Optimizing the benefits of inline chlorination in Nigeria and India

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Executive Summary

Unsafe drinking water is a leading cause of child mortality. New evidence suggests >4 billion people in low- and middle-income countries (LMICs) lack access to safely managed drinking water, with fecal contamination being the main limiting factor in achieving access. Inline chlorination (ILC) is a promising and cost-effective strategy for scaling up water treatment in LMICs, however it has not been widely field tested in settings with the highest levels of child mortality. Understanding drinking water source usage patterns, water quality, and compatibility with inline chlorination devices is necessary for assessing the potential for ILC to reduce waterborne disease and related child mortality in new contexts. Community acceptance of chlorinated drinking water is also critical to successful implementation, and it is often unclear if acceptance is driven by social norms or actual aversion to the taste of chlorinated water. Further, a better understanding of whether exposure to drinking chlorinated water can affect taste detection and acceptability thresholds is needed to inform appropriate dosing settings in new ILC installations (e.g. should the dose be set low and then gradually increased). Here, we propose to pilot implementation of ILC in high mortality settings in Nigeria, as well to conduct taste detection threshold testing of chlorinated water in Nigeria and in India (two settings with very different social norms around chlorination as a water treatment method). We propose the following two aims:

1. Evaluate the potential for inline chlorination devices to reduce exposure to fecally contaminated drinking water in Nigeria through two cluster randomized controlled trials in Kano and Ogun States (enrolling 40 communities in each).

   <u>Justification</u>: We will develop installation and operation protocols optimized for the infrastructure in Nigeria, determine user acceptability and uptake, and evaluate the effect of ILC on water quality and water source usage. A field study will inform the feasibility and expected costs of future scale-up of ILC in Nigeria.

2. Determine the taste detection threshold for chlorinated water in Nigeria (two states) and India (two states), and if prolonged exposure to drinking chlorinated water influences this threshold in each country. In India, additionally assess if users can identify rice fermented with chlorinated water.

Justification: Understanding the taste detection threshold in Nigeria and in India will inform the potential target dose for ILC implementation in similar settings. Further, determining if exposure to chlorinated water affects taste detection and acceptability will be valuable for designing information campaigns and how long they should be implemented. In India, determining if users can taste the difference between rice fermented with chlorinated water versus unchlorinated water will be valuable for understanding the potential success of scaling up ILC in populations that consume fermented rice.

Our findings will inform the feasibility and cost-effectiveness of future randomized controlled trials to determine the effect of ILC on child mortality in Nigeria and in India. Our results will also benefit ILC implementation programs by determining if exposure to drinking chlorinated water affects taste detection and acceptability thresholds.

Introduction

In 2019, an estimated 1.4 million deaths were attributed to inadequate access to safe drinking water and sanitation (Wolf et al. 2023). Global progress towards achieving universal access to safely managed drinking water is not on track to reach Sustainable Development Goal 6.1 - universal access to safe drinking water - by 2030. New evidence suggests that 1 in 3 people in low- and middle-income countries (LMICs) lack access to safely managed drinking water, defined as an improved water source accessible on premises, available when needed, and free from fecal and priority chemical contamination. **Importantly, fecal contamination is the limiting factor to achieving access to safely managed drinking water for almost half of the population living in LMICs (Greenwood et al. 2024), emphasizing the importance of developing scalable water disinfection strategies for these settings.**

Water treatment is a cost-effective strategy to reduce diarrheal disease and child mortality globally. A systematic review of water treatment interventions found that water treatment interventions can have protective effects against diarrhea in children under five (~25% reduction) (Clasen et al. 2015). A recent meta-analysis conducted by Kremer et al (2023) suggests that the reduction in all-cause under-5 mortality from water treatment is 24% (Kremer et al. 2023). However, implementing water treatment interventions in low-resource settings has proved to be challenging. Point-of-use water treatment methods such as boiling or manual chlorination place the burden on individuals to purchase water treatment products and treat their water daily, resulting in greater time and financial burdens on individuals, especially women, and lower compliance (Cherukumilli, Ray, and Pickering 2023). Recent large-scale randomized controlled trials (RCT) in Kenya, Bangladesh, and Zimbabwe found that basic water, sanitation, and hygiene (WASH) interventions had mixed effects on diarrhea and did not improve linear growth among children under five (Null et al. 2018; Luby et al. 2018; Pickering, Null, et al. 2019). Another challenge with basic WASH interventions is that they can require intensive behavior change programming to promote and sustain user adoption (Luby et al. 2018; Pickering, Null, et al. 2019). Other evidence suggests that consumers are often willing to pay for convenient access to water but have low willingness to pay for water treatment (Ahuja, Kremer, and Zwane 2010), making it further challenging to sustain use over time.

In-line chlorination (ILC) offers a promising low-cost water treatment solution that addresses behavioral barriers to adoption. Chlorination has been historically used in industrialized countries to disinfect drinking water supplies and has reduced child mortality and enteric disease burden in these settings (Cutler and Miller 2005). ILC is a point-of-collection drinking water treatment method that reduces cost and time burdens by ensuring that the water supplied is automatically chlorinated. ILC raises user adoption, disinfects microbial contamination in drinking water supplies, and reduces child diarrhea (Pickering, Crider, et al. 2019). Approximately 2.3 billion individuals globally have drinking water infrastructure that is compatible with ILC, presenting an opportunity to continue scaling up across multiple contexts (Cherukumilli et al. 2022). A variety of ILC devices are now available in the market, including open source products such as erosion tablet dosers that can be constructed locally (Lindmark et al. 2022). Given the diversity of water infrastructure and management structures of water sources in LMICs, piloting of ILC device options and operation models is valuable before scaling ILC implementation in new contexts.

User acceptance of chlorinated water is critical to the success of ILC. The taste of chlorinated water has been cited as a barrier to adoption of chlorinated drinking water, particularly when users have to dose drinking water themselves (Luby et al. 2008; Freeman et al. 2009). In the context of ILC, understanding local taste detection and acceptability thresholds is important for setting a target dose and designing information campaigns for ILC installations. Lowering target chlorine concentrations in response to complaints from a small number of community members without knowing if the complaints are associated with true aversion to taste and smell associated with chlorination presents a risk for scale-up of ILC. If chlorine concentrations are below the taste detection limit, but complaints persist, lowering the chlorine concentrations could result in ineffective disinfection or disrupt the process of communities becoming accustomed to the taste of chlorine, without addressing the true reason for complaints. When a few outspoken individuals can influence water treatment decisions in their community, designing the appropriate messaging and chlorine dosing procedures for new installations is important (Crider et al. 2018). Median chlorine taste detection thresholds can vary globally, though there have been limited studies (Crider et al. 2018; Flanagan, Meng, and Zheng 2013; Luby et al. 2008; Osler, Alfredo, and Mihelcic 2024; Piriou et al. 2014). While some have hypothesized that consuming chlorinated water over time increases acceptability thresholds (Piriou et al. 2014), there have been no rigorous studies investigating if exposure over time affects the taste detection and acceptability thresholds of chlorinated water. Better understanding of how acceptability changes with exposure to chlorinated water would be valuable for designing ideal dosing strategies to maximize adoption (e.g. starting at a low dose and increasing over some specified amount of time).

Study Objectives

We have based this proposal on the findings from previous scoping and piloting activities to assess the potential for ILC in Nigeria and India (see additional details on previous work below).

1) **Conduct two implementation RCTs of inline chlorination devices in one North (Kano) and in one South (Ogun) state in Nigeria.** A field trial will inform the feasibility of a mortality study as well as the expected costs of future scale-up of ILC in Nigeria. We will develop installation and operation protocols optimized for the infrastructure in Nigeria, determine user acceptability and uptake, and evaluate the effect of the intervention on water quality and water source usage.

2) **Determine the taste detection threshold for chlorinated water in Nigeria and India, if it varies by state within each country, and if prolonged exposure to drinking chlorinated water influences the threshold.** In India, we will also add a taste test to assess if users can identify rice fermented with chlorinated water. These experiments will allow us to understand the taste detection threshold in each country (Kano and Ogun in Nigeria, and Odisha and Madhya Pradesh in India) and will inform the potential target dose for ILC implementation across different countries. In Nigeria and India, we are planning to enroll two groups of participants: one with prolonged exposure to chlorinated drinking water and one without exposure. In Nigeria, these will be participants who have been exposed to chlorine for ~4 months following installation, and in India, these will be participants from the original pilot study in Odisha who have been exposed to chlorine for ~12 months. Further, determining if exposure to chlorinated water affects taste detection and acceptability will be valuable for planning dosing of new ILC installations and designing effective information campaigns. Finally, knowing if users in India can taste the difference between rice fermented with chlorinated water versus unchlorinated water is critical for understanding if ILC will be successful in populations that consume fermented rice, and in particular whether this issue could be overcome for a mortality study in Odisha.

Previous Scoping and Piloting Activities

We have conducted scoping activities in Nigeria and ILC piloting in India, and our results are detailed in the Phase 1 reports submitted to Givewell. Here, we summarize the findings, ongoing activities, and motivate what we believe are important next steps for scaling ILC and informing a future mortality study in either country.

Nigeria context and preliminary data

Nigeria has the third-highest U5 mortality rate in the world, at 111 deaths per 1,000 births in 2021 (United Nations, United Nations Children's Fund, and IGME 2022). Diarrhea is the third leading cause of death among children under 5, both in Nigeria and globally, and more than 80% of global diarrheal deaths are attributable to contaminated drinking water (IHME 2024). As of 2021, 68% of households in Nigeria used water sources contaminated with *Escherichia coli (E. coli)*, including 60% of households using improved water sources (Federal Ministry of Water Resources, National Bureau of Statistics Nigeria, and UNICEF 2022).

We conducted initial scoping meetings and water infrastructure visits in Kano and Ogun (as well as Kwara) states. We conducted informal interviews with water system operators from 31 water systems (18 in Kano, 5 in Ogun, and 8 in Kwara State) and carried out observational surveys of these systems. Additionally, we interviewed government officials from the Rural Water Supply and Sanitation Agency (RUWASSA) and the Ministry of Rural Development, which has been supporting us for the current exploratory activities (August-September 2024). Based on the our original criteria for selection of sites for a potential mortality study (i) existing primary water supply infrastructure; (ii) availability and frequency of use of alternative water supply systems (iii) operation and maintenance of water supply, and (iv) under 5 child mortality rates and morbidity prevalence, we selected Ogun and Kano to further explore the potential for ILC.

Water infrastructure assessments in Ogun and Kano. Between August and October 2024, we conducted a water infrastructure census and household surveys in 30 communities in Kano and Ogun states to understand drinking water source infrastructure and household water usage and management patterns. We worked in 5 LGAs in Ogun and 6 LGAs in Kano states. After reviewing available data on water infrastructure and number of compatible water points per community from RUWASSA and WASH departments, we proceeded with water infrastructure mapping for 30 communities in each state. In each community, we mapped all primary drinking water sources and conducted household surveys with 10 households in each community (n=300 household surveys per state). Preliminary results suggest that the primary source of water is surface water (27%), private boreholes (23%), public boreholes (18%) or sachet water (14%) in Ogun, while in Kano is manual handpumps (24%), public boreholes (22%), private wells (11%) in Kano. We also found *E. coli* of 93.3% in drinking water samples in Kano, and 63.2% in Ogun. Given the different water infrastructure, level of contamination, primary and secondary sources of drinking water as well as child mortality across the two states, a pilot RCT in both states will better inform a potential mortality study in either state.

Installation of three ILC devices. In Ogun, we have collaborated with RUWASSA to install 3 erosion tablet ILC devices (1 Aquatabs Flo and 2 Aquatabs Inline chlorinators) in three communities. One of the devices was installed at the RUWASSA office as it was also serving a community nearby, while the other 2 devices were installed in 2 neighboring communities in Yewa North LGA. We plan to monitor chlorine dosing weekly at these sites for 5 months. Preliminary results from the installations demonstrated a dose between 0.4 and 1.7mg/L free chlorine across all three devices when testing the water at the primary collection tap. Initial feedback from the communities where the devices were installed has been positive with no complaints regarding the test or smell of chlorine. The high acceptability of drinking chlorinated water to date could be due to social norms that chlorine is an acceptable water treatment technology, or higher chlorine taste acceptability thresholds in Nigeria which we plan to test as part of this proposal. Based on this small pilot, we believe that the Aquatabs Flo (good for lower flow rates and tank inlet installations) and Inline (for higher flow rates) are promising ILC technology options for the future RCT. We will also explore implementing open source tablet dosers when there is compatible infrastructure.

Context and previous learnings in India

Although India has made progress in reducing child mortality in recent decades, one-third of the 9.7 million yearly deaths of children under 5 globally still occur in India (Rabbani and Qayyum 2017), and as many as 300,000 of these deaths yearly are attributable to diarrheal diseases from inadequate access to safe drinking water (Lakshminarayanan and Jayalakshmy 2015). Based on findings from Kremer et al (2023), we estimated that the Jal Jeevan Mission (JJM) could prevent 136,000 under-5 deaths per year in India if able to ensure that the water supplied is free from microbiological contamination (Ministry of Jal Shakti).

Our previous work in India aimed to develop installation and operation protocols for implementing ILC devices, and evaluate performance of available ILC tablet dosers in India when installed in typical single village schemes. We conducted a pilot RCT with 20 villages (10 treatment and 10 control) and installed two different devices between December 2023 and January 2024 (PurAll tablet dosers in 4 villages and CTI-8 tablet dosers in 6 villages). We then conducted high-frequency process monitoring to assess dosing performance over 6 months. We were able to successfully install and adapt ILC tablet dosers for pressurized supply schemes across a variety of underlying infrastructure as well as verifying the costs of installing and refilling a locally assembled open source CTI-8 tablet doser device compared to the commercially available PurAll tablet dosers.

Under the Ministry of Jal Shakti's JJM and several state programs, the government is constructing household tap connections in rural areas that provide safe drinking water daily. As of August 2024, around 74.6% of rural households in Odisha were estimated to have functional household tap connections, which was close to the current national average of 78.2% ("JJM Dashboard," 2024). This single-village drinking water distribution infrastructure is compatible with ILC, as it involves piped water supply from a groundwater source that feeds into a central community tank. Since drinking water is provided to individual tap connections on a daily basis, we found that 80% of households in our study site were relying on them as their primary drinking water source. The availability of ILC-compatible drinking water infrastructure, combined with a high proportion of people using it as their primary source of drinking water, allows for opportunities to scale ILC across Odisha.

However, while we were able to successfully pilot ILC in India, we learned that additional behavioral factors, like cooking and taste preferences, could affect the future success of ILC at-scale. The first main issue to tackle in Odisha (or other states where households cook similar dishes) is rice fermentation. One common complaint from households that our implementing partner received in treatment villages was that chlorinated water prevented them from making a traditional fermented rice dish (*pakhala*). The dish is made by soaking cooked rice in water, and chlorine could inactivate the bacteria usually responsible for fermentation. We propose to conduct an experiment in treatment and control study villages to better understand taste preferences of consuming fermented rice made with chlorinated water. Given it would be difficult to change cooking practices, we believe this work is important to understand whether issues around rice fermentation are likely to impede a mortality study in Odisha and other parts of India.

Pilot results motivate the need to better understand chlorine taste and acceptability thresholds

In addition to context-specific issues which may arise (like rice fermentation in parts of India), another major issue to address to further improve ILC implementation is user **reported aversion to the taste and smell of chlorine**. In our ILC treated villages in India, the degree of complaints varied across villages and had varying effects on the success of the ILC intervention. Although 94% of participants in the treatment group reported being satisfied with the drinking water provided by their tap connection and only 10.5% of participants in the treatment group reported an aversion to taste and odor of chlorinated water, frequent complaints about the taste created pressure on the implementing partner and pump operators to reduce the dose or close off devices. Our implementing partner set the dosing range at 0.2-0.4mg/L which was well below the median taste detection threshold determined by a study in Bangladesh (0.7mg/L) (Crider et al. 2018), but still received varying levels of complaints in each village over time. The implementing partner responded in two primary ways: 1) Conducting village meetings both with individuals, including pump operators, and at-large, and 2) Lowering the chlorine concentration in hopes of being below the assumed taste detection threshold. However, the resulting chlorine concentration often decreased below 0.2 mg/L and user complaints still persisted, implying that decreasing the target chlorine concentration alone is ineffective in resolving complaints and increasing user adoption. Chlorine concentrations below 0.2 mg/L are also below the ideal residual for protecting drinking water during household storage. In contrast, initial results from the small ILC pilot in Nigeria where dosing was often between 1mg/L-2mg/L indicate that people are more accepting of the taste and smell of chlorinated drinking water, as we have not received community complaints after several weeks of dosing. It's not clear if the difference in chlorine acceptability could be due to actual differences in taste detection thresholds, exposure to chlorinated water, or social norms. Parsing out these reasons has important implications for delivery of chlorine water disinfection programs in Asia and Africa.

Study Design

We propose the following specific activities:

Conduct two implementation RCTs of inline chlorination devices in one North and one South state in Nigeria

We plan to conduct scoping activities across 100 communities to identify 40 communities with ILC-compatible drinking water infrastructure to be enrolled in an RCT in each state (Kano and Ogun). We consider infrastructure to be compatible with ILC if drinking water is supplied at least once daily or when needed, everyone in the community has access to the drinking water source(s), baseline turbidity levels are below 0.5 NTU, and no known priority chemical contamination exists. Multiple water source use is common in Nigeria, particularly when drinking water sources are not reliable, so we aim to identify communities with the best reliability of ILC compatible sources.

In each state, following enrollment of 40 communities, we will randomly select 20 communities to receive an ILC installation in compatible drinking water sources. We plan to install two types of ILC devices to evaluate their technical performance and cost: 10 communities will receive the AquaTabs tablet-based dosers and 10 communities will receive the TuriTap liquid chlorine dosers (that are able to dose liquid chlorine solution precisely at taps). We are also open to testing the open-source CTI-8 design in compatible sites (e.g. accessible tanks where the doser can be installed at the inlet under low pressure flow). We have budgeted to install up an average of 3 devices per community.

We will conduct household surveys and water infrastructure mapping surveys across all 40 communities in each state. We plan to conduct a baseline survey among 15 households per community using ILC compatible water points enrolled in the study to understand household drinking water usage and existing perceptions of chlorination. Following baseline data collection, we will conduct sensitization activities in the 20 treatment communities prior to ILC installation. Following ILC implementation, we will conduct 3 additional follow-up survey rounds (n=15 households per community) at 4-month, 8-month, and 12-month timepoints post-installation (600 household surveys per time point). Household surveys will include water source usage (including secondary sources), user perceptions and acceptability of chlorinated water, and water treatment and management practices. During each household survey round, a subset of 5 households from each community will have their stored drinking water tested for residual chlorine concentrations and microbiological contamination by measuring concentrations of *E.coli* (n=200 samples per round). We will also conduct weekly chlorine concentration monitoring thereafter for the 12-month study period.

Power calculations for ILC RCTs

Our primary outcomes for the Nigeria RCTs will be the proportion of drinking water samples positive for E. coli (>= 1 MPN per 100 mL sample) and free chlorine (> 0.1 mg/L).

In Kano, assuming a baseline prevalence of *E. coli* of 93.3% in drinking water samples (based on the original pilot), an ICC = 0.15, 20 communities per study arm, and 15 budgeted drinking water samples per community collected over the study period (N = 300 total samples), we expect to have an MDE of 14%. In Ogun, assuming a baseline prevalence of *E. coli* of 63.2% in drinking water samples (based on the original pilot), an ICC = 0.15, 20 communities per study arm, and 15 budgeted drinking water samples per community collected over the study period (N = 300 total samples), we expect to have an MDE of 20%. In both Kano and Ogun, these MDEs are far smaller than the typical reductions in E. coli contamination that we have observed in other studies.

Across the study sites, chlorination is not commonly used, and we expect the baseline proportion of samples positive for free chlorine to be low. Assuming this baseline prevalence of free chlorine in drinking water (based on our pilot data), an ICC = 0.15, 20 communities per study arm, and 15 budgeted drinking water samples per community collected over the study period (N = 600 total samples), we expect to have an MDE of 10%.

Desk research

We plan to conduct desk research on cultural practices or cuisine that could be affected by chlorine in India, in addition to the issue of consuming *pakhala* in Odisha. We plan to conduct a literature search of published and grey literature, as well as interview experts and those with knowledge of Indian cuisine and cooking practices. This research may influence the choice of the second state in addition to Odisha to conduct the taste test experiment (currently we have proposed the second state to be Madhya Pradesh, given the government support/relationships we have developed, and the relevance for the programs and policy initiatives of Evidence Action in this state).

Determine the taste detection threshold for chlorinated water and if prolonged exposure to chlorinated water influences this threshold.

In each state, we plan to enroll 300 individuals across both treatment and control communities (600 in each country) and conduct chlorine taste detection threshold experiments. We will use the 3-alternative forced choice test method, in which participants will be provided a series of 3 drinking water samples where one sample has been prepared with varying chlorine concentrations between 0.2-2.0 mg/L and the other two samples are unchlorinated. This experiment will be repeated 3 times, meaning participants will taste 9 samples total, and the chlorine concentration will be increased by a fixed value across each experiment set. For each set, participants will be asked if they can identify which drinking water sample has been prepared with chlorine and if they find the water acceptable. Participants and surveyors will be blinded to which samples were prepared with chlorinated versus non chlorinated drinking water. Assuming power of 0.80, alpha of 0.05, standard deviation of 0.57 mg/L (based on Crider et al., 2017), and sample size of 150 per arm, we will be able to detect a minimum difference in the median taste acceptability threshold of 0.18 mg/L between treatment (chlorine exposed) and control groups. The taste experiment will be conducted among participants in Nigeria following exposure to chlorinated water for 4 months in the treatment group and among participants in India after 12 months of exposure to chlorinated water in the treatment group. We hope to understand how exposure to chlorinated drinking water may influence chlorine taste acceptability across India and Nigeria, and identify a threshold for acceptability across treatment and control groups.

Conduct a taste test experiment to assess if users can identify rice fermented with chlorinated water in Odisha

In Odisha only, we will enroll 150 individuals from both treatment and control villages (300 total) and ask participants to taste fermented rice samples (*pakhala*). Participants will be asked to taste a series of 3 fermented rice samples (~100 grams each) in which 2 samples will be prepared with unchlorinated drinking water from nearby villages and 1 sample will be prepared with chlorinated drinking with a chlorine concentration varying between 0.2-2.0 mg/L. Participants and surveyors will be blinded to which samples were prepared with chlorinated versus unchlorinated drinking water. Participants will then answer questions about the samples they prefer the most and if they can identify which sample has been prepared with chlorinated water. To characterize taste acceptability, participants will also be asked to rate the taste of the fermented rice on a 5-point scale.

Note on optimizing ILC implementation in India

We acknowledge that there is a need for more experimentation and adjustments to define clear ILC installation protocols to be incorporated into future implementing contracts, and we believe Evidence Action is best suited to continue this process. Here we have proposed to study key factors that will influence the ability to scale chlorination in Odisha, including taste aversion and cooking practices. Our results will be able to directly inform Evidence Action's scale-up of ILC and future efforts to implement ILC in a study on child mortality.

Timeline

Overall, our proposed activities will last 30 months, but field work will last 24 months in Nigeria and up to 12 months in India.

Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Nigeria																														
Preparation, IRB, Approvals, contracts	■	■	■	■																										
Implementation RCT (Kano)																														
Scoping in 100 communities					■	■	■																							
Enrollment of 40 communities							■	■																						
Baseline data collection								■	■																					
Implement ILC in 20 treatment communities									■	■																				
Follow-up data collection										■	■	■	■	■	■	■	■	■	■	■	■	■								
Taste test experiment and data collection														■	■	■	■													
Implementation RCT (Ogun)																														
Scoping in 100 communities									■	■	■																			
Enrollment of 40 communities											■	■																		
Baseline data collection												■	■																	
Implement ILC in 20 treatment communities													■	■																
Follow-up data collection														■	■	■	■	■	■	■	■	■	■	■	■					
Taste test experiment and data collection																		■	■	■	■									
Data analysis/writing																				■	■	■	■	■	■					
Results dissemination																								■	■	■	■	■	■	■
India																														
Taste test/Pakhala experiment																														
Preparation, IRB, approvals, contracts	■	■	■																											
Monitoring chlorine dosing	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■															
Taste test experiment and data collection (Odisha)					■	■	■	■																						
Taste test experiment and data collection (MP)									■	■	■	■																		
Data analysis/writing												■	■	■	■															
Results dissemination																■	■	■												

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Budget Notes

This proposal is led by co-PIs Amy Pickering and Elisa Maffioli. UC Berkeley will lead the project and administer a subcontract to the University of Michigan, and service contracts to data collection partners (Hanovia in Nigeria and JPAL in India) and to an implementation partner in Nigeria for ILC installations and refills. Our research team is currently interviewing research partners. Field costs have been updated based on our recent experience implementing ILC devices in a pilot of Ogun, and revised estimates from Hanovia and JPAL. UC Berkeley personnel include PI Amy Pickering, doctoral student Jeremy Lowe, doctoral student Hannah Wharton, a postdoctoral scholar (to be identified) to lead the RCTs in Nigeria, and a part time postdoctoral scholar (TBD) to oversee the India desk research (conducted by a masters student) and taste test detection experiments. Research supplies include purchase of ILC devices, chlorine testing materials, microbial water quality testing supplies, and supplies for conducting the taste test experiments.

	Summary Budget				Ver.14.5 1/25
Principal Investigator:		Pickering			**4/1/25**
Title:	Optimizing the benefits of inline chlorination in Nigeria and India				**9/30/27**
SALARIES	Year:	**One**	**Two**	**Three**	**TOTAL**
	Faculty	18,339	19,072	0	37,411
	Summer Salary	1 mos	1 mos		
	Grad. Student Researchers	86,184	98,796	45,426	230,406
	1 GSRs lvl II. In-state tuit	50% sem - 100% sum	50% sem - 100% sum	50% sem - 100% sum	
	1 GSRs lvl II. In-state tuit	50% sem - 50% sum	50% sem - 50% sum	50% sum only	
	Other Personnel	128,779	137,260	42,867	308,906
	1 postdoc lvl III	12 mos @100%	12 mos @100%	6 mos @100%	
	1 postdoc lvl III	12 mos @50%	12 mos @50%		
	1 Student Title at $25/hr	3 mos	3 mos		
	Salary Subtotal	233,302	255,128	88,293	576,723
BENEFITS	Fringe	22,806	24,551	7,664	55,021
	Tuition	46,040	47,882	12,205	106,127
	Benefits Subtotal	68,846	72,433	19,869	161,148
	Personnel Subtotal	302,148	327,561	108,162	737,871
TRAVEL	Domestic	2,276	2,276	0	4,552
	Foreign	48,750	33,725	7,350	89,825
	Travel Subtotal	51,026	36,001	7,350	94,377
EQUIPMENT	**Equipment Subtotal**	0	0	0	0
SUPPLIES					
	GAEL Insurance	4,783	5,230	1,810	11,823
	Publications	0	0	0	0
	Service Provider in India for chlorine device installation and refills	28,000	0	0	28,000
	Service Provider in Nigeria for chlorine device installation and refills	103,324	60,272	8,610	172,206
	Service Provider - JPAL	112,677	12,520	0	125,197
	Service Provider - Hanovia	192,403	236,338	0	428,741
	Expendable Research Supplies	66,163	19,143	0	85,306
	Supply/Expense Subtotal	507,349	333,503	10,420	851,273
	U Michigan	73,627	70,010	6,135	149,772
SUBAWARDS	**Subaward Subtotal**	73,627	70,010	6,135	149,772
Total Direct Costs		934,150	767,075	132,067	1,833,293
Modified Total Direct Costs		839,483	649,183	113,727	1,602,394
Indirect Costs		83,948	64,918	11,373	160,239
	TOTAL COST FOR YEAR	**1,018,099**	**831,994**	**143,440**	**1,993,532**

Budget Justification

A. Senior Personnel

Amy Pickering, Ph. D., will serve as the Principal Investigator.
Dr. Pickering will oversee all research and administrative aspects of the project and requests 1 month of summer salary support in Yr 1 and Yr 2.

The budget reflects 4% COLA increase in each successive year.

B. Other Personnel

Graduate Student Researchers (GSR): Salary support is requested for 1 Graduate Student Research appointment at 50% effort during academic semester months and 100% effort during summer months per year for the duration of the project and for 1 Graduate Student Research appointment at 50% effort during academic semester months and 50% effort during summer months in Yr 1 and Yr 2 and 50% effort during summer months only in Y3.
https://www.ucop.edu/academic-personnel-programs/_files/2024-25/oct-2024-scales/t22.pdf

There is a 6.4% increase each Oct 1st in subsequent years for GSR rates.

Postdoc: Salary support is requested for 1 postdoc at 100% each year for the duration of the project (to lead the Nigeria ILC trials) and 1 postdoc at 50% effort in years 1 and 2 (to lead the India taste test experiments and lead the desk research).
https://www.ucop.edu/academic-personnel-programs/_files/2024-25/oct-2024-scales/t23.pdf

There is a 3.5% increase on each Oct 1st in subsequent years for Postdoc rates.

Student Assistant: Salary support is requested for 1 Student Assistant for 3 months per year in Yr 1 and Yr 2 to support the field activities and desk research.

C. Fringe Benefits

The **composite fringe benefit rates** for fiscal years 2024-25 have been published. See below. FY 2024-25 rates should be applied to UC personnel costs that will occur during this time period. Projected rates (FY26-FY27) are estimates for planning purposes only (e.g., multi-year budgeting, financial aid planning, contract and grant proposal submissions, etc.) and are subject to change.
Fringe benefits are assessed as a percentage of the respective employee's salary. The benefit rates are as follows

UCB Composite Benefit Rates (effective 4/10/2024)

	Approved Rates (UCPath Rates)				**Projections for Planning Purposes**
CBR Rate Group	**FY22**	**FY23**	**FY24**	**FY25**	**FY26-27**
Academic	35.9%	35.4%	34.4%	35.5%	35.5%
Staff	43.8%	42.8%	42.8%	42.8%	42.8%

Limited (Postdoc & Faculty summer salary)	14.4%	14.0%	12.2%	14.7%	14.7%
Employees with no benefits eligibility	4.2%	5.3%	5.4%	4.4%	4.4%
Students (Graduate and Undergraduate)	2.6%	2.8%	2.3%	3%	3%

https://spo.berkeley.edu/policy/benefits/benefits.html

D. Equipment: None.

E. Travel:

A total of $94,377 is requested for 1 domestic travel for 1 person in Yr 1 and in Yr2, and a total of 10 foreign travel trips for 30 days stay (for postdocs and graduate students to oversee field activities) and 9 foreign travel trips for 10 days stay for the duration of the project (for PI and postdocs). The domestic travel is for technical meetings with project collaborators and/or to present research result in a technical conference. The foreign travel is for the PI, Postdocs, PhD student to travel to India and Nigeria to visit field sites, train field teams, and meet with collaborators.

Domestic travel breakdown per trip based on 3 night stay/trip	**Foreign travel breakdown per trip per person.**
Airfare: $600/trip	Airfare: $2500/trip
Lodging: $225/night	Per Diem: $100/day
Meals: $92/day	Ground transportation: $75/trip
Ground transportation: $75/trip	VISA: $100
Conference registration: $550-$650	

F. Other Direct Costs:

Tuition remission: an estimated of $106,127 is requested for Graduate Student tuition and fees for the duration of the project. Graduate students who are supported 45% or greater are eligible for the full tuition remission (including non resident supplemental tuition), which includes coverage of the SHIP fee plus campus fees. This is UCB's practice to similarly compensate students in nonsponsored as well as sponsored activities. The budget reflects a 4% increase in tuition remission in each successive year. https://registrar.berkeley.edu/tuition-fees-residency/tuition-fees/fee-schedule/

Materials and Research Supplies: A total of $85,306 is requested for research supplies for the duration of the project. These include surveyCTO subscription ($300/mo for 30 months), colorimeters (24 colorimeters at $700 each), tablets for electronic data collection, chlorine test reagents (40,000 free chlorine tests and 35,000 total chlorine tests), and reagents and supplies for *E. coli* water quality testing in Nigeria (2000 tests using Aquagenx).

Service Providers: The following is requested for service providers in India and Nigeria:

-J-PAL: will conduct data collection and chlorine monitoring in 20 communities over a 12 month period. They will also conduct a taste test experiment of chlorinated water and fermented rice in 600 households (300 households in Odisha and 300 households in MP). Estimated total cost is $125,197

-Hanovia Lmtd: will be involved with data collection in Nigeria in the states of Kano and Ogun. Hanovia will conduct scoping in 100 communities in each state, baseline data collection in 40 communities in each state, and then follow up data collection in the same communities over a 1 year follow up period. They will also conduct a chlorine taste test experiment with 600 households (300 in each State). Estimated cost is $428,741.

-Service provider for chlorine device operation and delivery of refills in India will cost $28,000 in year 1 (includes extending chlorine refills, sensitization, and maintenance in 10 communities, as well as hand over activities to the government after 12 months). Service provider for chlorine device installations, refills, and monitoring in Nigeria will cost $103,324 in Yr 1, $60,272 in Yr 2 and $8,610 in Yr 3. This includes installing an average of 3 devices in each treatment community (40 communities in total), refills, and monitoring and maintenance.

Subcontracts:
-University of Michigan: $149,772

GAEL: an estimated total of $12,262 is budgeted for Liability insurance. The GAEL rate is assessed at $2.05/$100 of payroll.

https://riskservices.berkeley.edu/insurance-programs/liability

URCP: an estimated total of $255 is budgeted for UCRP Supplemental Interest Assessment for a certain payroll title at 0.66% in Yr 1 and 0.70% in Yr 2

https://controller.berkeley.edu/ucrp-supplemental-interest-assessment

G. Indirect Costs:
Per the sponsor’s policy, indirect costs rate is 10% of MTDC.