers and communities, income generating activities in schools such as tree and crop planting, and water levies.

Due to the success of the first phase of F4WASH and sustained advocacy, the initiative is now being expanded to cover 90 more schools in three counties, with the county governments committed to leverage resources by contributing USD 830,000 for improvement of the WASH services in the schools. At national level, the F4WASH initiative has influenced many WinS policies including the MHM policy, which now mandates free provision of quality sanitary towels and MHM facilities in schools. The policy frameworks and structures in place will ensure scaling-up and sustainability of WASH in schools, which will ultimately contribute in keeping children in schools and improving their health and performance.

Advancing WinS Progress Nationwide in Fiji Through Enhanced Monitoring

Mamita Bora Thakkar, UNICEF Fiji

Additional Authors: Kate Shields; Ryan Cronk; Waqa Tikoisuva

Every child deserves an opportunity to learn in a safe and healthy environment. Fiji, like many other countries, faces the challenge of ensuring that every school provides safe drinking water; toilets that are private, gender segregated and located in a safe place on school grounds; and encourages daily healthy hygiene practices such as handwashing with soap and water after using toilet and before eating. Lack of data on WASH in Schools and in particularly, the geographical context of Fiji which makes it vulnerable to frequent floods and cyclones, are contributing factors to this challenge. UNICEF, in collaboration with local partners, is leveraging two existing national monitoring mechanism in place in Fiji to enhance WinS monitoring: The Fiji Educational Management Information Systems (FEMIS) and the District Education Officers who have the conduct routine in-person monitoring and inspection of the schools (teachers performance and schools facilities). Scale-up approach: With the revised FEMIS and inclusion of WinS indicators in
the School Standard Monitoring and Inspection Checklist, and the capacity building on the indicators, nationwide, schools administrators and teachers are incentivized to ensure provision of WASH facilities and practice healthy hygiene behaviors such as handwashing.

In Kiribati, everybody WinS!

Mamita Bora Thakkar, UNICEF Kiribati

Schools are entry points for WASH practices to reach communities by enabling children as agents of change. This is the foundation for WASH in Schools in Kiribati, a country situated in the Central Pacific Region, stretching from North of Fiji up to Hawaii with less than five percent of the country consisting of land. Kiribati’s unique context, makes WASH in Schools as necessary and challenging at the same time. An annual increasing population of 3% per year. The number of people living in Kiribati is expected to double in the next 20 years. With an increased demand for fresh water compounded by the threat of the effects of climate change such as longer drought and salt water intrusion plus high open defecation rates that pollutes ground water lenses, water supply will dwindle and become more limited in the years to come. Kiribati WASH in schools (K-WINS), targeting 40 schools, mitigates these risks by making school communities and children take action to get sanitation facilities and basic hygiene practices spread from schools to homes. Group handwashing activities; Daily school ground and toilet cleaning; Weekly WASH pledges as part of routine school activities facilitates behavior change and reinforces health living classes. The Ministry of Education, through the island education coordinators, mandates all school heads to strictly implement WASH activities in schools. The program has been implemented beyond the target areas reaching school children to as far as Kiritimati island.

WASH in Schools for DRR

Lalit Patra, UNICEF Vietnam

Additional Author: Viet Xuan Vu

WASH in Schools is an important support to protect children’s right to safe drinking water, sanitation and hygiene in their learning environment. There are growing bodies of evidence that explains the impact of WASH in Schools on children’s health and cognitive development. This has also positive implications to their quality of learning environment and in building their long-term hygiene behaviour. Children also serve as ‘change agents’ in transforming community behaviours. The recent emergency triggered as a result of large-scale drought and saltwater intrusion in Viet Nam that affected over 400,000 school children, WASH in Schools was explored as an imperative component of the recovery and risk resilient programme. The interventions included rehabilitation of defunct WASH facilities, provision of water storage, hand wash and toilets, and water purifying equipment, with supportive operation and
maintenance management arrangements and institutional development, apart from the promotion of group handwashing and other sanitary behaviours. Two educational board games namely ‘Cool Down the Earth’ and ‘Eat Poo WASH’ were promoted in more than 100 schools with successful field-testing. Government of Viet Nam is seriously considering to strengthen WASH in Schools at scale as a key component of disaster risk reduction programming with the lessons learnt in implementing this initiative in selected schools.

**Improved functionality of School Water Supply, Sanitation and Hygiene (WASH) through MSH (Mind-Soft-hard ware) and MnE tools in Nepal**

Katak Bahadur, UNICEF Nepal

Additional Authors: Bishow Raj Bhatta, Rokaya

In Nepal, Department of Education (DoE) has been leading school WASH program and supporting for toilet construction and water supply connection which is reflected in education sector strategy, school sector development plan (2016-2022), child friendly school framework-2010, Child friendly local governance framework-2011 and draft school WASH guidelines-2017. EMIS/DoE, 2015/2016 shows that 80% schools have sanitation and 78% water supply facilities but the functionality and management of WASH facilities are questionable. UNICEF has been working on school WASH in partnership with the Department of Education providing support for policy advocacy, capacity building and software & hardware activities since 2002. UNICEF had introduced MSH (mind-soft-Hard ware) approach for improvement of school WASH facilities since 2014 in some schools in coordination with District Education Offices and civil society organizations. This process starts with assessment of school WASH status, and identify the problem with participatory approach which is followed by capacity building of stakeholders, teachers, management committees and child clubs, develop school WASH improvement plan and its implementation accordingly. Finally, progress is monitored against 3 star indicators and locally developed monitoring & evaluation (MnE) framework. This process is coordinated by government line agencies, adopted by other stakeholders including local bodies. Consequently, schools management team, teachers and child clubs are capacitated, activated and mobilized for WASH management, developed improvement plan and incorporated in school improvement Plan. Moreover, WASH focal teachers are nominated to coordinate for WASH facilities management, upgraded WASH facilities making child gender and disable friendly, established school WASH management mechanisms. Initially, 59 schools were supported in 2014, of Baitadi district in Nepal, which was gradually scaled-up in other districts in 2015, 2016 & 2017 and reached to 1057 schools. Additionally, this approach seems cost & time effective to improve functionality of school WASH, strengthen management mechanism ensuring participation of entire team including children. The learning of this process are reflected in School WASH guidelines-2017 as well.

**What it Takes to Mobilize Public Finance for Improving WASH in Schools? A Case Study of Mirzapur District in Uttar Pradesh of India**
Pratibha Singh, UNICEF India – Pradesh

UNICEF in partnership Government of Uttar Pradesh (GoUP), IDBI (Industrial Development Bank of India) and Unilever Foundation demonstrated an approach to mobilize public finance to improve WASH infrastructures in Mirzapur district in the State of Uttar Pradesh, directly benefitting 37,000 girls and boys of 273 schools. The approach has been widely recognized by the GoUP and a Government Order (GO) has been issued on 20 May 2017 to use untied public finance available within the Fourteenth Finance Commission of the Government of India (GOI) and GoUP for improving sanitation in schools and Anganwadi Centers on priority basis. Successful implementation of the GO is expected to improve WASH facilities in 158,873 primary and upper primary schools of UP, benefiting about 36 million children. Strategies implemented in Mirzapur district in the pilot phase (2014-2016) included: i) construction and repair of girls and boys toilets, ii) menstrual hygiene management and incinerators in upper primary schools, iii) water supply for drinking, handwashing and use in toilets, iv) group hand-washing facilities with soap stands, v) software activities to ensure ownership of school children, parents and teachers on the WASH issues, and vi) evidence based advocacy at the State level. Following the initial success of program, Mirzapur district has started implementation of ‘Vidhyalaya Kayakalp Mega Campaign’ with the objective of making all 2,212 elementary schools in the district child friendly and WASH compliant, with an estimated budget of IRs. 220 Crores (approx. USD 34 million). Other districts (e.g. Bhadohi, Sonbhadra) have also started similar programmes. The Swachh Vidyalaya Award strategy introduced by the GOI and the Right to Education Act, 2009 have provided legal framework to implement such programs. The key conclusion of the Mirzapur approach is that right enabling environment combined with a visionary leadership at the decentralized level, strong ownership of school children, parents and teachers, gender mainstreaming in programming, participatory planning and monitoring system are important to successfully mobilize public finance for School WASH.

Strengthening Government Capacity and Community Commitment Toward Improving WinS in Indonesia

April M. Klein, Emory University

Sanitation and hygiene access in schools contributes to better health outcomes for school-aged children. The Government of Indonesia is committed to improving sanitation access nationwide, but strategies for extending access to schools are not systematically applied, and only half of Indonesian schools currently meet the Sustainable Development Goal (target 4.a) for school sanitation. Issues of decentralization and limited collaboration across government agencies responsible for Indonesia’s school and health programming pose serious challenges to the development of sanitation policy that reaches down to school level. Research findings from a 2016 study on synergy between school and community sanitation programming in Indonesia were followed up with 12 key-informant interviews with government officials and community stakeholders. The purpose of the interviews was to identify aspects of existing sanitation strategy that can be linked to schools to build capacity and foster government and community commitment to school sanitation across Indonesia. Analysis of the interview responses and existing policies along with UNICEF’s guidelines for strengthening the enabling environment was
used to develop a set of recommendations to enhance specific areas that may improve outcomes for school sanitation. The resulting recommendations included inserting school sanitation indicators into verification of ‘open defecation free’ communities, creating a pathway for schools to access village development funding, and redistributing funds for a school sanitation hardware program to reach a greater number of schools. These recommendations can strengthen government and communities’ commitment and accountability to ensure schools are safe and healthy learning environments for children with regards to sanitation access. Additionally, these findings offer useful insights for other low and middle-income countries that face similar challenges to developing and scaling up school sanitation strategies.

**DepED WinS: Scaling-Up WASH in Schools in the Philippines**

Jon Michael R. Villasenor, UNICEF Philippines

In late 2016, the Philippine Department of Education (DepED) rolled-out the National WASH in Schools (WinS) Three-Star System to its sixteen (16) regions for nationwide implementation. The roll-out followed the enactment of the National WinS Policy in early 2016. The National Three-Star System operationalizes an incremental approach to achieve the aims of the Policy, which codifies the standards and harmonizes the guidelines on WASH education and service delivery in 44,000 public elementary and secondary schools. The Three System provides an integrated system for planning, monitoring, quality assurance and merit, while enabling DepED’s organizational processes and action from national to school level for WinS. The national roll-out of the Three-Star System marks what has been an eight-year journey of the DepED with its partners, particularly UNICEF, towards scaling-up WinS in the Philippines. The journey moved with the evolution of the roles and relationship between the DepED and its partners, organized under the National WinS Technical Working Group (TWG). It saw DepED claim ownership of WinS and the process for scaling up and sustaining WinS. The Policy, Three-Star System and adjunct mechanisms are an effective reflection of the evolved roles and relationship and DepED’s ownership of the process. They reflect the contributions and evolving role of UNICEF as it navigated the upstream and downstream work in WASH in Schools and ensuring the two movements benefited each other. Anchored on the formation of the WinS TWG in 2011, UNICEF’s WASH in Schools journey with DepED has covered building evidence for WASH in Schools, policy formulation and standards setting, demonstrating quality program implementation, integration of WinS in the national basic education information system, increasing investments for WinS at national and local levels, integration of WinS in the education curriculum, decentralization of WinS governance, and leveraging public and private support to WinS.

Tuesday, October 17th

**Increasing Women’s Participation in Water Governance Institutions by Transforming Social Norms**

Aditi Krishna, Iris Group

Additional Authors: Hannah Taukobong; Anne Eckman; Christina Sudi; Christopher Magomba
In many contexts, although women and girls disproportionately bear the burden of scarce water resources and inadequate provisions for sanitation and hygiene, their needs are often not represented in institutions governing water use and supply. In Tanzania, water supply and use are overseen by several water governing bodies, operating at different geographical levels (national, regional, district, ward, and village). Representation of women is mandated by national policy; however, formative research found that women are appointed to fulfill quotas or because they are related to influential individuals. In these cases, membership in water governance institutions does not always lead to their meaningful participation of women. A set of factors - and point of intervention - are social norms sanctioning women, particularly younger women, from speaking in public. These norms are critical levers because they inform knowledge, attitudes, and practices inhibiting women from participating in public decision-making fora. Our intervention seeks to alter gendered social expectations regarding women’s participation in water governing institutions. Greater participation of women will enable these institutions to better meet the needs of women and girls. The gendered social norms change intervention will occur within the context of an ongoing integrated water resources management project in Tanzania funded by USAID - Water Resources Integration Development Initiative (WARIDI). During the first phase of the intervention, the research team will conduct formative research (community consultations), which will inform intervention design. Following baseline assessment of social norms, knowledge attitudes, practices and behaviors relating to women’s participation in public fora, the intervention will seek to transform social norms through a media campaign (radio, posters), advocacy with community leaders, and peer education. The end line assessment will occur one year after the intervention. Phase I of the intervention will begin in June 2017 and the intervention will culminate in December 2018. In advance of presenting results from the intervention, we will discuss our innovative approach of changing social norms to improve WaSH outcomes. To our knowledge, there has been little work in this area. Additionally, we will present the initial findings from Phase I, which will reveal the particular social norms that sanction women from speaking publicly and participating in community institutions as well as the social networks and referent individuals supporting these social norms. Critically, these findings will reveal how gendered social norms affect WaSH outcomes and identify potential entry points to improve health and well-being. These contributions will demonstrate that social norms are key levers to improve WaSH conditions and must be considered in addition to the individual-level and environmental determinants typically targeted in WaSH programs.

**Addressing Girls Menstrual Health and Hygiene Needs through Improved WaSH Infrastructure and Education in Kyrgyzstan**

Jacquelyn Haver, Save the Children

Additional Authors: Jeanne Long

The onset of menstruation marks an important transition from childhood to womanhood, yet remains an under-recognized public health issue (Sommer et al., 2015). Additionally, with the increased attention on girls’ education by the global development community, we have seen improved retention and grade promotion for girls in many countries - meaning many girls are
having their first menstrual period while in school. Though puberty education is often part of national-level curricula in many countries, information arrives too late or it is skipped altogether due to the insecurities of teachers and a lack of in-service training. A lack of formal and thorough education results in girls piecing together information from other sources, which are based in cultural taboos and myths. Girls enter puberty without a complete understanding of their own body; they are uninformed, unprepared and lacking support to manage their menstruation (Sommer, 2013; McMahon et al., 2011; Sommer, 2009). Formative evidence suggests that girls miss school days as a result of their period, and there is a strong desire to link menstrual hygiene to attendance, dropout and educational attainment. However, few studies have attempted to demonstrate quantitative associations with MHM and school absence and the effect has been minimal (Montgomery et al, 2012; Grant et al, 2013; Oster 2011). The purpose of this project was to attempt to create and measure outcomes that were more closely associated with poor menstrual hygiene, based on the qualitative knowledge base which consistently reports that girls across contexts feel fear, shame and confusion during their menses and at menarche (Sommer et al., 2012; Caruso et al., 2013; Sommer et al., in press; Long, et al., 2013; Sommer et al., 2012; Sumpter & Torondel, 2013). This study used a mixed-methods approach to understand how girls experienced menstruation-related stress, how their menstrual periods altered their participation in school, as well as girls’ self-efficacy to manage their menses. Qualitative data was used to inform school-level interventions in El Salvador and the Philippines, as well as to create new outcome-level measures to measure program success. This presentation will describe the process of creating new outcome measures, as well as the results and challenges of piloting new quantitative questions around stress, participation and self-efficacy in both El Salvador and The Philippines.

Formative Research for a School Program on Puberty and Menstrual Hygiene Management (MHM) in Urban and Rural Bangladesh

Farhana Sultana, icddrb

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Background: Girls in low-income countries, including Bangladesh, lack menstrual hygiene management (MHM) facilities combining privacy, access to products and disposal systems in schools. This contributes to sub-optimal MHM practices and school absence among menstruating girls. In this study, we explored how menstruation affects school attendance and performance among girls. Methods: We conducted a formative study from September-December 2016 in 4 schools in urban and rural Dhaka. Fieldworkers used a quota sampling method to select 185 respondents based on their availability during data collection and willingness to participate in the study. Fieldworkers conducted 4 spot checks of facilities, 82 in-depth interviews (48 with girls, 24 with boys, 8 teachers, 5 school management committee and parent teacher association members, and 4 janitors), and 16 participatory exercises (4 with boys and 12 with girls). Findings: Out of 28 school toilets, fieldworkers observed 21% functional toilet cubicles for 370 girls, and 2 disposal bins. Both girls and boys stated that they were completely uninformed about menstruation and puberty before they reached puberty which
they perceived caused fear and shame among girls at menarche, and misperceptions among boys. Both boys and girls reported being teased when they reached puberty. Girls preferred to not ask permission to leave school during menstruation, to not dry used rags outside, to not buy pads, and to not share their concerns about late menarche with adults. Most (54%) girls reported that they missed school, and used pads if they must attend school. None of them either changed or disposed of pads due to inadequate facilities; rather they go home to change/dispose pads, or reach the end of the school day in considerable discomfort. Nearly three-quarters of girls connected school absence with low performance, and stated that lack of MHM facilities leads to difficulty in exam attendance and concentration. Other commonly mentioned barriers included locked toilets, offensive statements on walls of toilets, delayed introduction, and lack of detailed explanations about puberty and MHM in curriculum. Girls ranked sanitary pads with belts and wings as first and second, and rags as third choice among products, and preferred paddle and swing top bins for disposal. Both boys and girls wanted to learn about each other’s puberty in gender segregated sessions. Conclusion: Menstruation was a proscribed subject among affected adolescents in Bangladesh, and schools lack basic facilities to support girls during menstruation that leads discomfort, school absence and low-performances. Boys also experience stigma when they reach puberty. Low-cost products and facilities could improve both comfort and education. Research on efforts to train female and male teachers as focal points, to form gender clubs to sensitize menstruation/puberty issues may provide a pathway to destigmatize MHM issues to the school community in Bangladesh.

Evidence-Based Programming in WASH and Menstrual Health to Ensure Gender Equality. The case of RITU in Bangladesh

Hilda Alberda, Simavi

Additional Authors: Jimena Duran

Menstrual health is a highly relevant theme as it plays a role in the interplay between health, WASH, gender and development issues. Cultural beliefs and social norms surrounding menstruation vary per country and even per region or community, but they generally restrict the participation by women and girls in society during their period. Women and girls often lack knowledge and understanding of menstruation and how to manage it correctly. Limited access to clean water, proper sanitation facilities and sanitary products make it difficult for women to manage their menstruation hygienically. Where schools do not have toilets, this can be a barrier for girls to attend. The result is that many girls and women around the world face considerable physical and social challenges during their menstruation. Taking into account the complexity around MHM, the objective of this presentation is to explore how evidence-based programming in the WASH sector contributes to achieve positive impact in gender equality beyond ensuring the practical needs of women and girls. This will be done by exploring the experience of Simavi in the RITU Programme, which was designed in an evidence-informed process (in collaboration with the Impact Centre of Erasmus University (ICE)). In first instance, we performed a rigorous analysis of evidence, impact studies, programme evaluations and in-depth field research into the specific situation in Netrokona, Bangladesh. The initial findings showed the importance of cross-sectoral collaboration between the health (especially sexual and reproductive health), WASH and education sectors in addressing gender inequality. Based on the evidence, the main
strategies and interventions within the RITU Programme were defined and carefully sequenced, which are the following: 1) Increasing knowledge, attitude and practice on menstruation of girls as well as women, men and boys; 2) Construction of MHM friendly WASH facilities in schools and communities; 3) Creating access to affordable biodegradable sanitary pads; 4) Influencing policy and practice of relevant (Government) stakeholders. As we found that there are important gaps in existing rigorous evidence, the selected mix of interventions of the RITU programme will be evaluated through a Randomized Control Trial (RCT). We will evaluate: the impact on 1) attendance and performance of girls in schools, 2) overall wellbeing of girls, as well as 3) gender equality and bodily integrity indicators. In conclusion, the RITU Programme represents an example of an evidence informed approach to increase gender equality in WASH interventions, as well as an opportunity to create rigorous evidence on the impact of multi-sectoral interventions on menstrual health of girls.

**Stakeholder Perspectives around Menstrual Hygiene Management in Uganda: Barriers and Key Priorities for the Sector**

Kathy Woodward, RTI International

Additional Authors: Julianne Norman; Xinyan Guo; Akifumi Kita; Patience Sowa; Emily Rothove; Harriet Namisi

In Uganda and other low- and middle-income countries, girls miss up to 20% of school days each year due to menstruation, causing them to fall behind in academic performance, which can lead them to drop out of school altogether. The factors contributing to missed school during menstruation are multi-faceted and have been widely acknowledged. These factors include: access to menstrual hygiene management (MHM) materials such as sanitary pads, private spaces, clean water and soap, and safe disposal options; education on puberty and menstruation; and cultural considerations such as social and religious norms, family perceptions, and influence from peers, teachers and others in the community. Several frameworks have been established showing the integration of these factors and the wider context for MHM programs to consider. However, the implications of these frameworks have not been fully explored, including the feasibility and effectiveness of implementing comprehensive MHM programs in complex social and political settings, like that of Uganda. To explore the challenges of implementing MHM frameworks, RTI International conducted one-on-one meetings with 14 stakeholder groups in Kampala, Uganda involved in different components of MHM programs. We then held a roundtable discussion with all stakeholders together (27 individuals in total) to discuss their experiences and challenges in MHM programming and implementation. Participating stakeholders included a mix of governmental, nongovernmental, and private sector entities, as well as teachers from public schools. Stakeholders identified barriers to success in MHM programming, gaps and priorities for the sector and provided key recommendations for MHM researchers and implementers. These findings are presented and discussed within the context of existing MHM frameworks.

**Promoting Menstrual Hygiene Management and Equal Access to WASH Facilities in Low Income Countries**
Access to safe water and sanitation facilities for all to maintain a basic hygienic lifestyle has been the frontline agenda of the WASH sector for over decades, yet still the gender inequity caused by improper menstrual hygiene management is a big challenge in the developing countries of Africa and South Asia. The women and adolescent girls are deprived of basic water and sanitation, education and health services to maintain proper hygiene during periods, as menstruation remains as a case of isolation for 4-5 days every month due to unavailability of materials (as women have been found using dirty rags, ash and even cow dung leading to infections), ashamed of leakages and social taboos as 'untouchables'. The commercial companies selling expensive cotton pads do not make much in the poverty driven rural communities and hence avoid those areas. The project will address all four pillars of MHM- breaking the silence, awareness among men, material availability and proper disposal, via women led entrepreneurship by producing low cost biodegradable sanitary pads from local agricultural waste. The low cost biodegradable sanitary pad is made from banana fiber that is locally extracted from banana stem waste from banana farming done in 625 hectares of land in remote Kailali district of Nepal. Using banana fiber over cotton reduces ecological footprints, decreases greenhouse gas emissions from organic waste ending in landfill and reduces cost by making it available at a cheaper rate of USD 0.7/10 pads than commercial USD 1.20. Technically, the extracted raw banana fiber is dipped in 5% sodium hydroxide solution (easily available cheap chemical in local market) and woven into a pad size mat before air entraining. This removes impurities including hydrophobic lignin part in the fiber leading to increased hydrophilicity, increased biodegradability, softened texture, increased surface area and 15% more absorptivity after air entraining. The processed fiber is wrapped with home-made banana paper and stitched with glue drop of locally available pine tree resin for sticking into the panty. The package of the 10 sets of pad contains a diagrammatic information sheet on raising awareness on the use of pad, awareness against taboos and disposal method of aerobic composting, that can be understood without the text. 3 women can produce 60 packages worth 42 USD at the production cost of 10USD at the wage rate of 6.5 USD in a day. The project will partner with social entrepreneurs in other low income countries; Saathi Pads-India and SHE-Rwanda for technology transfer through Water Supply & Sanitation Collaborative Council & Engineers Without Borders-Rwanda. The project will be mainstreamed with local government’s activities of WASH in schools and communities to reach the unreached with the menstruation kit. This environment friendly social entrepreneurship approach led by women will sustainably promote hygiene of women and girls and ensure gender equity in the WASH sector.
In June 2016, Save the Children’s Child Sponsorship program in Ethiopia, which implements health interventions for children in schools and communities, conducted a situational analysis to inform Menstrual Hygiene Management (MHM) interventions in the West Showa region. The purpose of this study was to explore national and local policy and advocacy efforts surrounding menstrual hygiene, existence and availability of girl-friendly school facilities, and the knowledge, attitudes and beliefs surrounding menstrual hygiene in Ejere District. Literature review; focused group discussions (FGD) and in-depth interviews (IDI) with school-going girls; key informant interviews (KII) with administrators in three schools and the district education office manager, as well as separate FGDs with mothers, father and boys, and school observations were done across 2-4 schools. The findings were that there is no policy on MHM in Ethiopia, though national MHM guidelines are under development with support from UNICEF. There are other organizations that support MHM interventions such as puberty education with booklets, pad production, and improvement of WASH facilities to make it girl-friendly. In the two schools observed, toilet facilities without accompanying water and handwashing facilities, and sometimes not segregated by gender were not conducive for menstruating girls. There was some knowledge on menstruation among girls and boys, mainly due to information shared in grade four in science; and grade six and eight in biology. Teachers in girls’ clubs covers MHM, but more information on it is needed. Girls often use thick underpants or rags to manage their period; pads are rarely an option, and less so in school emergency supplies. Menstruation is considered dirty; with cultural restrictions, and taboos around doing sports, going to religious places and eating some foods during periods being common. Fathers have low levels of awareness on the basic facts of menstruation; and teasing by boys was cited by all four schools. In early 2017, Save the Children held a workshop with community and school representatives, as well as district officials to validate the findings. Participants agreed with our analysis; and developed recommendations for constructing girl-friendly toilets and water schemes; producing and distributing sanitary materials to schools; and increasing MHM knowledge and awareness among all stakeholders both in and out of schools. In June 2017, Save the Children and health workers from the district conducted a baseline survey to collect quantitative information on knowledge and attitudes towards menstruation, girl-friendly toilet facility status, and girls’ self-efficacy and menstruation related stress. Over the next year, we will implement MHM interventions with schools and communities and conduct an end line in late 2018 to assess potential change brought about by activities.

How a Sanitation Program Empowers Women

Per Ljung, East Meets West/Thrive Networks

Additional Author: Tara Hill

Inadequate sanitation facilities disproportionately affect women and girls due to menstrual hygiene, personal safety, sexual harassment and violence-related challenges. However, relatively little research has been carried out on whether sanitation programs can go further in empowering women to give them a greater say in household decision making. Where such studies exist, they are generally qualitative in nature. This research takes a quantitative approach to the evaluation of a large scale rural sanitation program in Vietnam. In less than four
years, this program encouraged over 120,000 poor families to build hygienic latrines. This study examines who in the household was the primary decision maker and analyzes the aspects of the program that empowered women with a greater voice in the latrine decision. The starting point for the research is a conceptual model reflecting most recent gender research where women’s (and men’s) bargaining power is seen as a function of their human, financial, physical, and social capital. The Community Hygiene Output-Based Aid (CHOBA) program--financed by the Gates Foundation - was implemented by East Meets West (EMW) in 500 communes from 10 provinces. Some 5,000 VWU volunteers from the Vietnam Women’s Union (VWU) undertook the fieldwork. CHOBA targeted the poorest 40% of the rural population and focused on results through output-based incentives to poor households, the Women's Union and to participating communes. It incorporated key elements of traditional sanitation promotion programs: An information and education (IEC) campaign; Supply chain improvement; and Access to affordable credit. The research tool was an extensive KAP survey administered three times to the same 1,900 households. The main analysis was carried out on a sub-set from the end-line survey of 517 households for which we had detailed data on both spouses. Binary logistical regressions were used to analyze the impact of household and spouses' characteristics as well as program elements on which spouse was the main decision maker in the latrine purchase. The results regarding socio-economic factors were consistent with most gender research: the wife’s bargaining power increased with her age, education and outside cash income. Similarly, she had a greater say in the decision if she was more educated than her husband. Family size and income did not have any impact. More importantly, the results showed that two of the program components significantly increased the decision making role of the wife: help with obtaining a loan and the IEC campaign. Promoting hygienic latrines and education on health benefits did not influence the "balance of power," while practical information regarding latrine options, costs, and masons did increase the wife’s bargaining power. Finally, the analysis showed that men gave greater weight to costs while women emphasized family health. When the wife decided rather than the husband, the latrines were more hygienic.

Assessing International Engineering Effectiveness Through Failure: A Stakeholder's Perspective

Kelsey Schreiber, University of Illinois

As the international community attempts to aid in the pursuit of equal access to water and sanitation services, it is important that a unifying system of project work and analysis is pursued. A review of published literature and statistics shows that international development project failure rates vary significantly, some as high as 64% (Lovegrove et al, 2011). The inconsistencies in reported statistics motivates this research. This study aims to define the term 'failure' in reference to international water development projects from the perspective of each stakeholder involved in project planning, implementation, management, and funding. Utilizing qualitative data collection methods (direct surveys and observations) of project participants, individual stakeholder failure metrics are determined. The results between stakeholders are then compared to show possible inconsistencies. For example, a funding agent may credit a project as a success if it satisfies donors, however the project may not have met the community recipients desired outcomes. The process of identifying key components of project success or failure from the perspective of individuals most responsible and impacted can ultimately lead to
better project formulation, management, and sustainability. These failure metrics can then be utilized in the development field to better homogenize and analyze statistics across one, common metric and eliminate ambiguity of the term ‘failure’.

**Indicator Efficacy: Anthropological Approaches to Evaluating Household Water Access in the Colombian Amazon**

Lily Rubino, Iona College

The growing demand in the development sector for evidence-based decision making requires data that accurately captures the real, lived experiences of communities. This study attempts to evaluate the accuracy of drinking water access data collected using Millennium Development Goal (MDG) indicators. MDG indicated access is compared to access data collected during nine weeks of fieldwork in Leticia, Colombia, using a mixed-methods approach grounded in Anthropology. This study also explores how Anthropology can challenge conceptualizations of drinking water access indicators and help forge new directions for monitoring frameworks in time for progress reporting on the 2030 Sustainable Development Goal agenda.

**The Anaerobic Digestion Pasteurization Latrine: Updates from Four Years of Field Experience**

Lucas Rocha Melogno, Duke University

Additional Authors: Aaron Forbis-Stokes; Brandon Hunter; Graham Miller; Kathy Jooss; Marc Deshusses

The Anaerobic Digestion Pasteurization Latrine (ADPL) is a self-contained and energy neutral on-site faecal sludge treatment system using anaerobic digestion of human excreta to generate biogas, and then uses the biogas to pasteurize the digester effluent at 65-75 °C to produce a safe effluent. The ADPL is a simple system, with no moving parts and relying on gravity-induced flows. Lab-scale proof-of-concept results and results from field implementation were presented at a previous UNC Water and Health conference (Deshusses et al. 2016) and a paper was published a month after (Forbis-Stokes et al. 2016). This poster will focus on the progress of ADPL field implementations of five prototypes in Kenya, India, and the Philippines. The ADPL is an emerging technology being tested at multiple scales and in multiple contexts. Long-term results in Kenya show that anaerobic digestion of minimally diluted faecal waste can produce more biogas than is required to power the pasteurization tank, indicating that the ADPL is a self-sustaining system that can remove pathogens from faecal waste before entering the environment. The system is replicable in many contexts, using simple and readily available materials. ADPL installation costs across locations ranged from $1,600-2,600, or $0.03-0.07 p-1 d-1 based on expected lifespan. Users have provided positive feedback due to the system having little to no odour or flies, and they have expressed interest in using any excess biogas for domestic use as well as treated effluent as fertilizer. Up-to-date observations, new improvements, and key findings of field operation of Kenya, India, and Philippines systems will be presented and discussed at the conference. References: Deshusses, M. A., Forbis-Stokes, A., Hunter, B., Rocha-Melogno, L. and Jooss, K. (2016). Study of fecal sludge treatment with the

Understanding Interventions with Multiple Water, Sanitation, and Hygiene Elements (multi-WASH) in Low and Middle Income Contexts

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Additional Authors: Grace van Velden; Rebecca Hardin; Arun Agrawal; Lutgarde Raskin

Water, sanitation, and hygiene (WASH) interventions have been studied extensively in the past several decades. However, research on projects incorporating multiple WASH elements (a.k.a “multi-WASH”) is still lacking. A number of recent literature reviews and meta-analyses have integrated multi-WASH interventions into their analyses or conceptual arguments, but without fully exploring the extent of evidence on multi-WASH efforts in the literature. Among the few analyses that have been performed, results are highly mixed and the number of studies included is very low. One review that more specifically targeted multi-WASH interventions and the interdependencies among water, sanitation, and hygiene is restricted to epidemiological studies and does not adequately explore multi-WASH interventions across the many disciplines involved in WASH development work. This review aims to define multi-WASH interventions, understand their diversity, compare them to other types of WASH interventions, determine their prevalence in the literature, and document their health and non-health impacts. It will do so by first examining a select set of WASH studies published in English language academic and grey literature since 1990 across multiple disciplines including development science, economics, engineering, environmental science, epidemiology, public health, and psychology. The second stage of this work, after stakeholder feedback, will consist of a more complete, systematic review. The complexity of WASH studies often makes it difficult to synthesize findings across studies. The heterogeneity of factors affecting WASH along with the lack of agreed-upon outcome indicators, methods of data collection, and definitions of effectiveness contribute to the complexity. These challenges then perpetuate the difficulty in applying, with confidence, the WASH body of evidence to future projects. This review effort will add clarity to the body of WASH knowledge with regard to multi-WASH interventions in a way that increases the practical application of WASH research and the overall achievement of positive impacts from WASH programs.

Application of Continuous Quality Improvement Methods to Improve the Microbial Quality of Household Stored Water and Decreasing Borehole Repair Times in Northern Ghana

Michael Fisher, The Water Institute

Additional Authors: Leslie Danquah; Allison Fechter; Greg Allgood; Jamie Bartram; Rohit Ramaswamy
Background: Access to adequate quantities of safe water is critical to human health and development. In many low- and middle-income country (LMIC) settings, this access is threatened by low functionality of water sources and microbial contamination of household stored water for consumption (HSW). We report on the results of a study applying quality improvement (QI) methods to improve the microbial quality of HSW and improve borehole repair times in 216 communities in four districts of rural northern Ghana. Methods A continuous quality improvement (CQI) team was formed, comprising staff of World Vision Ghana (WVG), an NGO implementing WaSH programs in Ghana. Baseline data were collected from randomly selected households in each of 216 communities in four districts where WVG had previously implemented WaSH programs. These data were analyzed to identify determinants of borehole functionality and microbial contamination in HSW. Based on this analysis, the CQI team identified an improvement package comprising refresher training for community water management committees, replacement of missing tools, and the iterative design and delivery of locally appropriate safe water storage containers (SWSCs) to households. Study communities were randomized, and this package was implemented in a random 50% of communities. Data were collected on uptake of the improvement package, and on borehole functionality and HSW quality. Results High uptake of the improvement package was observed. Microbial water quality of HSW was significantly better in households that received an SWSC than households that did not (p<0.01), and this effect persisted two years after implementation. Significant differences in HSW quality were also observed at the intention-to-treat level (p<0.10). Multivariable regressions suggested that intervention communities were more likely to have functional boreholes (p<0.10) and to have breakdowns repaired within one week (p<0.05) than control communities at midline. These effects did not persist at end line. Discussion These results suggest that SWSCs adapted to local needs may provide long-lasting benefits, while refresher trainings of water committees may require regular repetition. This work demonstrates the utility of a QI approach in diagnosing and improving the performance of a WaSH program in rural Northern Ghana, with applications to improving the microbial quality of stored HSW and the functionality of water sources. This approach provides a model for improving the implementation of WaSH programs in other contexts, as well as other community-based development programs, with potential relevance to the achievement of Sustainable Development Goal targets in Ghana and other LMIC settings.

Determinants of Latrine Use and Open Defecation in 4 Districts of Northern Ghana

Michael Fisher, The Water Institute

Additional Authors: Allison Fechter; Zakaria Seidu; Jamie Bartram

Access to and uptake of safe sanitation services are critical to human health and development. Like many countries in West Africa, Ghana has made strides in increasing access to sanitation and reducing open defecation in its rural districts over recent decades. However, concern remains about the low proportion of the rural population with access to improved sanitation facilities that are not shared with other households, as well as with the ongoing practice of open defecation in some rural communities. Ongoing interventions are being implemented to end open defecation and improve latrine access, but uptake of these interventions in rural areas
is far from universal. Latrine access and use may depend on a variety of physical, economic, social, and environmental factors. However, few studies have rigorously and simultaneously explored the determinants of sanitation uptake in rural low- and middle-income country (LMIC) settings across these diverse dimensions. To address this question, a study of 216 communities was conducted in four districts of Northern Ghana. Surveys were conducted at the community, household, and sanitation facility level to characterize households with respect to latrine ownership, access, and use, as well as open defecation practices. Households were also characterized with respect to their proximity to a sanitation facility, and with respect to socioeconomic status and other demographic variables of interest. Communities were characterized with respect to open-defecation-free status, previous community-led total sanitation (CLTS) triggering, and the presence of a water and sanitation management committee in the community. Sanitation facilities were characterized with respect to facility type, condition, and sanitary inspection score. The results suggest that a variety of physical, technical, and demographic factors affect sanitation uptake in the study setting. These findings add to the growing literature on determinants of sanitation uptake, and may highlight opportunities for improving the impact of sanitation programs targeting rural households in Ghana, and potentially in other LMIC settings as well.


Nancy Githugo, Nakuru Defluoridation Company

In the Kenyan water sector, it is well known that the Nakuru Defluoridation Company (NDC). NDC’s products are described in the following sections (1) Filter materials (contact precipitation, synthetic Hydroxyapatite-HAP (2) Fluoride removal filters (community, institutional, household) (3) Laboratory services (4) Awareness trainings. As production costs for bone char and HAP are almost similar but the uptake capacity of HAP much higher, more focus was given to HAP. In collaboration with Water & Sanitation for the Urban Poor (WSUP), Naivasha Water and Sewerage Company (NAIVAWASS) a business model was initiated in 2012, which incorporated several small water supply schemes and Defluoridation systems in every water selling kiosk in poor and densely populated settlements around the flower farms at Lake Naivasha. The systems consisted of two groundwater pumping stations to deliver water to around 14 water kiosks. At each kiosk part of the water was treated using contact precipitation or HAP technology. The supply schemes were based on an innovative approach where NAIVAWASS sub-contracted a private operator for serving certain areas in town. The raw water was sold for USD 0.02 per 20 L and the treated water for USD 0.03 per 20 L. Savings of 0.01 USD/m³ per 20 L were reserved for filter material replacements/regeneration at the water kiosks. The results indicate that the filters were able to treat around 1000 m³ of water (raw water: 10 mg/L) before the WHO guideline of 1.5 mg/L was exceeded. Monitoring results showed that the patterns of the fluoride levels varied depending on residence time before the water samples were taken. Each filter contained 2,000 L filter material (around 1,600 kg). This paper aims at sharing the experiences of NDC in implementing a management business model in Defluoridation.
From Words to Action: Linking Policy and Institutional Frameworks to Sanitation Provision and Hygiene Promotion in Rwanda and Uganda

Nelson Ekane B, KTH, Royal Institute of Technology

The gap between policy and implementation is not new and not specific to the sphere of sanitation. Yet, sanitation lags development achievements in other fields, including water provision, and is one of the unmet Millennium Development Goals (MDG) targets. This article explores the “missing link” between policy intentions and outcomes in relation to sanitation provision and hygiene promotion in Rwanda and Uganda. The gap is analyzed in a comparative study of sanitation sector performance in the two countries. The gap between strong political will, as asserted e.g. in policy statements and coordination efforts on the one hand, and insufficient resource allocation and actual implementation on the ground on the other, is explained by drawing on policy and implementation theories. Whereas over 5 million people have gained access to sanitation in each of the countries in the past 25 years, this represents 42% of the population in Rwanda, but only 13% in Uganda. The “good progress” in Rwanda may be partly explained by strategic investment in rural sanitation, strong leadership and support for sanitation and hygiene, stringent performance monitoring, and an organized community-based approach. Whereas the policy climate and prioritization of sanitation has been favorable in much of sub-Saharan Africa, resource allocation to the sector and capacity constraints of the responsible agents remain a major constraint to sector performance. It is noted, however, that with individual households being the primary implementers of sanitation policy (construction of facilities as well as the actual application of hygiene behavior), general economic development is strongly associated with improved sanitation.

Fecal Sludge Management in Haiti, or What Really Happens to All That ""stuff""?

Jean Allain Darius, CDC

Additional Authors: Andrea Martinsen; Rick Gelting

Prior to the 2010 earthquake, little treatment of fecal sludge took place in Haiti. No centralized sewer systems to collect or treat waste exist, including in the capital Port au Prince. Most residences or businesses disposed of human waste onsite, in septic tanks, cesspools or latrines. In dense urban areas, when these waste disposal sites are desludged, the waste must be transported offsite. Before 2010, with the exception of a composting program in the Cap Haitien area, fecal sludge collected from latrines, cesspools and septic tanks was often buried, dumped into canals, other bodies of water or solid waste dumps. Efforts to construct adequate waste treatment facilities started soon after the earthquake, especially to dispose of fecal sludge from settlements which housed more than one million internally displaced persons (IDPs). The cholera epidemic that began in Haiti ten months after the earthquake also catalyzed additional interest to improve fecal sludge management. Several facilities utilizing waste stabilization pond systems were constructed in Haiti. Stabilization pond systems are suitable for treating waste in warm climates, and are relatively simple and inexpensive to operate. For various reasons, only one of these facilities is currently operating in Haiti, although others are being renovated. This facility, located at Morne a Cabri on the outskirts of Port au Prince, is operated by the National
Directorate for Potable Water and Sanitation (DINEPA). The fecal sludge that is treated at Morne a Cabri comes from two sources: pumper trucks that empty septic tanks or cesspools through hydraulic suction and barrels carrying fecal sludge from latrines that have been manually excavated. The facility receives fecal sludge trucked from both the capital and other parts of Haiti, sometimes from surprisingly large distances, showing that demand exists for waste disposal facilities. Renovating the facilities mentioned above to expand fecal sludge management capacity in Haiti will help in addressing a very large public health risk in the country, as informal dumping still occurs, potentially leading to large scale exposure to fecal pathogens. This issue was evident again during the response to Hurricane Matthew in 2016, when there were no adequate treatment facilities available for sludge from latrines serving large shelters of displaced people following the storm. Many challenges remain, however. Evaluations of the Morne a Cabri system reveal that the influent waste is very high strength, containing a higher load of organic material and suspended solids than accounted for in the facility design. The system is therefore overloaded with solids, and accumulated sludge has to be removed frequently. Design modifications to better accommodate the high-strength waste are being considered. At the global scale, more research is needed on treatment of high strength fecal sludge from latrines, including impacts on traditional treatment facilities.

WASH Interventions in Emergencies and Outbreaks: Results from Two Systematic Reviews

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Additional Authors: Myriam Leandre-Joseph; Jelena Allen; Daniele Lantagne

Background. Water, sanitation, and hygiene (WASH) interventions are used in low and middle-income countries to reduce the risk of disease by providing safe water, reducing open defecation, and promoting hygiene practices. Currently, the number of people affected by emergencies is increasing, while the gap between needs and funding is widening. To address these growing needs, emergency responders need confidence in choosing effective WASH interventions and increased understanding to improve impact. Unfortunately, there is a lack of robust evidence on the efficacy and effectiveness of these interventions because of the difficulty in conducting high-quality research in emergency contexts. Methods. To bridge the evidence gap, we conducted two parallel systematic reviews: 1) on WASH interventions in disease outbreaks, and 2) on short-term emergency WASH interventions in all emergencies. Key-word strings were used to search nine academic journal databases. Responder and UN websites were searched for grey literature documents, and active members of the Global WASH Cluster were also solicited for relevant studies. Inclusion criteria were categorized with the PICOS framework, which represents: populations, interventions, comparisons, outcomes, and study types. Experimental, non-experimental, and qualitative assessments were eligible for inclusion and assessed for bias. Results. Together, 15,026 titles were identified which led to 47 studies from 19 countries included in the outbreak review and 106 studies from 39 countries included in the short-term emergency review. In the respective outbreak and short-term emergency reviews, half of the included studies originated from grey literature (49% and 50%), few randomized control trials (4% in each review), and limited reported health impacts (12% and 8% of studies). Risk of bias was evaluated as 'high' in the majority of studies (70% and 77%). Health
impact measured through a measured change in disease rates were rarely conducted (6 and 4 studies), as risk of disease transmission was more commonly assessed by measuring free chlorine (19 and 35 studies). WASH intervention effectiveness depended on program design factors such as whether the intervention was simple, appropriately timed, community-driven, and linked between relief and development. Additionally, beneficiary preferences, such as taste and smell of water treatment, communication methods, inaccurate perception of efficacy, and trust/fear also impacted project delivery. Discussion. Overwhelmingly, WASH interventions benefit affected populations by reducing both the risk of disease and the risk of transmission; however, the manner of implementation and depth of community engagement greatly influence response effectiveness. Despite the low quality, grey literature was synthesized with published studies into pertinent results for responders. Research on identified commonly implemented but severely under-researched WASH interventions is recommended.

**WASH Microfinance Operations in India: An Assessment of Challenges and Successes**

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Additional Author: Sambhu Rathi

Large segments of the Base of Pyramid have the potential to finance their own household water and sanitation solutions. However, lack of access to formal banking solutions and technical know-how prevent these communities from availing water and sanitation improvements. Through affordable capital, microfinance has helped to break down barriers to household WASH solutions for the poor. This paper evaluates the welfare outcomes of a large scale microfinance program in India reaching over 1.5 million people in poor and marginalized rural communities. Using multiyear (2012-2016) panel data of 2,883 households (treatment-559 and control- 2,324) across eight states in India, we employ fixed effects analysis and propensity score matching to estimate the treatment effects due to the program on people's welfare. Apart from improving access to sufficient water and better sanitation facilities, results suggest that access to microfinance improves the overall welfare outcomes of poor people. We find that households in the treatment group spend less on healthcare, spend less time collecting water, and have better income and quality of life than households in the control group. In particular, we find that women are much better off due to access to water and sanitation. Being primarily responsible for collecting water, women feel much safer and less worn out as there is reduced drudgery associated with water collection.

**Community Water Systems in Rural Guatemala and Benin**

Colleen Leonard, CARE

Additional Authors: Kelly Alexander, Stephanie Ogden

Background Water schemes and water pumps are rarely sustainable in remote, rural areas. Challenges may be due to lack of spare parts, lack of skilled labor, insufficient funds, poor management, or other reasons. CARE Guatemala has worked with local water offices to
promote a sustainable operation and maintenance system for remote community water supplies. CARE Benin has not worked as closely with local government agencies. Methods In Guatemala we conducted surveys with water committees, community members and observed functionality in over 30 rural community water points (with projects initiated by CARE or other NGOs). In Benin we conducted surveys with water committees in 20 communities that were part of a CARE-initiated WASH project which ended mid-2016. Results Results will be completed and analyzed by August 21, 2017. We expect to present the following: characteristics of water committees and their management of funds, maintenance, transparency with the community, etc., and potential associations with water scheme functionality. One focus of this will be to present how we are taking what we have learned from the research in these two countries (and from the literature) and how we will apply them to CARE water programs moving forward.

Men’s and Boys’ Attitudes toward Menstruation and Factors that Influence These Attitudes

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Additional Authors: Dina Rakotomalala, Ghislain Mukuna

In 2016, Catholic Relief Services (CRS) in Democratic Republic of Congo (DRC) launched an Operational Research project called ADMiRE (Amélioration de la Dignité Menstruelle pour Renforcer l’Education des Filles) to better understand the relationship between Menstrual Hygiene Management and girls’ school attendance, identifying obstacles to inform future interventions to address these challenges. Specific quantitative surveys were conducted with each target group in Mbandaka, DRC and surrounding areas: girls, boys and caregivers. In addition, Focus Group Discussions (FGDs) were held with health workers, teachers and fathers, in addition to in-depth-interviews with girls. In CRS Benin’s Food for Education project, the team focuses on improving menstrual hygiene practices for schoolgirls by working closely with local health authorities and Community Health Workers (CHWs) to implement a culturally appropriate approach (inclusive approach, accompanying the communities step-by-step, to avoid communities feeling shocked or offended and to reduce taboos around menstruation). CHWs will provide continual mentoring of schoolgirls over the age of ten and hold annual information sessions. Results from the analysis in DRC and experience in Benin revealed negative men and boy attitudes related to menstruation. Specifically, boys participate in social rejection, bullying, harassment of menstruating girls. About 35% of boys surveyed say they treat girls differently at school when they are menstruating and 27.7% of girls surveyed report being harassed during menstruation. For men (and fathers), the onset of menses is associated with potential danger of pregnancy and sexual activity but they defer all responsibility to mothers as they find it extremely difficult to talk about menstruation with girls. Caregivers, who have decent knowledge about menstruation, do not share this information with girls whose level of knowledge is inferior.1 This is compounded by the fact that menstruation is often not discussed in schools, despite reports of bullying and harassment. In both DRC and Benin, these attitudes are due in part to lack of knowledge and erroneous beliefs and poor communication on this taboo subject. But the fact that boys are curious to know more and that fathers are open to learning how to help their daughters manage their menstruation, is an opportunity to
work towards a more favorable and positive education experience for girls during menstruation. The proposed response of CRS includes the following goals. In DRC, improve girls’ and boys’ access to accurate knowledge on MHM and puberty by adapting the Positive Parenting approach to promote communication between children and parents on taboo subjects. In DRC and Benin, develop education/communication tools, coach schoolboys on puberty, continue coaching schoolgirls on menstrual hygiene, training CHWs on topics about menstruation and puberty and in basic training techniques. In Benin, pilot a small project to introduce the use of sustainable menstrual cups.

**Unpacking a Nesting Doll: The Layered Challenges of introducing Menstrual Hygiene Management to Girls’ Schools in Afghanistan**

Nasratullah Rasa, UNICEF Afghanistan

Additional Author: Zahida Stanakzai

Afghanistan is in its seventh year of delivering MHM services and education to girls in the formal school system. In this time, we have observed that the country shares many of the challenges faced in MHM interventions globally. These include a male-dominant education system, inadequate sanitation facilities for girls in school, and poor inter-generational communication between girls and their mothers or teachers about puberty, leading to shame, embarrassment and a high drop-out rate from schools, decade after decade. However, Afghanistan is distinguished from other places: it has a century-old history of public dispute about the right of girls to access school. The era of the Islamic Emirate of Afghanistan (1996-2001) was particularly damaging to female equality, and many of its influences continue to be felt today. We allude to “nesting dolls” in our title because the delivery of an MHM package in this context is much like unpacking layers of (sometimes unanticipated) problems: no sooner is one revealed, and efforts made to solve it, then another presents itself. The starting point for MHM in Afghanistan, after the 2010 study, was to implement more girl-friendly sanitation designs in schools, with a limited focus on teacher orientation. At this time, it was felt that building better WASH facilities would encourage positive behaviour changes. WASH in Schools and the Ministry of Education’s Health Managers conducted limited teacher training. As the years went on, it became clear that in some areas, the hoped-for changes in adolescent attitudes remained unrealised. A 2016 small-scale MHM study revealed ongoing levels of stress, confusion, and absenteeism among girls entering puberty. 2017 has seen the development of a teacher’s Guideline designed especially for Afghanistan, accompanied by a booklet for girls illustrated by a young Kabul-based female artist. Even in the process of designing this package, the next layers of social challenges are being revealed. What are we going to do to support the significant number of out-of-school girls, especially in rural or unstable regions? Will young girls be able to take MHM back to homes where their parents may resist new ideas? Our messages are not only on hygiene: we strongly assert that menstruation is a normal process of growing up, but not a signal of readiness for marriage! Perhaps most difficult of all, we have reached a point where ad hoc teacher trainings on MHM, while helpful, are insufficient. The MoE has indicated its strong support for Afghan-specific MHM, but the challenge we face now is of making it part of the curriculum, while motivating and educating teachers to support an approach that contradicts some deeply-held beliefs, in a country that does not easily adapt to social change.
Can teachers and schoolgirls influence those beyond the school, even religious leaders? Can we engage community health workers to reinforce MHM messages so mothers support daughters with new MHM approaches at home?

**A Systematic Review of Menstrual Hygiene Management Interventions in Populations Comparable to Students of Chicago Public Schools**

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Additional Authors: Q. Eileen Wafford, Melissa Simon, Leah Neubauer

Menstrual Hygiene Management (MHM) has recently become the subject of research and debate within the global health community. Results from recent studies demonstrate the value of improved access to MHM resources in lower and middle-income countries. The arguments that have brought MHM to the forefront as a public health, education policy, and feminist issue internationally should be applied to advocate for women and girls domestically. While we can extrapolate research findings supporting improved access to MHM in low and middle income countries to the United States, where many women continue to have inadequate access to MHM, there is a need to systematically search the literature for research that examines Americans. To find all studies on the topic, we developed a comprehensive search strategy that we applied to major bibliographic databases. Our initial review of literature indicates that, especially among low-income and racial minority groups in the United States, young women have experiences with menstruation that are unnecessarily shameful, confusing, and potentially harmful to their health. We plan to apply these findings from our systematic review of MHM research to support a policy proposal for improved access to MHM in Chicago Public Schools, an important target for public health interventions.

**MHM and WASH: Supporting a Gender-Responsive Learning Environment**

Mamita Bora Thakkar, UNICEF Pacific and Emory University

Additional Authors: Amber Lauff, Maria Carmelita Francois

Supported by the Fijian Ministry of Education, Heritage and Arts, UNICEF—in partnership with Emory University, Fijian Teacher’s Association (FTA) and Project HEAVEN—completed the first formative research on menstrual hygiene management (MHM) in Fiji. Following devastation from category 5 Tropical Cyclone Winston in late February, Education sector partners focused on restoring WASH services to damaged schools, with specific emphasis on gender conscious approaches to recovery and rebuilding. These efforts provided an entry point to conduct MHM research in cyclone-devastated schools in the Western Division of Viti Levu from May to September, 2016. Data was collected from 7 schools (2 urban, 3 rural and 2 peri-urban) in three educational sub-districts; 116 girls (n=75) 75 girls, boys (n=42), and teachers (n=34) openly shared their experiences, knowledge, and attitudes on menstruation, providing recommendations and valuable insight for improving school WASH facilities and resources for menstrual hygiene management (MHM). The research provided a better understanding of girls’ experiences and needs around menstruation in the school environment as well as insight into
cultural, social, and religious norms that add limitation to girls’ ability to confidently manage menses. These results have identified recommendations around advocacy, program, and policy that includes: involving parents and churches in curriculum development; teacher training; school-based management and operation of WASH facilities; and sustainable options for sanitary materials and disposal methods.

**Menstrual Hygiene Management for the Visually and Hearing Impaired**

Archana Patkar, WSSCC

Additional Authors: Irene Gai, Virginia Kamowa, Patricia Mulongo, Kamini Prakash

Women and girls are not homogenous and have different needs based on the stage of the lifecycle they are in. MHM programmes need to be adapted to the specific age, physical and socioeconomic conditions governing women and girl’s lives. One such group is girls and women with visual or hearing impairments. There are very few communication materials in braille or sign language or thinking around how MHM will be adapted for the visually or hearing impaired. In short this is an unheard and unseen constituency. This presentation will address the following key questions: How can we develop appropriate environments and educational materials on MHM for women and girls in order to break the silence, install confidence and knowledge to understand what menstruation is, manage their periods with confidence and dispose menstrual waste safely? How can we also change attitudes towards persons with disabilities so they are not only included, but also seen as a valuable resource?

**Menstrual Hygiene Endeavors: Journey from Breaking Silence to Period Power**

Therese Mahon, WaterAid Nepal

Additional Author: Shikha Shrestha

Menstruation is still a social taboo in Nepal where adolescent girls and women in some parts of the country are not allowed to stay in their homes during menstruation. A recent WaterAid study revealed that 21.5% in Sindhuli district missed a whole day of school during menstruation. Cultural links between menstruation and vulnerability and reinforcement of restrictions discourages girls from participating in everyday activities. Yet over a period of 10 years the menstrual hygiene needs of women and girls has become a national priority and in 2017 a policy dialogue was initiated by the Ministry of Water and Sanitation with multi stakeholder consultation. The presentation will explain a journey how evidence and advocacy has contributed to increased priority on MHM in Nepal through the perspective of WaterAid Nepal and its collaboration with diverse stakeholders. WaterAid Nepal started MHM campaign with a call for breaking the silence with renowned artists to raise issues of MHM in 2007. It was further enriched by a comparative study of four schools in different settings of Nepal in 2009. These analyses influenced the master plan of sanitation and hygiene, 2010 which included that schools must have menstrual hygiene facilities, and the National framework of Child Friendly School that included separate toilet for boys and girls. Collaborative research by WaterAid Nepal and Department of Education (DoE) on WASH Financing in Community Schools on 2014
highlighted the gap in separate latrines for girls at school and financing requirements, paved a path for a strong partnership with the education sector. The study was launched in coordination with Nepal Fertility Care Center (NFCC) and Family Health Division of Department of Health Services. It was the milestone event to bring Department of Education (DoE) and Department of Health Services together. The partnership further developed a commonly agreed upon MHM training package for frontline workers. Research based discourses has contributed for initiating discussion for preparing WASH in School Guideline in leadership of DoE. incorporating MH indicators including management of menstrual pads for emergency, regular and safe disposal of menstrual pads, etc. 2 Raising voice and conducting research alone is not enough and WaterAid has also implemented demonstrable initiatives to showcase MH friendly WASH services integrating key components: (i) MH friendly WASH services in schools, (ii) increasing access to affordable and hygiene sanitary materials, (iii) promoting CSO campaigns and research and (iv) promoting accountability of local government authorities. This comprehensive programmatic approach helped in expanding campaigns such as the recently launched “Period Power” campaign to reinforce people voices in MHM policy and plan of action that is under process of development in leadership of Ministry of Water Supply and Sanitation. In this decade long journey, there are more organizations working for MHM which is a positive indication. There is increased attention from government stakeholder for preparing MH policy and plan of action. More coordinated efforts for bringing diverse stakeholders in government leadership will help not only in breaking silence but also recognizing power of period for ensuring dignified lives of women and girls.

Population-level Assessment of Menstrual Hygiene Management Practices in Rajasthan, India

Alexandra Shannon, Bill & Melinda Gates Institute for Population and Reproduction Health

Additional Authors: Natalie Exum, Kellogg Schwab

India is one of few countries that has National Menstrual Hygiene Management (MHM) Guidelines, yet there are no data available to measure progress. Performance Monitoring and Accountability 2020 (PMA2020) is the first monitoring platform to provide state-level data on MHM in India. In this presentation, we will share results from household-level surveys conducted across Rajasthan State and stratify by age comparing females ages 15 – 19 to older groups. The data presented will include where women are managing their menstruation, their WASH practices, what absorbent materials they are using and how they are disposing of these materials.

Advancing the MHM Agenda in Partnership with School-Based Personnel: Describing MHM Familiarity and Engagement in Rural Kenya

Leah C. Neubauer, Northwestern University

Additional Authors: Penny Phillips-Howard, Garazi Zulaika, Alex Mwaki, Alie Eleveldsing
This qualitative study spanned 24 months in secondary schools (n=84) in Siaya County, Western Kenya with the goal of increasing knowledge and improving the Menstruation Hygiene Management (MHM) school-based intervention process and personnel. The study is aimed at increasing engagement of teachers and school-based personnel in MHM programming and training. Research has actively examined the role of teachers in ensuring education for all children, youth and adults. In addition to meeting basic education requirements, teachers are often charged with facilitating health-related information (e.g., HIV/AIDS, STIs, sexual/reproductive health) in the classroom with very limited content area training and with scarce resources (overcrowded classrooms, lack of materials). These vast teaching duties demand adequate teacher training, ongoing continuing education, and educational resources. In some countries one teacher is designated the health ‘focal’ point, but no research has established whether such persons are appropriate or are adequately skilled to support girls' MHM. The study’s focus is guided by the understanding that school-based personnel are an essential component of MHM efforts. Personnel’s knowledge, attitudes and experiences surrounding MHM and programming are diverse, limited, and potentially conflicting. The study is nested within a larger longitudinal trial examining interventions to address girls' MHM and is focused on three key areas: 1) School-based personnel’s MHM knowledge, 2) School based personnel’s MHM attitudes, and 3) School-based personnel’s experiences with MHM implementation. The presentation will highlight previous focus group data with teachers and discuss the current study's participatory methods and inquiry-oriented phenomenological approach analysis approach. The dissemination plan for study findings will be described including, recommendations for teacher training, ongoing continuing education, MHM implementation, and support beneficiary development of educational resources for intervention scale-up.

WinS4Girls: Learning from 14 countries

Brooke Yamakoshi, UNICEF

Effective Menstrual Hygiene Management (MHM) programmes are essential to improve the health and educational outcomes for girls and eventually lead to attainment of human rights by adolescent girls. Girls need timely information and gender-segregated safe WASH facilities. Moreover, there is need for more evidence about the issues related to Menstrual Hygiene Management. UNICEF has been involved in evidence based advocacy on MHM in order to ensure safe school environment for girls. The WinS4Girls project funded by the Global Affairs of Canada (GAC) contributed substantially to awareness raising, mobilizing partners, evidence generation and capacity building. The main to strengthen evidenced-based advocacy and action on MHM in low- and middle-income countries through the UNICEF-supported WASH in Schools global program, leading to a more supportive school environment that is ready for girls.

A Pilot Project: Training of Trainers for Girl's & Women's Health Empowerment in Kasese District, Uganda

Elizabeth Becker, Wandering Minds LLC

Additional Author: Molly Dingledine
Will a menstrual hygiene management (MHM) program designed for school girls in Lima work equally well with street orphans in Lesotho? Can a pad made from locally-sourced materials in Uzbekistan be made from similar materials in Uganda? Is this program sustainable? Is that program cost-effective? What other factors need to be taken into consideration? What outcomes are we seeing from intervention programs and to what should we attribute those outcomes? That the condition of being a woman who menstruates could, in and of itself be debilitating, came as a surprise to many of us in the industrialized world. And changing that fact is not a simple proposition. As the literature in the field suggests, aid agencies, program planners, advocacy groups, health professionals, researchers, and many others are putting forth great effort to help girls manage their periods so that they can stay in school. Obviously, there is no one-size-fits-all intervention appropriate for every location. But can we apply lessons learned from one MHM program to another one halfway around the world? Last year, mWater created a demonstration app for UNC’s Water & Health Conference. That app is now widely used all over the world to collect water and sanitation data, which is then aggregated into a publicly-accessible database. I believe that using this same technology to create data collection instruments for MHM intervention programs will allow researchers, policymakers, stakeholders, and someday, even the girls themselves, to contribute to the knowledge base; we could create a database that would allow us to tease out answers to the hard questions, perform cross-sectional analyses, and determine longitudinal trends and outcomes. This August I am traveling to Uganda as an evaluator for a modest, but highly innovative MHM program run by Omukali Villages Arise (OVA), a new nonprofit. In short, nine women (mostly teachers) and two men will travel from rural Kasese District to Kampala to participate in an intensive training-of-trainers program that addresses many aspects of MHM. They will then return to their villages to train others. The overarching goal is that the program is sustainable and self-perpetuating. The executive director of OVA, Molly Dingledine Curtis, and I will collect evaluation data, in part using mWater customized for this application. In October I would like to share the story of this remarkable, collaborative startup. And I would like to share the data collection instruments and the software with other conference participants. I hope that in doing so, I can contribute to some fruitful discussion.

**Wednesday, October 18th**

**Water and Sanitation Services in Dispersed Rural Areas of Honduras**

Andres Gil, IRC

Additional Authors: Stef Smits; Brenda Martínez; Ruben Hernández; Henry Gudiel; Tupac Mejía

Providing WASH services to people living in dispersed rural areas is generally believed to be one of the biggest challenges for reaching the SDGs in countries across Latin America. By definition, these settlements are small and spread out, resulting in very high per capita costs for developing WASH infrastructure. Due to limited economies of scale, tariffs would need to be unaffordably high to cover all operation and maintenance costs. This paper provides evidence of these challenges from Honduras. It finds that in dispersed rural areas access to WASH and existing WASH service levels are far below those in more concentrated rural areas. In response
to this, users and communities have resorted to self-supply through manguera (hose) systems. These are hoses installed in a perennial stream or spring which bring water to the homestead, typically from less about 250 meters away. These provide a medium level of service, as water access at the homestead is established, but quantity and continuity depend on fluctuations in water levels in the stream or spring, and water quality is problematic. The paper also reviews experiences of programs in Honduras - both past and present - that focused specifically on serving dispersed rural areas. We found that past water system construction programs in Honduras applied a standard approach for rural areas, mostly developing piped systems, regardless of whether settlements were concentrated or dispersed. Some programs focused specifically on solutions deemed appropriate for dispersed areas, particularly protected household wells with handpumps. Over time, the water supply aspiration of rural families grew towards piped supply, and household options - such as wells or rainwater harvesting - are only considered feasible in very specific cases. The likelihood for such alternatives to scale is also limited. Based on these findings, the research suggests seven different intervention models for WASH in dispersed rural areas of Honduras which consider the aspiration of users, the technical and financial limitations of each alternative, and the possibilities to build upon existing self-supply solutions.

**Open-Source Technology for Water-Quality Monitoring: Opportunities and Challenges**

Chris Kelley, Johns Hopkins University

Achieving universal access to adequate quantities of potable water in low- and middle-income countries (LMICs) is a pressing global challenge. One key aspect of this challenge (out of many) is the development of sustainable water quality monitoring networks, to detect and diagnose water quality issues, and help ensure the continued operation of water treatment infrastructure. The commercial market for water quality monitoring technology is well established in high-income countries, guided by design standards that suit American and European regulatory requirements, and steered by technology companies with manufacturing and repair centers largely clustered in the Global North. The majority of the world's people, particularly those in rural and economically marginalized communities, are largely unserviced by this commercial market for water quality monitoring technology. Open-source design of water quality monitoring devices may be able to address this imbalance by offering new opportunities for the development of sustainable water quality monitoring networks. Open-source design makes it possible for any engineer, public health researcher, or concerned citizen to contribute to the development of affordable water-quality monitoring devices, and the power to rapidly iterate potential device designs with the input of specific communities of potential users opens vast new possibilities for water quality monitoring development. There are many recently published examples of open-source water quality monitoring tools that could be built, maintained, and afforded in LMICs, and building locally for a given region can encourage the manufacture of devices that are tailored to the specific needs of local customers. Furthermore, producing and repairing water quality monitoring devices in country lowers the cost and transportation requirements associated with the upkeep of monitoring hardware, thus potentially improving the long-term sustainability of water quality monitoring efforts globally. Challenges exist, perhaps the most central of which is translating open-source designs into field-
and market-ready devices. While open-source water quality monitoring has seen some implementation in higher-income countries in academic and citizen-science efforts, it has not yet been implemented at significant scale in LMICs. A key enabling mechanism could be the development of suitable design standards to guide the manufacture and testing of open-source monitoring devices. Further, while low-cost open-source monitoring devices may be feasibly produced and maintained in LMICs, there is the challenge of setting up suitable manufacturing and repair shops and maintaining them given uncertain demand for their products and services. To expand the uptake of open-source water quality monitoring technology in LMICs, it will also be useful to address any perceived "prestige gap" between high-cost commercial monitoring devices and low-cost open-source monitoring devices.

**Occurrence of Human and Avian Fecal Contamination in Urban Mozambican Households: Assessing Fecal Transmission in the MapSan Trial**

David Holcomb, UNC Chapel Hill

Additional Authors: Jackie Knee; Trent Sumner; Joe Brown; Jill Stewart

A primary goal of onsite sanitation is to improve health by preventing transmission of fecal pathogens, though it fails to address transmission from non-human or non-domestic sources. As part of the MapSan trial, we are investigating whether shared, onsite sanitation can reduce fecal contamination and protect child health in dense, semi-formal urban settlements that house increasing numbers of the world’s poor. We assessed fecal contamination in a subset of MapSan study compounds immediately before and one year after construction of pour-flush latrines in half the compounds, which replaced pit latrines in poor condition. The remaining compounds retained initial sanitation conditions and served as controls. General and host-specific fecal indicator organisms (FIO) were measured at potential exposure points on established fecal transmission pathways to assess the relative importance and susceptibility to sanitation of different transmission routes. We assessed FIO in household stored water, compound source water, household entrance soil, latrine entrance soil, and household food preparation surfaces using both culture methods and molecular microbial source tracking (MST) assays to characterize contamination extent and fecal source. Samples were membrane filtered for culture enumeration of E. coli, a general-source FIO with regulatory significance, and for MST analysis using qPCR. We tested each sample using four locally-validated qPCR assays: two human assays, HF183/BacR287 and Mnif, which respectively target a bacterium and an archaeon and jointly offer increased sensitivity; avian assay GFD, as widespread domestic poultry represents a key non-human fecal source; and EC23S857 targeting the general indicator E. coli, permitting comparison of molecular and culture results. Baseline environmental samples were collected at 43 households in 26 intervention compounds and 50 households in 31 control compounds; end line samples were collected at 55 households in 33 intervention compounds and 58 households in 31 control compounds. At baseline, E. coli was detected frequently (>85%) by both culture and qPCR in most sample types, though we detected E. coli in only 30% of source water samples using culture methods but in 65% by qPCR. Human marker HF183 was detected infrequently in source water (4%) and food surfaces (2%) and occasionally in stored water (16%), latrine soil (38%), and household soil (25%). Human marker Mnif was also detected in 4% of source waters, less frequently than HF183 in stored water (11%), and more
frequently on food surfaces (12%), latrine soil (84%), and household soil (75%). Avian marker GFD was not detected in any source water samples and infrequently in stored water and food surfaces (1%), latrine soil (4%) and household soil (2%). Completed analysis of post-intervention samples will permit evaluation of the effect of the latrine intervention on fecal transmission along the different routes and from different fecal sources.

The Need for Fecal Sludge Management Among the Poorest: Evidence from Demographic and Health Survey Data

David Berendes, Georgia Tech

Additional Authors: Habib Yakubu; Katharine Robb; Amy Kirby; Suraja Raj; Joseph Ampofo; Benjamin Doe; James Michiel; Yuke Wang; Christine Moe

The SaniPath tool (SaniPath.org) has been used to evaluate public health risks from unsafe fecal sludge management (FSM) in low resource urban neighborhoods of Accra, Ghana, Vellore, India and Maputo, Mozambique. Based on the results shared from these studies with development partners and local government decision makers, there was a demand for an assessment that could characterize a citywide sanitation condition. We set to evaluate whether the SaniPath tool can be used to characterize city level exposure from unsafe fecal sludge management using a sub set of representative neighborhoods with varying sanitation coverage, population density and socio-economic status. Accra Metropolis is a city with poor fecal sludge management. Using publicly available data, we selected four representative neighborhoods from Accra of varying population density, sanitation coverage and socio-economic status. The four neighborhoods were classified using a score scale into "very poor", "poor", "moderate" and "good" sanitation neighborhoods. From April 2016 to August 2016, we collected behavior survey and environmental sampling data to understand public health risks from unsafe FSM associated with these neighborhoods. The behavior survey consisted of key informant interviews, transect walk with community leaders, surveys with community members and surveys with school children. The environmental samples were collected in public areas within the neighborhoods from the sea, beach sand, swabs from public latrines, soil, piped drinking water, open drains and produce. The data was analyzed using the SaniPath tool software. Overall, there was a general trend of fecal exposure that followed the classification of neighborhoods. However, produce had the greatest risk of exposure to fecal contamination regardless of the classification of the neighborhood. The proportion of the population exposed to produce across all four neighborhoods ranged from 93% to 96% and there was no significant difference in the high level (10^{6.18} CFU per 100ml to 10^{7.14} CFU per 100ml) of average E.coli concentration. Piped drinking water had the least risk of exposure to fecal contamination in all the neighborhoods and the trend of neighborhood classification was as hypothesized. Publicly available data available to decision makers may be used to characterize a citywide sanitation condition to advocate for action. Unsafe FSM can lead to exposure to fecal contamination irrespective of where you live.

The Role of Social Capital and Sense of Ownership in Rural Community-Managed Water Systems: Qualitative Evidence from Ghana, Kenya, and Zambia
Many water systems in rural areas of low- and middle-income countries are community-managed. Ensuring the long-term sustainability of community-managed systems is important to achieve Sustainable Development Goal (SDG) six, which calls for universal access to safe water. Social capital and sense of ownership are theorized to influence the effectiveness of community-management. To explore this relationship, we conducted a qualitative study of how and why social capital and sense of ownership facilitate water system sustainability, and their relationship to one another. Individual interviews and focus group discussions with community members, water committee members, local leaders, and external support actors were conducted in eighteen communities with successful community-managed water systems in Ghana, Kenya, and Zambia. We found that social capital facilitates water system solicitation, water committee elections, resource mobilization, and information sharing. Sense of ownership plays a role in organizing and enabling water system decision processes, physical labor, and resource mobilization. Both social capital and sense of ownership facilitate different forms of community participation that are crucial to processes which support water system sustainability. Further, our results suggest that social capital and sense of ownership are inherently linked through community participation and can thereby interact to magnify or undermine each other’s effects. Results also suggest that social capital and sense of ownership can have meaningful effects on socioeconomic and gender equality in rural communities by creating opportunities for alternative resource mobilization and female participation. We suggest external support actors actively assess and leverage the social strengths of rural communities, identify successful and skilled community members, encourage female leadership, and emphasize activities and trainings that incorporate social capital and ownership.


James Tidwell, LSHTM

Improving peri-urban sanitation is a complex challenge with increasing public health implications as the proportion of the population living in cities continues to grow. While major expenditures are being made on large-scale infrastructure improvements, few studies have focused on improving individual toilets in peri-urban settings. The Behavior Centered Design approach (Aunger and Curtis, 2016) was used during formative research for the 'SanDem' trial to understand the multiple, complex behaviors involved in several aspects of toilet improvement, with particular emphasis on the roles of the brain (executive, motivated), environment (social, physical), and behavior settings (roles, scripts) on improvement processes. Individuals interviews were conducted with residents (n=66) in Bauleni Compound, Lusaka, Zambia in fall 2016. Respondents were asked about plot characteristics, toilet histories, and financial decision
making; toilets were observed; and interactive activities were conducted to understand sanitation improvement preferences. Analyzing the plot as a "behavior setting" revealed the distinct roles and scripts associated with being landlords and tenants as the primary dynamic that affects the process of sanitation improvement. Landlords initiated improvements only when necessitated by loss of functionality of existing toilets, but failed to make desired improvements due to lack of preparation for these adverse events. Landlords viewed tenants as interchangeable, functioning mostly as sources of profit, rather than social equals. Tenants expressed a desire to have better toilets, but lamented a sense of powerlessness to communicate these desires. Both tenants and landlords were motivated to have better sanitation by social and relational motives more than health concerns. The key, but undiscussed role of the toilet in matching tenants with landlords also made clear that inefficient markets for sanitation were created by the reluctance to discuss this taboo subject. The findings have important implications for selecting the most effective targets and mechanisms of change for demand-side interventions for improving peri-urban sanitation and specifically for understanding individual- and plot-level drivers of peri-urban inequities in household sanitation quality.

**Combined Outcome of Three Reviews of CLTSH in Ethiopia**

Jane Bevan, UNICEF Ethiopia

Additional Authors: Zufan Abera Damtew

The CLTSH approach has been implemented in Ethiopia since 2007. It was soon after adopted as the national approach for sanitation promotion, and training was accordingly rolled out throughout the country using the Health Extension Workers as the key facilitators of the process. The impact on the sanitation coverage has been well documented by the JMP 2015 Report, which recorded that Ethiopia has made the most progress globally in addressing open defecation (OD) over the last 20 years. During 2016, three different reviews were conducted to examine the progress of sanitation in detail: a) A UNICEF study, both qualitative and quantitative, conducted in 8 Regions (Tigray, Amhara, SNNP, Oromia, Benishangul, Gambella, Afar, Somali), reaching 24 Woredas and 3,168 Households. b) A Global Sanitation Fund Qualitative and Quantitative review in 4 Regions (Tigray, Amhara, SNNP, Oromia), covering 22 Woredas, 2,100 Households c) A CLTS Rapid Appraisal Protocol (CRAP) Assessment conducted by the CLTS Foundation - a qualitative study which took place in Somali and SNNPR as well as combining national level consultations. This paper looks at the combined outcomes of the reviews and suggests ways forward for sanitation in Ethiopia. The key findings showed that OD is decreasing; however, the progress has been very uneven across the country, with strong advances in the central regions, but still very high levels of open defecation in e.g. Afar and Gambella. The studies found that traditional or unimproved pit latrines were used by >85 % of households. Conversely, the findings also indicated minimal 'improved' sanitation (as defined by the former MDGs) - 93% of existing toilets are unimproved and are unlikely to be providing the intended health impact. Monitoring of progress was also found to be a major issue, with definitions of ODF and 'improved' varying across the country. Creating ODF kebeles is a target of woreda transformation, which is one of the agendas of the Health Sector Transformation Plan (2016-2020) of Ethiopia. The country has a well-designed health structure extending from federal to the community levels. To move towards the national target and the ambitious goals
of the SDGs stating universal coverage of basic sanitation (formerly improved) by 2030, these key issues will now be addressed systematically by the government of Ethiopia to move its population up the sanitation ladder.

**Drying Kinetics of Human Feces for Onsite Sanitation**

Katelyn Sellgren, RTI International

Additional Authors: Brian Hawkins; Brendon Lynch; Stephanie Teleski; Tate Rogers; David Rogers; Brian Grant; Jeffery Piascik; Brian Stoner

Safe disposal of human excreta is essential for human health in addition to social and economic development [1]. Sanitation in developing and remote regions presents a significant challenge and despite great progress in sanitation, an estimated 2.5 billion people still live without improved sanitation facilities, almost half of whom engage in open defecation, leading to more than 3.4 million deaths annually [2-4]. To address these inadequacies, our research is focused on the development and implementation of a decentralized, self-contained toilet system enabling onsite water reuse. The toilet operates by 1) separating urine and feces, post flush, 2) drying feces into usable fuel, 3) combusting the fuel and using the heat to dry the next batch of feces, and 4) electrochemically treating the urine and flush water which is then recycled as flush water. Previous studies show moisture content and fuel sizing have significant impacts on the energy recovery potential of human feces with combustion Moisture content also affects the capacity of feces to be extruded and sized into usable fuel [5, 6]. Therefore, the need to understand and optimize the drying process is critical to harvesting sufficient energy from feces to enable a fully self-sustaining, integrated toilet system. Here, we define the drying kinetics of human feces under typical smoldering and rapid combustion exhaust conditions and examine the impact convection and conduction have on the overall drying rate and total energy expenditure within the drying system. Further, we have found ambient drying air conditions impact the time and energy of the process and determine whether the drying fecal material smolders before it enters the combustion unit. We also found the effect of the surface area to volume ratio of feces on temperature profiles and water flux during drying to be minimal in the range of 1.0 -1.3. Additionally, we have examined the effects of drying on shrinkage and density of the dried fecal matter. Future efforts will investigate the bounds in which a self-contained toilet can operate, such as necessary throughput and time/temperature/energy trade-offs. 1. Mara, D., et al., Sanitation and health. PLoS Med, 2010. 7(11): p. e1000363. 2. WHO and UNICEF, Progress on Sanitation and Drinking Water. 2015 Update and MDG Assessment. 2015, Geneva, Switzerland: WHO. 3. Wardlaw, T., et al., Diarrhoea: why children are still dying and what can be done. Lancet, 2010. 375(9718): p. 870-872. 4. WHO and UNICEF: Progress on drinking water and sanitation. Hydrologie Und Wasserbewirtschaftung, 2014. 58(4): p. 244-245. 5. Onabanjo, T., et al., An experimental investigation of the combustion performance of human faeces. Fuel, 2016. 184: p. 780-791. 6. Onabanjo, T., et al., Energy recovery from human faeces via gasification: A thermodynamic equilibrium modelling approach. Energy Conversion and Management, 2016. 118: p. 364-376.

**Household Uptake of the SolarBag Technology in Bellavista, Perú: A Qualitative Study to Inform Government Approaches**
CARE Peru has partnered with the Government of Peru (GoP) for over twenty years. CARE engages with candidates and elected officials for them to commit to reducing malnutrition in Peru - through development initiatives including increasing water and sanitation coverage. Most recently, the GoP sees CARE as a partner in piloting new models to increase coverage, specifically of drinking water, in remote, rural, and dispersed communities. Methods In the Amazonian communities of Peru we are piloting a safe water technology called the Bolsa Solar. We are doing long-term community observations and in-depth interviews with men and women regarding water use, social acceptance, and the feasibility of this safe water technology. Results CARE Peru does not necessarily see the Bolsa Solar as an affordable or sustainable solution for service provision in the Amazon region. What we are doing, however is continuing to engage with the Peruvian government to jointly test (and learn from) models in the hardest to reach communities of the Amazon, Andes, and coastal regions. We are and thinking strategically through GoP plans to reach 100% water coverage across the whole country; a daunting task due to the remoteness of many communities in Peru. We expect to have results by August 15, 2017. We will share the feasibility of the technology, about plans to iterate on learning from the pilot and the technology's strengths and weaknesses alongside the GoP. We will also share further about CARE's engagement with the GoP and how our work over 20 years has impacted GoP methods to increase sustainable WASH coverage.

Comparison of Analytical Techniques to Explain Variability in Stored Drinking Water Quality and Microbial Hand Contamination of Female Caregivers in Tanzania

Angela Harris, Stanford University

Additional Authors: Amy Pickering; Alexandria Boehm; Mwifadhi Mrisho; Jenna Davis

Exposure to fecal contamination continues to be a major public health concern for low-income households in sub-Saharan Africa. Drinking water and hands are known transmission routes for fecal pathogens in household environments. Much effort has been given to identify correlates of water and hand contamination; however, the WASH sector has not been successful in developing statistical models of fecal contamination that have accurate predictive power. Linear regression techniques with continuous outcomes, such as ordinary least squares regression and general estimating equations, are often used in these contexts. Alternative modeling schemes may be better suited to the phenomena under study (e.g., non-linear relationships). For this study, three different modeling techniques — ordinary least squares regression, logistic regression, and classification tree — were used on the same set of primary data collected from 1217 household in Bagamoyo, Tanzania, to model variation in E. coli contamination as a function of household and behavioral characteristics. Variation in hand and water contamination was poorly explained by all modeling approaches. For household drinking water quality, the
ordinary least squares regression model correctly predicted the drinking water quality categories (i.e., low, medium, and high) for 36% of cases overall, statistically no different from chance. Multinomial logistic regression predicted 44% of cases correctly, and classification tree modeling predicted 45% of cases correctly; both models predicted cases better than would be expected by chance. For the hand rinse samples, the ordinary least squares regression model, the binary logistic regression model, and the classification tree model correctly predicted the classification of 0%, 3%, and 14% of cases negative for E. coli, respectively. The poor prediction accuracy of all model types suggest that variation in hand and water contamination is difficult to capture using modeling techniques of one-time water and hand rinse samples. For improved prediction using correlates to contamination, future studies could explore modeling of repeat measures of household stored water quality and female caregiver hand contamination.

**Establishing a Drinking Water Safety Strategy in Mid-Western Nepal**

Ariane Schertenleib, Eawag

Additional Authors: Madan Bhatta; Bal Mukunda Kunwar; Rubika Shrestha; Dorian Tosi Robinson; Sara Marks

Establishing effective and sustainable strategies for ensuring drinking water safety in developing countries is a global challenge. This is especially the case in rural communities such as those found in remote mountainous regions in Nepal, where diarrheal disease burden is highest, and where the need for safe drinking water supplies is critical. A major barrier to achieving continuous safe water in this setting is establishing an ongoing monitoring system aimed at identifying risks and informing treatment processes for gravity-fed piped schemes. Through a one-year study that began in January 2017, Eawag and HELVETAS Nepal aim to establish a risk-based water safety strategy for piped water supplies across the Mid-Western Nepal using robust water quality monitoring tools adapted to field settings. The aim of the study is to demonstrate a viable approach to achieving effective water safety planning by integrating targeted sanitary inspections, three laboratory units equipped with microbial and chemical testing capacity and adapted to field conditions, low-cost scheme level treatment upgrades and centralized data management collecting real time data from the field. These interventions were implemented for 5 piped water schemes serving 282 rural households, and for one peri-urban distribution system serving about 15,000 tap stands. To improve local capacity for long-term management and operation, a regular sanitary inspection system by users and real time report in an integrated information management platform (Akvo) was established, as well as intensive repetition training sessions and a local knowledge hub. The results of this study will provide a relevant and timely case study of how rural water supply programs can effectively gauge their own progress toward national and global water quality targets. The project also contributes empirical evidence to several knowledge gaps on best monitoring practices for low resources settings.

**The Effects of Periodic Abandonment on the Reactivation of Biosand Filters on a School Schedule**

Barbara Stewart, Bangor High School
One of the most effective water filtration systems for rural areas in developing countries is the biosand filter (BSF). The filters have been widely tested and accepted for daily household use by removing pathogens through mechanical trapping and activity of the biolayer, a diverse microbial community on the upper layer of sand that takes up to thirty days to establish and is disrupted by cleaning or inactivity. BSFs have not been widely implemented in rural schools, where school breaks and weekends are longer than the BSF user guidelines of 1-48 hours. A recent study found no statistically significant difference in E. coli removal by extending the abandonment period to 72 hours, but there has been little research on the effects of abandonment periods beyond 72 hours or how intermittent use will impact BSF performance. Working in collaboration with a nongovernment organization in Honduras, four BSFs were installed, tested, and maintained in the laboratory on a typical school schedule. Chemical and microbial measurements were taken during the activation period of the four filters, as well as during three reactivations of the filters after three-month breaks. Total coliform and E.coli were found using IDEXX Colilert Quantii-Tray/2000 and quantification methods based on the Standard Methods’ Most Probable Number (MPN). Microbial reduction during the activation period on a school schedule, which included weekend breaks, ranged from 29.6% to 92% total coliform reduction during the first two weeks; total coliform and E.coli reduction during the second two weeks averaged 97.6% and 96.1% (n=40), respectively. These results were similar to published activation periods with daily dosing in a household setting. One fifteen-day reactivation period with daily dosing resulted in average total coliform and E. coli reduction of 98.6% and 97.4% (n = 56), with the greatest variation in performance during the first five days. Another fifteen-day reactivation period containing intermittent pause periods of three days and six days resulted in microbial reduction ranging from 40% to 99%, with an average total coliform and E. coli reduction of 95.6% (p<0.01) and 92.4% (p<0.01). Similar results were found when a five-day reactivation was conducted by passing varying numbers of buckets of source water through the BSFs daily, four through the first filter, three through the second, two through the third, and one through the fourth. These results suggest that BSF biolayers are resilient to the presence of abandonment periods; although more research is needed to determine the long-term impact of frequent reactivation periods, particularly on the flow rate and the microbial performance. This research will help determine the protocol and amount of time needed to revitalize abandoned filters.

Sources of Fluoride Intake and Risks to Human Health, the Cases of 4 Villages in Oromia and SNNPR Regions of Ethiopia

Belay Siyoum Leggesse, Ministry of Water, Irrigation and Electricity

To mitigate fluorosis, areas with both high fluoride in water and also high prevalence of dental fluorosis were identified. Three Woredas(district) (Bora, Alaba, and Dugan Fango) were taken as assessment locations and dental and skeletal survey of 936 individuals in four villages was conducted. The results indicate that in three villages’ larger exposure to Fluoride is attributed to drinking water; however, in one village larger exposure is from foods. From the sampled
population of Malima Beri village, 17% is free from fluorosis, 2.8% very mild; 7.7% mild; 19.7% moderate and 37.3% showed severe dental fluorosis. 16.9% of the population is affected by skeletal fluorosis. Combining the two, 83% of the population is affected by fluorosis. In Berta Sami village, 4% very mild, 12% mild, 14.5% moderate, 31.4% severe dental fluorosis and 14.1% of the population is affected by skeletal fluorosis. This shows that 76% of the populations is affected by fluorosis. In Halaba liyu Woreda, Kulfo village, 13.7%, 28.8%, 25.1% of the population encountered very mild, mild, and moderate dental fluorosis, respectively. Skeletal fluorosis was not detected during the survey. Generally, 72.6 % of the population is affected by fluorosis. In Dimtu town, 1.2%, 33.6%, 68.8% of the population encountered very mild, mild, and moderate dental fluorosis, respectively and 6.8% of the population is affected by skeletal fluorosis. Generally, 89.6 % of the population is affected by fluorosis.

**Household Water Chlorination Reduces Incidence of Diarrhea Among Under-Five Children in Rural Eastern Ethiopia: A Cluster Randomized Controlled Trial**

Bezatu Alemu, Haramaya University

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Background: Household water treatment has been advocated as a means of decreasing the burden of diarrheal diseases among young children in areas where piped and treated water is not available. However, its effect size, the target population that benefit from the intervention and its acceptability especially in rural population is yet to be determined. The objective of the study was to assess the effectiveness of household water chlorination in reducing the incidence of diarrhea among children under the age of five years. Method: A cluster randomized community trial was conducted in 36 rural neighbourhoods of Eastern Ethiopia. Households with at least one child under-five years of age were included in the study. The study compared diarrhea incidence among children who received sodium hypochlorite (liquid bleach) for household water treatment and children who did not receive the water treatment. Generalized Estimation Equation model was used to compute adjusted incidence rate ratio (IRR) and the corresponding 95% confidence interval. Result: In this study, the incidence of diarrhea was 4.5 episodes/ 100-person week observations in the intervention arm compared to 10.4 episodes/ 100-person week observations in the control arm. A statistically significant reduction in episode of diarrhea was observed in the intervention arm compared to the control (Adjusted IRR=0.42, 95% CI 0.36-0.48). Conclusion: Expanding access to household level water treatment with chlorine can help to substantially reduce child morbidity and achieve millennium development goal until reliable access to safe water is achieved.

**Manganese Removal from Drinking Water in Selected Rural Areas in Bangladesh; An Action Research**

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Studies in Bangladesh and elsewhere indicate that exposure to high concentrations of manganese from drinking water holds potential risks to the optimal cognitive development of children. Furthermore, the nuisance effect of black deposits and staining of laundry, predisposes households to drink other sources of water which though more aesthetically pleasing may be more microbiologically or arsenic contaminated. UNICEF and the Government of Bangladesh are currently conducting action research in two districts in Rangpur Division of Bangladesh where 90% of household drinking water samples had manganese concentrations above 0.6mg/l and less than 45% of the water sources complied with the drinking water standard. The first phase incorporated reconnaissance (114 households) and baseline (90 households) surveys which explored user preferences, knowledge, attitudes and practices in relation to sanitation, water supply, water treatment. Preliminary findings indicate that all the tubewells were shallow and some were contaminated with arsenic (28%), iron (93%) and manganese (100%) above the Government of Bangladesh standards. Users complained about taste and colour and used local made household sand filters to remove iron. They indicated willingness to pay between (1-2 cents) for a communal manganese removal unit. Ease of use, time required and availability of local materials were some of the considerations used to design the manganese removal unit with aeration, sedimentation, slow sand filtration and manganese coated slow sand filtration. Field tests of the efficiency of the first four units indicated a manganese removal efficiency ranging from 96% to 99% with no difference between the manganese coated slow sand filter and the slow sand filter. Microbiological contamination increased significantly after treatment with both slow sand f and manganese coated filters. The findings are being used to improve design e.g. by incorporating chlorination. The project is being implemented with Asia Arsenic Network and Bangladesh University of Environment and Technology.

The Associations Between Drinking Water Source, Enteropathogen Prevalence in Child Stools, and Child Growth in Rural Communities in Limpopo Province, South Africa

Bridgette McCarty, University of Virginia’s College at Wise

Fecal coliform bacteria have been widely established as an indicator of safe water treatment systems and used to assess the performance of emerging water treatment technologies in field studies, particularly when funding constraints do not allow for testing of specific enteropathogens. Since fecal coliform serve as only a general indicator of water quality, it was aimed to understand how this single indicator relates to the prevalence of enteropathogens that are responsible for the greatest burden of diarrheal disease in children. Culture and molecular methods were compared to detect pathogens in 100 drinking water samples taken as part of a point-of-use drinking water intervention randomized control trial in the Vhembe District of South Africa. Membrane filtration was used to detect fecal coliform bacteria, and polymerase chain reaction (PCR) was used to detect diarrheagenic E. coli, Shigella, Giardia, Cryptosporidium, Campylobacter, and Adenovirus. Pathogen prevalence across the two methods were also compared, and pathogen burden was associated with self-reported water source in the Vhembe District. Fecal coliform levels were correlated with the detection of some, but not all of the specific enteropathogens detected by PCR. Households that retrieved water from rivers in the area had the highest overall pathogen prevalence and fecal coliform, while the municipal tap and springs had the lowest pathogen prevalence and fecal coliform. This
study suggests that demonstrating a reduction in fecal coliforms by point-of-use water interventions may not directly correlate to a reduction in all enteropathogens that affect early childhood illnesses. The direct assessment of specific enteropathogens will likely better indicate the performance of drinking water interventions in future studies.

**Water Ambassador Program II: Furthering the Understanding and Protection of Watersheds and Hydrology in the US Virgin Islands**

Christina Chanes, Cooreative Extension Service

The United States Virgin Islands is a small territory in the Caribbean Sea, just to the east of Puerto Rico that consists of four main islands, Saint Thomas, Saint Croix, Saint John, Water Island and a few smaller, unpopulated islands. A significant proportion of the population of these islands draws their water from cisterns filled by rooftop collection. The Water Ambassador Program is designed to advance the literacy of hydrology in students, teachers and the public in the USVI. topics covered are water conservation, water quality, water resources and their management within the USVI. Over 12 teachers participated in trainings, more than 42 participated in the program territory-wide and over 670 students under the age of 15 participated in the program. Specifically, WAP benefited UVI Cooperative Extension Services, the Etelman Observatory, UVI researchers and officials of the Department of Agriculture interested in the quality of water and agriculture in schools and community. The program gave CES experience in teaching youth of hydrological issues, installed six more weather station at schools for use by teachers in St. John and St Croix which had previously not been exposed to the program. These weather stations report to the GeoCAS web page (geocas.org). The program also led to, the construction of a WAP Outdoor Hydrologic Learning Center at the Addelita Cancryn Junior High School which was built out to include two greenhouses and several raised beds for the youth to test water and soil in the agriculture funded by IGY Marinas. The program has exposed 670 students including those enrolled in schools on St. Thomas, St. John and St. Croix. Large and small scale assemblies on many school sites across the USVI have been a part of the program this year in an effort to share what the WAP youth have learned to share with the broader school community. Presentations nationally and internationally on the program have taken place and been given high marks for its creative use of education and science. Recently, the EPA asked to have UVICeS WAP coordinate a training and asked that youth from the program present their outcomes. In doing so, more than 30 youth presented to professionals from a variety of government agencies, community groups and professors from in and around UVI at the EPA Region at the Science Consortium meeting which took place in January. After the event, UVICeS was contacted about the WAP Program as it was determined by EPA that it should be nominated for the Environmental Champion Award which was submitted for consideration. Awardees are notified in the Spring of 2017. Other notable outcomes include the fact that youth from the UVICeS sponsored WAP also submitted films to the 4H Film Festival held in Missouri this year, VI Montessori and Peter Gruber Academy won second place in the category of promotional films. To date, water testing is ongoing.

**Virus Removal by Chitosan Coagulation Pretreatment in Natural Waters to Optimize Ceramic Water Filtration for Household Drinking Water Treatment**
Collin Knox Coleman, UNC Chapel Hill

Introduction: Viruses are major contributors to the global burden of diarrheal disease morbidity and mortality. Rotavirus is the leading cause of moderate-to-severe diarrhea in infants and children under age 5 and noroviruses are most common among adult populations. To combat diarrheal disease from contaminated drinking water, water treatment technology and safe storage (HWTS) have been developed, researched, and deployed for resource-limited settings of developing countries for users to treat water at the household level. While household level purification technologies have appreciably reduced diarrheal illness, the majority of filtration technologies fail at removal of viruses due to their inability to physically filter viruses because of their small-size, without sacrificing flow rate. In order to address this major shortfall in virus removal efficiency in household water treatment, we combine chitosan, a promising natural, organic, polymeric coagulant, as a form of pretreatment with ceramic water filters (CWFs) and evaluate the coagulation and pretreatment capacity of chitosan to remove viruses and bacteria from drinking waters. Objectives: Our approach is to integrate chitosan use with the CWFs and determine the coagulation effects of chitosan by evaluating the removal of bacteria, virus, and turbidity. To evaluate the effectiveness of chitosan coagulation we assessed performance of two types of chitosan in test waters of varying quality: lake water spike with indicator microorganisms, and lake water spiked with pasteurized raw sewage and indicator microorganisms. We allowed for coagulation, promoted flocculation, and sedimentation of flocs, and subsequently transferred the pre-treated water (the supernatant water after coagulation and floc sedimentation) into the CWF for further treatment by filtration. Methods: To evaluate microbiological removal in lake water spiked with indicator microorganism, test water was prepared by adding E. coli B, Clostridium perfringens spores, and MS2 bacteriophages as surrogates for bacteria, protozoan cysts, and virus contaminants. The spread plate method and membrane filtration method was used to enumerate E. coli B and C. perfringens, and the Single Agar Layer (SAL) assay and Double Agar Layer (DAL) assay was used for MS2 enumeration. Log10 reduction values were calculated based on the microbiological counts from influent water, chitosan treated water, and post filtration effluent water. Test waters were also evaluated for changes in total organic carbon, pH, and turbidity. Results and Conclusions: Results indicate that chitosan is a promising coagulant that optimizes the removal of indicator viruses and bacteria in natural waters of varying quality by up to 8 Log10 PFU/100 mL and 7 Log10 CFU/100 mL when used as a pretreatment for CWF.

Scaling Laws Governing Contaminant Intrusion in Intermittent Water Supplies

David Taylor, MIT

Additional Authors: Alexander Slocum; Andrew Whittle

The Sustainable Development Goals use the proportion of the population with access to "safely managed drinking water services" (UN 2016, 6.1.1) to track access to safe water. The definition of access to safely managed water services requires that water is "available when needed" and is free of faecal contamination (UN 2016, 6.1.1). Urban distribution networks which provide intermittent water supplies (IWS) are particularly vulnerable to contamination due to the
potential for backflow and contaminant intrusion into the buried pipes. As there are almost one billion urban people who drink from IWS, it is important to develop management practices that improve the water safety of IWS. This study describes a set of first-order scaling relations that have been used to investigate the relationships between the supply pressure, supply duration, leakage rates, and the volume of intruded contaminants present during the flushing phase and steady-state operation of IWS. When IWS are first pressurized, accumulated contaminants flush through the system. Factors which govern flushing water quality differ from those which govern steady-state quality. While current policy priorities push for longer water supply periods, we find that increasing the supply duration can degrade the steady-state water quality while concurrently improving the water quality during the initial flushing phase. The degradation in steady-state water quality can be offset only by extensive leak repairs. Regulators and utilities must be careful in scheduling their water sampling operations when investigating the impacts of changes in supply periods. The scaling relations also show that increasing supply pressures and/or duration always increases leakage. We propose quantifying leakage in terms of an equivalent orifice area (EOA) that provides a more stable metric for managing IWS systems. The volume of intruded contaminants is directly proportional to EOA. We have applied the scaling laws to self-reported performance indicators for IWS systems serving 108 million people described in either the IBNET database or in the Benchmarking and Data Book of Water Utilities in India. Current high-pressure continuous water supply targets will require extensive reductions in EOA. In order to achieve these national targets, water utilities in India will need to reduce their EOA by a median of 90%.

Safely Managed Intermittent Water Supplies? New Evidence from New Delhi

David Taylor, MIT

Additional Author: Alexander Slocum

Almost one billion people drink from intermittent water supplies (IWS). Therefore, understanding the conditions under which IWS can be free of faecal contamination will be critical to reporting and managing progress towards Sustainable Development Goal 6.1. Erickson et al. (2017) found that an IWS could deliver water the is generally free of faecal contamination during steady-state in Arraiján, Panama. Kumpel and Nelson (2013) found the opposite in Hubli-Dharwad, India, despite the studies’ similar methodologies. The two studied-systems differed in five important ways: 1) the degree of intermittency (on 50% of the time vs. 3.5%); 2) system pressure (>20 m vs. 9m); 3) free residual chlorine (0.8mg/L of vs. 0<.2mg/L); 4) source water quality (total coliform detected in 0% of reservoir samples vs. 35%); and 5) prevalence of environmental contaminants (not quantified). To help identify which of these factors were responsible for enabling safer IWS, we measured water quality in a third IWS: New Delhi, India. In June 2017, we took a total of 140 grab samples from one service reservoir, inlets to four zones, and four houses in each zone. Samples were taken for seven of nine consecutive days and tested for free and total chlorine, turbidity, total coliform, E. coli, and aerobic endospores. Additionally, soil samples were taken in each zone to quantify the presence of environmental contaminants. Like Erickson et al., we found only 1.4% of grab samples taken in the distribution network and at customer homes (n=72) to be positive for E. coli or total coliform. None of the 19 samples from the service reservoir were positive for total coliform or
E. coli (n=19). (Some data processing is still ongoing). Similar to Hubli-Dharwad’s system, Delhi’s had low pressure (mean 4<\text{m}) and ubiquitous (but dry) contamination sources. Similar to Arraiján’s system, Delhi’s had good source quality and high levels of free residual chlorine (0.9mg/L). Delhi’s level of intermittency (on 17% of the time) was between the other two cities. These results suggest that an IWS with low pressure and four hours of supply per day may still deliver water that is generally free of faecal contamination. This, however, is a preliminary result; much additional work is required to confirm these findings and to explore the risk induced by higher levels of contamination during an IWS’ flushing phase.

A Continuous, Objective Metric for the Usage of Household Water Treatment and Safe Storage Devices

David Taylor, MIT

Additional Authors: Natasha Wright; Courtney Hill; Kelly McCain; Elizabeth Rogawski; Dan Frey

Simulations (Enger et al. 2013; Chu et al. 2009; Brown and Clasen 2012), systematic reviews (Wolf et al. 2014; Clasen et al. 2015; Hunter 2009), and the WHO’s toolkit for the monitoring and evaluation of household water treatment and safe storage (HWTS) programs (2012) agree: the consistent and sustained adoption of HWTS is essential to realizing HWTS’ health benefits. Despite the importance of HWTS’ adoption, Parker et al.’s review (2012) found that only 15 of 26 (58%) of studies that considered HWTS’ adoption used an objective metric; further, none used a continuous metric. Since that review, the use of an objective, continuous monitoring device has been demonstrated by Thomas et al. (2013, 2016), but their results were limited by the sensor’s high cost ($100-$500) which has limited its large-scale deployment to four weeks. Large-scale, long-term deployment proved useful for stove-use-monitors (Wilson et al. 2016), but has yet to be achieved for HWTS. We, therefore, introduce a low-cost, long-term, continuous sensor that is embedded into the spout/spigot of a HWTS: The SmartSpout. It records usage data for up to a year; data is then collected through a cell phone app. The SmartSpout logs when a HWTS is used and the duration for which it is used, providing critical data on how usage varies with time, season, and study interventions. In large volumes, the SmartSpout costs less than $20 per unit and can therefore affordably be installed in many, if not all, HWTS devices studied in future randomized control trials. The SmartSpout provides an objective metric that can: quantify the relative effectiveness of different behavior change interventions; control for adoption difference among different HWTS types; and measure discontinuance rates. To exemplify the SmartSpout’s utility, we present preliminary data gathered in an un-blinded clustered RCT with four arms: filtering & safe storage, treatment & safe storage, safe storage alone, and a control group. We share the variance in HWTS’ use within households, between households, and between clusters. Understanding the largest sources of variance will allow future studies to: a) focus behavior change efforts appropriately; b) optimize sample size; and c) have increased power by decreasing the unexplained variance.

Health and Environmental Impact of SODIS in Uganda

Gregor Riss, Helioz
Health and Environmental Impact of SODIS in Uganda

Executive Summary

The report presents results of an Evaluation of the Project titled "Improvement in potable water through Solar Disinfection (SODIS) with UV - indicator" implemented by Agency for Co-operation and Research in Development (ACORD) in seven peri-urban water-stressed Sub Counties of Mbarara and Rwamwanja settlement in Kamwenge Districts of South Western Uganda (SWU) and Western Uganda respectively. The evaluation is for the project period between October 2015 and March 2016. The project is implemented in collaboration with a number of Women groups and with support from Bread for the World (Bftw). The evaluation report provides a detailed review of the findings and recommendations regarding the progress, achievements, impact and accomplishments during the project period. Data for this Evaluation report was collected during the months of late May 2016 and early June 2016 through a consultative and participatory approach using quantitative and qualitative methodologies were adopted for this evaluation. Data collection was through focus group discussions and structured questionnaires. Key findings to a larger extent, findings revealed a positive shift in the realization of project outcomes specifically practice. Of the 131 respondents reached with the survey, majority 90.8% reported practicing SODIS with WADI as opposed to the 0% at the onset of the project. The study revealed that, the major source of drinking water for the household members was rain water at 77.9%, followed by protected well at 18.3% with open well/spring taking 3.8%. This showed a direct linkage with the project target where by the emphasis and entry point was on households with domestic rain water tanks at their households. At the onset of the project majority 59.2% of the households reached with the survey tool said that they were using 5 pieces of firewood to boil drinking water, and the same question was posed to respondents at the end of the project majority 69.2% of the respondents reported using 2 pieces of firewood to boil drinking water. Findings revealed a significant percentage 87.5% respondents registered a reduction in water related diseases as opposed to the 12.5% who responded that there was no reduction in water related diseases. Findings revealed that majority 93.8% respondents received training on water disinfection using SODIS-WADI as opposed to 6.2% respondents who did not receive training. Ideally, majority (93.8%) respondents received training thus project sustainability as they would use the knowledge and skills post project span.

The Extended Laboratory Use of Ceramic Water Filters with Antimicrobial Silver Ion Technology

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Additional Authors: Barbara Stewart; Catherine Hopper; Cordelia Stewart; Ellen Tobin

The use of antimicrobial silver ion technology has shown promise in the WASH community to reduce waterborne disease in the household setting. The MadiDrop is a ceramic water filter embedded with silver that is being pilot tested as a versatile method to reduce microbial contamination for low levels of contamination in safe water storage applications or for high levels in an unprotected water source. To our knowledge, there have been no published studies evaluating the effectiveness of the MadiDrops over the course of a year and for a large range of microbial contamination. Source water from a local stream was spiked with E. coli concentrations of 10^5 and 10^7 E. coli per 100 mL and used to evaluate the performance of
the MadiDrop in 10 Liters of water after two, two and a half, seven, ten and twelve months. IDEXX Colilert Quanti-Tray/2000 and quantification methods based on the Standard Methods’ Most Probable Number (MPN) were used to quantify total coliform and E.coli. After 24 hours, a three to five log reduction was observed in the first seven months but dropped to 0 log reduction at ten and twelve months. In deionized water, a seven log reduction was observed in the first ten months which dropped to a six log reduction after twelve months. Silver ion concentrations were also characterized using inductively coupled plasma mass spectrometry (ICP MS). Silver ion concentrations were taken after one week, two weeks, seven months, eight months and nine months of use with lengths of exposure varying from twenty-four hours to three months. Silver ion concentrations in source water ranged from 26.5 µg/L to 110.56 µg/L with all but one below the WHO guideline of 100 µg/L. In deionized water, under similar conditions of time and exposure, values ranged from 21.8 µg/L to 3087 µg/L. A MadiDrop after 9 months of use and seven days of exposure to deionized water spiked with 10^7 E.coli had a silver ion concentration of 449 µg/L, suggesting that that ions and particulate matter in the source water influence the solubility of the silver ions in solution. We also investigated the use of MadiDrops as a safe water storage solution for elimination of residual contamination in effluent water from biosand filters during reactivation of the biolayer. A new MadiDrop showed complete reduction of total coliforms and E.coli after 24 hours of exposure in low levels of contamination (average 237.7 MPN/100 ml total coliform and 4.4 MPN/100 ml E.coli). Three twelve-month-old MadiDrops under similar conditions had a total coliform reduction range of 26.8% to 100%. Preliminary results indicate that antimicrobial silver ion technology is effective during the first 6 months of use, regardless of contamination levels, but decreases in performance after ten to twelve months of use. As such, this research has implications for the use of MadiDrops in safe water storage applications as well as emergency treatment situations.

**Water Safety Plan Review and Approval in the Philippines**

Joselito Riego de Dios

Water Safety Plan Review and Approval Process in the Philippines Prepared by: JOSELITO M. RIEGO DE DIOS, CE, SE, MPH, Chief Health Program Officer, Disease Prevention and Control Bureau, Environmental Health Relate Disease Division, Department of Health, Manila, Philippines The institutionalization of Water Safety Plan Program of the Philippine Department of Health requires control of water safety plan (WSP) prepared by drinking water service provider. It is a mandatory requirement to the later since 2014 and the need for guidelines for WSP review and approval is inevitable to ensure the completeness and acceptability of any WSP. Administrative Order (AO) No. 2017 - 0006 dated April 20, 2017 outlined the process for the WSP Review and Approval by the Department of Health (DOH). The responsibility is not lodged solely to DOH but also to the DOH Authorized and Deputized Agencies. It is a joint partnership between DOH and other Water Regulatory Agencies. The process will involve the use of Evaluation Tool that sets criteria covering the eleven (11) steps for WSP Preparation. A WSP Review Committee at national, regional and local level will be established with five members representing various water related agencies. The process will entail 45 days from application, review and approval. The AO also provides requirements for renewal of WSP Certificate of Acceptance every after three (3) years to incorporate any changes or updates on
the WSP as a result of regular review of WSP implementation by the drinking water service provider.

**Field Experiences in Removing Fluoride from Water Using Synthetic Apatite Medium Produced and Applied in Kenya**

Julius Kubai, Nakuru Defluoridation Company (CDN)

In laboratory trials where the adsorption methods of removing excessive fluoride from water were tested, the apatite showed advantage against the other adsorption materials due to its higher uptake capacity and nearly no problem of leaking ions from the filter material. Nakuru Defluoridation Company (NDC) has been in the field of research and implementation of defluoridation filters by use of some of these processes. This has practically been applied both at community and household levels to mitigate fluorosis. Since the year 2000, we have largely applied the adsorption through bonechar filter medium as well as contact precipitation (CP) based filters, using calcium and phosphate rich pellets mixed with bonechar. Though the CP based filters have been working better than bonechar only filters, the technique experienced challenges of high fluoride levels in some water sources, necessitating bigger volumes of the filter material and frequent material replacements after breakthrough due to the fact that the medium cannot be regenerated. This posed a challenge of sustainability. In collaboration with the Swiss Federal Institute of Aquatic Science and Technology (EAWAG) and Dr. Michael Ecker from Germany, NDC is now in full scale production and in use of a synthetic apatite filter material called FLUOROLITH®. FLUOROLITH® is a colourless (whitish) granulate which is insoluble in water. The material composes of CaO, P2O5 and H2O as the main chemical components, with a mineral composition of over 95% apatite phase. The material has a moisture content of less than 5% with a bulk density of 500 -750 kg/m3. In practice, the material is produced between 0.5 - 2mm, over 90%, to increase the surface area for adsorption and has a filter velocity of 3-6m/h. The reaction time is between 10 -20 min and can be regenerated with sodium hydroxide. Only food grade chemicals are used in its production. In the filtration process, FLUOROLITH® is filled in plastic or steel containers, just like you would do with sand filters or filters for activated carbon. The fluoride containing water is passed through the filter from top to bottom, with recommended flow rate of 3 to 6 bed volumes per hour. The reaction between FLUOROLITH® and the fluoride containing water can be described by the following chemical formula: F- + Ca5[OH / (PO4)3] -> Ca5[F / (PO4)3] + (OH)- After the material is exhausted, the filter is regenerated and replaced to serve for another round. The aim of this paper is to share the field experience and performance of these synthetic apatite filters, installed in different community water supplies, schools and other institutions like the flower farms in Kenya to provide fluoride safe water.

**Evaluation of Five Chromogenic Clinical Diagnostic Culture Media for Direct Detection and Enumeration of Antimicrobial Resistant E. coli in Surface Water and Sewage**

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The reduced efficacy of antimicrobials against infectious diseases poses enormous health challenges. Alongside, the environment plays a key role in mediating fate and transport of antimicrobial resistance (AMR) across different settings. The World Health Organization has called for a globally harmonized culture-based indicator system and methodology for the direct detection and quantification of important AMR in clinical, agricultural, and environmental settings. The proposed indicator system utilizes the presence and concentration of Extended-spectrum-β-lactam resistant Escherichia coli (ESBL-Ec) in these environmental hotspots, but a final methodology has yet to be rigorously validated. This study evaluates five such candidate agar media - two generic products (MacConkey, Tryptone bile glucuronide (TBX) agars) and three commercial products (ChromAgar ESBL, HiChrome ESBL, and Chromatic ESBL) - supplemented with antibiotics for use in this ESBL-Ec indicator detection system. Surface water and raw sewage samples were analyzed on each medium, using standard membrane filter methods for surface waters and spread plating methods, respectively. Colony forming units (CFU) were observed and discretely recorded as discrete counts following manufacturer color guides. The resulting medium- and site-specific concentration and proportion of ESBL-Ec were then statistically compared. Samples were then streaked to isolation. MALDI-TOF and VITEK analysis confirmed the identity and antimicrobial susceptibility profile of each isolate. Averaged across raw sewage sampling events, MacConkey supplemented with antibiotic and X-gluc chromogen detected the lowest concentration of ESBL-Ec (4.5 log10 CFU/100 mL) while HiChrome ESBL detected the highest ESBL-Ec concentration, at 5.5 log10 CFU/100 mL). Across surface water samples, HiChrome ESBL detected the highest average ESBL-Ec concentration (36 CFU/100 mL) while TBX and Chromatic ESBL agars detected the lowest average concentrations (0.2 CFU/100 mL). Concerning specificity, 100% of confirmed E. coli across all media were confirmed resistant to cefpodoxime. The proportion of E. coli confirmed resistant was highest from TBX (100%) and MacConkey (75%) agars and lowest from Chromatic ESBL agar (0%). This study builds on results of a prior methodological evaluation and emphasizes the iterative improvement and increased accessibility of this indicator system methodology. The global spread of AMR demands further coordinated, harmonized methodological assessments across other geographic regions and fields of practice using parallel, matching methods to identify threats and detect outbreaks.

**SaniPath Assessment of Exposure to Fecal Contamination in Informal Settlements and Formal Neighborhoods of Siem Reap, Cambodia**

Jamie Green, Emory University

Additional Authors: Suraja Raj; Yuke Wang; Dany Duong; Makiko Yakushima; Sothyreak Chhun; James Wicken; Christine Moe; James Michiel; Habib Yakubu

Background The SaniPath Tool assesses exposure to fecal contamination in low-resource urban settings to guide sanitation intervention strategies. The SaniPath Tool was deployed in Siem Reap, Cambodia to assess exposure to fecal contamination in 5 environmental pathways in 5 neighborhoods (3 formal and 2 informal settlements). The purpose of this assessment was to
determine which pathways posed the greatest risk of exposure to fecal contamination and how exposure varies within and between informal and formal areas. Methods Data collection was conducted in 5 neighborhoods of Siem Reap during August-October 2016. Between 45 and 114 household surveys were conducted per neighborhood (n=410). Approximately 10 environmental samples per neighborhood for each pathway were collected from the public domain (n=193). Environmental samples included raw produce, well water, bottled water, municipal water, floodwater, and ice and were tested for E. coli using membrane filtration. Household surveys asked frequency of behavior associated with exposure to different pathways for adults and children. Behavior and environmental data were analyzed using Bayesian methods, and Monte Carlo simulation was used to develop risk profiles for each pathway. The risk profiles illustrate the estimated percentage of the neighborhood population that is exposed to fecal contamination from a particular pathway and the mean dose of exposure (average amount of E. coli ingested per month). This work was done in collaboration with WaterAid Cambodia and Water for Cambodia. Results and Conclusions Raw produce posed one of the greatest risks of exposure to fecal contamination across all 5 neighborhoods (100% of adults exposed to dose ranging from 7.59E5 to 1.78E7 CFU/month). Participants in all neighborhoods reported using bottled water and well water as main drinking sources, while few reported drinking municipal water. No E. coli was found in municipal water, while bottled and well water had moderate amounts of E. coli. Exposure to floodwater was high across all neighborhoods, with 94-100% of people reporting contact with floodwater. The lowest exposure dose for floodwater was found in the only neighborhood with a drainage system (4.79E2 CFU/month). These results provide evidence for decision makers to prioritize efforts to reduce exposure to fecal contamination in Siem Reap. Improving access and increasing use of municipal water to make it a viable source of drinking water may reduce exposure to fecal contamination from well and bottled water. Improving drainage systems throughout the city may reduce exposure to contamination from floodwater during the rainy season. Raw produce is an important part of the Cambodian diet and an often unrecognized pathway of exposure to fecal contamination. Additional investigation is needed to better understand how, and at what point, produce becomes contaminated and how to effectively reduce the risk from this pathway.

Integrating CLTS and SanMark: A Solid Lever for Behavior Change in the Ivorian Context

Jean-Marc Leblanc, FRC

Launched in Ivory Coast in 2009 by the Ministry in charge of sanitation, with the support of UNICEF, Community-Led Total Sanitation (CLTS) facilitates access to sanitation for rural populations. With the intention of scaling up the promotion of autonomous sanitation, CLTS stimulated the demand and creates a healthy emulation amongst local authorities. While some initiatives such as the coupling CLTS - PHAST (Participatory Hygiene and Sanitation Transformation) have been able to slow down communities’ desire for an Open Defecation Free status, causing them to expect subsidies that inhibit conventional CLTS, a pilot project CLTS - Sanitation Marketing (SanMark) in two regions (Duékoué and Soubré) gave very hopeful results. In the "Hydraulic and Sanitation Program for the Millennium"(PHAM) put in place by the French Red Cross in collaboration with the Ivorian Coast Red Cross and the support of the European Union and UNICEF from 2013 until 2017, CLTS has triggered and aroused the
demand for sanitation infrastructures. Meanwhile, SanMark enabled a wider offer of new sanitation facilities, complementing and diversifying the classic CLTS option of self-building single pit latrines. In Ivory Coast, where part of the population has the will as well as the economic capacity to pay for products and services, sanitation becomes a market. Thus SanMark's offer provides commodities that appeal to and prompt motivation amongst the population to equip themselves with sustainable sanitation infrastructures, whilst achieving the initial objective of improving health through the "social prestige" lever. By adapting itself to a socioeconomic context and implementing a CLTS - SanMark contiguum, PHAM has altered the sanitation scale's levels. It is particularly interesting to note that people were attracted to the most expensive products. This goes to show that the population has the means to access products and services as soon as they perceive an added value aspect, in spite of an economic context that remains difficult. However, it is important to be aware that the success of these slabs isn't merely based on the added "health" value that we put forward but rather rely on a "prestige" feature: these most expensive slabs, considered as luxurious, offer an extra value both to the surrounding environment as well as the population's daily life. This last point calls into question our approach as such that, if it remains too "health based", it fails to completely trigger all the levers of sustainable behavior change. Namely, we need to find other levers as to remove any potential standoffs, as to ensure a population that is fully subscribing and perceiving the real interest in what we claim to do in our sanitation programs.

Improved Functionality of Water Systems: How Solar Power Increases Resilience to Drought in Somali Villages

Kamal Farah, CARE

Additional Author: Kelly Alexander, Stephanie Odgen

Background Despite a quarter century of donor investment through small scale projects the rural water supply in Somaliland suffers high rates of dysfunctional and unreliable water supply, where over 54% of the rural water points have fallen into disrepair at any given time. Little effort has been put into improving the sustainability of rural water supply, especially during the dry season. The Quenching the Thirst project which CARE International was implemented 2013-2016 in Somaliland with a close partnership of the Ministry of Water Resources (MoWR), with an effort to implement models that prioritized long-term operations and maintenance of water points. Methods A baseline and endline survey was conducted in 60 villages, with the aim of 10-12 households surveyed per village along with at least two members of the local water committee and a representative of the local water office. Results The solar powered water pumping technology and village lighting business increased the income for spare parts by 60%. Intervention villages also had more water (volume) and more reliable water supplies than those in control villages. Sanitation efforts through ODF were relatively unsuccessful. Collaboration with the government has increased preparedness and coordinated response efforts of NGOs and the government in part due to the efforts of this program. Quenching the Thirst has ensured reliable & safe to drink rural water supply and enabled the villagers to be more resilient to the current severe drought prompted by El Nino in Somaliland.
Assessing the Iterative Factor Mapping and Learning Process for Water Service Planning and Management in Ethiopia

Kimberly Pugel, University of Colorado, Boulder

Additional Authors: Jeffrey Walters; Nicholas Valcourt; Amy Jaernick-Will; Karl Linden; Eduardo Perez

The United States Agency for International Development (USAID) recently funded a five-year learning initiative called Sustainable WASH Services (SWS) whose purpose is to improve WASH service practice and policy by developing, applying and testing systems-based tools and approaches. A key aim of SWS is to learn about how the sustainability of WASH services can be bolstered through understanding and engaging more effectively within "WASH systems". SWS conceptualizes WASH systems as a combination of context-specific factors (i.e., financing, technology, water resources) and key stakeholders that interact to influence service delivery outcomes within WASH sub-sectors and within a particular development context or geopolitical boundary. From this perspective, systems approaches must necessarily consider the interactions, interdependencies, and dynamics within and between factors and actors and their resulting impact on sustained WASH service delivery. This paper presents a technique that SWS is testing to routinely engage stakeholders in factor analyses, called the Iterative Factor Mapping and Learning (IFML) process. The IFML process is a participatory, stakeholder-driven approach for iteratively building, analyzing and interpreting factor maps that represent the interdependencies between factors that influence sustained WASH services. Iteratively analyzing factor maps lends insight into factor influence, importance, and dynamics to reveal potential areas where the WASH system could be strengthened. Findings are presented from a pilot application of the IFML with a formalized, district-level group of decentralized water service stakeholders in Ethiopia. In addition to describing the IFML process, this paper provides an analysis of the factors, assessment of factor influence on strengthening service sustainability, and assessment of improvements in stakeholder understanding of the WASH system through pre- post- tests. The utility and value for future application of the IFML in the WASH sector is assessed based on improvements in stakeholder understanding of the WASH system, and the alignment of actionable steps moving forward with WASH interventions to strengthen service sustainability.

Barriers and Opportunities for Achieving Safe Drinking Water in Bangladesh: A System Thinking Approach

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Naturally occurring arsenic (As) is present in the drinking water sources of 100 million people globally. The Bengal basin, which includes Bangladesh and neighboring parts of India, is the most severely affected region. Chronic exposure to As is associated with adverse health effects including skin lesions, cancer, cardiovascular and lung disease. Although the current WHO
recommended limit for drinking water is 10 µg/liter, developing countries such as India and Bangladesh have a less stringent standard of 50 µg/liter. To identify drinking water sources that exceed these levels, accurate As testing methods are needed. Methods for testing water for As contamination can be broadly categorized into lab- and field-based methods. Lab techniques such as Atomic Absorption Spectroscopy (AAS) and Inductively Couple Plasma Mass Spectroscopy (ICP-MS) offer unparalleled sensitivity and accuracy, but require costly lab instrumentation and staffing, uncommon in low and middle income countries. In addition, the cost per sample ($8-25) makes these techniques less viable for widespread use. Alternatively, field test kits are available that be conducted quickly (<30 minutes), on site, and at lower cost per sample ($0.5-5.0). For these reasons, kits are more widely used by NGOs, international development agencies, and government bodies in affected regions. In this study, eight commercially available As test kits were assessed under field and lab settings across a range of As concentrations (10-200 µg/liter). All kits measure As concentrations based on the "Gutzeit method" in which As in water is reduced to arsine gas that then reacts with mercury bromide to produce a yellow to orange color depending on the As concentration. The test strip color is matched to a reference color chart provided by the manufacturer to assess As concentration. A panel of five experienced test-kit users performed color matching, while a handheld color scanner was used to enable an instrumental color match. This allowed us to separate errors caused by inaccurate user color matching. Test-kit accuracy was assessed against lab AAS measurements of the same samples. The 'ease of use' for these kits was also assessed using a framework based on interviews with several test-kit users. Several shortcomings of kits in use today were identified. First, the test kits were better suited to determine compliance with the 50 µg/liter standard than the lower WHO recommendation. Second, the most widely used field kit in Bangladesh consistently underestimated As levels. Third, the color reference charts from manufacturers were not always reliable. Given that water sources are commonly classified as suitable or unsuitable for drinking based on such field test kit results, concerned stakeholders should carefully consider which test kits to use and how results are interpreted. This work will be communicated to water supply stakeholders in Bangladesh to enable more informed decisions about water testing.

Need in Kenya for a Major Scaling up to Meet SDGs

Mark Reimers

Overview: Waterlines in Southern Rift Valley of Kenya Since the 1990's WATERLINES, a small nonprofit organization, has been cost sharing with Kenyans to improve water, sanitation, and hygiene in homes, schools, and health facilities. In the highlands of Kenya, rainwater harvest is an attractive option to provide improved water supplies near the point of use. In 2003, Kenya established Universal Primary School Education. Students do not have to pay tuition fees to attend school. However, Capital Construction Costs and additional costs for Operations and Maintenance must be supplemented from other sources. In 2003, the government established the Constituency Development Fund (CDF) to provide direct funding for local development initiatives such as new classroom buildings. Parent Teacher Organizations also provide assistance for additional teachers, school equipment, and classroom construction. In 2008, WATERLINES formed a partnership with Tenwek Hospital Community Health and Development located in Bomet and Kericho Countries to provide a pilot program of rainwater
harvest, improved sanitation facilities, and teacher training including hygiene education, menstrual hygiene management, and formation of Health Clubs. This pilot program began with 15 schools and has expanded to include 81 schools. Lesson learned from the WaSH Program Rainwater harvest: This is a good system to provide improved water on site at schools. Schools need financial and technical assistant to construct, use, and maintain the system. Latrines: The construction of improved latrines is a major need. Schools need additional financial and technical assistant to construct, encourage proper use, and maintain the latrines with daily cleaning and provision for pumping out the latrines. Hygiene Education: The teachers need training in hygiene and in organization of student health clubs. Adequate water and hand washing facilities are needed. These require increased funding for operations and maintenance. Water purification treatment: Rainwater harvesting is an improved water source on site. Tanks need to be cleaned annually and have a provision in the collection system for first flush. Additional purification by boiling, chlorination, or filtering may be desired. Schools need advice and consultation regarding use of these methods. Routine monitoring is essential to achieving long term sustainability. Good News 2016/2017 1. Waterlines and Tenwek Hospital Community Health and Development have continued with the advance WaSH Program at 81 schools to document needs and improvements. 2. The new County governments are taking an active role in the devolution of activities. 3. Standardized hygiene curriculum is being developed. 4. Kenyan government is investing in the extension of electricity to public primary schools. FUTURE: Major scaling up of the WaSh program is needed to meet Sustainable Development Goals of improved water, sanitation, and hygiene education.

Shit Flow Diagrams and System Dynamics: Moving Beyond the Snapshot

Nicholas Valcourt, University of Colorado Boulder

Additional Authors: Jeff Walters; Karl Linden; Amy Javernick-Will; Kimberly Pugel

Shit-flow diagrams (SFDs) - also referred to as fecal sludge diagrams - have become a widely accepted tool for mapping the pathways and fate of fecal waste in urban sanitation contexts. SFDs provide impactful visualizations of the status of current sanitation services and have been shown as an effective approach for provoking action at local levels. However, in their current format, SFDs only offer a static snapshot of a complex and changing system. This fixed-in-time nature limits the utility of SFDs for informing complicated policy decisions past the time horizon of initial data collection. By pairing SFDs with system dynamics (SD) stock-and-flow models (SFD+SD models), we propose a new approach for adaptive modeling of time-varying fecal waste flows. This tool utilizes standard data collected for SFDs and animates the time-varying elements of the system to create dynamic visualizations waste flows. Once the model has been calibrated, it can be utilized to test proposed sanitation interventions (e.g. public latrine construction, increasing on-site disposal capacity). SFD+SD models explicitly consider the inputs and outputs of influential factors not accounted for in typical SFDs such as financing and paying for services, population dynamics and informal sector contributions to urban WASH. This work, part of USAID's Sustainable WASH Systems Initiative, presents case studies of divergent urban communities to demonstrate the value and versatility of the SFD+SD approach. With accelerating urbanization in developing countries, planning for sanitation in challenging urban and peri-urban contexts requires a new suite of dynamic tools. The SFD+SD approach
provides practitioners with the ability to translate collected evidence of fecal waste flows into actionable information for testing interventions and guiding decision making. This novel tool can greatly enhance effective infrastructure planning at the local level, which in turn will lead to increased and sustained urban sanitation coverage aimed at reducing disparities in urban WASH.

Community Engagement for Sustainable Community Managed Water Systems: Qualitative Evidence from Rural Ghana, Kenya, and Zambia

Nikki Behnke, Water Institute at UNC

Additional Authors: Katherine Shields; Ryan Cronk; Kristen Lee; Emma Kelly; Tori Klug

The sustainability and functionality of community-managed drinking water systems are a major concern in the global water sector. Some water systems continue to function for decades while others fail shortly after implementation. While many water, sanitation and hygiene (WaSH) stakeholders have sought to learn from failures, we looked closely at what processes have led to sustained functionality of community-managed water systems. We conducted qualitative field research in 18 rural communities in Kenya, Ghana, and Zambia through interviews, focus group discussions, community mapping, timeline activities, and structured observations. Additionally, we conducted interviews with World Vision (WV) stakeholders (the project sponsor), and local post-construction support providers. Data were collected between June and August 2015. Following coding, data were analyzed thematically. We explore how WV community engagement and training of committees foster sustainability, with a focus on themes of participation and ownership, resource mobilization, social capital, and resilience and backstopping. We find that the community entry process and training of committee members can build social capital of the committee members, increase community participation, and develop a sense of community ownership of the water system. Training on non-tariff resource mobilization strategies can help committees to better mobilize resources for system operations and maintenance, repair, and upgrade. Finally, training on hardware repair and strategies such as dispute resolution for management rehabilitation fosters community independence. We suggest that increasing social capital, ownership and participation of committee and community members through training can make community members more invested in and more likely to mobilize resources for the water system. This increased ability of the community to mobilize resources increases the likelihood that the community will be able to complete hardware rehabilitation using only community-level support actions, thus reducing their reliance on external actors and decreasing time to repair. Management committees, community members and external support actors often cited rapid hardware rehabilitation as a reason for thinking that a committee is successful. Perception of the committee as successful helps to build social capital of the committee. This increase in social capital can create a positive feedback loop where social capital facilitates greater resource mobilization which facilitates faster rehabilitation. In other words, success in hardware rehabilitation is likely to lead to greater success in hardware rehabilitation in the future. By providing support to communities that facilitates ownership, participation, building of social capital, and avoids fostering dependency by focusing on the opportunity for the committee to demonstrate their success, external actors can enable committees to enter this positive feedback loop.
**Willingness-to-Pay for Sanitation Surcharges in Kenya**

Ranjiv Khush, The Aquaya Institute

Additional Authors: Rachel Peletz; Joyce Kisiangani; Patrick Ronoh; Caroline Delaire; David Levine; Guy Norman; Charisma Acey

Background: In developing countries, most poor families lack safe toilets. One approach to funding sanitation for the poor is a pro-poor sanitation surcharge on water bills. The Kenyan water regulator, WASREB, is exploring the potential of such a surcharge to support the recurrent costs of providing sanitation services in low-income urban neighborhoods. As part of the WSUP Urban Sanitation Research Initiative, this research assessed customers' willingness-to-pay (WTP) for sanitation surcharges for two water utilities in Kenya. Specifically, we aimed to identify customer characteristics and beliefs that either promote or discourage support for pro-poor sanitation surcharges. We hypothesized that support for sanitation surcharges is increased when customers trust the utility more, believe the intervention is cost-effective, and perceive solidarity with the poor in their city. Methods in collaboration with WASREB, this research engaged the customers of two water utilities in Kenya: NAWASSCO in Nakuru and RUJWASCO in Ruiru Juja. We conducted 39 semi-structured household interviews, 26 key informant stakeholder interviews, and 4 focus-group discussions to assess initial feedback regarding sanitation surcharges. We then conducted 400 household surveys to measure WTP as a double-bound dichotomous choice, using quasi-experimental questions to compare different randomized scenarios with varying messaging, sanitation solutions, and fee structures.

Results Our qualitative results indicate that support for a pro-poor sanitation surcharge is linked to trust in the local water utility and government, perceived cost-effectiveness of sanitation to improve environmental cleanliness and community health, and solidarity with local low-income communities. A lack of support is often due to dissatisfaction with current water services and general distrust of government spending. Our preliminary findings suggest that WTP is typically about 10% of current water bills, though WTP ranges substantially from 0% to over 40%. We will present the complete results from the quantitative household surveys and provide recommendations regarding next steps for implementing a potential sanitation surcharge.

**Assessment of Sanitation-Related Environmental Health Effects in Poor and Rural Households in South Africa**

Renay Van Wyk, University of Johannesburg

Background: The environmental health effect of semi-compliant (some areas non-compliant) level of sanitation practices on recipient poor and rural households is not known. An important part of the reasons for this is the typical complexity of environmental health assessment for which suitable assessment methodologies are still being researched. Research question: What are the effects of semi-compliant sanitation practices and delivery on poor and rural households in South Africa? Aim of the study: To assess the effect of current modes of sanitation practices and delivery (or lack thereof in some parts) in a selected poor and rural household setting.
Sanitation-condition data, collected over a period of four years of rudimentary baseline studies in the North-eastern Limpopo, was assessed against the benchmarks devised from the review of national, provincial and local sanitation implementation strategies. A sanitation-related assessment was conducted based on the health, environment, sociology, economy and technology approach, in PRH settings in the Louis Trichardt / Makhado municipal area of the Limpopo province. Household level effect of the mode of sanitation practices will be assessed through structured observations, household level interviews and focus group discussions. This methodology integrates multivariate data to calculate and identify effect points. With more than 2.5 billion people worldwide, one third of the total population, living without access to proper toilets, the United Nations General Assembly has recognised sanitation as a separate human right in a bid to curb a major source of deadly infections. The World Health Organisation describes activities related to sanitation as interventions to reduce people's exposure to diseases by providing a clean environment in which to live; measures to break the cycle of disease. Inadequate sanitation is a major cause of disease world-wide and improving sanitation is known to have a significant beneficial impact on health both in households and across communities. The research question points to current sanitation services and poor and rural household perspective that is not conducive to environmental health.

Pathways to Sustainability: A Fuzzy-Set Qualitative Comparative Analysis of Rural Water Supply Programs

Sara Marks, EAWAG

Additional Authors: Emily Kumpel; Jean Guo; Jamie Bartram; Jenna Davis

Despite recent progress extending access to drinking water supplies globally, ensuring long-term functionality of rural water infrastructure remains a challenge. Past research on rural water project outcomes has used two approaches: large-N statistical studies estimating average effect sizes or case studies providing causal description. Notably lacking is a rigorous comparative analysis of the determinants of sustained service delivery. We use fuzzy-set qualitative comparative analysis (fsQCA) to identify causal configurations ("pathways") leading to sustained functionality of rural water supplies across diverse geographies. Twenty cases were selected through a review of the literature. We identified and coded five conditions to examine their influence on project outcomes for each case. Results reveal three distinct pathways sufficient for achieving sustained functionality: Pathway 1 features piped networks adopting a professionalized, service-oriented approach with high post-construction support. Pathway 2 consists of a self-supply approach (e.g., private wells) under scenarios of high freshwater availability. Pathway 3 describes community-managed water points (e.g., deep boreholes with handpumps) in the context of freshwater scarcity. Two factors were common across all pathways: good financial management and user participation in project-related decisions. These results highlight the need for matching service delivery models with local conditions in rural areas.

Impact of Human Movement along an Urban-Rural Gradient on Diarrhea and Pathogen-Specific Diarrhea Risk: Case Control Study in Ecuador, 2014 – 2015
Diarrheagenic E. coli (DEC) infections are associated with diarrheal disease globally. Despite reductions seen in diarrheal deaths, Ecuador still maintains a high burden of diarrheal disease. There is a need to further the understanding of diarrhea and pathogen-specific diarrhea risks, in addition to understanding how the burden of specific pathogens varies between urban and rural locations. The EcoZur study (E. coli en Zonas Urbanas y Rurales - E. coli in Urban & Rural Areas) is a case-control study of diarrheal diseases along an urban-rural gradient in Ecuador. Study sites included Quito, Ecuador's capital, Esmeraldas, Borbón, and outlying rural communities. These sites not only represent a gradient of socioeconomic status but also one of clean and safe water/sanitation access. At each of the four sites, ~100 diarrheal cases were recruited from Ministry of Health clinics and age-matched to ~100 non-diarrheal controls from the same facility. Demographics, medical history, WASH practices, animal contacts, and recent travel history information was collected on all participants using an electronic survey. Additionally, stool samples were collected within 24 hours from all participants and tested for enteric pathogens through PCR. Treatment of drinking water was found to be significantly protective against diarrhea in urban sites (Quito aOR: 0.58, 95% CI: 0.34, 0.97; Esmeraldas aOR: 0.41, 95% CI: 0.22, 0.75) and improved sanitation practices were protective against diarrhea in rural sites, specifically in the town of Borbón (aOR: 0.28; 95% CI: 0.09, 0.73). Travel in the past year was significantly associated with diarrhea among all participants (aOR: 1.36; 95% CI: 1.05, 1.77), and specifically among participants from Esmeraldas (aOR: 2.53; 95% CI: 1.36, 4.81), with travel to Quito being a greater risk for not only diarrheal disease, but also DEC infections in general. Urban sites were also found to be associated with a higher proportion of DAEC infection compared to rural sites that had higher EPEC-a and ETEC infections. Interestingly, DAEC infections were significantly associated with diarrhea only in urban centers and ETEC infections were significantly associated with diarrhea in the rural center of Borbón only. Overall, this study identified within-country travel as a risk factor for diarrhea disease and DEC, in addition to the differential risks presented by water and sanitation practices and E. coli pathotypes by site.

The Role of Social Capital and Collective Action Failure in Determining Shared Latrine Management Processes: Findings from a Shared Sanitation Intervention in Maputo, Mozambique

Tess Shiras, Abt Associates

A growing body of evidence demonstrates that women without access to appropriate sanitation experience psychosocial and emotional distress related to fear of sexual and physical violence, fear violence within schools, feeling unsafe at night, shame related to.... However, the data on WASH and psychosocial stress primarily focuses on users of unimproved latrines or those who practice open defecation. The impact of improving the quality and availability of private, shared
latrines on psychosocial stress and emotional well-being remains unexplored. This study investigated if and how improved, private, shared latrines in urban settings can mitigate sanitation-related stress and improve women's emotional well-being. Researchers collected 96 in-depth interviews, 7 focus group discussions, and 25 unstructured observations to compare attitudes towards and experiences with sanitation options between users of unimproved and improved shared sanitation facilities within an intervention setting in peri-urban informal settlements in Maputo, Mozambique (MapSan Trial, trial registration: NCT02362932). Participants included users of two types of MapSan intervention latrines and users of traditional latrines (control group). The study sample aimed to include 75% women and 25% men. Sampling was terminated once the research team determined that the data had reached theoretical saturation, the point at which themes are repeated and no new information appears in the data. Participants reported stress due to lack of safety; lack of privacy; feeling shame or disgust about the latrine condition; and collective action failure in terms of managing the latrine, often causing neighborhood conflict or unhygienic sanitation conditions. Traditional shared latrine users reported higher sanitation-related stress than users of "improved" intervention latrines. Additionally, the majority of respondents that had received the intervention (89%) stated that the new latrine decreased their stress-level. The leading cause of stress reduction was decreased disgust followed by increased privacy and then safety. Debates about the utility and viability of shared latrines as "improved" or "unimproved" have focused primarily on their impact on disease risk, while investigations into their impact on emotional and mental well-being have been limited. Our data suggest that "improved," shared facilities can increase privacy and reduce stress when proper maintenance and management systems are in place. Private, shared sanitation only had limited impact on users' perceptions of safety, particularly at night, suggesting that safety concerns extend beyond the physical latrine structure and attributes. Our research demonstrates that factors including latrine location and neighborhood violence are determinants of safety perceptions and corresponding psychosocial stress.

Thursday, October 19th

Management, Finance, and Effective Use in a Household Water Treatment and Safe Storage Program in Peru

Kristen Check, Water Mission

Additional Author: Georgia Humphries

This study follows the principles and methodology outlined in the WHO Toolkit for Household Water Treatment and Safe Storage (HWTS) Programmes (WHO, 2012) to monitor consistent, correct, safe use, storage and corresponding perceptions of Kohler® Clarity? Household Water Filters in a small rural community near the Amazon River in the Loreto region of Peru. Although efficacy of the filter technology and design have been reported under controlled conditions (Morrison, 2015), it is important to evaluate whether the filter can be used effectively to improve water quality at the household level in a real-world setting. The study assessed program implementation and achievement of targets through standard program monitoring, household surveys, direct observation, and water quality testing at each home. Preliminary results from the first follow-up showed that despite high reported and observed
indicators of correct consistent use and safe storage and high quality of the raw water collected by each household (≥0.2 and ≤0.5 mg/L FCR, ≤5 NTU turbidity, and <1 CFU/100mL sample); 81% of the samples taken from household water filters contained total coliforms (avg. 50.10 CFU/100mL) with fecal coliforms present in one sample. Residual chlorine was not found in 100% of the samples. Two additional follow-up visits are scheduled for 2017. Additionally, in order to guarantee the main benefits of HWTS, we must ensure that results from evaluation are used to inform future programs, policies, and investments to guide implementation and scalability. Therefore, this study also assessed the community-managed HWTS program in three key areas: 1) program management, 2) financial management; and 3) health and hygiene promotion. Study results offer recommendations for programmatic improvements such as ensuring a stronger emphasis on waterborne disease transmission pathways in health promotion activities, and supporting open communication and transparency between the community-managed water committee and the community at large. Preliminary results thus far highlight the importance of: 1) proper training on safe storage and maintenance of the filter; and 2) routine monitoring and evaluation to ensure uptake and proper use in any HWTS program.

**Institutionalizing HWTS in the WASH sector through effective Policy Regime**

Kweku Quansah, Ministry of sanitation and Water Resources

Provision of safe drinking water is a key output, which contributes largely to the protection of the health of the people and improves livelihoods and reduce poverty. The magnitude of problems related to water safety globally as well as in Ghana is enormous. An estimated 780 million people drink water from unimproved sources, and millions more drinks contaminated water from improved sources (UNICEF/WHO, 2012). Ghana has made significant progress in extending access to improved drinking source with an estimated 92% of urban population and 80% of rural dwellers having access by 2011. Notwithstanding this achievement, a substantial number of people remain without access to safe drinking water. 3.3 million people in Ghana are without access to safe drinking water with about 2.2 million people, especially in rural areas relying directly on water from rivers, irrigation canals and dug-outs as drinking water (MICS 2011). In Ghana, Bacteriological contamination is common. Implementation of the pilot Water Safety Plan at the Community Level The WASH in DPC programme introduced Water Safety Planning in 12 programme communities. The Communities were selected from 6 Districts in three Regions as pilot study areas for 3 months. As a sequel to the implementation of the Water Safety Plan, various activities were outlined. These were Training of relevant key people at National, Regional, District and Community levels, development and use of comprehensive templates to assess risks and mitigate them through participatory methodologies, Community entry and sensitization, Formation of Water safety Plan Teams (WSPTs), Field Assessment of the Water safety Situation in the community and identification of risks, Development of Water Safety Plans, Development of Action plans to mitigate the risks identified, financing of the action plan through community contribution and Unannounced visits to houses by WSPTs to check on how water is stored and advice accordingly. The results achieved from three months implementation of the WSP in the 12 piloted communities were (1) High level of awareness of risks associated with water sources, (2) Effective integration of existing community level WASH programmes like CLTS and Hand Washing with Soap, Management of community water facilities, (3) Keeping of high standard of water hygiene eg
regular cleaning of water storage containers, use of dedicated container for fetching water, separation of containers for drinking and containers for other uses (4) Keeping the community leadership on their toes to ensure water source is safe at all times (5) Community sanctions introduced to deter recalcitrant community members (6) Use of community’s own funds to undertake repairs on water facilities (7) Mobilization of Community people to undertake regular clean up campaigns (8) Community Dignity very high - community members proud themselves of having a clean communities and hence attracted some neighbouring communities to learn from them.

Scaling up Strategies for Household Water Treatment and Storage in Ghana

Kweku Quansah, Ministry of sanitation and Water Resources

Additional Authors: Akosua Kwakye

In Ghana the use of HWT products is very low and funding for the promotion of HWTS at the community level is limited, however opportunities exist for the integration of HWTS in other programmes. From 2014-2017 UN Partners and Government implemented a WASH in Disaster Prone communities Programme is aimed at improving health and disaster preparedness in select communities and schools in three regions of Ghana. The programme addressed HWTS as part of the comprehensive approach in the provision of safe drinking water at the household level. The activities implemented include the training of national, regional and district level staff in water quality assessment and monitoring included HWTS. Following the training regional and district teams were provided with the necessary logistics to conduct activities at the community level. Activities undertaken included community entry, community sensitization through durbars, and household visits. During household visits, demonstrations carried out to show the women how to keep water safe at the household level. These included washing of the water storage container, use of dedicated cup for fetching water, regular washing of storage containers and fetching cups, covering of water storage containers at all times, washing of hands with soap before handling water. Mothers were encouraged to teach their children how to fetch water without dipping hands into them. These activities need to be scaled up country wide if the required impact was to be achieved. A model was therefore adopted to guide the upscaling process. The outcome of rolling out this model includes Sustainable use of HWTS products, use of community instituted revolving fund to purchase HWTS products, Increased behaviour change, Integrated HWTS into other WASH flagship programmes and activities, well-structured institutional arrangements, Effective M&E in place with clear reporting lines.

Rapid Drinking Water Safety Estimation in Cities: Piloting a Globally Scalable Method in Cochabamba, Bolivia

Lucas Rocha Melogno, Duke University

Additional Authors: Joe Brown; Rebecca Yoo; Victoria Beard; Jose Garcia; Ann Johnson
Rapid Drinking Water Safety Estimation in Cities: Piloting a Globally Scalable Method in Cochabamba, Bolivia

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Background. Systematically collected, scientifically credible, and comparable data on drinking water safety is globally unavailable for cities, despite the stated importance of water safety monitoring at scale under the Sustainable Development Goals (SDGs). Together with colleagues at the Atlas of Urban Expansion, we developed a standardized, representative, and rapid urban drinking water quality assessment methodology to apply to cities. The method is intended to be replicable globally at relatively low cost and personnel requirements. We trialed this method in Cochabamba, Bolivia.

Methods. Together with local partners, we collected drinking water samples from 80 pre-selected households from across the urbanized area and matched survey data from household interviews on WASH access, behaviors, and infrastructure characteristics. This sample size is intended to generate mean water safety data but is too small for a single-city risk factor analysis or comparative analyses between water source types. This presentation summarizes the method, findings on water safety (including microbiological and physical-chemical parameters), and key WASH variables.

Results. We found that the per-site consumable cost was US$ 27 and the total person-hours required to complete all sampling, interviews and laboratory analyses for 80 sites were 300-512 h. We found that 71% of drinking water samples were classified as safe (non-detect of E. coli in 100 ml sample). Households with access to water that was continuous and on premise had safer water than households with non-continuous piped water, as indicated by E. coli counts (univariate association only). Of the two-thirds of study participants who reported that water had been boiled, 70% of the samples were considered safe. For those using untreated sources (which mostly included bottled water), 75% ranked as safe.

Conclusions. We demonstrate that this rapid method can result in statistically representative, credible drinking water safety data for a city at relatively low cost in terms of person-time and materials. We conclude that current safe drinking water access in Cochabamba does not meet normative safety targets under the UN SDG 6 normative goal at the time of the survey.

Prevalence of Free-Living Amoebae in Households, Farming and Healthcare Potable Water of South Africa

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Free-living amoebae (FLA) have gained interest over the past decades as an important component of microbial ecology in various aquatic environments. Although most FLA are non-pathogenic and beneficial to the environment, some species for example Naegleria fowleri, Balamuthia mandrillaris and Acanthamoeba species are known human pathogens. FLA has also been shown to host and transmit pathogens such as Legionella spp., Pseudomonas aeruginosa and methicillin-resistant Staphylococcus aureus. In the past five years, the University of Johannesburg has done studies on the prevalence of FLA and associated bacteria in different aquatic environments. A total of 910 samples were collected from household tap water in five areas (n=182), borehole water of seven farming communities (n=453) and tap water of three...
public hospitals (n=275). FLA were isolated and identified based on morphology using the amoebal enrichment technique. FLA were isolated in 50 (27%), 154 (56.0%) and 102 (22.5%) of households, hospital and farm samples respectively. Using microscopy, PCR and 18S rRNA sequencing, Acanthamoeba spp. (T3, T1 and T20 genotypes), Vermamoeba vermiformis and Naegleria gruberi specie were identified. Although Acanthamoeba species are known to the most abundant in the environment, V. vermiformis was the most abundant amoebae species in the three water sources analyzed. The low prevalence of the genus Acanthamoeba in our study relative to Vermamoeba can be attributed to the use of FLA common primers, which might have been more effective in amplification of Vermamoeba rather than Acanthamoeba. Nonetheless, Acanthamoeba T1, T3 and T20 genotypes identified in our studies have been implicated in eye and central nervous system infections. These results may present a potential public health risk to farming communities, immuno-compromised patients in hospitals and city residents if exposed to contaminated water. Therefore, there is a need in South Africa to investigate microbiomes in these environments in relation to human infections.

**Shining a Light on Microbial Contamination Risk: How In-Situ Fluorimetry can Improve Assessment of Groundwater Supplies**

Katrina Charles, University of Oxford

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Infections from microbially contaminated water continue to account for an immense portion of global water-related disease. When free from anthropogenic impact, groundwater usually has good microbial quality; however, widespread reports of contamination demonstrate that this natural state is often vulnerable and management is an ongoing challenge. Assessment of microbial risk from groundwater supplies relies primarily on Escherichia coli monitoring and sanitary inspection scores, both of which have well documented limitations. Better management of groundwater quality could be achieved by using in-situ fluorimetry to complement the conventional approach, particularly in low-income settings. Fluorimetry is less resource-intensive than E. coli monitoring because it is reagentless and provides instant results with no incubation period. Specific organisms cannot be targeted, but fluorimeters are able to measure tryptophan-like fluorescence, which is associated with microbial breakdown of labile organic carbon. This study explored the potential of in-situ fluorimetry for improving groundwater quality assessment in a rural, low-income setting in Kwale County, Kenya. Sampling of tryptophan-like fluorescence (TLF), E. coli and thermotolerant coliforms was conducted for 38 water points in wet (May/June 2016) and dry (March 2017) seasons. The water points included 12 boreholes, 15 covered wells with handpumps, and 13 open wells. Sample sets included duplicates and replicates and at least two sets were taken at each of the water points. Daily sampling was conducted at 8 water points for 20 days. Within this small study, TLF was found to be predictive of E. coli presence and the results suggest a relationship between TLF concentration and E. coli based health risk categories (as defined by the WHO). Furthermore, the results provided insight into microbial water quality variability on four levels: 1) between water points, 2) from day to day, 3) within wells/boreholes and 4) within samples. It is found that measurement of TLF in groundwater at the source has value independent of and in addition to the information derived from E. coli monitoring. Fluorimetry has potential to
improve understanding of water quality variability and to enable better targeting of interventions and monitoring of their effectiveness.

**Water Governance Self-Assessments: Providing a Road Map for Action**

Adam Keough, Catholic Relief Services

Additional Authors: Paul Hicks

Accessing freshwater for human consumption is complex, involving environmental, social, and cultural factors. Improving water governance is a critical factor in securing water resources for vulnerable populations in developing countries. While there is a consensus that water governance plays an essential role in water resource management, most frameworks do not provide tools and guidance on how to build capacities for managing common pool resources. The Water Governance Self-Assessment (WGSA) tool was designed by distilling relevant variables of the Social-Ecological Systems (SES) framework for water management to measure water governance through participatory processes. Implementing the WGSA tool involves coordinated efforts with local stakeholders. The scope of the assessment is defined as a political or geographic boundary; clearly stating the area, key stakeholders, and types of local activities that affect water resources. The outputs of the tool allow stakeholders to identify strengths in their region as well as areas in need of improvement and create actionable plans to address deficiencies in water management. The WGSA tool has been implemented in 17 watersheds across Central America. In nine cases a follow-up was conducted to monitor water governance progress. In all but one study site the participates in the follow-up workshop produced self-assessments that maintained or improved from the baseline. Over and above the quantifiable scores of each governance self-assessment workshop, the implementation of the tool acts as a platform to bring different stakeholders together to facilitate a discussion on water resources in their region. Implementation teams stated that the greatest benefit of the self-assessment tool is its ability to unify different stakeholders in a shared vision of the complex elements surrounding water governance and that it presents the results in an easily interpreted format that can be converted into an actionable plan. The qualitative results from the implementation of the self-assessment workshop prove that it’s the process of the evaluation that, in itself, has a significant value for improving local governance. When water users and other stakeholders come together to identifying strengths and deficiencies in water governance they themselves are putting in place actions to improve or correct their shortcomings. This produces a greater likelihood that these improvements will be carried out. The WGSA tool shows potential for integrating IWRM and SES frameworks by creating spaces for dialogue and action among stakeholders. The strength of the WGSA tool is the participatory approach that fosters reflection and analysis by local stakeholders while quantifying key governance indicators relevant to those stakeholders. Further evaluation is required and ongoing; however, early results demonstrates that the tool produces a road map to achieving good water governance.

**Improving Inter-Sectional Programming with Better Reporting System Using Unique Programe Data Points**

Akshobhya Dahal, UNICEF
This paper addresses the inherent evidences challenges of working on emergency and recovery programs with development involving different departments of the same organisation or between agencies. Looking at an earthquake recovery construction program managed by UNICEF Nepal Country Office, we argue rather than different teams talking together more, the data points both departments are using must converge and these data points must fit into a common reporting system and frequency for reporting. Primary keys are a data concept used in programming whereby a set of numbers are ascribed to something to make it identifiable. In this case the primary key is a particular school, and our project made use of the national EMIS database (Educational Management Information System) in which data was stored against each school according to its EMIS code or primary key. We describe how the evidence of various challenges of the UNICEF WASH team to ensure water supply to more than 200 target schools under the Education team led project had major imperfections. Most of the challenges was due to the fact that the partnerships with the Implementing Partners to carry out the works, did not require them to provide their weekly and monthly updates with this primary key attached. This had the effect that although the WASH and Education teams believed that they were communicating effectively at headquarters and field level, in fact the field staff had the burden of chasing the Implementing Partner for information they were not contractually obliged to report on, with the result that certain construction changes went unmonitored and reported and finally some schools incorrectly received a water supply while others were left without. In conclusion we propose an emphasis on having a specific reference to utilize the strength of these primary keys by incorporating legal reporting requirements, such that reporting is based upon the school, according to activities linked with the program indicators. This enables a data hierarchy to be established from the weekly construction updates to the financial control system such as VISION SAP system used by UNICEF, allowing both departments to see how the respective elements of the work they are interested in are performing according to the same primary key data (i.e. by school code). This has the benefit of allowing managers to see and take action if an aspect construction implementation starts to go off target, without relying on verbal communication between members of staff in different teams and between the field and coordinating office. As our experience on this project shows, the system can also be used to link-in the activities not just of different department but different UN agencies as well as long as program utilizes same primary key. We also discuss applicability to other types of project within the United Nations working modality.

**Operations and Maintenance in Uganda's Rural Water Sector**

Alison Filler, International Lifeline Fund

Additional Authors: Vahid Jahangiri; Daniel Wolf

In recent years, sustainable water access has become a key focus of development agencies and organizations working in low- and middle-income countries worldwide, yet studies show that as many as 30-50% of water projects fail within two to five years. In Uganda, in particular, the government has reported that approximately 15% of all water systems are permanently
dysfunctional. In addition, it appears that about twice that number are temporarily non-functional - often owing to minor mechanical issues. Efforts to improve access to water in rural Uganda and across sub-Saharan Africa are failing to deliver promised benefits over the long-term due in large part to practitioners’ failure to engage local government, to provide for a system for water point maintenance, and to ensure the community buy-in and financial investment that is essential to ensuring long lasting behavioral change. Motivated by this evidence and first-hand experience on the ground, Washington, D.C.-based International Lifeline Fund, in partnership with Thrive Networks, conducted an operations and maintenance (O&M) pilot project in the rural Apac District of northern Uganda. In 13 target villages, Lifeline installed corrosion-resistant hardware into dysfunctional boreholes and introduced a preventative maintenance framework to support their long-term care and operation. This comprehensive "ecosystem" approach included: 1) training local hand pump mechanics to perform routine borehole assessments and pump calibrations; 2) establishing multi-year maintenance contracts between villages and hand pump mechanics; 3) standardizing fee schedules for repair services; 4) re-training Water User Committees (WUCs) in borehole O&M procedures; and 5) training and compensating a caretaker to track borehole functionality and report breakdowns. By approaching water point sustainability as an ecosystem and engaging community stakeholders in the design and implementation of the framework, this project has laid the foundation for the scaling of a community-funded, centralized maintenance infrastructure at the district level that will sustain the functionality of community boreholes at an affordable cost to households.

Effects of Ebola Preventing Interventions on Psychosocial Factors of the RANAS Model

Anna Gamma, EAWAG

Additional Author: Hans-Joachim Mosler

Background. This paper assesses the psychosocial factors, which predict three Ebola virus disease (EVD) preventive behaviours in the Gambia: Hand washing with soap, calling the Ebola Hotline and not touching a person who might be suffering from Ebola. Implemented Ebola promotion activities were evaluated to see if the crucial psychosocial factors were tackled. The last outbreak of Ebola is over, and promising effects of an EVD vaccine have been confirmed. However, further outbreaks of contagious diseases will come up. Besides vaccines to stop contagious diseases from spreading, preventive behaviours play a crucial role to avoid further transmissions in an affected population. Communication is a key activity during an emergency response, but the content of the messages should go beyond simple health information. Awareness-raising and information do alone not necessarily lead to the desired behaviour. To change behaviour successfully, promotion activities must target the psychosocial factors, which influence the behaviour. Methods. With structured face-to-face interviews, cross-sectional data from 498 primary care providers of households in the Gambia were collected. The questionnaire based on the psychosocial factors from the RANAS (risks, attitudes, norms, abilities and self-regulation) model. Data were analyzed by multiple linear regression analyses and PROCESS mediation analyses. Results. For hand washing with soap and for calling the Ebola hotline, the norm factors, especially the factor Others' behaviour, meaning the perception of
what other people do, had a great impact. Response belief, meaning the perceived certainty that a behaviour will prevent a disease, was a predictor for all three protection behaviours. The factor commitment to the behaviour emerged as especially relevant for the intention and willingness to call the Ebola hotline and not to touch a person who might be suffering from Ebola. Conclusions. The findings of this study show the important role of psychosocial factors for prevention behaviours in an Ebola context. Possible interventions based on these findings are recommended. Health behaviour change programs should be based on evidence in order to target the right psychosocial factors and in order to maximize their effects on the prevention behaviours, especially in emergency contexts.

**Oral Cholera Vaccine: Everything You Need to Know**

Anne Ballard, Johns Hopkins Center for Communication Programs

Additional Authors: David Sack; Christina Shaw

Each year, around 2.7 million people suffer from cholera and about 90,000 die from this preventable disease. Improvements in WASH are the long term solution for preventing cholera, however oral cholera vaccine (OCV) can be used in the short term to save lives. Vaccine reduces the risk of cholera by 65-75% for five years and can be administered to anyone over the age of one. The vaccine is available for emergency and proactive vaccination through an application to a stockpile of an annual 25 million doses managed by the World Health Organization. Over 30 million doses of the vaccine have been administered globally since the creation of the WHO stockpile in 2013. However, despite its benefits, the vaccine is not utilized to its full potential. This is in part due to a lack of knowledge among governments and program managers regarding the vaccine's existence, its availability, and knowledge of when and how to use it. In order for OCV to be used to its full potential, it is essential that decision makers have the information and knowledge they need to decide if they should use OCV and how to implement a cholera vaccine campaign. Aside from a general introduction to the vaccine including its safety and efficacy, this presentation will also include examples of how the vaccine has been used in various countries and among what populations. Additionally, this presentation will include an open discussion on the implications of the integration of OCV and WASH to save the lives of those most vulnerable.

**Integration of Oral Cholera Vaccine and WASH Interventions: Findings from a Literature Scan**

Anne Ballard, Johns Hopkins Center for Communication Programs

Additional Authors: Christina Shaw; Emily Nagourney; David Sack

Introduction: The long term solution for preventing cholera is improved WASH conditions, but until that happens, oral cholera vaccine (OCV) can prevent the disease and save lives. OCV and WASH work synergistically in that successful WASH programs reduce the amount of V. cholerae in the water and the use of OCV lessens environmental contamination by decreasing the amount of V. cholerae excreted by vaccinated individuals. Although the WHO recommends
integrated cholera control programs there has not been a review of how OCV and WASH have been integrated and the lessons learned. Methods: We searched PubMed, EMBASE and Google Scholar for literature published since 2010 that included evaluations of project descriptions regarding the integration of OCV and WASH in low and middle income countries to document 1) how OCV and WASH have been integrated and 2) lessons learned from integration. Findings: We reviewed 13 peer-reviewed articles. Three integration approaches from six countries were described including, vaccination with a WASH education intervention (n=9), vaccination alongside provision of WASH services (n=1), and vaccination alongside WASH education and provision of services (n=3). None of the studies included a description of the WASH messages, however dissemination channels included radio, community meetings, and pamphlets and WASH service provision included the distribution of soap and water treatment solutions. The primary objective of the majority of the studies was not to measure integration, however integrated programs had significant effects on knowledge regarding cholera transmission, prevention, and water treatment and behavior including water treatment and handwashing. Several of the articles recommended OCV as a promising tool for cholera control and articulated the need for integration between OCV and WASH. Conclusion/Recommendation: These findings demonstrate that the programmatic integration of OCV and WASH is feasible and shows promise in improving health outcomes. While WASH is the long-term solution for cholera control, OCV should be included in cholera control efforts as an essential tool for prevention.

Sustaining USAID WASH Investments: Learning from Post-Project Evaluation

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Community-led total sanitation (CLTS) is a common approach used in many countries to achieve demand-driven universal household latrine adoption without subsidies. While several qualitative studies have sought to draw lessons learned about CLTS effectiveness, few studies have quantified the longer-term sustainability of latrine and hygiene facility adoption achieved through these interventions and investigated factors contributing to measured rates of slippage. Three years following the completion of a large USAID-funded CLTS intervention in Madagascar, USAID contracted an independent evaluation to learn to what extent levels of sanitation and hygiene facility adoption and behaviors measured at the close of the project were still observed and which factors influenced the ability to sustain behavior. Replicating methodology used at the project's conclusion, USAID's Water Communications and Knowledge Management activity completed a survey and analysis among 688 households in 15 communes, open defecation free (ODF) verification methodology in 20 villages, and qualitative interviews with 53 beneficiaries and other stakeholders in six communes. The analysis found a statistically significant reduction in latrine use from 2013 levels, down from 69% to 45%, though 2016 levels still appeared to exceed the pre-project utilization rate of 34%. There was little evidence of households moving up the "sanitation ladder" other than the 15% of households that reported making improvements to their slab or superstructure in the past two years. Among villages certified as ODF in 2013, only one of five villages that underwent full ODF reverification and one of 15 that underwent a slightly less rigorous process still met the criteria
for ODF status. The analysis also found a significant decline in the presence of a handwashing station, from 8% to 2%. Though sub-analyses for vulnerable groups had small sample sizes, results suggest sanitation and hygiene facility use slippage was lower among female-headed households, which also appeared to opt for higher quality latrines over time than households with an adult male present. Recent practices, aspirations, and barriers to latrine maintenance and use as well as hand hygiene were examined in depth. Factors that influenced sustainability include pre-existing normative beliefs about the commonality of latrine use, financial and material constraints, availability of skilled latrine construction laborers, frequency of water, sanitation and hygiene (WASH) messaging follow-up, space constraints, and water scarcity.

From Evidence to Action: Scaling Up of Rainwater Harvesting in Rural Uganda Using a Revolving Fund Approach

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Uganda experiences excess water during the rainy season and too little water in the dry spell. Excess water is characterized with floods that destroy people’s property, infrastructure, result in injuries, deaths and also mark the peak of water related diseases such as cholera and typhoid. The period of too little water is characterized with drought, hunger, severe malnutrition, wasting and associated mortality. Over 33% people in rural Uganda do not have access to safe water. Some areas in the country either have highly saline water or complete absence of ground water. Under such circumstances, rainwater harvesting is envisaged to catalyze safe water coverage. The government and water stakeholders’ prior promoted rainwater harvesting with minimal results. There was neglect, poor operation and maintenance since these tanks were either subsidized or donated without tangible user contribution. Upon evaluation the government realized that donations and subsidization of harvesting tanks was not sustainable. A nationwide mapping of best practices in water supply revealed revolving fund as a promising approach to scale up rainwater harvesting. The Ministry of Water and Environment (MWE) through its research arm; the Appropriate Technology Centre for Water and Sanitation (ATC) identified 12 villages from water stressed districts in which they pilot revolving fund in partnership with local NGOs who administer the fund, construct tanks, follow up loan compliance; educate people water management. The ATC provides technical support, monitor quality of works, allocation appropriateness and adherence to revolving fund arrangements. Benefiting households supervise the construction process and ensure that they get what is worth. In one year 117 tanks with capacities vary between 3000l to 30000l depending on user population were constructed. The underlying assumption is that one person uses at least 20l of water a day. Of the money disbursed in the first round, 52% has been recovered and re-disbursed out for second round. The project has potential for sustainability, value for money, ability to supplement safe water provision in water stressed areas, contribute towards efforts to control of sporadic cholera outbreak resulting from drinking contaminated water. Delayed disbursement of seed money by the MWE slows down coverage.

Challenges and Progress in Emptying Pit Latrines
Pit latrines receive an estimated 0.6 billion kg of faeces and 2.1 billion kg of urine from 1.77 billion people around the world every day. Once pits are full, the faecal sludge has to be removed, transported, and treated/reused. One of the biggest challenges in this sanitation chain is devising a hygienic, efficient, and modern way of emptying pit latrines. Previous workers have focused on devising the 'best' machine that can effectively and reliably empty any pit. The ideal machine is envisioned to be safe, hygienic, and economical, while being mobile and lightweight, allowing access pits located away from main roads. The machine should be robust, should be amenable to easy operation by a few personnel, and can be maintained using local expertise and supplies. However, because conditions and culture in different countries and regions vary, developing such a technology is difficult. To date, there is not a single machine that can be used to effectively remove faecal sludge from pit latrines of all types and with varying contents. We discuss these issues, and suggest that classifying pit emptying technologies according to the type of pit (e.g., wet pits with little trash, wet pits with lots of trash, and dry pits with lots of trash), should be the direction for machine design. We discuss criteria for ideal pit emptying devices deployed in a region: robust to handle trash, different strengths of sludge within pits, and a range of water content encountered in the same region. Optimizing pit emptying needs to include considerations of FS collection from the pit, to the road, and transport to a treatment facility, and not just pit emptying. A systems approach to pit emptying is discussed and should include analysis of other issues such as supporting small business owners and providing for proper safety and training.

**Mix of Evidence and Innovations Helps City Authorities Achieve Clean India**

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Achieving the Clean India goals set by the Indian government for 2019 is a pressing concern for city authorities where over 40 million urban dwellers defecate in the open. India's goal is to achieve 100% coverage and the focus has been mainly on constructing toilets to eliminate open defecation. However, un-used toilets and half-built toilets and waste dumped into drains show that current solutions are not applicable nor sustainable for all communities in every environment. For those toilets that are used most cities of India do not have a regulatory body to monitor whether the faecal sludge produced ends up safely or whether it is disposed into water bodies or open fields. The National Institute of Urban Affairs in association with TARU, IRC and Ennovent has initiated the "innovation hub for Urban WASH Solutions" - funded by USAID - to do things differently and to support city authorities in linking up with relevant partners, businesses and finance institutions, to strengthen capacities and the use of evidence for city planning. Early 2017 city authorities of three cities, Faridabad, Mysore and Udaipur joint the initiative. They felt that technical solutions not necessarily solve the puzzle and that they have to take a step back to identify the root cause of sanitation problems in their city and to assess the actual needs of their citizens. This paper/poster describes how these cities went
through a process of using evidence from city-wide assessments of users, private sector, authorities and providers; and from applying scorecards which looked at existing institutional and legislative frameworks and construction standards for onsite sanitation facilities. Practical solutions are sought through exchange visits to other city authorities and through connecting and experimenting with entrepreneurs. Based on this mix city action plans are to be developed (due Oct 17).

A Dynamic Software Platform for Sanitation Data Acquisition, Data Monitoring and Data Management

Jeff Wong, Biomass Controls

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As the market moves toward evidence-based sanitation, the need to collect data in a flexible platform becomes more important. Proper management of decentralized wastewater treatment is essential to ensure effective system operation, but is challenging to maintain without a centralized management system (Massoud et al., 2009). Kelvin is a software platform, developed by Biomass Controls, LLC, which provides a multi-platform user interface allowing user(s) to monitor and manage the operation of a decentralized wastewater treatment solution from a variety of interactive technologies and third-party devices (https://www.biomasscontrols.com/kelvin-mobile-app-). The system architecture needs to accommodate decentralized wastewater treatment solutions that are both on-grid and off-grid. If cellular data or internet is available, data collection applications need to communicate with systems remotely, allowing for direct operational control. In remote locations, Kelvin can be used to communicate wirelessly with systems allowing for remote management through smartphone technology. In areas where systems are off grid, Kelvin Direct provides a method of manually collecting operational data which will be uploaded to the Kelvin cloud when networks are available. Kelvin has been developed to provide the user with system analytics that can be exported for further analysis through SAS, SPSS or R software. Analysis of these daily and real-time Key Performance Indicators (KPI) can help local operators, and can also help establish best practices through comparison of performance at multiple sites. These KPIs can then be used to continuously improve the procedures and system software to reinforce training and safety protocols. Future development of Kelvin will focus on adapting the dynamic user interface to support a variety of interactive technologies providing command, control and reporting from co-located interactive screen displays, mobile applications and web based interfaces. Biomass Controls, with support from the Bill & Melinda Gates Foundation, and in partnership with TriEHL and Tide Technocrats (based in India) is setting up four decentralized wastewater treatment products in India, for extended field testing. Additionally, a field unit has been deployed in Kivalina, Alaska, USA under a partnership with the Kivalina City and Tribal Councils, NANA (a regional native corporation in Alaska), and Teck. Data from these test units will be available in October 2017. References Massoud, M. A., Tarhini, A., & Nasr, J. A. (2009). Decentralized approaches to wastewater treatment and management: Applicability in developing countries. Journal of environmental management, 90(1), 652-659.
**Time Series Study of Weather, Water Quality, and Acute Gastroenteritis at Water Safety Plan Implementation Sites in France and Spain**

Karen Setty, The Water Institute

Additional Authors: Jamie Bartram; Jean-Francois Loret; Jerome Enault; Claudia Puigdomenech-Serra; Arnau Pla Mateu; Jordi Martin Alonso

Water Safety Plans (WSPs), recommended by the World Health Organization since 2004, seek to proactively identify potential risks to drinking water supplies and implement preventive barriers that improve safety. However, little evidence has been generated on the long-term impacts of WSPs on public health. To evaluate the outcomes of WSP application in large chlorinated drinking water systems in France and Spain, water quality, compliance, and health indicators were gathered between 2003 and 2015, before and after WSPs were implemented at five intervention and three comparison locations. Prior research found that implementation of a WSP generally resulted in unchanged or improved water quality, while compliance improved at most locations. Evidence for reduced acute gastroenteritis incidence following WSP implementation was found at only one of the three locations examined. Outcomes of WSPs varied widely across the systems examined, in part because the intervention itself must be adapted to the needs of each location. Follow-up analyses are being conducted to elicit causal factors for the outcomes identified in these case studies. This will include examining additional microbial water quality and customer satisfaction indicators, testing correlation between water quality and health indicators, and temporal modeling related to temperature and rainfall with attention to high-risk events. Overall, the study seeks to recommend best practices for scaling up WSPs.

**Urban Sanitation Characteristics Around the World: Comparison of Market and Technology Indicators for the Sanitation Sector**

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Additional Authors: Anna Aceituno; Akifumi Kita; Jamie Jones

The Sanitation Technology Platform (STeP) supports development and launch of new sanitation technologies by streamlining and de-risking field testing and commercialization. STeP is bringing an integrated, disciplined methodology to the path from "prototype to product", infusing the many elements and insights necessary (i.e., market, user, technical, regional) to successfully launch products into new markets. Technology developers and commercial companies in the sanitation sector want to identify the most appropriate geographic location to launch a new technology based on several factors related both to the market in that location (e.g., population and housing characteristics) and to aspects of the technology itself (e.g., based on cultural and behavioral preferences). However, it is difficult to provide a comprehensive portrait of these characteristics of interest in a way that is comparable across countries and easily digestible to the decision maker. A particular challenge is gathering country-level data around behavioral preferences for sanitation. The STeP team identified 9 indicators related to the sanitation market and 11 indicators related to sanitation technology structures and preferences and
carried out data collection for each indicator for 8 countries across three different geographic
regions (Asia, Africa, and Latin America/Caribbean). Whenever possible, data were collected
from reputable, publicly available secondary data sources. To fill data gaps, interviews were
conducted with in-country experts to gather insights, and in some cases, additional analyses
were performed to arrive at a single number for each indicator. Results are provided as a two-
page infographic allowing for information to be easily compared across selected regions and
countries. Those in the sanitation sector can use this information to obtain a comparable and
digestible portrait of the urban sanitation characteristics to support early discussions around
where to geographically focus.

Optimal Recall Period for Caregiver Reported Diarrhea in Children Under Five:
Evidence from A Multi-Country Monitoring And Evaluation Tool

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Many community-based studies that measure child diarrheal illness rely on a recall period of
two weeks, which is problematic due to recall bias. Recent literature indicates that caregiver
reported illness should be ascertained using a 7-day recall period. This study aimed to be the
first large, multi-country analysis using the shorter 7-day recall period to identify the household
level water, sanitation and hygiene (WASH) risk factors associated with diarrheal illness in
children under five years old. As part of the 11 country Performance Monitoring and
Accountability 2020 (PMA2020) WASH program, nationally representative household data
were obtained between 2014 and 2016 from the Democratic Republic of the Congo, Ethiopia,
Ghana, Kenya, and Uganda where diarrheal outcomes were ascertained. A total of 14,689
children from 10,754 unique households were analyzed. Logistic regression was used to
examine the relationship between childhood diarrheal outcomes and household WASH and
demographic factors. The overall prevalence of diarrhea in the five study countries was 22% (N
= 14,689) with the lowest prevalence in Kenya (16%, N=2,655) and the highest in Uganda
(32%, N=3,059). Maternal education, household wealth quintile, number of household
members, sanitation classification, drinking water reliability, disposal of children's feces in a
latrine and presence of a hand washing location were found to be significantly associated with
diarrhea in children under five, after adjusting for other variables (p<0.05). Children in homes
with unimproved sanitation had significantly higher odds of diarrhea than those in homes with
improved sanitation (AOR= 1.22, 95% CI 1.06-1.41), as did children in homes with intermittent,
unpredictable water sources when compared to homes with predictable water sources
(AOR=1.21, 95% CI 1.07-1.37). For child feces management, in households that reported
children using the latrine, the odds of diarrhea were significantly lower (AOR=0.74, 95% CI
0.66-0.83). A significant difference in diarrhea prevalence was not seen between households
with improved versus unimproved drinking water sources (OR=1.00, 95% CI 0.91-1.09, p=
0.99). Using an optimal 7-day recall period, this study confirms the need to prioritize adequate
sanitation as a driver in reducing diarrheal disease in children under five. The PMA2020 WASH
program which collects these data on a rapid, low-cost, and real-time basis is a robust
monitoring tool to measure progress toward achieving targets set for water and sanitation
under Sustainable Development Goal 6.
Barriers to Managing Private Wells and Septic Systems in Underserved Communities: Mental Models of Homeowner Decision Making

Chelsea Fizer, ORAU contractor to EPA

Some African-American communities in the American South are excluded from nearby municipal water and sewer services and therefore rely on private wells and septic systems. These communities are disproportionately exposed to water contaminants and have an elevated risk for poor health outcomes. Outreach efforts encouraging proper well testing and maintenance are needed to protect health in these communities. To identify knowledge gaps and misconceptions that such outreach programs should target, we conducted semi-structured interviews with 18 residents of such communities in Wake County, North Carolina. Only one interviewee tested and inspected their well annually as recommended by the county health department. Interview results suggest that testing is inhibited by lack of awareness of well maintenance guidelines, overreliance on sensory information, poor understanding of exposure pathways, and cost. Links between private septic systems, well water contamination, and health are poorly understood, hindering proper septic maintenance. These findings highlight the need for risk communication materials targeting at-risk communities.

Inactivation of Ascaris eggs in Human Fecal Material Through In-Situ Production of Carboxylic Acids

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The development of new sanitation technologies is critical for addressing the global sanitation challenge and to transform current resource-intensive waste treatment processes. Here, we propose to inactivate pathogens in human fecal material (HFM) through in-situ biological production of carboxylic acids. Carboxylic acids have been known to inhibit growth of many bacteria due to the ability of the uncharged form of the acid to cross lipid membranes. Recent work has also shown that carboxylic acids are effective at inactivating eggs of the roundworms Ascaris lumbricoides and Ascaris suum, which are often used as indicators for pathogen inactivation due to their extreme resiliency in the environment. Through batch fermentation experiments with inoculum derived from a semi-continuous n-caproic acid-producing reactor, we showed that anaerobic microbiomes can produce up to 257 mM n-butyric acid and 27 mM n-caproic acid (total concentration of uncharged acid plus conjugate base) using HFM as substrate. We then showed that Ascaris inactivation was directly controlled by the concentration of the uncharged form of carboxylic acids, which is a function of pH and the total concentration of uncharged acid plus conjugate base. The pH and concentration of conjugate base did not have any direct effect on inactivation. To better understand the ability of biologically produced carboxylic acids to inactivate Ascaris eggs, we exposed eggs at 30°C to n-butyric acid and n-caproic acid individually at four different exposure times (2, 6, 12, and 20 days) and at eight concentrations for each time. We fit a two-parameter logistic model to the data to model inactivation as a function of concentration for each carboxylic acid and exposure
time. Using these models, we predicted that at 30°C, 257 mM uncharged n-butyric acid can inactivate Ascaris eggs with an exposure time between 12 and 20 days, and 27 mM uncharged n-caproic acid can inactivate Ascaris eggs with an exposure time between 2 and 6 days.

**Are Cleaner Households Associated with Taller Children in Rural Communities of the Guatemalan Highlands?**

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Background: Infections account for approximately 15% of all neonatal deaths globally (Blencowe et al., 2011). This is also the highest risk period for maternal deaths (Li, Fortney, Kotelchuck, & Glover, 1996), with an estimated 10% of all maternal deaths attributable to sepsis. USAID’s Maternal and Child Survival Program (MCSP) and the London School of Hygiene and Tropical Medicine are currently conducting a multi-phase study investigating the behavioral determinants of poor WASH practices during the time period from the onset of labor through the first 2 days of life. Phase 1 of this activity included a literature review and scoping visit. Phase 2 (ongoing) includes an intensive direct observation period at critical moments at health care facilities and the home environment. Methods: A two-stage systematic literature review explored current evidence of the effectiveness of interventions to improve hygiene practices by health care staff, mothers, and other caregivers during the perinatal period. This review identified a total of 19 systematic reviews and meta-analyses examining intervention effectiveness. An additional 212 studies were included in a structured mapping of literature to identify barriers and enablers to effective hygiene. Scoping visits and key informant interviews in Nigeria explored the literature review findings in context. Both literature and scoping visits informed the protocol of a mixed-methods observational study of hand hygiene and infection prevention and control in labor, delivery, and newborn/maternity wards and the household environment for 30 births in rural Nigeria (data collection: July 2017). Findings: Literature review identified the impact of interventions ranged from a 93% reduction in neonatal tetanus associated with clean birthing surfaces to a 15% reduction in neonatal sepsis mortality associated with generic "clean birth practices". Generally, health impacts were based on limited and/or low-quality evidence and for several practices, including those in the WHO Six Cleans list, there was insufficient data to produce pooled effect estimates. Scoping visit identified a lack of standardized infection prevention and control (IPC) strategies compounded by inadequate essential supplies. Chlorhexidine gel - the WHO recommended method for clean cord care - was given to a small percentage of neonates due to lack of supplies and health care worker preferences. All facilities operated within the context of severe manpower shortages and limited IPC training. Interventions to improve hygiene during the perinatal period must be understood within the context of under-resourced, overly-burdened health care systems in low-income countries. More robust data on the impact of intervention is required in order to inform policy priorities for reducing maternal and neonatal survival. Forthcoming structured observations of labor, birth, and the transition to the home environment will identify possible intervention points.

**Bioaerosol Generation During Pit Emptying in Malawi, Africa**
Pit latrines are the most common sanitation option for the majority of the developing world. Though simple to build and use, they require periodic emptying. Much has been written about the challenges of sludge removal and transport, but little is known about the health risks associated with mechanically agitating and pumping semi-liquid human faeces. Specifically, bioaerosol generation during the emptying of pit latrines could pose an unknown risk to the equipment operators, bystanders, and nearby households. The exposure route of any bioaerosols generated during pit emptying could either directly affect impact operators and bystanders via inhalation, or be deposited onto nearby surfaces, which would then create a potential exposure route from surfaces after pit emptying is completed. As far as we know, this is the first attempt to quantify the types and abundance of some potentially harmful bioaerosols that could be generated during the emptying of pit latrines. We investigated the generation of bioaerosols during pit emptying using a vacuum truck in Ndirande, a densely populated, informal area of Blantyre, Malawi. Using an MAS-100 ECO Sampler, the air around pit emptying operations was sampled directly onto nutrient agar (NA) plates and MI Agar (MIA) plates, a selective medium for E. coli and total coliforms. Additionally, colonies from selected plates were extracted and processed, then tested with the GPP Luminex assay for presence or absence of 15 enteric pathogens. Selective agar (MIA) showed values as high as 30 CFU m-3 total coliforms 1 meter away from the exhaust of the vacuum truck vent. Colonies counted on NA plates ranged from 198 to 782 CFU m-3 in the vicinity of the pit compared to a background concentration of 135 CFU m-3. Equipment limitations allowed for only one sample extremely close to the operations (1 meter), and the MIA plate sample resulted in 350 and 790 CFU m-3 for E. coli and total coliforms respectively. Additionally, eight samples tested positive at both the vacuum exhaust, and the pit area for Enterotoxigenic E. coli (ETEC) at four of seven pit latrines. These preliminary results indicate that bioaerosols are generated during pit emptying. It is not known whether this is specific to the pit emptying method, however a second point of bioaerosol generation (vacuum truck vent) would be specific to technologies employing the use of vacuums to empty pits. Further, we showed that samples at four of seven pits tested positive for ETEC, a known E. coli strain that causes diarrhoea. The primary route for exposure to bacteria such as ETEC is primarily considered to be by the fecal-oral route, while generally, bioaerosols are considered a potential pathway for virus transport. This work shows that the aerosolization of a variety of pathogens can occur—not just viruses—and that a potential infection risk to both workers and households exists.

Sanitation Labor and Human Rights: Manual Scavenging in India and the Challenges for the Sanitation Sector

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In the WASH sector, the laborers who enable and run sanitation systems are often a neglected topic. In accordance with WASH actor goals, the construction and maintenance of functioning
sanitation systems is usually prioritized, and matters regarding labor are considered the domain of other actors. In India, much of the ground-level sanitation labor is carried out by manual scavengers. According to the 2013 government act, a manual scavenger is any person who cleans or handles human excreta before the excreta fully decomposes. This can include manual emptying of dry latrines, cleaning of railroad tracks, and cleaning of sewers and septic tanks. This work subjects the workers and their community to stigma, violence, disease, and death. Most of the people engaged in this work are from the Dalit or so-called “Untouchable” castes, considered to be the most polluted of people. While manual scavenging and Untouchability have been illegal for years, it continues to persist in both rural and urban settings. In 2014, Prime Minister Narendra Modi of India launched the Swachh Bharat Mission (SBM), which aims to eliminate open defecation and provide universal sewage treatment by 2019. While sanitation actors have celebrated the government spotlight on and increased resources for sanitation, organizations that focus on the emancipation of manual scavengers are warier, seeing the hectic push towards universal sanitation coverage as being at the expense of their community: with hasty construction of septic tanks and pit latrines, who will empty them? The sanitation sector faces internal challenges to incorporate manual scavenging issues into their work. These challenges include (1) conflicting understandings of the problem and its significance; (2) different understandings of actor responsibilities; (3) the sanitation sector’s traditional avoidance of political topics; and (4) different understandings of cleanliness. This paper is part of a dissertation project that is based on 13 months of ethnographic study in Delhi, India (March 2016-April 2017). The study included interviews of sanitation actors; participant observation with organizations engaged in sanitation; media analysis; and attendance at relevant conferences, meetings and events. This paper includes additional work conducted while volunteering at WaterAid India and at Safai Karmachari Andolan (Manual Scavenger Mission). In conclusion, this paper collates suggestions from advocates and suggests ways for sanitation organizations to better engage with labor issues, not only in India, but in different global contexts.

Social Dynamics Around Toilet Maintenance and Improvement in a Peri-Urban Area in Lusaka, Zambia

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Background: Despite high prevalence of shared sanitation in sub-Saharan Africa, increasing from 30% of all urban sanitation in 1990 to 34% in 2015, little attention has been focused on finding means to ensure shared toilets are well maintained and improved. Recognising this is a common-pool resource management problem, this study details the social dynamics affecting collective management of shared sanitation. Methods: In-depth interviews were conducted with residents (n=66) to understand social dynamics through the lens of Ostrom’s 8 design principles for the management of common-pool resources. The study took place in Bauleni compound, a typical peri-urban area of Lusaka. Results: Both landlords (n=33) and tenants (n=33) were interviewed. Toilets on a residential plot were shared by an average of 15 residents, and up to a maximum of 47. In light of clearly defined boundaries (#1), landlords are responsible for physical maintenance of the toilet, while tenants are required to clean the toilet. While non-plot members are not supposed to use the toilet, plots are not enclosed and toilets often do not
have locks to exclude outsiders. The benefits accrued by the tenants from toilet maintenance is sometimes incongruent (#2) because households do not dirty it equally or fulfil their responsibility to clean it. The inability of tenants to express their opinions to landlords represent poor collective-choice arrangements (#3). Landlords usually monitor (#4) the condition of toilets, but actual cleaning and dirtying behaviours are difficult to observe. Accountability for toilet cleanliness and physical damage is challenging, as non-plot members also use the toilets. This often makes it difficult to impose graduated sanctions (#5) as the violators are usually not known, and evicting tenants who won’t clean is more common than financial penalties. The situation gives rise to conflict amongst plot members, but there were no organised conflict-resolution mechanisms (#6). There are no local organisations regulating landlord and tenant agreements around sanitation (representing minimal recognition of rights to organise (#7)). Lastly, there are few well-functioning nested enterprises (#8), as there is no sewerage system in many peri-urban areas and few pit emptying services. Conclusion: The study provides important findings for the development of interventions targeting the maintenance and improvements of shared toilets.

Application of a Salivary Immunoassay to Assess Waterborne Cryptosporidium Infections in a Prospective Community Study

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Background: Salivary antibody is a promising non-invasive biomarker of specific infections. This exploratory study used an in-house salivary immunoassay to assess waterborne transmission of Cryptosporidium. Methods: Families with children were followed during summer-early winter periods in a Massachusetts city using a microbiologically contaminated river as its only source, before and after construction of a new water treatment plant. Monthly saliva samples (7,754 samples from 2,178 individuals) were analyzed for immunoglobulin (Ig) G responses to the recombinant protein gp15 protein of Cryptosporidium hominis using an in-house Luminex immunoassay. Immunoconversion was defined as at least four-fold increase in a ratio of anti-pathogen IgG response and total IgG with post-conversion response above the upper 90% prediction limit of spline function of age. Results: Self-reported gastrointestinal illness during the previous month was associated with 2.9 (95% confidence limits 1.0; 8.5) adjusted odds ratio (aOR) of immunoconversion to Cryptosporidium. Swimming in natural water bodies or chlorinated pools during previous month was associated with 3.7 (1.2; 11.5) and 4.2 (1.4; 13.0) aORs of immunoconversion respectively. Analysis of interaction effect of self-reported non-boiled tap water consumption (dichotomized) and study phase demonstrated that drinking water from the municipal system was associated with 6.5 (1.4; 30.3) lower adjusted odds of Cryptosporidium immunoconversion after the introduction of new water treatment than before it. Conclusion: Improved treatment of drinking water was associated with a significant reduction of transmission of Cryptosporidium through consumption of non-boiled tap water. Disclaimer: This abstract does not necessarily reflect EPA policy.

Strategies for Improving Public Private Partnerships for Community WASH in Arid and Semi-Arid Kenya: Assessing the Kenya RAPID program
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Additional Author: Stephanie Ogden

Background The Kenya RAPID program is a large USAID-funded program, run by the Millenium Water Alliance (MWA), coordinating the work of 5 NGOs in 5 different counties of Kenya. MWA also coordinates collaboration with the Government of Kenya at national, regional and local levels. Kenya RAPID works closely with private partners such as Safaricom, SweetSense, IBM, Coke and others in order to pilot innovative technologies to increase functionality of water points in arid and semi-arid areas of Kenya. The project also focuses on developing public-private-partnerships which support sustainable WASH systems in communities. Methods We conducted a series of in-depth interviews with a wide variety of respondents either working directly or collaborating with the Kenya RAPID program at the national or local level. When completed in July 2017, these interviews will be analyzed by thematic area according to the piece of the project discussed. Results Respondents from government agencies, each of the private sector partners, and each of the NGOs managing implementation will share findings on at least one of the following topics: technologies for improving water point functionality, technologies for improving monitoring of water point functionality, approaches for increasing sanitation coverage and use, successes or lessons learned regarding partnership development with public or private partners, among other themes. The outcome of this study will be interesting to other trying to develop PPPs in similar geographical settings, and for practitioners working in collaboration with a diverse set of partners.

Local Population Density and Enteric Disease in the Maputo Sanitation Trial

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A primary goal of onsite sanitation is to improve health by preventing transmission of fecal pathogens, though it fails to address transmission from non-human or non-domestic sources. As part of the MapSan trial, we are investigating whether shared, onsite sanitation can reduce fecal contamination and protect child health in dense, semi-formal urban settlements that house increasing numbers of the world’s poor. We assessed fecal contamination in a subset of MapSan study compounds immediately before and one year after construction of pour-flush latrines in half the compounds, which replaced pit latrines in poor condition. The remaining compounds retained initial sanitation conditions and served as controls. General and host-specific fecal indicator organisms (FIO) were measured at potential exposure points on established fecal transmission pathways to assess the relative importance and susceptibility to sanitation of different transmission routes. We assessed FIO in household stored water, compound source water, household entrance soil, latrine entrance soil, and household food preparation surfaces using both culture methods and molecular microbial source tracking (MST) assays to characterize contamination extent and fecal source. Samples were membrane filtered for culture enumeration of E. coli, a general-source FIO with regulatory significance, and for MST analysis using qPCR. We tested each sample using four locally-validated qPCR assays: two
human assays, HF183/BacR287 and Mnif, which respectively target a bacterium and an archaeon and jointly offer increased sensitivity; avian assay GFD, as widespread domestic poultry represents a key non-human fecal source; and EC235857 targeting the general indicator E. coli, permitting comparison of molecular and culture results. Baseline environmental samples were collected at 43 households in 26 intervention compounds and 50 households in 31 control compounds; end line samples were collected at 55 households in 33 intervention compounds and 58 households in 31 control compounds. At baseline, E. coli was detected frequently (>85%) by both culture and qPCR in most sample types, though we detected E. coli in only 30% of source water samples using culture methods but in 65% by qPCR. Human marker HF183 was detected infrequently in source water (4%) and food surfaces (2%) and occasionally in stored water (16%), latrine soil (38%), and household soil (25%). Human marker Mnif was also detected in 4% of source waters, less frequently than HF183 in stored water (11%), and more frequently on food surfaces (12%), latrine soil (84%), and household soil (75%). Avian marker GFD was not detected in any source water samples and infrequently in stored water and food surfaces (1%), latrine soil (4%) and household soil (2%). Completed analysis of post-intervention samples will permit evaluation of the effect of the latrine intervention on fecal transmission along the different routes and from different fecal sources.

Microbiological Effectiveness and Consistent Use Within Pilot Trials of New Household Water Treatment Options

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Background: Household water treatment (HWT) options have been shown to improve microbiological water quality and reduce diarrheal disease among users without safe drinking water supplies. Options should be microbiologically effective and consistently used to achieve maximum health gains. There is a global push to develop innovative HWT options, although industry standard metrics to evaluate use over time are lacking. We applied a methodology to quantify realistic use of three prototype HWT options, including microbiological effectiveness, consistent use, and barriers to use. Methods: Field evaluations were conducted with a biosand filter (BSF) in Nicaragua, a household chlorine generator (electrochlorinator) in Haiti, and a combined ceramic filter and bromine disinfection system (ceramic filter) in Kenya and Haiti. Evaluations consisted of a baseline survey, training and distribution with 60-82 households, and four follow-up surveys between one week and 14 months after distribution. At each visit, respondents were asked about use, barriers to use, and for a drinking water sample. Paired treated and untreated samples were assayed for E. coli using membrane filtration and m-ColiBlue24 media. Enumerators also observed if water was treated with the HWT option (confirmed use). Consistent use was defined as the proportion of total visits where users demonstrated confirmed use. Variables associated with high or low consistent use were identified through multivariate logistic regression. Results: HWT options demonstrated between 68-96% reduction in mean E. coli concentrations. Overall, 72% of BSF users in Nicaragua, 2% of electrochlorinator users in Haiti, and 43% and 33% of ceramic filter users in Kenya and Haiti, respectively, had confirmed use at all visits (or 100% consistent use). Variables
positively associated with high consistent use included HWT knowledge and reported use at baseline. Variables negatively associated with consistent use included baseline belief that drinking water was safe, and reported problems per follow-up. Barriers to use were both behavioral and technical. Most respondents reported drinking untreated water for behavioral reasons like being away from home or forgetting (82-95% of responses), and breakage was the primary reason for abandoning use (reported by 82% of electrochlorinator and 47% of ceramic filter non-users). Discussion: HWT options improved water quality, although microbiological effectiveness was lower than documented laboratory performance. Consistent use was often low, despite regular household follow-up and availability of technical assistance. These combined challenges call into question sustained HWT health impact in realistic use settings. It is critical that HWT developers design robust products, pilot them, and remedy design flaws prior to scaled distributions, as was done in these evaluations. Motivations that drive adoption and consistent use should be considered alongside technology development.

**Exposure to Animal Feces and Human Health: A Systematic Review and Proposed Research Priorities**

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Nearly two-thirds of human pathogens and three-quarters of emerging pathogens are zoonotic in origin. While research has focused on zoonotic transmission of respiratory and vector-borne pathogens, such as Ebola and West Nile Virus, less attention has been given to pathogens found in animal feces that are transmitted via water, sanitation, and/or hygiene (WASH)-related pathways, as illustrated by the classic "F-diagram." Insufficient separation of animal feces from human domestic environments, which is common in low-resource countries, can lead to fecal-oral transmission of zoonotic pathogens through direct contact with humans and/or fecal contamination of fingers, food, surfaces, and water sources. The primary objective of this review was to examine the human health impacts of exposure to poorly managed animal feces transmitted via WASH-related pathways. To do so, we conducted a systematic review of peer-reviewed and grey literature and identified 68 publications assessing human exposure to poorly managed animal feces. We identify routes of contamination of the human environment by animal feces, potential control measures to reduce human exposure, and gaps in the literature and propose research priorities for further inquiry. We develop a modified F-diagram detailing the routes of human exposure to animal feces in settings and mapped the control strategies we found in our search to identify gaps in research and programming. The literature in this review suggests that exposure to animals and animal feces has mixed effects on diarrhea, child growth, and asymptomatic infection by specific zoonotic fecal pathogens and potentially increases risks of environmental enteric disorder, STH infection, and trachoma. There is evidence that humans are exposed to animal feces through the contamination of water sources, soil, food, vectors, and hands. The means of characterizing exposure to animals and animal feces varied considerably among publications in this review; researchers assessed presence of or contact with animals, presence of or contact with animal feces, animal ownership, environmental contamination of public and private (domestic) spaces, and risky husbandry practices. Few studies have evaluated measures to control the transmission of pathogens in animal feces and
limit human exposure to animal feces, but suggested interventions include reducing cohabitation with animals, provision of animal feces scoops, controlling animal movement, creating safe child play spaces, improving animal veterinary care, and hygiene promotion. Our review highlights the scarcity of information available on the human health impacts of exposure to poorly managed animal feces transmitted via WASH-related pathways. To accurately capture human exposure to animal feces, future research could consider longitudinal measurements with in-home observations. Human exposure to animal feces via WASH-related pathways has known health effects, but data on its contribution to the globe.

A Novel Approach for Detecting Cryptosporidium Contamination in Surface Water Supplies

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Current methodology for Cryptosporidium monitoring in water supplies (EPA Method 1623.1) relies on filtering and processing 10 L of water, providing a “snapshot” of river conditions at the time of filtration. Because oocysts are discrete particles in water, a sample deemed negative by Method 1623.1 does not mean that oocysts are not (or have not recently been) present in the water supply, only that no oocysts were detected in that 10-L water sample. We have shown that biofilm sampling provides comparable oocyst detection compared with filtration-based methods. Oocysts attach to aquatic biofilms, and biofilms offer an integrated look at stream conditions over time. We deployed glass slides (substrates for biofilm growth) at a water treatment plant (WTP) intake and a sewage-contaminated creek for one year. We recovered slides (and deployed fresh slides) each day that samples were filtered (~14 d between samples). Biofilms were scraped from slides and filters were eluted; oocysts were then detected by immunomagnetic separation (IMS) and an immunofluorescent assay (IFA). At the WTP, oocysts were detected in 36% (10/28) of slides compared to 32% (9/28) of filters; at the creek, oocysts were detected in 56% (9/16) of slides compared to 59% (10/17) of filters. Biofilm sampling is cheaper than filtration ($3/set of slides vs. $110/filter) and could be performed more often and at more locations than current budgets allow. Benthic rock biofilm sampling may also identify oocyst point sources. Rock scrapings collected upstream and downstream of a sewage outfall were processed by IMS and IFA; 5 oocysts were counted upstream compared to 19 downstream. At a second outfall, oocysts were detected in 16% (1/6) and 50% (3/6) of upstream and downstream rock scrapings, respectively. While the potential for naturally grown biofilms to capture oocysts is significant, the use of biofilms for standardized detection of Cryptosporidium oocysts in water supplies is contraindicated due to the natural variation in biofilm composition and development (based on season, geography, and other natural watershed differences). Thus, we are in the process of engineering an inexpensive, standardized, biomimetic substrate that will permit oocyst attachment similar to what we observe in environmental biofilms. Water sampling with the biomimetic substrate could replace or supplement filtration-based Cryptosporidium monitoring required by the EPA, and these manufactured substrates could be strategically placed along the length of a complex watershed to identify point sources of oocyst contamination which require intervention. Sampling with the
substrates could also enable local and state agencies to quickly identify contaminated watersheds and the associated utilities at risk for increased oocyst loads in the water supply.

**Development of a Combined Growth and Persistence Model for Legionella Pneumophila in Biofilms in Drinking Water for QMRA Models**

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Legionella pneumophila (L. pneumophila) has been a consistent water health hazard since its discovery. The lesser of the two symptomologies can present with flu-like characteristics and is typically termed Pontiac Fever. L. pneumophila can also present as a pneumonia, which accounts for the greater number of mortalities between the two symptomologies. Due to the ability for it to harm public health from both diseases L. pneumophila is considered a significant public health hazard. With the recent developments in Flint, MI it can also be observed that with deteriorating drinking water infrastructure risks of exposure to L. pneumophila may increase. It has been known that L. pneumophila can grow and persist in drinking water and other biofilms. Interacting with the biofilms’ microbial ecology and surviving disinfectant residuals makes system-wide L. pneumophila control strategies challenging. The ability to model the growth and persistence of L. pneumophila in drinking water biofilms would be invaluable to quantitative microbial risk assessment (QMRA) models for drinking water systems. We present a model that has been developed specific to drinking water biofilms that accounts for persistence of L. pneumophila with respect to time and growth of L. pneumophila with respect to iron concentration and temperature. The model was developed as a non-linear multiple regression with interaction that is incorporated into a 2-dimensional (2D) simulation. The 2D simulation is an integral part of the model so as to remove the limitations of data resulting from experimental trials and allow for the modeling of real world conditions. The 2-D simulation method also allows for uncertainty and variability of input variables and model operation. This final 2-D simulation model therefore allows for the simulation of real world conditions and prediction of likely L. pneumophila biofilm growth and persistence in the drinking water biofilms. Since this model is intended for use in QMRA models the use of a 2D simulation method is not a limiting factor rather can be considered a valuable addition to its structure. Development and examples of the use of this model will be presented.

**A Systematic Review of Nosocomial Waterborne Infection in Neonates and Mothers**

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Additional Authors: Wilson Guo; Trudy Li; Ryan Cronk; Lydia Abebe; Jamie Bartram

Background: Water is an important, overlooked, and controllable source of nosocomial infection. Hospitalized neonates and their mothers are particularly vulnerable to nosocomial waterborne infections. Our objectives through this systematic review were to: investigate water sources, reservoirs, and transmission routes that lead to nosocomial waterborne
infections in neonates and their mothers; establish patient risk factors; compile measures for controlling outbreaks and recommended strategies for prevention; and identify information gaps to improve guidelines for reporting future outbreaks. Methods: We searched PubMed, Web of Science, Embase, and clinicaltrials.gov. Peer-reviewed studies reporting contaminated water as a route of transmission to neonates and/or their mothers were included. Results: Twenty-five studies were included. The most common contaminated water sources in healthcare facilities associated with infection transmission were tap water, sinks, and faucets. Low birthweights, preterm or premature birth, and underlying disease increased neonatal risk of infection. Effective control measures commonly included replacing or cleaning faucets and increased or alternative methods for hand disinfection, and recommendations for prevention of future infections highlighted the need for additional surveillance. Discussion/Conclusion: The implementation of control measures and recommended prevention strategies by healthcare workers and managing authorities of healthcare facilities and improved reporting of future outbreaks may contribute to a reduction in the incidence of nosocomial waterborne infections in neonates and their mothers.

Delivering WaSH in Australia’s Remote Aboriginal Communities: Cultural and Historical Context That Affects Uptake, Behaviour and Change

Nina Hall, The University of Queensland

A recent scan of water, sanitation and hygiene (WaSH) status in remote Australian Aboriginal communities identified a range of issues arising from a lack Menstrual Health Management (MHM) options for young girls. These include logistical challenges in feminine hygiene supplies to a lack of appropriate health education tools delivered through culturally-sensitive channels. The impacts of this lack of MHM has caused regular school absences, an inherent sense of shame, and negative health issues. This presentation examines the current challenges, and then details several case studies that have sought to improve MHM opportunities for young rural girls and women in these indigenous communities. This is presented within the context of the UN Sustainable Development Goals (SDGs), which relate to WaSH and MHM though the Goals for water, sanitation and hygiene (SDG 6), gender equality (SDG 5), quality education (SDG 4) and good health and wellbeing (SDG 3). Australia is a signatory to the UN SDGs, and is thus committed to attaining these Goals both at home and abroad. The results of this scan and identified MHM solutions are crucial for ensuring that no one is ‘left behind’ under the sustainable development agenda towards 2030.