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'I know how stressful it is to lack water!' Exploring the lived experiences of household water insecurity among pregnant and postpartum women in western Kenya

Shalean M. Collins^a, Patrick Mbullo Owuor^{ib a}, Joshua D. Miller^{ib a}, Godfred O. Boateng^{ib a}, Pauline Wekesa^{ib b}, Maricianah Onono^b and Sera L. Young^{ib a,c}

^aDepartment of Anthropology, Northwestern University, Evanston, IL, USA; ^bKenya Medical Research Institute, Kisumu, Kenya; ^cInstitute for Policy Research, Northwestern University, Evanston, IL, USA

ABSTRACT

There is rapidly evolving literature on water insecurity in the general adult population, but the role of water insecurity during the vulnerable periods of pregnancy and postpartum, or in the context of HIV, has been largely overlooked. Therefore, we conducted an exploratory study, using Go Along interviews, photo-elicitation interviews, and pile sorts with 40 pregnant and postpartum Kenyan women living in an area of high HIV prevalence. We sought to (1) describe their lived experiences of water acquisition, prioritisation, and use and (2) explore the consequences of water insecurity. The results suggest that water insecurity is particularly acute in this period, and impacts women in far-reaching and unexpected ways. We propose a broader conceptualisation of water insecurity to include consideration of the consequences of water insecurity for maternal and infant psychosocial and physical health, nutrition, and economic well-being.

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HIV; water insecurity; maternal and child health; first 1000 days

Introduction

Household water insecurity is the inability to access and benefit from affordable, adequate, reliable, and safe water for wellbeing and a healthy life (Jepson, Wutich, Collins, Boateng, & Young, 2017). Water insecurity has consequences for physical (Geere, Hunter, & Jagals, 2010; Prüss-Ustün et al., 2014) and mental health (Aihara, Shrestha, Kazama, & Nishida, 2015; Jepson, 2014; Stevenson et al., 2012; Workman & Ureksoy, 2017; Wutich & Ragsdale, 2008), interpersonal and community relations (El Didi & Corbera, 2017; Mason, 2014; Wutich, 2011), and daily routines (Sultana, 2009). Water insecurity is expected to worsen due to climate change, increased global water use, and inequalities in water distribution (Cook & Bakker, 2012; Department of Defense, 2014).

Water insecurity often occurs in areas of high HIV prevalence, such that it is possible that these epidemics are overlapping (Krumdieck et al., 2016; Workman & Ureksoy, 2017), or syndemic, as with food insecurity and HIV (Weiser et al., 2011).

Missing is the consideration of the role of water insecurity during one of the most socially and biologically vulnerable periods: pregnancy and postpartum (Pelto, 1987). The first 1,000 days (i.e. the year prior to delivery and two years postpartum) set the trajectory for health, social, nutrition, and economic outcomes across the life course (Hoddinott et al., 2011). The study of water insecurity among pregnant and postpartum women is particularly important because women

CONTACT Sera L. Young  sera.young@northwestern.edu  Department of Anthropology, 1819 Hinman Ave, Evanston, IL 60208, USA

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disproportionately bear the physical and psychological brunt of water acquisition and water-intensive domestic chores (Baguma, Hashim, Aljunid, & Loiskandl, 2013; Harris, Kleiber, Goldin, Darkwah, & Morinville, 2017; Ray, 2007). This life stage both makes water acquisition more difficult and entails additional water needs.

Water is imperative to the biological demands of pregnancy, lactation, and caregiving in the first 1,000 days. During pregnancy, placental development and amniotic fluid accretion depend on maternal hydration status (Rasmussen & Yaktine, 2009; Widen & Gallagher, 2014). In late gestation, maternal total body water can increase by 6 L to accommodate fetal needs (Soma-Pillay, Nelson-Piercy, Tolppanen, & Mebazaa, 2016). Women require at least 16% more fluid per day to support breastmilk production (Bentley, 1998); women living in warm environments with limited access to safe water may be more likely to become dehydrated during breastfeeding (Rosinger, 2015), which may reduce milk production. Fetching water from unsafe sources can expose women to parasites (Grimes et al., 2014) and pathogens, and drinking unsafe water increases the likelihood of gastrointestinal distress (Schmidlin et al., 2013). Unhygienic practices and the use of contaminated water during delivery increase the risk of infections (Cheng, Schuster-Wallace, Watt, Newbold, & Mente, 2012). Postpartum, carrying heavy water containers may increase the risk of uterine prolapse (Gjerde, Rortveit, Muleta, Adefris, & Blystad, 2017).

Additionally, little is understood about water insecurity in the context of HIV. Water is needed to maximise efficacy of antiretroviral medications and preserve the hygiene of people living with advanced HIV and their caregivers (Lesho & Gey, 2003; Ngwenya & Kgathi, 2006; WaterAid & SAfAIDS, 2014). People living with HIV need more water to counteract side effects of antiretroviral therapy and ameliorate co-morbidities. They are also more vulnerable to waterborne disease (Yallev et al., 2012), and have reported being unable to access choice water sources due to social stigma (WaterAid Ethiopia, 2006).

Therefore, in light of the scant literature on the consequences of water insecurity in the first 1,000 days and in the context of HIV, we sought to first describe the experiences of water acquisition, prioritisation, and use, and second, outline the perceived consequences of water insecurity among pregnant and lactating Kenyan women living in an area of high HIV prevalence.

Methods

Field sites

Research was conducted at the end of the short rainy season, from September to October 2015 within the context of Pith Moromo (Dholuo for 'Enough Food'; NCT02974972 [clinicaltrials.org]), a pregnancy cohort study spanning seven field sites in Nyanza, Kenya.

This was a suitable setting to achieve our study objectives for two major reasons. First, despite the region's proximity to Lake Victoria, households in the area experience wide variation in water access and quality, and water security is contingent on seasonal rainfall (Loewenberg, 2014; O'Reilly et al., 2008). Second, the area has among the highest prevalence of HIV among pregnant women in Kenya (20%); this is 3.4 times higher than the national average (National AIDS and STI Control Programme, 2016).

Data collection

Forty pregnant and postpartum women were purposively recruited by study nurses across five clinics where HIV care and prevention services were available (Table 1). All women with known HIV status who were pregnant or had a child one year of age or younger and were not enrolled in the Pith Moromo cohort study were approached to participate in the study. Participants were remunerated 500 Kenyan Shillings (approximately \$5 USD).

Table 1. Characteristics of women participating in qualitative exploration of lived experiences of water insecurity in Nyanza region, Kenya, by method ($n = 40$).

	Go-Along & thematic rankings ($n = 20$)	Photovoice ($n = 20$)
Age , (mean, SD)	28.1 (4.4)	27.6 (4.1)
Education \leq primary school , %	70	36.8
Married , %	85	95
Occupation , %		
Formal labour	5.3	15.8
Informal labour	10.5	5.3
Business	36.8	21.1
Farming	15.8	15.8
Housewife	5.3	36.8
Unemployed	26.3	5.3
HIV Status , %		
HIV+	50	35
HIV-	40	65
Not reported	10	0
Pregnant/postpartum , %		
Pregnant	30	40
Postpartum (child <6mo)	35	35
Postpartum (child >6mo)	35	25

Twenty women were interviewed using a ‘Go-Along’ method (Kusenbach, 2003), during which they were accompanied, observed, photographed, and interviewed while acquiring and using water for daily activities. Interviews were largely unstructured, but followed a guide [Supplemental Material (SM 1)] developed from the investigators’ knowledge and prior work on water insecurity, especially (Jepson, 2014; Stevenson et al., 2012; Wutich, 2009).

Immediately following Go-Along interviews we conducted thematic ranking exercises; participants were presented with illustrations of male and female figures and 13 common, water-intensive household chores identified in earlier work (SM 2). After discussing cards with participants to ensure understanding of each depiction, women were asked to perform four sorts: (1) rank water-related domestic activities from most to least difficult, (2) rank activities from most to least time-consuming, (3) rank activities by amount of water needed, and (4) sort activities categorically into ‘male,’ ‘female,’ and/or ‘shared’.

Twenty women were interviewed using photo- and narrative-elicitation ‘Photovoice’ activities (Wang & Burris, 1997). This activity occurred over three visits. In the first encounter, sociodemographic data were collected and women were shown how to use digital cameras and asked to take 20–30 photographs related to household water acquisition and use. Participants returned 3–4 days later to discuss photographs they had taken and select 3–5 images they felt best illustrated their household water situation. In the third visit, images selected in the second visit were shared with peers in focus group discussions (SM 3).

These methods were selected for their ability to provide both emic and etic perspectives of the lived experiences of water insecurity. The ‘cultural insider’ perspectives of water insecurity using photos that the participant chose to take allowed for both a richer understanding (visual, oral data) as well as the topics discussed to be set by the participant. The accompanied interviews and sorting, in contrast, allowed an external observer to probe on experiences of water access, use, and prioritisation that had been identified as important *a priori*, and/or were not spontaneously discussed by participants.

Data analysis

Interviews were transcribed and translated from Dholuo and/or Swahili into English, and three of the authors identified emergent and some *a priori* themes, and constructed an initial coding tree, which evolved iteratively until consensus was reached (SM 4). Interviews were inductively coded by two of

the authors following principles of Grounded Theory (Charmaz, 2014) using Dedoose (Sociocultural Research Consultants, LLC., Los Angeles, CA). In this manuscript, quotes are identified by data type (GA = Go-Along, PV = Photovoice, FGD = Focus Group Discussion), and self-reported HIV and reproductive status (e.g. pregnant, postpartum with age of child).

Tabulation of code frequencies was performed using Microsoft Excel (2009) (Microsoft Corp., Redmond, WA, USA). Salience is expressed using number of mentions (nm=) and number of participants (n=). Ranking exercises were photographed and entered into a frequency matrix in Excel; mean, mode, and standard deviation were calculated. Differences in experiences by HIV status were tabulated using chi-square, *t*-tests, and Fisher's exact tests in Stata 14.0 (StataCorp, College Station, TX, USA).

Ethical approval

All phases of this study were approved by institutional review boards at Cornell and Northwestern Universities and the scientific ethical review board at Kenya Medical Research Institute (KEMRI). Written consent was obtained from all participants.

Results

Overall, we found that women were responsible for the majority of water-related household activities, and experienced the consequences of water insecurity through four distinct pathways: physical and psychosocial health, nutrition, and economic wellbeing. These experiences did not differ by HIV status.

Water acquisition, prioritisation and use

Water acquisition

Women were responsible for water acquisition, even in late pregnancy, and shortly after delivery. Many were obliged to walk over steep, rocky, or otherwise dangerous terrain, and wade in rivers and streams to acquire water. That the collection of water was 'women's work' was mentioned by 75% of participants.

No [your husband] cannot get water for you! [PV Kisumu, HIV-, lactating, child >6mo]

Carrying water was the most 'female' aspect of acquisition. Four women reported that their husbands assisted with water acquisition, although one noted that while her husband would draw water, he would not carry containers back to the household.

He doesn't want to fetch water or be seen by people fetching water. [PV Rongo, HIV-, pregnant]

Male partners were more likely to provide instrumental support (typically money) rather than direct labour contribution for household water. Women who received assistance from male partners said they did so rarely, and under special circumstances, such as illness, in late pregnancy, or in the days following delivery. One woman indicated that her partner fetched water in her last month of pregnancy, but that she resumed responsibility soon after delivery.

When households lacked sufficient water, or if women were unable to fetch water, social networks of family, friends, and neighbours were leveraged. This manifested in three distinct ways. First, 27.5% of the 40 women interviewed engaged in reciprocal borrowing and loaning with the intention that these relationships could be called upon later. Second, 15% of women indicated that friends, family members, and neighbours could be asked to deliver water to their homes in times of need. Finally, 10% of women reported that family members and neighbours brought them water unprompted when they were unable to fetch it themselves during pregnancy or in the postpartum recovery period.

I gave birth during dry season and I had to fetch water from a far place. My sisters-in-law would go and fetch water for me for washing, because when you have a little baby you wash all the time. [GA Nyahera, HIV-undisclosed, lactating, child >6mo]

While most community relations around water sharing were positive, there were reports of neighbours or landlords padlocking taps and interpersonal conflict at water points when individuals jumped the queue or took more than the perceived appropriate amount.

Sources

The quality of water sources varied among participants ($n = 40$) (Table 2). Over half of urban (60%) households and 40% of rural households used what would be considered by Joint Monitoring Programme to be improved sources (e.g. taps, protected dug wells) with a collection time less than 30 min roundtrip (UNICEF & World Health Organization, 2017). One-third of urban households (32%) and half of rural households (53.3%) relied on open sources. Unimproved sources were used by the smallest proportion of households in both urban (8%) and rural (6.7%) areas. None of the households accessed improved sources more than 30-minutes roundtrip from homes. Water sources fluctuated seasonally; in dry seasons, women travelled further to alternative sources, relied on water of worse quality, and purchased water.

Prioritisation and use

Women were responsible for the majority of water-intensive domestic chores (Table 3a). Men tended to fetch water only if it was needed for their own livelihoods; e.g. livestock, irrigation, construction, and washing cars. Watering livestock and irrigating crops were perceived to be the responsibility of male partners (Table 3c), though many women were tasked with these activities as well.

Women buffered other household members from experiences of water insecurity by prioritising water needs of others before themselves. For example, household stores were reallocated or reduced to ensure that male partners had enough water for bathing and drinking. When water was limited, women prioritised consumption (drinking water, taking medications, cooking) and hygiene (washing hands, bathing, washing clothes, and dishes) over other water-related activities (Table 3b).

[Your husband] can even use abusive words towards you if he needs water to bathe and can't get it. To avoid chaos, you give him drinking water to bathe. [FGD Migori]

Differences by HIV status

The only difference in water prioritisation by HIV status was the use of water for taking medications, which was more highly prioritised by HIV-infected women [mean (SD) 3.9 (3) vs 8.2 (3.4), $p = 0.01$] (data not shown). Beyond this, only food insecurity was mentioned more frequently by HIV-infected women (52.9% of HIV+ women vs. 9.5% of HIV- women; $p = 0.005$; SM 5).

Table 2. Primary water sources among women of mixed HIV status in Nyanza, Kenya, by quality of source^a.

Basic. Drinking water from improved source ^b , collection time less than 30 min roundtrip, %	52.5
Limited. Drinking water from improved source, collection time more than 30 min roundtrip, %	0
Unimproved. Drinking water from unprotected dug well or unprotected spring, %	7.5
No Service. Drinking water collected from open source, %	40.0

^aClassification developed using Joint Monitoring Programme guidelines for water quality (WHO/UNICEF Joint Water Supply and Sanitation Monitoring Programme et al., 2014); data not available on water microbial quality such that the categorisation 'safely managed' could not be applied.

^bImproved sources include piped water, public taps/standpipes, tubewells and boreholes, protected dug wells, protected springs, and rainwater

Table 3. Thematic sorting exercises with women indicated: (A) which household activities required the most water; (B) the prioritisation of water-intensive activities; and, (C) water-related household responsibilities by gender, among pregnant and lactating women in Nyanza, Kenya ($n = 20$).

Mode ^a	A. Quantities of water required for common household activities	Mode ^a	B. Prioritisation of water-intensive household activities	Score ^b	C. The gendered responsibility of water-intensive activities
1	Washing clothes	1	Drinking	1	Washing clothes
2	Watering livestock	1	Taking medications	1	Washing dishes
3	Watering garden	2	Cooking	1	Cooking
4	Smearing dung	4	Washing hands	1	Bathing child
4	Cooking	4	Washing dishes	1	Mopping
6	Washing dishes	5	Bathing self	0.9	Smearing dung
7	Bathing self	6	Bathing child	0.1	Bathing self
7	Mopping	7	Washing clothes	0	Drinking water
9	Bathing child	9	Watering livestock	0	Washing hands
10	Drinking	10	Brushing teeth	-0.1	Brushing teeth
11	Washing hands	11	Mopping	-0.7	Watering crops
12	Brushing teeth	12	Watering garden	-0.7	Taking medication
13	Taking medications	13	Smearing dung	-0.9	Watering livestock

^aModal ranks are reported.

^bScores for gendered responsibility were assigned by taking the mean score assigned across all pile sorts. Activities considered to be women’s responsibility were scored as ‘1’, men’s as ‘-1’, and shared activities as ‘0’.

Consequences of water insecurity

Our second goal was to explore consequences of water insecurity specific to the first 1,000 days. We conceptualised our findings heuristically into four pathways and found consequences for psychosocial and physical health, nutrition, and economic wellbeing (Figure 1).

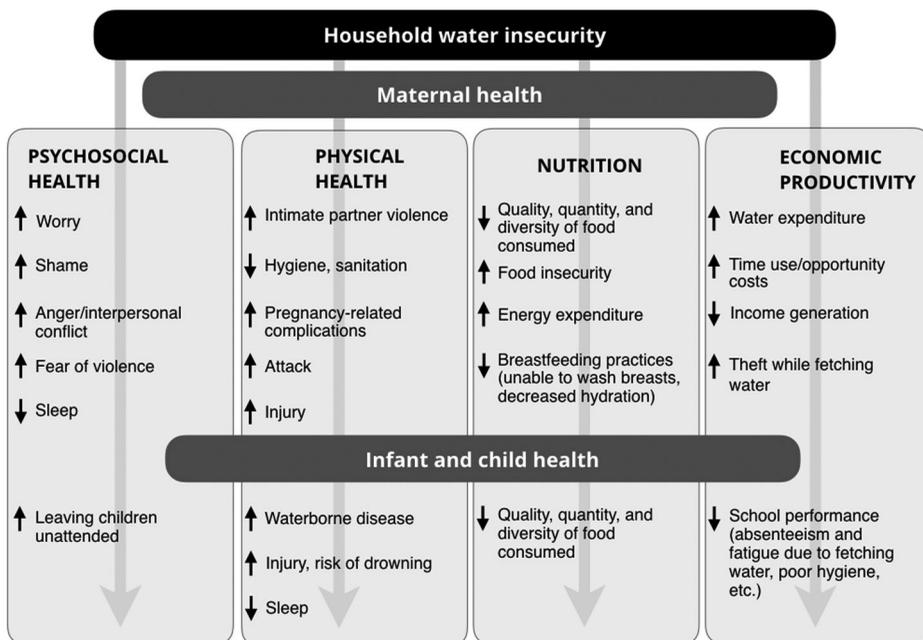


Figure 1. Perceived consequences of water insecurity in the first 1,000 days among women in western Kenya by domain; ordered by decreasing salience.

Psychosocial health

Psychosocial consequences of water insecurity included anxiety, worry, shame, anger, and fear. These themes were pervasive in almost all interviews and encompassed water quality and insufficiency, concerns for children and household members, interpersonal conflict, interrupted sleep, and fears of harm (SM 5, Figure 1).

Many of these experiences extended across the maternal-child dyad; women worried about themselves, and their children, falling into sources or drowning in rivers and streams during water acquisition.

Look at the surroundings [of the well], it is very bushy, anything can get in. A small girl is fetching water, what if she falls in? [FGD Rongo]

Women felt ashamed when they were unable to maintain hygiene of household members or provide water as a gesture of hospitality.

You may get visitors asking for drinking water, you will tell them you don't have it and they will ask themselves what kind of life you lead if you do not even have drinking water. [GA Migori, HIV+, lactating, child <6mo]

Water acquisition was stressful; women became restless and frustrated when they were forced to wait for water. This sometimes resulted in interpersonal conflict and violence.

The mental burden of planning and organizing where, when, and how to acquire water kept women awake at night. To avoid queues and get water before sources were depleted, women woke up at irregular hours and walked to sources, especially during dry seasons. This carried additional risks of physical and sexual violence.

When you are sleeping, you are thinking of how you will fetch water. You wake up early to fetch water, even at three in the morning. [GA Nyahera, HIV- undisclosed, lactating, child >6mo]

Physical health

Physical consequences of water insecurity included gender-based violence, compromised hygiene and sanitation, pregnancy complications, and attacks by animals and individuals. Infants and children had an increased risk of contracting waterborne diseases, risked injury and drowning while fetching water, and lost sleep (SM 5, Figure 1).

Almost half of the women interviewed ($n = 18$) experienced intimate partner violence (e.g. verbal or physical abuse) as a result of insufficient water. Water was tied to ascribed household roles and feelings of worth.

When my husband comes home, he wants to bathe, he will ask why there is no water and I tell him that I went and found a long queue ... You will quarrel, and the man will ask you what your importance is to the family if you cannot fetch water. [GA Nyahera, HIV-, lactating, child >6mo]

Fears of intimate partner violence shaped intra-household water allocation to favour male partners and resulted in women making difficult tradeoffs, such as providing drinking water for male partners to bathe or forgoing water entirely.

Breastfeeding women faced the additional challenge of having insufficient water to wash breasts and felt unclean if breastmilk leaked through clothing.

When I am breastfeeding I need to be clean, I need to take care of myself so I can take care of my child. [GA Nyahera, HIV-, lactating, child >6mo]

Insufficient water resulted in children sleeping without being bathed, which was worse for infants, who needed to be bathed and changed multiple times throughout the day. This led to child distress and sleeplessness, skin infections, rashes, and illness.

Fetching water was physically taxing and contributed to back, abdomen, and chest pain, breathlessness, and fatigue. Women frequently slipped and fell, resulting in injury, and also had an

increased risk of animal attacks (e.g. snakes and crocodiles). The physical burden of water acquisition was understood by many women to be a precipitating cause of pregnancy complications.

I think the cause of her miscarriage is the hustle she went through to get water. [GA Macalder, HIV+, pregnant]

Nutrition

Nutrition consequences of water insecurity included consumption of fewer, poorer quality foods, lower dietary diversity, and greater food insecurity. This was coupled with increased energy expenditure associated with water acquisition (SM 5, [Figure 1](#)).

In dry seasons, households were sometimes forced to purchase water, which caused a shortage of money to purchase food, especially high-quality, nutrient-rich foods.

Sometimes I buy just one jerrycan of water and I use the remaining money for food. If I don't have money, I forget about food. [GA Migori, HIV+, lactating, child >6mo (27)]

Even when food was available, women were sometimes unable to prepare it the way they wanted because of insufficient water. Water-intensive foods were prepared in smaller amounts or replaced with other foods.

Economic consequences

Economic consequences of water insecurity included increased water expenditures, time and opportunity costs, decreased income generation, theft while fetching water, and interference with school performance (SM 5, [Figure 1](#)).

Many households engaged in water purchasing. Situations that prompted water purchasing included fatigue, illness, pregnancy, contamination of regular water source, and as a way to avoid queues. The cost of water increased in dry seasons. Women also purchased water if they were unable to acquire it themselves, especially immediately after delivery.

You are forced to use money that otherwise you would have used to buy something else. You give first priority to water. [GA Migori, HIV+, lactating, child <6mo]

Water acquisition precluded women from engaging in income-generating activities, posed time and opportunity costs, and hampered water-related livelihoods. Further, 32.5% indicated that their livelihoods were interrupted by water fetching, while 10% engaged in occupations that required water (e.g. hair dressing, selling vegetables).

Instead of going to work, you go looking for water [GA Rongo, HIV+ pregnant (006)]

Other economic consequences of water insecurity included theft of animals and other household possessions while individuals were fetching water.

Discussion

Taken together, these experiences of water acquisition, prioritisation, and use indicate that water insecurity is particularly burdensome to women and their infants in the first 1,000 days of life. Further, these data suggest that the consequences of water insecurity occur across four distinct, but overlapping pathways: psychosocial and physical health, nutrition, and economic wellbeing ([Figure 1](#)).

Water acquisition, prioritisation and use

Acquisition

Our work further supports the unmistakably female burden of household water acquisition and use identified elsewhere (Caruso, Sevilimedu, Fung, Patkar, & Baker, 2015; Geere et al., 2010; Hadley &

Wutich, 2009; Stevenson et al., 2012; Workman & Ureksoy, 2017). Our findings add to this literature by indicating that even during one of the most vulnerable stages in the life course (i.e. the first 1,000 days) deeply entrenched gender norms surrounding the physically and emotionally taxing activities necessary for water acquisition are reinforced by both men and women. That in some instances men fetched water if it served their own livelihoods or occasionally helped their partners indicates that the gendered nature of water acquisition may be malleable; though this was never made explicit.

Prioritisation

Women managed multiple competing demands to ensure that water was distributed in accordance with male partner's expectations and family members' needs. This often meant that women's needs were met last, which has been seen in Bolivia (Wutich, 2009). It also alludes to maternal buffering against consequences of water insecurity, which has been seen in mother-child pairs with regard to food insecurity in the Amazon (Piperata, Schmeer, Hadley, & Ritchie-Ewing, 2013). Future work should explore maternal water insecurity coping strategies and differences in intra-household experiences of water insecurity.

Use

Two-thirds of participants used water from unprotected or open sources (Table 2). Many women reported increased demand for water in the first 1,000 days, both for hygiene and for breastfeeding and preparation of complementary foods, which to our knowledge has not been reported.

HIV-infected women more frequently prioritised water for medications. This is an expected finding, given that the clinics where women were recruited provide comprehensive, HIV-focused care and prioritise adherence. While intuitive, this finding has not, to our knowledge, been discussed. There were no mentions of social exclusion at water sources because of HIV status, as in Ethiopia (WaterAid Ethiopia, 2006). That food insecurity was mentioned more frequently by HIV-infected women may indicate that HIV worsens experiences of food and water insecurity, as in Lesotho (Workman & Ureksoy, 2017).

Consequences of water insecurity

For our second objective, outlining the consequences of water insecurity unique to the first 1,000 days, we identified four pathways: psychosocial and physical health, nutrition, and economic well-being (Figure 1). These pathways, first observed among Kenyan women in the first 1,000 days using exploratory survey data (Krumdieck et al., 2016), were further supported in our in-depth qualitative exploration amongst other individuals.

Psychosocial consequences

Anxiety about water (quantity and quality) was one of the most salient themes (SM 5, Figure 1) and has been discussed elsewhere, including in sub-Saharan Africa (Stevenson et al., 2012; Workman & Ureksoy, 2017) and Latin America (Coêlho, Adair, & Mocellin, 2004; Wutich & Ragsdale, 2008). Concern for physical safety, including fear of sexual violence while fetching water, has been reported in eastern Congo (Kirchner, 2007) and briefly in rural Ethiopia (Stevenson et al., 2012), but to our knowledge is not well-documented elsewhere. Animal attacks during acquisition have been reported in Uganda (Mugumya, Asaba, Royal Kanya, & Asingwire, 2017) and Australia (Sinton & Byard, 2016). Beyond this, reported concerns included injury and drowning (Geere et al., 2010; Mugumya et al., 2017; Prüss-Ustün et al., 2014).

Discussions of water sharing were generally positive; however, community stability was occasionally jeopardised by water insecurity. Similar to findings in Bolivia, women queued for hours at crowded water sources, which sometimes led to verbal and physical violence when individuals jumped the line or took more than their perceived share (Wutich, 2009). An empirical exploration of the contribution of water insecurity to stress and depression would be informative.

Physical consequences

Water insecurity had numerous implications for physical health in the first 1,000 days (SM 5). First was the frequent and explicit connection between water insecurity and intimate partner violence, which has only been briefly discussed elsewhere, in Ethiopia (Stevenson et al., 2012). Second was the direct link between water insecurity and birth outcomes. Women attributed early delivery, still-birth, and miscarriage to water acquisition. Underlying much of this concern was the physical exertion that fetching and drawing water requires. While the impacts of physically demanding occupational labour on adverse pregnancy outcomes have been reported (Mozurkewich, Luke, Avni, & Wolf, 2000), to our knowledge, water acquisition has not been previously acknowledged as a precipitating cause of adverse birth outcomes. Other consequences have been observed elsewhere, and include poor hygiene in Mexico (Ennis McMillan, 2001), sleep disruptions in Ethiopia (Stevenson et al., 2012), interrupted breastfeeding in Bolivia (Rosinger, 2015), and increased risk of waterborne diseases (Figure 1, SM 5). Future studies should quantify the physical burden of water acquisition, determine its impacts on health, particularly in the maternal-fetal dyad, and outline the physical consequences of water insecurity beyond infectious disease.

Nutrition consequences

Water insecurity limited the amount of food purchased, and the quality, quantity, and diversity of food prepared and consumed, as in Lesotho (Workman & Ureksoy, 2017). In several cases, women reported making the difficult trade-off between buying food or water due to lack of resources to purchase both, which been discussed in the Philippines (Mason, 2014).

Water acquisition leaves less time for food preparation, and creates energy and nutrient deficits; these relationships merit further inquiry. Quantification of the caloric costs of water acquisition would also be informative.

Participants remarked on the role of water availability on the quality of children's diet. To our knowledge, this is the first direct exploration of water insecurity and infant and young child feeding beyond associations with maternal hydration (Rosinger, 2015). Future research should explore these relationships.

Economic consequences

Women were often faced with choosing between income-generating activities and water acquisition, as in Bolivia (Wutich, 2009). Improved water infrastructure in Pakistan (Ilahi & Grimard, 2000) increased women's engagement with income-generating activities, and allowed for more leisure time in Morocco (Devoto, Duflo, Dupas, Parienté, & Pons, 2012). It would be interesting to evaluate the cost-effectiveness and subsequent benefits for health and wellbeing of such interventions. It would also be useful to evaluate if women's workload changes seasonally when more water is available and if water security affects the types of occupations they are able to engage in.

Many households indicated that while water was a consistent household expenditure, the purchasing of water was conditional on maternal illness and fatigue, pregnancy and the immediate postpartum period, as a mechanism to avoid queuing, and if the regular source was contaminated. Future work should seek to quantify the number of water sources households rely upon and explore when and why households choose to diversify sources.

While this study had many strengths, there were also some shortcomings. Most prominently, we are unable to report on how the severity of water insecurity experiences, measured quantitatively, influenced the consequences across these pathways. However, a validated scale to measure water insecurity in this population, which was being developed in tandem with the work presented here, is now complete (Boateng et al., 2018), thus permitting such comparisons in the future.

Second, this research was collected during the harvest season; research during a rainy season may have yielded findings on rainwater catchment and experiences with flooding. Conversely, similar efforts during a dry season may have linked more explicitly to diversification of water sources, increased water costs, and coping with limited household water supplies. However, findings from

this foray have yielded a first framework for understanding water insecurity experiences in the first 1,000 days, which can be the basis for future longitudinal exploration of these relationships.

Finally, our results are drawn from the responses of pregnant and lactating women who were purposively selected; therefore, the experiences reported are not generalisable to the larger population. However, we used multiple and participatory qualitative methods in five catchment areas, such that we have captured a diversity of experiences whose salience indicate the transferability of our findings.

Conclusion

Water insecurity in western Kenya is acute in the first 1,000 days and has far-reaching and unexpected consequences to women and their infants. In light of these data, we encourage researchers and programme managers to consider the consequences of water insecurity well beyond the standard focus of water, sanitation, and hygiene (WASH), and instead consider how water insecurity can impact psychosocial and physical health, and nutrition and economic well-being among other vulnerable populations (Figure 1). When these domains are concurrently investigated in other settings, we anticipate that similarly unexpected findings will emerge.

From a policy point-of-view, we have shown here that water insecurity has truly multi-sectoral consequences, spanning concerns about health and nutritional status, as well as economic and psychosocial well-being. The interconnected nature of these phenomena will be both a challenge and an opportunity to explore if interventions can have synergistic effects.

Unpacking mechanisms employed to cope with the consequences of water insecurity and exploring maternal buffering behaviours are clear next steps. Beyond this, there are clear indications that water insecurity may contribute to stress and depression, and these could be evaluated using biomarkers. Further, the consequences of water insecurity for infant feeding and child development should also be explored, given that water insecurity shows promise as a modifiable determinant of health disparities.

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ORCID

Patrick Mbullo Owuor  <http://orcid.org/0000-0002-4550-2667>

Joshua D. Miller  <http://orcid.org/0000-0002-2171-856X>

Godfred O. Boateng  <http://orcid.org/0000-0001-5898-6966>

Pauline Wekesa  <http://orcid.org/0000-0003-4591-6402>

Sera L. Young  <http://orcid.org/0000-0002-1763-1218>

References

- Aihara, Y., Shrestha, S., Kazama, F., & Nishida, K. (2015). Validation of household water insecurity scale in urban Nepal. *Water Policy*, 17(6), 1019–1032. doi:10.2166/wp.2015.116.
- Baguma, D., Hashim, J. H., Aljunid, S. M., & Loiskandl, W. (2013). Safe-water shortages, gender perspectives, and related challenges in developing countries: The case of Uganda. *Science of The Total Environment*, 442, 96–102. doi:10.1016/j.scitotenv.2012.10.004
- Bentley, G. R. (1998). Hydration as a limiting factor in lactation. *American Journal of Human Biology*, 10(2), 151–161. doi:10.1002/(SICI)1520-6300(1998)10:2<151::AID-AJHB2>3.0.CO;2-O
- Boateng, G. O., Collins, S. M., Mbullo, P., Wekesa, P., Onono, M., Neilands, T. B., & Young, S. L. (2018). A novel household water insecurity scale: Procedures and psychometric analysis among postpartum women in western Kenya. *PLoS ONE*, 13(6), e0198591. Retrieved from <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0198591#abstract0>
- Caruso, B. A., Sevilimedu, V., Fung, I. C.-H., Patkar, A., & Baker, K. K. (2015). Gender disparities in water, sanitation, and global health. *Lancet*, 386(9994), 650–651. doi:10.1016/S0140-6736(15)61497-0
- Charmaz, K. (2014). *Constructing grounded theory*. Thousand Oaks, California: SAGE. Retrieved from https://books.google.com/books/about/Constructing_Grounded_Theory.html?id=v_GGAWAAQBAJ.
- Cheng, J. J., Schuster-Wallace, C. J., Watt, S., Newbold, B. K., & Mente, A. (2012). An ecological quantification of the relationships between water, sanitation and infant, child, and maternal mortality. *Environmental Health*, 11(1), doi:10.1186/1476-069X-11-4
- Coêlho, A., Adair, J. G., & Mocellin, J. (2004). Psychological responses to drought in northeastern Brazil. *Interamerican Journal of Psychology*, 38(1), 95–103.
- Cook, C., & Bakker, K. (2012). Water security: Debating an emerging paradigm. *Global Environmental Change*, 22(1), 94–102. doi:10.1016/j.gloenvcha.2011.10.011
- Department of Defense. (2014). 2014 *Climate Change Adaptation Roadmap* (pp. 1–20). Retrieved from: https://www.acq.osd.mil/eie/downloads/CCARprint_wForward_e.pdf.
- Devoto, F., Duflo, E., Dupas, P., Parienté, W., & Pons, V. (2012). Happiness on tap: Piped water adoption in urban Moroco. *American Economic Journal: Economic Policy*, 4(4), 68–99. doi:10.3386/w16933
- El Didi, H., & Corbera, E. (2017). A moral economy of water: Charity wells in Egypt's Nile delta. *Development and Change*, 48(1), 121–145. doi:10.1111/dech.12286
- Ennis McMillan, M. C. (2001). Suffering from water: Social origins of bodily distress in a Mexican community. *Medical Anthropology Quarterly*, 15(3), 368–390. doi:10.1525/maq.2001.15.3.368
- Geere, J.-A. L., Hunter, P. R., & Jagals, P. (2010). Domestic water carrying and its implications for health: A review and mixed methods pilot study in Limpopo Province, South Africa. *Environmental Health*, 9(1), 52–13. doi:10.1186/1476-069X-9-52
- Gjerde, J. L., Rortveit, G., Muleta, M., Adefris, M., & Blystad, A. (2017). Living with pelvic organ prolapse: Voices of women from Amhara region, Ethiopia. *International Urogynecology Journal*, 28(3), 361–366. doi:10.1007/s00192-016-3077-6
- Grimes, J. E. T., Croll, D., Harrison, W. E., Utzinger, J., Freeman, M. C., & Templeton, M. R. (2014). The relationship between water, sanitation and schistosomiasis: A systematic review and meta-analysis. *PLoS Neglected Tropical Diseases*, 8(12), e3296. Retrieved from <https://journals.plos.org/plosntds/article?id=10.1371/journal.pntd.0003296>
- Hadley, C., & Wutich, A. (2009). Experience-based measures of food and water security: Biocultural approaches to grounded measures of insecurity. *Human Organization*, 68(4), 451–460. doi:10.17730/humo.68.4.932w421317680w5x
- Harris, L., Kleiber, D., Goldin, J., Darkwah, A., & Morinville, C. (2017). Intersections of gender and water: Comparative approaches to everyday gendered negotiations of water access in underserved areas of Accra, Ghana and Cape Town, South Africa. *Journal of Gender Studies*, 26(5), 561–582. doi:10.1080/09589236.2016.1150819
- Hoddinott, J., Maluccio, J., Behrman, J. R., Martorell, R., Melgar, P., Quisumbing, A. R., ... Yount, K. M. (2011). *The consequences of early childhood growth failure over the life course*, (pp. 1–48). Retrieved from <https://core.ac.uk/download/pdf/6314946.pdf>.
- Ilahi, N., & Grimard, F. (2000). Public infrastructure and private costs: Water supply and time allocation of women in rural Pakistan. *Economic Development and Cultural Change*, 49(1), 45–75. doi:10.1086/452490
- Jepson, W. (2014). Measuring no-win waterscapes: Experience-based scales and classification approaches to assess household water security in colonias on the US-Mexico border. *Geoforum; Journal of Physical, Human, and Regional Geosciences*, 51(C), 107–120. doi:10.1016/j.geoforum.2013.10.002
- Jepson, W. E., Wutich, A., Collins, S. M., Boateng, G. O., & Young, S. L. (2017). Progress in household water insecurity metrics: A cross-disciplinary approach. *WIREs Water*, 4(3), e1214–e1221. doi:10.1002/wat2.1214

- Kirchner, S. (2007). Hell on earth-systematic rape in Eastern Congo. *The Journal of Humanitarian Assistance*. Retrieved from <https://sites.tufts.edu/jha/archives/50>.
- Krumdieck, N., Collins, S., Wekesa, P., Mbullo, P., Boateng, G., Onono, M., & Young, S. L. (2016). Household water insecurity is associated with a range of negative consequences among pregnant Kenyan women of mixed HIV status. *Journal of Water and Health*, 14(6), 1028–1031
- Kusenbach, M. (2003). Street phenomenology: The Go-along as ethnographic research tool. *Ethnography*, 4(3), 455–485. doi:10.1177/146613810343007
- Lesho, E. P., & Gey, D. C. (2003). Managing issues related to antiretroviral therapy. *American Family Physician*, 68(4), 675–686.
- Loewenberg, S. (2014). Breaking the cycle: Drought and hunger in Kenya. *Lancet*, 383(9922), 1025–1028. doi:10.1016/s0140-6736(14)60492-x
- Mason, L. R. (2014). Examining relationships between household resources and water security in an Urban Philippine community. *Journal of the Society for Social Work and Research*, 5(4), 489–512. doi:10.1086/678923
- Mozurkewich, E. L., Luke, B., Avni, M., & Wolf, F. M. (2000). Working conditions and adverse pregnancy outcome: A meta-analysis. *Obstetrics and Gynecology*, 95(4), 623–635. doi:10.1016/s0029-7844(99)00598-0
- Mugumya, F., Asaba, R. B., Royal Kamya, I., & Asingwire, N. (2017). *Child maltreatment: Children and domestic water collecting in Uganda: Exploring policy and intervention options that promote child protection* (pp. 95–112). New York, NY: Springer.
- National AIDS & STI Control Programme. (2016). *Kenya HIV county profiles*. Retrieved from <http://nacc.or.ke/wp-content/uploads/2016/12/Kenya-HIV-County-Profiles-2016.pdf>.
- Ngwenya, B. N., & Kgathi, D. L. (2006). HIV/AIDS and access to water: A case study of home-based care in Ngamiland, Botswana. *Physics and Chemistry of the Earth, Parts A/B/C*, 31(15), 669–680. doi:10.1016/j.pce.2006.08.041
- O'Reilly, C. E., Freeman, M. C., Ravani, M., Migele, J., Mwaki, A., Ayalo, M., ... Quick, R. (2008). The impact of a school-based safe water and hygiene programme on knowledge and practices of students and their parents: Nyanza Province, Western Kenya, 2006. *Epidemiology and Infection*, 136(1), 80–91. doi:10.1017/S0950268807008060
- Pelto, G. (1987). Cultural issues in maternal and child health and nutrition. *Social Science and Medicine*, 25(6), 553–559. doi:10.1016/0277-9536(87)90079-7
- Piperata, B. A., Schmeer, K. K., Hadley, C., & Ritchie-Ewing, G. (2013). Dietary inequalities of mother–child pairs in the rural Amazon: Evidence of maternal-child buffering? *Social Science & Medicine*, 96, 183–191. doi:10.1016/j.socscimed.2013.07.024
- Prüss-Ustün, A., Bartram, J., Clasen, T., Colford, J. M., Cumming, O., Curtis, V., ... Cairncross, S. (2014). Burden of disease from inadequate water, sanitation and hygiene in low- and middle-income settings: A retrospective analysis of data from 145 countries. *Tropical Medicine & International Health*, 19(8), 894–905. doi:10.1111/tmi.12329
- Rasmussen, K. M., & Yaktine, A. L. (2009). *Weight gain during pregnancy: Reexamining the guidelines*. Washington, DC: The National Academies Press. doi:10.17226/12584
- Ray, I. (2007). Women, water, and development. *Annual Review of Environment and Resources*, 32(1), 421–449. doi:10.1146/annurev.energy.32.041806.143704
- Rosinger, A. (2015). Dehydration among lactating mothers in the Amazon: A neglected problem. *American Journal of Human Biology*, 27(4), 576–578. doi:10.1002/ajhb.22672
- Schmidlin, T., Hürlimann, E., Silué, K. D., Yapi, R. B., Hounbedji, C., Kouadio, B. A., ... Raso, G. (2013). Effects of hygiene and defecation behavior on helminths and intestinal protozoa infections in Taabo, Côte d'Ivoire. *PLoS ONE*, 8(6), e65722. doi:10.1371/journal.pone.0065722
- Sinton, T. J., & Byard, R. W. (2016). Pathological features of fatal crocodile attacks in Northern Australia, 2005–2014. *Journal of Forensic Sciences*, 61(6), 1553–1555. doi:10.1111/1556-4029.13171
- Soma-Pillay, P., Nelson-Piercy, C., Tolppanen, H., & Mebazaa, A. (2016). Physiological changes in pregnancy. *Cardiovascular Journal of Africa*, 27(2), 89–94. doi:10.5830/CVJA-2016-021
- Stevenson, E. G. J., Greene, L. E., Maes, K. C., Ambelu, A., Tesfaye, Y. A., Rheingans, R., & Hadley, C. (2012). Water insecurity in 3 dimensions: An anthropological perspective on water and women's psychosocial distress in Ethiopia. *Social Science & Medicine* (1982), 75(2), 392–400. doi:10.1016/j.socscimed.2012.03.022
- Sultana, F. (2009). Fluid lives: Subjectivities, gender and water in rural Bangladesh. *Gender, Place & Culture*, 16(4), 427–444. doi:10.1080/09663690903003942
- UNICEF, & World Health Organization. (2017). *Progress on drinking water, sanitation and hygiene: 2017 update and SDG baselines*. Retrieved from https://www.unicef.org/publications/files/Progress_on_Drinking_Water_Sanitation_and_Hygiene_2017.pdf.
- Wang, C., & Burris, M. A. (1997). Photovoice: Concept, methodology, and use for participatory needs assessment. *Health Education Behavior*, 24(3), 369–387. doi:10.1177/109019819702400309
- WaterAid Ethiopia. (2006). Equal Access for all? Meeting the needs for water and sanitation of people living with HIV/AIDS, 1–5. Retrieved from: https://wedc-knowledge.lboro.ac.uk/resources/conference/33/Tesfu_M.pdf.

- WaterAid, & SafAIDS. (2014). *Integrated approach to HIV and water, sanitation and hygiene in Southern Africa: A gap and needs assessment* (pp. 1–50). <http://catalogue.safaid.net/sites/default/files/publications/Integrated-approach-to-HIV-and-water-sanitation-and-hygiene-in-Southern-Africa.pdf>.
- Weiser, S. D., Young, S. L., Cohen, C. R., Kuschel, M. B., Tsai, A. C., Tien, P. C., ... Bangsberg, D. R. (2011). Conceptual framework for understanding the bidirectional links between food insecurity and HIV/AIDS. *The American Journal of Clinical Nutrition*, 94(6), 1729S–1739S. doi:10.3945/ajcn.111.012070
- WHO/UNICEF Joint Water Supply and Sanitation Monitoring Programme, World Health Organization, & UNICEF. (2014). *Progress on Drinking Water and Sanitation: 2014 Update*.
- Widen, E. M., & Gallagher, D. (2014). Body composition changes in pregnancy: Measurement, predictors and outcomes. *European Journal of Clinical Nutrition*, 68(6), 643–652. doi:10.1038/ejcn.2014.40
- Workman, C. L., & Ureksoy, H. (2017). Water insecurity in a syndemic context: Understanding the psycho-emotional stress of water insecurity in Lesotho, Africa. *Social Science & Medicine*, 179, 52–60. doi:10.1016/j.socscimed.2017.02.026
- Wutich, A. (2009). Intrahousehold disparities in women and men's experiences of water insecurity and emotional distress in urban Bolivia. *Medical Anthropology Quarterly*, 23(4), 436–454. doi:10.1111/j.1548-1387.2009.01072.x
- Wutich, A. (2011). The moral economy of water reexamined: Reciprocity, water insecurity, and Urban survival in Cochabamba, Bolivia. *Journal of Anthropological Research*, 67(1), 5–26. doi:10.3998/jar.0521004.0067.102
- Wutich, A., & Ragsdale, K. (2008). Water insecurity and emotional distress: Coping with supply, access, and seasonal variability of water in a Bolivian squatter settlement. *Social Science & Medicine* (1982), 67(12), 2116–2125. doi:10.1016/j.socscimed.2008.09.042
- Yallow, W. W., Terefe, M. W., Herchline, T. E., Sharma, H. R., Bitew, B. D., Kifle, M. W., ... Adane, M. M. (2012). Assessment of water, sanitation, and hygiene practice and associated factors among people living with HIV/AIDS home based care services in Gondar city, Ethiopia. *BMC Public Health*, 12(1), 1057. doi:10.1186/1471-2458-12-1057