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Household Water and Food Insecurity Are Positively Associated with Poor Mental and Physical Health among Adults Living with HIV in Western Kenya

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ABSTRACT

Background: Household food insecurity (FI) and water insecurity (WI) are prevalent public health issues that can co-occur. Few studies have concurrently assessed their associations with health outcomes, particularly among people living with HIV.

Objectives: We aimed to investigate the associations between FI and WI and how they relate to physical and mental health.

Methods: Food-insecure adult smallholder farmers living with HIV in western Kenya were recruited to participate in a cluster-randomized controlled trial of a multisectoral agricultural and asset loan intervention. We used baseline data on experiences of FI (using the Household Food Insecurity Access Scale, range: 0–27) and WI (using a modified scale developed for this region, range: 0–51) in the prior month ($n = 716$). Outcomes included probable depression (using the Hopkins Symptom Checklist), fatigue and diarrhea in the prior month, and overall mental and physical health (using the Medical Outcomes Study HIV Health Survey, range: 0–100). We first assessed Pearson correlations between FI, WI, and sociodemographic characteristics. We then developed 3 regressions for each health outcome (control variables and FI; control variables and WI; control variables, FI, and WI) and compared model fit indexes.

Results: Correlations between household FI, WI, and wealth were low, meaning they measure distinct constructs. FI and WI were associated with numerous physical and mental health outcomes; accounting for both resource insecurities typically provided the best model fit. For instance, when controlling for FI, each 10-point higher WI score was associated with a 6.42-point lower physical health score ($P < 0.001$) and 2.92 times greater odds of probable depression ($P < 0.001$).

Conclusions: Assessing both FI and WI is important for correctly estimating their relation with health outcomes. Interventions that address food- and water-related issues among persons living with HIV concurrently will likely be more effective at improving health than those addressing a single resource insecurity. This trial was registered at clinicaltrials.gov as NCT02815579. *J Nutr* 2021;151:1656–1664.

Keywords: diarrhea, fatigue, mental and physical health, probable depression, resource insecurity

Introduction

Food and water are critical resources that are becoming increasingly scarce or difficult to access owing to climate and population change, conflict, and inequitable resource distribution (1–3). After decades of decline, the prevalence of world hunger (i.e., the proportion of the population whose energy intake is insufficient to maintain a healthy lifestyle) has remained stagnant at nearly 9% since 2015 (4). World hunger is expected to increase further owing to food supply disruptions and financial instability caused by the COVID-19 pandemic (5). Meanwhile, an estimated 4 billion individuals experience severe water scarcity for ≥1 mo of the year (6), a condition that is projected to become more acute and widespread (7).

The global food and water crises are distinct, but interconnected, forms of resource insecurities (8). Food and water

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are both used for consumption to maintain physiological homeostasis (9), as well as numerous social and spiritual practices (10, 11). Water diverges from food in that it also has essential roles in nonconsumptive everyday practices such as bathing and personal hygiene, myriad household chores, and income-generating activities. In addition, water is necessary for food production (i.e., fisheries, crops, and livestock) and food preparation (e.g., cooking starchy staples, washing produce), such that water insecurity may be a driver of food insecurity, especially in smallholder farming communities (12–14). Yet the preponderance of the scholarship to date has only considered the consequences of single resource insecurities, namely food insecurity.

Household food insecurity, or the inability to reliably access sufficient quantities of nutritious foods, is a well-defined construct that has been extensively researched over previous decades (15, 16). Given the importance of food insecurity for economic and foreign policy decisions, as well as the strong relations between food insecurity and diverse health outcomes, including subjective well-being (15), depression (17), and HIV transmission and progression (18), the UN FAO has monitored food insecurity through individual surveys globally since 2014. In contrast, household water insecurity, or the inability to reliably access and benefit from adequate water (i.e., appropriate quantities of water of sufficient quality for all household uses) (19), has received considerably less attention, even though it is likely a significant determinant of health and can cause food insecurity (11, 12, 20, 21). The paucity of empirical research on household water insecurity is due, in part, to divergent definitions of water insecurity, the conflation of water availability with water access and use, and a dearth of household- and individual-level metrics (8, 19). In the past decade, 1 global (22) and several site-specific scales (e.g., 23–25) have been developed and validated to quantify household water insecurity (which includes aspects of water availability, accessibility, quality, stability, and use), thereby expanding our ability to quantify this complex phenomenon and understand its relation with health outcomes.

There is increasing recognition that the concurrent investigation of multiple insecurities is imperative for understanding how resource insecurities may interact to negatively affect well-being, and for identifying the most salient barriers to good health (8, 14, 26–28). It is has been theorized that problems with water limit an individual's ability to meet social norms or fulfill personal needs, thereby causing stress and feelings of shame that may contribute to poor mental health (11). Further, water insecurity may limit the ability of households to prepare nutritious foods that are foundational for good health (12). Water-insecure households are also more likely to collect water from an off-premises source, which can increase the risk of physical injury or assault (29). But only a few studies have empirically examined both food and water insecurity using validated instruments, and fewer still have jointly considered their consequences for well-being.

The handful of studies that have examined food and water insecurity concurrently have primarily quantified their impact on mental health outcomes. For example, work in Ethiopia and Lesotho found that food and water insecurity were associated with greater psychosocial distress (23, 30), and a longitudinal study among mothers in western Kenya found a syndemic relation between food insecurity, water insecurity, and HIV on probable depression (21). In Haiti, household water insecurity was both directly associated with greater anxiety and depression, and indirectly associated through its relation with household food insecurity (31). In addition, a study in India found that individual food and water insecurity experiences varied within households and had differential associations with mental health outcomes (32). Taken together, these studies suggest that examination of both food and water insecurity provides critical insights into the underlying causes of psychosocial distress.

To our knowledge, only 1 study has examined food and water insecurity in relation to physical health. Among Tsimane' children, food and water insecurity, when considered jointly, were found to be positively associated with odds of hypohydration (33). Although previous studies have found food insecurity and limited water access to be associated with elevated blood pressure (34) and greater risk of experiencing the dual burden of under- and overnutrition (35), they provide limited evidence because they did not consider other critical components of water insecurity, i.e., water accessibility, reliability, and use (19, 36).

To date, only 2 studies have examined food and water insecurity jointly in the context of HIV, and these investigated mental health outcomes only (21, 30). This relationship is important to consider because HIV can exacerbate a range of resource insecurities, and those living with HIV may experience the consequences of food and water insecurity differently or more acutely (18, 37). For example, people with compromised immune systems are more vulnerable to waterborne diseases at lower pathogen concentrations (38). These diseases can lead to enteric dysfunction and diarrhea, which in turn cause severe dehydration and limit nutrient uptake (39, 40). Additional food and water are also needed to swallow and absorb HIV medicines, as well as counteract side effects of antiretroviral therapy (41–44). Food and water insecurity thus present considerable barriers to antiretroviral therapy adherence and may ultimately lead to worse health outcomes, including higher viral loads and greater risk of opportunistic infections (41, 45, 46).

We therefore sought to investigate the relations between food and water insecurity and individual-level well-being among persons living with HIV in western Kenya. We concurrently examined the relations between food and water insecurity and multiple indicators of mental and physical well-being in the context of HIV. Our first aim was to understand the relation between household food and water insecurity. We hypothesized that the correlation between food and water insecurity would

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Supplemental Tables 1 and 2 are available from the "Supplementary data" link in the online posting of the article and from the same link in the online table of contents at https://academic.oup.com/jn/.
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Abbreviations used: AUC, area under the receiver operating characteristic curve; FI, food insecurity; HFIAS, Household Food Insecurity Access Scale; WI, water insecurity.

be low, consistent with them being distinct constructs. Our second aim was to quantify the relation between food and water insecurity and a range of physical and mental health outcomes. We hypothesized that both food and water insecurity would be positively associated with adverse physical and mental health outcomes.

Methods

Study design and setting

Data were drawn from *Shamba Maisha* (NCT02815579), a cluster-randomized controlled trial of a multisectoral agricultural and asset loan intervention in Homa Bay, Kisumu, and Migori counties, which are in the former Nyanza region of Kenya. Individuals were eligible for participation if they were living with HIV, were aged 18–60 y, screened positive for moderate or severe food insecurity [using the Household Food Insecurity Access Scale (HFIAS) (47)] or had a BMI (in kg/m^2) <18.5 based on medical records from the prior year, had available farmland and access to surface water, and were patients at 1 of 16 participating HIV-care facilities.

Many households in the study region lack access to improved or clean drinking water sources (48). Intra-annual rainfall variability also shapes water availability, such that many must travel longer distances to fetch sufficient water during the dry season (49). Food insecurity is also prevalent and varies across seasons; in 2014, this region had the highest proportion of households with suboptimal food consumption scores in the country (48). This setting was thus an appropriate area to test our hypotheses given the co-occurrence of food and water insecurity.

Ethical approval

All study procedures were approved by the Human Research Protection Program at the University of California, San Francisco and the Scientific and Ethics Review Unit at the Kenya Medical Research Institute. All participants in the study provided written informed consent before enrollment. Participants were reimbursed ≤800 Kenyan shillings (~$8 USD) for their transportation to each clinic-based interview and given 400 Kenyan shillings (~$4 USD) for home-based interviews.

Data collection

Baseline data were collected at 1 home visit and 1 clinic visit between June 2016 and December 2017 by local research assistants who administered surveys in each participant's preferred language (Dholuo, Swahili, or English). All nonlaboratory study measures were collected using Open Data Kit (ODK) software installed on password-protected tablets. At baseline, 1127 individuals were screened and 720 were enrolled into *Shamba Maisha*. Of those enrolled, 83.0% were moderately to severely food insecure, 16.6% were food insecure and had a low BMI, and 0.4% had a low BMI without being food insecure. The sample for these analyses was restricted to individuals with complete data for calculating food and water insecurity scores ($n = 716$). Included individuals had, in general, good HIV control; 73.9% of participants had suppressed viral loads (<40 copies/mL) and 96.0% had high CD4 counts (>200) at baseline.

Sociodemographic data

Sociodemographic data including participant age, educational attainment, and marital status were collected at baseline. Household wealth was derived from a principal component analysis of dwelling characteristics (e.g., roof materials, sanitation facilities) and self-reported asset ownership using methods from the Kenya Demographic and Health Survey (50). A small value was added to household wealth scores and the natural log was then taken to reduce positive skew.

Household food insecurity

Household food insecurity in the prior month was measured using the 9-item HFIAS (47), a cross-culturally validated tool that has been used in similar HIV-affected populations (51). Each item has 4 response options (never = 0, rarely = 1, sometimes = 2, often = 3) that are summed together (range: 0–27). Higher scores indicate greater household food insecurity in the prior month. Cronbach's α for the HFIAS (0.81) suggested high internal consistency, meaning the composite scale items were closely related.

Household water insecurity

Water insecurity in the prior month was measured using a modified version of a household water insecurity scale that was developed and validated for this region (24). Although only 17 items from the original 20-item scale were collected at baseline (items related to feeling angry about one's water situation, missing meetings owing to water insufficiency, and missing meetings owing to lack of water for bathing had not yet been developed), the modified water insecurity scale captured multiple components of water insecurity, including availability, access, and use. Each item has 4 response options (never = 0, rarely = 1, sometimes = 2, often/always = 3) that are summed together (range: 0–51). Higher scores indicate greater water insecurity. Cronbach's α for the modified water insecurity scale (0.89) suggested high internal consistency.

Health and well-being outcomes

Mental and physical health summary scores (range: 0–100) were created using the 35-item Medical Outcomes Study HIV Health Survey (52), which has been validated for use in low-resource settings in sub-Saharan Africa (53). Summary scores captured a diverse range of experiences. The mental health survey probed about feelings of anxiety and ability to focus on critical tasks, whereas the physical health survey asked about illnesses and activities that were limited owing to health problems. Mental and physical health summary scores were developed using a 2-factor analysis and single imputation was used for missing items (5 individuals were missing 1 item, 1 person was missing 2 items). Higher scores indicate better mental and physical health in the prior month.

Probable depression was screened for using the Hopkins Symptom Checklist (54), which has been validated for use in sub-Saharan Africa (55). Depression scores were calculated by taking the mean of the responses to each of the 15 items (range: 1–4). We used single imputation for 26 individuals who were missing data on just 1 item. Individuals with depression scores ≥1.75 were classified as having probable depression (54). Finally, individuals reported to clinicians whether they had experienced "fatigue or loss of energy" or "diarrhea or loose bowel movements" in the prior month.

Statistical analysis

Analyses were completed using Stata 14.0 (StataCorp). We used descriptive statistics (Wilcoxon's rank-sum test, *t* test, Pearson's chi-square test) to characterize the study population. To achieve our first aim, we assessed Pearson correlations between household food insecurity, water insecurity, and sociodemographic characteristics; a low correlation coefficient is indicative of distinct constructs (56). We also examined differences in household food and water insecurity by respondent sex. Variables that were associated with food or water insecurity at $P < 0.2$ were included as control variables in all subsequent models. Month of interview was also included in all models as a proxy for seasonal factors (e.g., rainfall, harvest schedules) that influence food and water availability.

For our second aim, we developed 3 multivariable linear or logistic regressions for each outcome, using the clustered sandwich estimator to account for clustering at the facility level. The first was a model with control variables and food insecurity; the second, a model with control variables and water insecurity; the third, a model with control variables and both food and water insecurity. We compared fit across each set of models for continuous variables using adjusted R^2 (i.e., the proportion of the variance in the outcome explained by the independent variables) and root mean square error. For dichotomous outcomes, we examined fit based on the area under the receiver operating characteristic curve (AUC; i.e., the probability that the model correctly classifies the outcome). We also considered potential multiplicative

TABLE 1 Household- and individual-level characteristics of *Shamba Maisha* participants at baseline, by sex of respondent[1]

	Men ($n = 321$)	Women ($n = 395$)	P
Household size[2]	5 [4–7]	5 [3–6]	0.001
Household wealth[3]	1.4 ± 0.5	1.4 ± 0.5	0.597
Household water insecurity score (0–51)	6.1 ± 7.6	5.8 ± 6.6	0.517
Household food insecurity score (0–27)	12.1 ± 4.3	12.9 ± 4.1	0.009
Age[2]	42 [37–48]	38 [31–45]	<0.001
Education of respondent			<0.001
None or some primary	102 (31.8)	201 (50.9)	
Primary school	100 (31.2)	115 (29.1)	
Secondary school or higher	119 (37.1)	79 (20.0)	
Married	287 (89.4)	231 (58.5)	<0.001
Mental health summary score (0–100)	62.4 ± 16.3	58.5 ± 16.1	0.001
Probable depression[4]	96 (30.0)[5]	179 (45.3)	<0.001
Physical health summary score (0–100)	81.9 ± 12.6	75.9 ± 17.5	<0.001
Fatigue in prior month	88 (27.4)	160 (40.7)[6]	<0.001
Diarrhea in prior month	18 (5.6)	21 (5.3)[6]	0.877

[1] $n = 716$. Values are n (%) for categorical variables and mean ± SD for continuous variables, except for household size and age, which are median [IQR].
[2] Wilcoxon's rank-sum test was used to compare medians between men and women.
[3] Household wealth was derived from a principal component analysis of self-reported asset ownership (range: 0.10–2.60).
[4] Probable depression was defined as a mean depression score ≥1.75.
[5] Missing 1 observation owing to nonresponse.
[6] Missing 2 observations owing to nonresponse.

interactions between food and water insecurity, although the interaction terms were not significant for any outcome (**Supplemental Tables 1, 2**). We considered a 2-sided $P < 0.05$ to be statistically significant.

Results

Sociodemographic characteristics

Slightly more participants were women than men (55.2%). Men and women had similar household wealth and water insecurity scores but differed across most other characteristics (**Table 1**). For instance, a greater proportion of men than women were married (89.4% compared with 58.5%, $P < 0.001$) and attended secondary school or higher (37.1% compared with 20.0%, $P < 0.001$).

Pearson correlations between independent variables of interest

Water insecurity had a small positive association with food insecurity ($r = 0.26$; $P < 0.001$) (**Table 2**). Wealth was negatively associated with food and water insecurity. Both household size and respondent age were also associated with food and water insecurity. As such, household size and respondent age were included as control variables, along with respondent sex (Table 1), in subsequent models.

Physical health

Food and water insecurity were separately associated with worse physical health summary scores (**Table 3**, Models 1 and 2). When considered jointly, water insecurity, but not food insecurity, was negatively associated with physical health summary scores (β: −0.64; 95% CI: −0.89, −0.39; $P < 0.001$) and model fit was similar to that with water insecurity only (Table 3, Model 3). In addition, greater food and water insecurity, both when considered separately and jointly, were associated with greater odds of experiencing fatigue in the prior month (Table 3, Models 4–6). Model fit was best when both food and water insecurity were included. Finally, when considered separately, water insecurity, but not food insecurity, was associated with higher odds of experiencing diarrhea in the prior month (aOR: 1.05; 95% CI: 1.00, 1.10; $P < 0.05$) (Table 3, Models 7 and 8). Accounting for both food and water insecurity (Table 3, Model 9) did not improve model fit compared with the model only controlling for water insecurity (Table 3, Model 8).

Mental health

Greater food and water insecurity were both associated with lower mental health summary scores and higher odds of probable depression across all models when considered separately or jointly (**Table 4**). For instance, when considered jointly, each 1-point higher food insecurity score was associated with a 0.47-point lower mental health summary score (95% CI: −0.82, −0.13; $P = 0.010$) and each 1-point higher water insecurity score was associated with a 0.64-point lower mental health summary score (95% CI: −0.94, −0.33; $P < 0.001$) (Table 4, Model 12). Models that accounted for both food and

TABLE 2 Pearson correlation coefficients between respondent characteristics and resource insecurities[1]

	Household size	Respondent age	Wealth index	Food insecurity	Water insecurity
Household size	1.00				
Respondent age	0.18***	1.00			
Wealth index	0.03	0.03	1.00		
Food insecurity	0.11**	0.10**	−0.16***	1.00	
Water insecurity	0.07	0.11**	−0.10**	0.26***	1.00

[1] $n = 716$. ** $P < 0.01$, *** $P < 0.001$.

TABLE 3 Multivariable linear regressions of physical health summary score on sociodemographic characteristics and resource insecurities (Models 1–3), as well as logistic regressions of fatigue and diarrhea in the prior month on living conditions and resource insecurities (Models 4–6 and 7–9, respectively)[1]

Physical health summary score (0–100)			
Model	Model 1	Model 2	Model 3
Female respondent	−6.31 (−9.90, −2.72)**	−6.71 (−9.87, −3.54)***	−6.64 (−9.91, −3.37)**
Respondent age	−0.17 (−0.32, −0.02)*	−0.15 (−0.29, 0.00)*	−0.15 (−0.29, 0.00)
Household size	0.14 (−0.22, 0.51)	0.18 (−0.19, 0.55)	0.19 (−0.20, 0.57)
Wealth	0.32 (−3.86, 4.49)	−0.36 (−3.48, 2.77)	−0.43 (−3.67, 2.80)
Food insecurity (0–27)	−0.33 (−0.66, −0.01)*	—	−0.06 (−0.34, 0.24)
Water insecurity (0–51)	—	−0.65 (−0.89, −0.41)***	−0.64 (−0.89, −0.39)***
n	696	696	696
Adjusted R^2	0.06	0.13	0.13
RMSE	15.33	14.71	14.72
Fatigue in the prior month			
Model	Model 4	Model 5	Model 6
Female respondent	1.84 (1.31, 2.59)***	1.98 (1.42, 2.77)***	1.88 (1.34, 2.64)***
Respondent age	1.00 (0.98, 1.02)	1.00 (0.99, 1.02)	1.00 (0.98, 1.02)
Household size	1.01 (0.97, 1.05)	1.02 (0.98, 1.06)	1.01 (0.97, 1.05)
Wealth	0.97 (0.65, 1.44)	0.93 (0.63, 1.37)	1.00 (0.67, 1.48)
Food insecurity (0–27)	1.07 (1.02, 1.12)**	—	1.06 (1.01, 1.10)*
Water insecurity (0–51)	—	1.04 (1.01, 1.06)**	1.03 (1.00, 1.05)*
n	695	695	695
AUC	0.65	0.64	0.66
Diarrhea in the prior month			
Model	Model 7	Model 8	Model 9
Female respondent	0.93 (0.51, 1.71)	0.98 (0.54, 1.78)	0.97 (0.53, 1.79)
Respondent age	0.99 (0.97, 1.01)	0.98 (0.97, 1.00)	0.98 (0.96, 1.00)
Household size	1.04 (0.87, 1.25)	1.04 (0.87, 1.25)	1.04 (0.86, 1.26)
Wealth	0.70 (0.35, 1.37)	0.71 (0.40, 1.25)	0.72 (0.37, 1.40)
Food insecurity (0–27)	1.04 (0.93, 1.15)	—	1.01 (0.91, 1.12)
Water insecurity (0–51)	—	1.05 (1.00, 1.10)*	1.05 (1.00, 1.10)*
n	695	695	695
AUC	0.64	0.66	0.66

[1]Values are β-coefficients (95% CIs) for continuous outcomes (Models 1–3) and adjusted ORs (95% CIs) for binary outcomes (Models 4–9). All models account for clustering at the facility level and control for month of interview. AUCs for logistic regressions only. *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$. AUC, area under the receiver operating characteristic curve; RMSE, root mean square error.

water insecurity had best model fit, although the difference between the model with food and water insecurity and that with only water insecurity was small. For example, the adjusted R^2 increased from 0.14 to 0.15 when adding food insecurity to the model of mental health summary score with only water insecurity (Table 4, Models 11 and 12) and the AUC increased from 0.69 to 0.75 when water insecurity was added to the model of probable depression with only food insecurity (Table 4, Models 13 and 15).

Discussion

In this concurrent assessment of food and water insecurity, we have demonstrated how intersecting household-level resource insecurities are mentally and physically embodied among individuals living with HIV. Specifically, to our first hypothesis, household food insecurity, water insecurity, and wealth were weakly associated (Table 2). This is consistent with the understanding that each construct is distinct (11, 57) and complements prior work demonstrating that food insecurity, as well as other resource insecurities, can result from poverty but may also exist independently of it (16, 27, 58).

To our second hypothesis, food and water insecurity were associated with a range of adverse physical health outcomes. Specifically, greater food and water insecurity were associated with lower physical health summary scores and higher odds of experiencing fatigue (Table 3, Models 1–6). Greater water insecurity, but not food insecurity, was associated with higher odds of experiencing diarrhea in the prior month (Table 3, Model 8).

This concurrent consideration of both food and water insecurity on physical health outcomes extends previous research that has demonstrated that each of these resource insecurities independently undermines well-being (59–63). For example, with regard to fatigue, food insecurity has previously been shown to be associated with restricted energy intake and micronutrient deficiencies (64), which in turn can cause feelings of lethargy. Water insecurity may operate through similar biological mechanisms (e.g., dehydration, limiting nutrient absorption) (9, 65). Further, coping strategies associated with water insecurity, such as changing sleep schedules and traveling longer distances to acquire preferred water (37, 66), may also exacerbate feelings of fatigue. This is particularly salient given that fatigue is the most common complaint reported by individuals living with HIV (67).

TABLE 4 Multivariable linear regressions of mental health summary score on sociodemographic characteristics and resource insecurities (Models 10–12), as well as multivariable logistic regressions of probable depression on sociodemographic characteristics and resource insecurities (Models 13–15)[1]

Mental health summary score (0–100)			
Model	Model 10	Model 11	Model 12
Female respondent	−3.26 (−5.73, −0.78)*	−4.15 (−6.30, −1.99)**	−3.58 (−5.71, −1.45)**
Respondent age	0.04 (−0.13, 0.21)	0.05 (−0.11, 0.20)	0.07 (−0.09, 0.23)
Household size	−0.12 (−0.64, 0.40)	−0.15 (−0.66, 0.37)	−0.07 (−0.56, 0.41)
Wealth	3.88 (0.18, 7.58)*	3.79 (0.38, 7.20)*	3.14 (−0.16, 6.43)*
Food insecurity (0–27)	−0.75 (−1.16, −0.34)**	—	−0.47 (−0.82, −0.13)*
Water insecurity (0–51)	—	−0.71 (−1.01, −0.40)***	−0.64 (−0.94, −0.33)***
n	696	696	696
Adjusted R^2	0.08	0.14	0.15
RMSE	15.59	15.10	15.00
Probable depression			
Model	Model 13	Model 14	Model 15
Female respondent	1.91 (1.34, 2.72)***	2.36 (1.76, 3.17)***	2.16 (1.55, 3.02)***
Respondent age	1.00 (0.98, 1.02)	1.00 (0.98, 1.02)	1.00 (0.98, 1.01)
Household size	1.00 (0.96, 1.04)	1.00 (0.95, 1.05)	0.99 (0.94, 1.04)
Wealth	0.91 (0.51, 1.62)	0.90 (0.50, 1.61)	1.04 (0.59, 1.83)
Food insecurity (0–27)	1.14 (1.09, 1.20)***	—	1.11 (1.06, 1.16)***
Water insecurity (0–51)	—	1.13 (1.09, 1.17)***	1.11 (1.07, 1.15)***
n	696	696	696
AUC	0.69	0.73	0.75

[1] Values are β-coefficients (95% CIs) for continuous outcomes (Models 10–12) and adjusted ORs (95% CIs) for binary outcomes (Models 13–15). All models account for clustering at the facility level and control for month of interview. AUCs for logistic regressions only. *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$. AUC, area under the receiver operating characteristic curve; RMSE, root mean square error.

The positive association between water insecurity and diarrhea is similar to previous work among adults in rural Bolivia (68), as well as research in the Democratic Republic of Congo and Zambia (63). In contrast to our hypothesis, food insecurity was not associated with self-reported diarrhea in the previous month; this may in part be because food insecurity was an inclusion criterion for study enrollment, which means that its variation was restricted. Associations between food insecurity and diarrhea have previously been reported among Colombian children (69), and some food-insecure individuals report eating less preferred foods that may cause gastrointestinal distress (70).

Food and water insecurity were also associated with lower mental health summary scores and higher odds of probable depression, as hypothesized (Table 4). This finding aligns with studies in sub-Saharan Africa that found that both food and water insecurity, when considered concurrently, were associated with greater psychosocial distress (23, 30). It is also consistent with a study among pregnant and postpartum women in western Kenya that found that household water insecurity predicted future individual food insecurity, and that both were associated with greater maternal depressive symptomatology (21). This suggests that water insecurity may be a distal cause of poor health and that future studies should investigate the longitudinal relations between resource insecurities and poor health. We are unable to compare magnitudes of association across studies, however, because each used a different method for operationalizing resource insecurities and mental health outcomes. Given that depression has strongly and consistently been associated with lower antiretroviral therapy adherence and viral load suppression (71, 72), health practitioners should consider that individuals experiencing food and water insecurity may require additional support to ensure medication adherence.

These findings are relevant to global health policy because food and water insecurity have traditionally been treated as independent challenges to global health. Although there are separate Sustainable Development Goals for food and water, the goals make no explicit mention of their joint relations and overlap (73). As a result, most policies and programs are designed to reduce the burdens of either food or water insecurity, but not both. The data presented in this article, however, suggest that mitigating only 1 of these phenomena would leave another driver of adverse health in place. When water insecurity causes food insecurity, interventions to improve food security will not be maximally effective or sustainable if water insecurity persists. Further, if only water insecurity is addressed, a range of problems with food can remain in place, e.g., unavailability and unaffordability. Taken together, our findings support recent work that suggests that interventions that address food- and water-related issues concurrently will be most effective at improving physical and mental health (12, 14, 21, 28).

Data from our study also demonstrate that food and water insecurity are related but can exist independently of each other. Longitudinal data on household- and individual-level food and water insecurity are therefore needed to understand how these resource insecurities vary across time, as well as their causal relations with priority public health outcomes (26). Recently developed experience-based scales that comparably measure water insecurity across diverse settings (22, 74), similar to other cross-culturally validated food insecurity scales (47, 75), have expanded our ability to collect such critical data on water access and use relatively quickly and cheaply (36). Empirical data on the myriad relations between food and water insecurity can be used as evidence to demonstrate that scientific, funding, and political bodies should prioritize policies and interventions that address problems with food and water jointly (8, 14).

This work is also germane to interventions that aim to improve health outcomes among people living with HIV. Whereas

food insecurity has been a target of many HIV prevention and treatment programs (76, 77), few have addressed household water security, or even water for sanitation and hygiene more broadly (exceptions: 38, 41). To our knowledge, none have specifically addressed household food and water security jointly; such interventions could be quite powerful. Finally, in terms of analyzing the roles of resource insecurity, our findings demonstrate that accounting for both food and water insecurity in models of mental and physical health outcomes is important for ensuring that the influence of 1 resource insecurity is not over- or understated (32).

Strengths and limitations

This study is novel for its joint consideration of food and water insecurity in relation to physical and mental health. The generalizability of our findings, however, may be limited given the restrictive inclusion criteria (i.e., smallholder farmers living with HIV who are food insecure or have very low BMI). Furthermore, the restricted variability of food insecurity in the sample means that the magnitudes of associations of food and water insecurity are not comparable. As such, future studies should assess whether these relations exist in other populations. We used a water insecurity scale validated for the study setting (24) that was slightly modified by the exclusion of 3 items because the scale had not yet been finalized when data collection began. Future studies should consider using a cross-culturally validated water insecurity scale that would allow for comparability across location and time, such as the Household Water Insecurity Experiences Scale (22). Further, mental and physical health were measured by self-report and as such are subject to recall and social desirability bias. Use of biomarkers (e.g., cortisol as a measure of stress) would likely provide even stronger evidence of the deleterious role of resource insecurities and their physiological embodiment. Intervention studies could be useful for demonstrating causality and assessing whether improving food and water insecurity results in better mental and/or physical health.

Conclusions

Water insecurity is a resource insecurity that is distinct from poverty and food insecurity. Both water and food insecurity are associated with diverse adverse physical and mental health outcomes among people living with HIV, and most models explained the greatest variability in outcomes when including both food and water insecurity. Correspondingly, policies and programs that ameliorate both food and water insecurity among persons living with HIV may have the greatest impact in improving physical and mental health.

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