

Food Insecurity, Socioeconomic Status, and HIV-Related Risk Behavior Among Women in Farming Households in Tanzania

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Abstract Food insecurity (FI) is associated with higher-risk sexual behavior in some studies. However, the overlap between FI and socioeconomic status (SES) has been poorly described. The study objectives were to: (1) determine the relationship between household FI and four dimensions of SES among sexually active Tanzanian women in farming households: expenditures, assets, flooring material of the home, and land ownership; and (2) determine whether FI is associated with higher-risk sexual behavior and relationship power. In male-headed households, FI was associated with assets, flooring material, and land ownership but not expenditures. There was no association between FI and the four dimensions of SES in female-headed households. Among women in male-headed households, but not female household heads themselves, severe FI was associated with a non-significant increase in the likelihood of being in a relationship because of material goods [adjusted prevalence ratio (PR_a) = 1.76, 95 % confidence interval (CI) 0.81, 3.81] and was inversely associated with being able to ask partners to use condoms (PR_a = 0.47, 95 % CI 0.25, 0.88). There was

not a strong association between food security and relationship power. Our findings suggest that the association between FI and HIV risk behavior may differ depending on the type of household.

Keywords HIV prevention · Food security · Economic empowerment · Socioeconomic status · Women

Introduction

Women's economic empowerment is increasingly regarded as a promising approach to HIV prevention in Sub-Saharan Africa [1–3]. Economic empowerment is defined as having the tools (e.g., skills or capital) to advance economically and/or the agency to define and make choices to benefit from economic activities [4]. Indeed, a growing body of observational research suggests that when women are economically constrained, their ability to refuse sex, negotiate condom use, and leave risky relationships is compromised, heightening their susceptibility to HIV infection [3, 5, 6]. Further, economically insecure women may engage in high-risk sexual behavior to procure money, food, or other goods [6–10]. In addition to these observational data, experimental evidence supports the hypothesis that economic interventions can improve reproductive health [11–14].

Food insecurity (FI) in particular has emerged as a key dimension of economic insecurity that is associated with high-risk sexual behavior and undermines economic empowerment. People are considered food secure when they have adequate physical, social, and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life [15]. Food security encompasses dimensions of food

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availability, access, and utilization [16, 17]. Several studies have reported an association between FI and HIV-related risk behaviors, [7, 9, 18] including a study among women in Botswana and Swaziland that found that food insufficiency was associated with inconsistent condom use and exchange of sex for money or other goods [6]. Together, these studies support conceptual models hypothesizing that women may engage in high risk sexual behaviors, including transactional sex and unprotected sex, to mitigate the effects of FI [17, 19]. Likewise, these data also suggest that interventions to bolster food security could have downstream effects on sexual and reproductive health.

However, some ambiguity remains about whether FI is simply a proxy for poverty or whether it captures a unique construct that exerts independent effects on sexual risk behavior. Certainly, FI is highly correlated with socioeconomic position [20, 21]. However, FI at the individual level may be prevalent even in wealthier households due to unequal intra-household allocation of food, which, for example, can result in women eating last or having less access to fats, protein, or micronutrient-rich foods [22–24]. Further, a 2012 World Food Programme report highlighted that economic growth does not necessarily translate to enhanced household food access, and even when the poor have additional income, it is not always used to purchase more food or more nutrient-dense food [25]. In this way, FI and socioeconomic status (SES) are hypothesized to be overlapping but unique concepts with one not necessarily implying the other. Indeed, the effect of FI on sexual risk behavior persists in some studies after adjustment for SES [6, 18]. However, there are few empirical studies exploring both the joint distribution of FI and SES as well as the independent association between FI and women's risk behavior and empowerment; the goal of this study.

In Tanzania, both HIV and hunger are highly prevalent. The HIV epidemic is generalized (5.6 % in 2009 [26]) and the global hunger index (GHI) is 19.3, indicating serious levels of hunger [the average world GHI score is 14.7, and the highest score in 2012 was 37.1 (Burundi)] [27, 28]. Thus, Tanzania was an ideal setting for the current study. The first objective was to explore the relationship between FI and four aspects of SES among women living in smallholder farming households: household expenditures, assets, the flooring material of the home, and land ownership. Second, we examined whether FI was associated with sexual risk behavior and relationship power, a measure of gender-based imbalances in an intimate partnership and its effect on women's ability to negotiate safer sex [29].

Methods

We conducted a secondary analysis of data from the impact evaluation of Tanzania's National Agricultural Input Voucher

Scheme. The program, launched in 2009 by the Tanzanian Ministry of Agriculture, Food Security and Cooperatives (MAFC), aims to increase household incomes and bolster food security by distributing vouchers for a 50 % subsidy on a package of inputs (fertilizers and improved seeds) to maize and rice farmers. There is a specific emphasis on preferentially selecting female-headed households for the program. The quasi-experimental impact evaluation was conducted among 2,000 households and will evaluate the program's effects on fertilizer and seed use, agricultural productivity (maize or rice yield per hectare), profitability, and household health and welfare.

This analysis uses cross-sectional household data from the baseline survey, and is restricted to women who were in a sexual relationship in the past 12 months. Women self-identified as either heads of household themselves or as living in male-headed households.

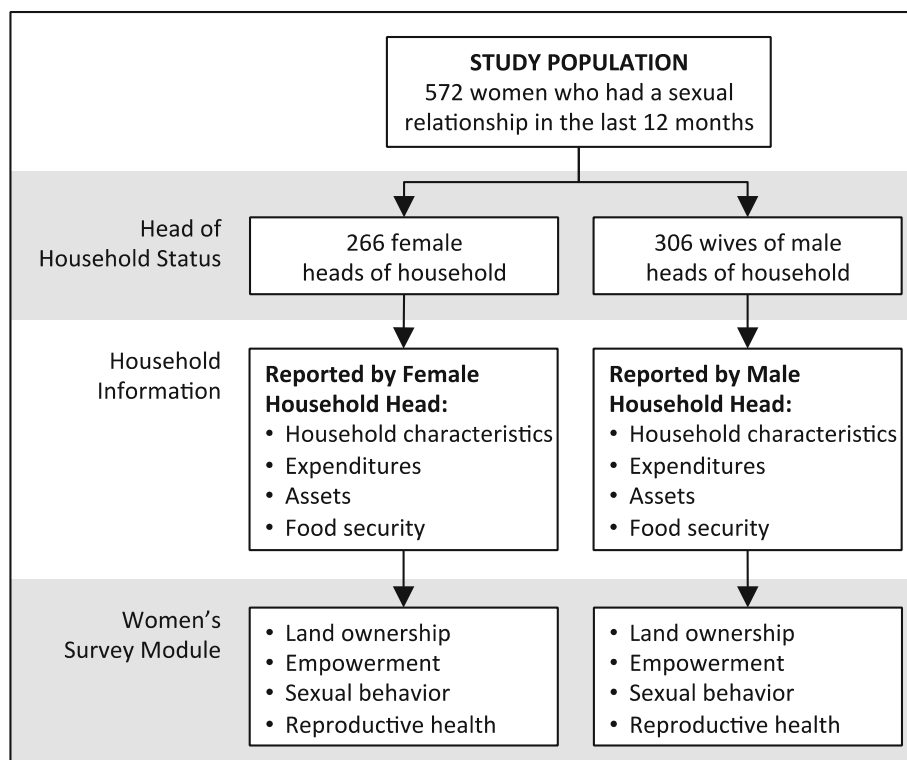
Study Population

The study was conducted between December 2010 and February 2011 in eight regions with the highest potential for maize production that were being targeted for the subsidy program: Ruvuma, Iringa, Rukwa, Mbeya, Morogoro, Kigoma, Arusha and Kilimanjaro. A multi-stage cluster sampling strategy was used to identify households for the survey. First, districts were weighted by the number of farming households and then one in four districts were randomly selected from each region (one district was sampled from all regions except from Iringa and Mbeya, where two were sampled). Wards were then randomly selected from each district and 200 villages (total) were randomly selected within the sampled wards. Within each village, a Village Voucher Committee (VVC) determined whether households were eligible to participate in the subsidy program based on eligibility criteria: ≤ 1 hectare of land, able to afford the top-up for the inputs, and preference given to female-headed households. VVC records were used to sample ten households for the evaluation, where half of the households were beneficiaries of the voucher program and half were eligible non-beneficiaries. In order to investigate gender-related impacts of the subsidy program, women were oversampled such that 50 % of the household survey sample in each village consisted of female-headed households.

Data Collection

Heads of household (male or female) were invited to participate in the impact evaluation. Those providing verbal consent completed a face-to-face interview about household characteristics, agricultural practices, expenditures,

Fig. 1 Collection of individual- and household-level data from women in the study sample. Female household heads reported all data used in the study, whereas women in male-headed households completed the women's survey module and the male heads of household reported household characteristics



household assets, and food security. Thus, household characteristics such as food security status and expenditures were reported by men in male-headed households and by women in female-headed households (Fig. 1). Additionally, a module assessing land ownership, empowerment, and sexual and reproductive health was designed to be administered to all female household heads and a convenience sample of the wives or female partners of male household heads (one wife or female partner was instructed to be interviewed from the sample of five male-headed households in each village). In the final sample, 96.7 % of the 306 women living in male-headed households who were interviewed for the study self-identified as being married or in an informal union.

Outcome Assessment

Recognizing that SES is multidimensional construct, we selected four indicators that were related to income and wealth for the analysis [30]. Monthly per capita expenditures in Tanzanian shillings (TZS) was computed from reported expenditures on food and transportation in the last 4 weeks and on non-food household items, education, and medical expenses in the last 12 months. Expenditure data is often preferred to income data as income is sometimes difficult for the respondent to assess due to multiple income sources that may vary seasonally [31]. A household asset index was created using a principal component analysis

(PCA) with a polychoric correlation matrix based on ownership of the following household assets: radio, telephone, video/DVD, sofa, motorcycle, bicycle, wheelbarrow, hoes, spraying machine, plough, and livestock [32]. PCA is a multivariable statistical technique used to reduce a set of correlated variables into fewer dimensions, and avoids the assumptions inherent with a simple summation of assets; namely, that all assets are of equal value [33, 34]. The first principal component was used as the asset index [33]. Both monthly per capita expenditures and the asset index were divided into quartiles for the analysis. The flooring material of the home was directly observed by the interviewer and classified into: (1) earth, mud, or straw; (2) concrete; or (3) other. Women's land ownership was reported by women directly and classified as owning land alone, owning land jointly with someone else, and not owning land [which included landed households where the woman did not own land (84 %) as well as landless households (16 %)].

We considered three outcomes as indicators of sexual risk behavior and empowerment: (1) whether a woman entered into or stayed in a relationship longer than desired because of material goods; (2) whether a woman could ask her partner to use a condom; and (3) sexual relationship power defined by the sexual relationship power scale (SRPS) [29, 35]. To determine whether women entered into or stayed in relationships longer than desired because of material goods, women were specifically asked the

following question regarding each of her last three sexual partners: “Did you enter (or stay) into a relationship with this partner because he provided you with or you expected that he would provide you with gifts or other material goods?” Women who answered affirmatively for any of their last three sexual partners were classified as having entered into or stayed in the relationship because of material goods. Because the exchange of goods for sex has been reported to be widely accepted in non-marital relationships in some areas of Tanzania, [36, 37] we selected the *initiation* or *continuation* of a sexual relationship for economic gain as the best measure of the underlying motivation for the relationship, and to help distinguish transactional sex from exchanges of material goods that occurred because of care-taking or affection [38].

We asked women who were currently in a sexual relationship whether they could ask their partner to use a condom if they wanted him to (yes/no). Relationship power was assessed among women with a main or regular sexual partner in the past 12 months with a 16-item version of the SRPS, originally validated for use in U.S. populations, [29] and adapted for use in Malawi [35]. The adapted scale includes four subscales with four questions each: autonomy, communication, love and trust, and relationship dominance. A 4-point Likert scale was used to measure responses to each of 16 indicators (e.g., “my partner/husband and I sit down and discuss important matters together”: 1 = strongly agree, 2 = agree, 3 = disagree, 4 = strongly disagree), with some indicators being reverse-coded. Higher scores indicate higher sexual relationship power. An overall score was computed by adding together the mean scores for each subscale and dividing the total by the number of subscales (4); the final score was rescaled to range from 1 to 4 [35]. Cronbach’s alpha indicated that the scale was internally consistent ($\alpha = 0.78$). No more than 3 % of data were missing for each of the three outcome variables.

Exposure Definitions

Household food security was determined from the responses to a subset of questions from the Household Food Insecurity Access Scale (HFIAS) [39]. Due to interview time constraints, we selected three questions for inclusion, one from each of the three different domains of FI included in the HFIAS: (1) anxiety and uncertainty about household food supply; (2) insufficient quality, including food variety and preferences; and (3) insufficient food intake and its physical consequences [39, 40]. This strategy also reduced redundancy in the HFIAS. Heads of household (male or female, depending on household type) were asked how often, in the last 4 weeks, they worried that their household would not have enough food (which

measures anxiety and uncertainty), how often they were not able to eat preferred foods because of lack of resources (which measures insufficient quality), and whether anyone in the household went to bed hungry (which measures insufficient food intake). Based on the distribution of these responses, consideration of the recommendations for categorizing responses to the full HFIAS, and examination of the coding of other FI scales [41], we determined an algorithm to classify households in the sample into three mutually exclusive groups: food secure, some FI, and severe FI. Severe FI was defined as a household experiencing at least one household member going to bed hungry (even if infrequently or rarely) or “often” worrying (more than ten times in the last month) about food access or food quality. Households were classified as having some FI if they “sometimes” (three to ten times in the last month) worried about food access or food quality. Food secure households experienced either none of the FI conditions or they only rarely worried about food access or food quality.

Covariates

The following covariates, in addition to the aforementioned indicators for per capita expenditures, assets, flooring material, and land ownership, were included in the analysis: age (years), sex of household head (which was also an indicator of who reported household characteristics), whether an adult male (≥ 18 years) was present in the household, marital status, whether the woman currently has a regular sexual partner, highest educational level of the woman, household size, ownership of main dwelling, total land owned by the household (acres), and whether anyone in the household was ever a beneficiary of the subsidy program. We hypothesized that these covariates, which are likely to have temporally preceded the exposure and outcomes, may be associated with both FI and sexual risk behavior and/or relationship power. They were therefore considered for inclusion in multivariable models as potential confounders. No more than 1 % of any covariate was missing.

Statistical Analysis

We first performed basic descriptive analyses, including a comparison of baseline characteristics stratified by sex of the household head and food security status. To determine the extent to which FI and SES are distinct indicators, we then examined the joint distribution of FI and four dimensions of SES: monthly per capita expenditures, assets, flooring material, and land ownership. We hypothesized that if food security lies in the causal pathway between SES and sexual risk behavior, or is conceptually

the same as socio-economic position, we would expect a strong correlation between food security and increasing levels of per capita expenditures, assets, higher quality flooring materials (concrete), and land ownership. We present the Pearson's Chi square (χ^2) statistic or Fisher's exact test for the null hypothesis of no association for each comparison. In addition, for the comparisons between food security and per capita expenditures and assets, we also present the Cochran Mantel–Haenszel χ^2 , which tests the null hypothesis of no association versus a linear association when both variables are ordinally scaled [42].

To determine whether FI was associated with entering into or staying in a relationship because of material goods and/or the inability to negotiate the use of condoms, we constructed two Poisson regression models. In these models, with cross-sectional data, the exponentiated parameter estimates represent prevalence ratios (PR), a conservative and more interpretable measure of association than the odds ratio, especially when the outcome is common [43–45]. We present PRs and 95 % confidence intervals (CIs). To determine the association between FI and sexual relationship power, we used ordinary least squares (OLS) linear regression with SRPS as the linear dependent variable. For this model, we present the parameter estimates (representing the change in SRPS associated with a unit change in the level of food security) and standard errors.

The analyses for both objectives were stratified by the sex of the head of household, as we hypothesized that the relationships between FI and sexual risk behavior and relationship power may be strongest for women who were themselves heads of household. For the multivariable analyses, we assessed confounding by examining the change in effect estimates when each covariate was added to the model containing food security as the only predictor variable; confounding was defined as a ≥ 10 % change in parameter estimate. The fully adjusted models included all confounders in addition to covariates strongly associated with the outcomes or those determined a priori for inclusion (e.g., age, education, marital status). We checked for multicollinearity between FI and other covariates in fully adjusted models; indicators with variance inflation factors >10 were excluded from the final models [46]. All models include robust standard errors to account for clustering within villages [47, 48]. The analysis was conducted with STATA statistical software (v.12, College Station, TX, USA).

Human Subjects Protection

This secondary data analysis was reviewed by the University of California, Berkeley Committee for Protection of Human Subjects.

Results

Characteristics of the Study Population

Overall, 572 women who reported being in a sexual relationship in the last 12 months were included in the analysis; 266 (47 %) were heads of household and 306 (53 %) were living in male-headed households (Table 1). The average age was 37 years, and 53 % of women in female-headed households and 97 % of women in male-headed households reported that they were married or in an informal union. In general, households headed by women were worse off than male-headed households based on several dimensions of SES. Female-headed households had lower monthly per capita expenditures, less land (3.9 vs. 5.0 acres), and were less likely to be included in the highest asset index category (15 vs. 34 %) than male-headed households. In addition, female headed households were less likely to own their dwelling (81 vs. 92 %) and more likely to have homes with earth, mud, or straw floors compared to male-headed households (74 vs. 66 %).

One hundred eighty-five (32 %) households reported any FI; 86 (15 %) had some FI and 99 (17 %) were severely food insecure. Female-headed households were not more likely to be food insecure than male-headed households (33 vs. 31 %). However, food security status differed by relationship status, whereby women living in households that were severely food insecure were less likely to currently be in a sexual relationship with a regular partner compared to women living in food secure households (83 vs. 94 %). In addition, compared to women living in food secure households, women living in severely food insecure households were more likely to have no education (20 vs. 11 %) and were more likely to own their dwellings (97 vs. 85 %), which were more often constructed with an earth, mud or straw floor (86 vs. 64 %). Further, severely food insecure households had more members and less land than food secure households.

Sexual Behavior and Relationship Power

Overall, 86 (15.5 %) women reported that they entered into or stayed in at least one of the last three sexual relationships longer than desired because of material goods. This was significantly different by household type, whereby female heads of household were almost twice as likely to report entering into or staying in a relationship because of material goods compared to women in male-headed households (11 vs. 21 %). Of the 522 women currently in a sexual relationship with a regular partner, 253 (49 %) could ask their partner to use a condom if she wanted him to do so, but there was significant variability by household type with female heads of household more likely to be able

Table 1 Characteristics of 572 women included in the study population, stratified by sex of the household head and food security status, Tanzania, 2010

Characteristic	Total		Household status				Food security status in the last 30 days					
			Female headed		Male headed		Food secure		Some FI ^a		Severe FI ^b	
	<i>N</i>	(%)	<i>N</i>	(%)	<i>N</i>	(%)	<i>N</i>	(%)	<i>N</i>	(%)	<i>N</i>	(%)
Total	572	(100)	266	(100)	306	(100)	387	(100)	86	(100)	99	(100)
Age (mean, SD)	37.4	(11.7)	37.8	(11.6)	37.1	(11.7)	36.7	(11.5)	38.7	(11.7)	39.4	(12.3)
Age category												
≤30 years	178	(31.1)	74	(27.8)	104	(34.0)	131	(33.9)	23	(26.7)	24	(24.2)
31–40 years	208	(36.4)	105	(39.5)	103	(33.7)	132	(34.1)	33	(38.4)	43	(43.4)
41–50 years	119	(20.8)	56	(21.1)	63	(20.6)	86	(22.2)	17	(19.8)	16	(16.2)
>50 years	67	(11.7)	31	(11.7)	36	(11.8)	38	(9.8)	13	(15.1)	16	(16.2)
Female headed household	266	(46.5)	–	–	–	–	177	(45.7)	49	(57.0)	40	(40.4)
Marital status												
Married	331	(57.9)	90	(33.8)	241	(78.8)	220	(56.8)	46	(53.5)	65	(65.7)
Informal union	107	(18.7)	52	(19.6)	55	(18.0)	83	(21.4)	13	(15.1)	11	(11.1)
Widow	29	(5.1)	28	(10.5)	1	(0.3)	17	(4.4)	5	(5.8)	7	(7.1)
Divorced or separated	61	(10.7)	56	(21.1)	5	(1.6)	32	(8.3)	17	(19.8)	12	(12.1)
Never married	44	(7.7)	40	(15.0)	4	(1.3)	35	(9.0)	5	(5.8)	4	(4.0)
Currently in a sexual relationship with a regular partner	522	(91.3)	237	(89.1)	285	(93.1)	364	(94.1)	76	(88.4)	82	(82.8)
Education												
No education	72	(12.6)	33	(12.4)	39	(12.8)	42	(10.9)	10	(11.6)	20	(20.2)
Less than primary school	65	(11.4)	36	(13.5)	29	(9.5)	39	(10.1)	10	(11.6)	16	(16.2)
Completed primary school (Standard 7)	390	(68.3)	176	(66.2)	214	(70.2)	266	(68.9)	63	(73.3)	61	(61.6)
More than primary school	44	(7.7)	21	(7.9)	23	(7.5)	39	(10.1)	3	(3.5)	2	(2.0)
Household owns main dwelling	496	(86.7)	216	(81.2)	280	(91.5)	327	(84.5)	73	(84.9)	96	(97.0)
Floor of main dwelling												
Earth, mud, straw	399	(69.8)	198	(74.4)	201	(65.7)	248	(64.1)	66	(76.7)	85	(85.9)
Concrete	168	(29.4)	65	(24.4)	103	(33.7)	134	(34.6)	20	(23.3)	14	(14.1)
Other	5	(0.9)	3	(1.1)	2	(0.7)	5	(1.3)	0	(0)	0	(0)
Household ever received voucher for agricultural subsidy program	197	(34.4)	95	(35.7)	102	(33.3)	136	(35.1)	28	(32.6)	33	(33.3)
Household size (mean, SD)	5.3	(2.1)	4.8	(2.0)	5.7	(2.1)	5.1	(2.1)	5.3	(2.1)	5.7	(2.1)
Monthly per capita expenditures (TSH, mean, SD)	27,624	(35,318)	25,337	(29,768)	29,612	(39,455)	28,812	(36,609)	18,832	(19,466)	30,618	(39,720)
Asset index (quartile)												
1st (lowest)	143	(25.0)	86	(32.3)	57	(18.6)	87	(22.5)	26	(30.2)	30	(30.3)
2nd	143	(25.0)	83	(31.2)	60	(19.6)	82	(21.2)	31	(36.0)	30	(30.3)
3rd	143	(25.0)	58	(21.8)	85	(27.8)	95	(24.6)	22	(25.6)	26	(26.3)
4th (highest)	143	(25.0)	39	(14.7)	104	(34.0)	123	(31.8)	7	(8.1)	13	(13.1)

Table 1 continued

Characteristic	Total		Household status				Food security status in the last 30 days					
			Female headed		Male headed		Food secure		Some FI ^a		Severe FI ^b	
	<i>N</i>	(%)	<i>N</i>	(%)	<i>N</i>	(%)	<i>N</i>	(%)	<i>N</i>	(%)	<i>N</i>	(%)
Total land owned by household (acres)	4.5	(6.0)	3.9	(3.9)	5.0	(7.4)	4.7	(7.0)	4.3	(3.6)	3.6	(3.0)
Food security in last 30 days												
Food secure	387	(67.7)	177	(66.5)	210	(68.6)	–		–		–	
Some FI	86	(15.0)	49	(18.4)	37	(12.1)						
Severe FI	99	(17.3)	40	(15.0)	59	(19.3)						
Entered into or stayed in a relationship because of material goods	86	(15.5)	54	(20.9)	32	(10.8)	55	(14.5)	13	(15.7)	18	(19.4)
Could ask partner to use condom ^c	253	(48.9)	149	(53.1)	104	(37.0)	188	(51.9)	39	(52.0)	26	(32.5)
Sexual relationship power score (mean, SD) ^d	2.5	(0.4)	2.5	(0.3)	2.5	(0.4)	2.5	(0.4)	2.4	(0.3)	2.4	(0.3)

FI food insecurity, *SD* standard deviation

^a In the last 30 days, “sometimes” worrying about food access (three to ten times in the last month) or “sometimes” not being able to eat preferred foods

^b In the last 30 days, having at least one household member go to bed hungry, “often” (more than ten times in the last month) worrying about food supply, or “often” not being able to eat preferred foods due to a lack of resources

^c Limited to the 522 women currently in a sexual relationship with a regular or steady partner

^d Sexual relationship power score was available for 532 (93 %) women reporting a main or regular sexual partner in the last 12 months

to request that partners use condoms. The overall relationship power score, among the 532 women who had a main or regular sexual partner in the last 12 months, was 2.5 (range 1–4, standard deviation 0.4) with no difference by household type.

Relationship Between Food Security and Dimensions of SES

Among female-headed households, food security was not significantly associated with monthly per capita expenditures, assets, the flooring material of the home, or land ownership (Table 2). In male-headed households, food security was inversely associated with assets; 26 % of households in the lowest asset index quartile were severely food insecure compared to 7 % in the highest category (Cochran Mantel–Haenszel $\chi^2 = 22.6$, $p < 0.01$). Food security was inversely associated with the floor material of the home in male-headed households, with 25 % of households with earth, mud, or straw floors severely food insecure compared to only 9 % of households with concrete floors (Fisher’s exact test $p < 0.01$). FI was also associated with women’s land ownership among

male-headed households; women who owned land jointly with another person were most likely to be living in food secure households (71 %), followed by women who owned land alone (65 %), and women who did not own land (60 %, $p < 0.01$).

Association Between Food Security, Risk Behavior, and Relationship Power

Among female heads of household, household FI was not associated with entering into or staying in a relationship because of material goods or asking a partner to use a condom after adjustment for SES and other covariates (Table 3). Also among female heads of household, some household FI was nonsignificantly associated with relationship power after adjustment for covariates, but the effect size was small (Table 4, some FI: $\beta = -0.10$, SE 0.07), representing a 2.5 % reduction in relationship power compared to women in food secure households.

However, among the women in male-headed households, household FI was more strongly associated with risk behavior. Women in male-headed households that were moderately or severely food insecure were more likely to

Table 2 Relationship between FI and other dimensions of socio-economic position among 572 sexually active women living in farming households, Tanzania, 2010

Characteristic	Household food security among female heads of household (<i>N</i> = 266)						Household food security among women in male-headed households (<i>n</i> = 306) ^a					
	Food secure		Some FI		Severe FI		Food secure		Some FI		Severe FI	
	<i>N</i>	(%) ^b	<i>N</i>	(%)	<i>N</i>	(%)	<i>N</i>	(%) ^b	<i>N</i>	(%)	<i>N</i>	(%)
Total	177	(66.5)	49	(18.4)	40	(15.0)	210	(68.6)	37	(12.1)	59	(19.3)
Monthly per capita expenditures (TZS)												
1st quartile	45	(60.8)	16	(21.6)	13	(17.6)	44	(63.8)	13	(18.8)	12	(17.4)
2nd quartile	55	(69.6)	15	(19.0)	9	(11.4)	45	(70.3)	8	(12.5)	11	(17.2)
3rd quartile	38	(67.9)	12	(21.4)	6	(10.7)	58	(66.7)	10	(11.5)	19	(21.8)
4th quartile	39	(68.4)	6	(10.5)	12	(21.1)	63	(73.3)	6	(7.0)	17	(19.8)
Pearson χ^2	6.23, <i>p</i> = 0.40						5.65, <i>p</i> = 0.46					
CMH $\chi^{2,c}$	0.12, <i>p</i> = 0.73						0.11, <i>p</i> = 0.74					
Asset index												
1st quartile	55	(64.0)	16	(18.6)	15	(17.4)	32	(56.1)	10	(17.5)	15	(26.3)
2nd quartile	51	(61.4)	20	(24.1)	12	(14.5)	31	(51.7)	11	(18.3)	18	(30.0)
3rd quartile	41	(70.7)	10	(17.2)	7	(12.1)	54	(63.5)	12	(14.1)	19	(22.4)
4th quartile	30	(76.9)	3	(7.7)	6	(15.4)	93	(89.4)	4	(3.8)	7	(6.7)
Fisher's exact test	<i>p</i> = 0.44						<i>p</i> < 0.01					
CMH $\chi^{2,c}$	1.64, <i>p</i> = 0.20						22.56, <i>p</i> < 0.01					
Flooring material ^d												
Earth, mud, straw	130	(65.7)	33	(16.7)	35	(17.7)	118	(58.7)	33	(16.4)	50	(24.9)
Concrete	44	(67.7)	16	(24.6)	5	(7.7)	90	(87.4)	4	(3.9)	9	(8.7)
Fisher's exact test	<i>p</i> = 0.08						<i>p</i> < 0.01					
Land ownership												
Owens land alone	67	(59.3)	22	(19.5)	24	(21.2)	11	(64.7)	4	(23.5)	2	(11.8)
Owens land jointly	90	(70.3)	23	(18.0)	15	(11.7)	169	(70.7)	20	(8.4)	50	(20.9)
Does not own land	20	(80.0)	4	(16.0)	1	(4.0)	30	(60.0)	13	(26.0)	7	(14.0)
Fisher's exact test	<i>p</i> = 0.11						<i>p</i> < 0.01					

TZS Tanzanian shilling, NA not applicable

^a Household food security, expenditures, and assets were reported by the male household head. Land ownership was reported by women

^b Row percentages shown in table

^c Cochran-Mantel-Haenszel χ^2 with integer scores

^d The "other" category of flooring types was excluded due to small numbers

have entered into or stayed in a relationship because of material goods compared to women in food secure households, even after adjustment for covariates including SES (some FI: adjusted $PR_a = 1.94$, 95 % CI 0.78, 4.79; severe FI: $PR_a = 1.76$, 95 % CI 0.81, 3.81), although these results were not statistically significant. In addition, women in male-headed households that were severely food insecure were 53 % less likely to be able to ask their regular partner to use a condom compared to women in food secure male-headed households ($PR_a = 0.47$, 95 % CI 0.25, 0.88). Severe household FI among women in male-headed households was associated with a small and non-significant 0.10 point reduction in the sexual relationship power score ($\beta = -0.10$, SE 0.06).

Discussion

In this study, we examined the relationships between food security, SES, and HIV-related risk behavior and relationship power among sexually active women living in smallholder farming households in Tanzania. Given the potential overlap between food security and SES, the first objective of our study was to explore the relationship between FI and four dimensions of SES related to income and wealth. We found that among female-headed households, food security was not associated with monthly per capita expenditures, assets, flooring material, or women's land ownership, suggesting that food security is a distinct construct independent from these indicators of SES in these

Table 3 Relationship between FI and transactional sex and condom use among women in sexual relationships, stratified by sex of the household head, Tanzania, 2010

Characteristic	Entered into or stayed in a relationship because of material goods					Could ask partner to use condom				
	N (%)	Unadjusted ^a		Adjusted ^b		N (%)	Unadjusted ^a		Adjusted ^c	
		PR (95 % CI)	<i>p</i>	PR (95 % CI)	<i>p</i>		PR (95 % CI)	<i>p</i>	PR (95 % CI)	<i>p</i>
Female heads of household (<i>N</i> = 266)										
Food security status										
Food secure	38 (21.7)	1		1		109 (66.5)	1		1	
Some FI	8 (17.0)	0.78 (0.40, 1.55)	0.78	0.85 (0.43, 1.69)	0.81	23 (54.8)	0.82 (0.61, 1.12)	0.36	0.90 (0.68, 1.19)	0.61
Severe FI	8 (22.2)	1.02 (0.50, 2.08)		0.83 (0.40, 1.71)		17 (56.7)	0.85 (0.62, 1.17)		0.88 (0.66, 1.18)	
Women in male-headed households (<i>N</i> = 306)										
Food security status										
Food secure	17 (8.3)	1		1		79 (39.9)	1		1	
Some FI	5 (13.9)	1.67 (0.67, 4.17)	0.10	1.94 (0.78, 4.79)	0.15	16 (48.5)	1.22 (0.80, 1.84)	0.03	1.38 (0.87, 2.20)	0.01
Severe FI	10 (17.5)	2.11 (1.04, 4.26)		1.76 (0.81, 3.81)		9 (18.0)	0.45 (0.24, 0.85)		0.47 (0.25, 0.88)	

^a Unadjusted Poisson regression with food security status as the outcome variable and robust standard errors to account for clustering within village

^b Female head of household model adjusted for age category, whether there is an adult male in the household, marital status, regular sexual partner, education, home ownership, household size, dwelling floor type, asset index (quartiles), per capita expenditures (quartiles), acres of land, land ownership, and ever being a beneficiary of the voucher program. No covariates were excluded due to multicollinearity. The model for women in male-headed household is adjusted for age category, marital status, education, dwelling floor type, asset index (quartiles), per capita expenditures (quartiles), acres of land, land ownership, and ever being a beneficiary of the voucher program. In this model, the following covariates were excluded due to multicollinearity: whether there is an adult male in the household, regular sexual partner, home ownership, and household size

^c Female head of household model adjusted for age category, whether there is an adult male in the household, marital status, regular sexual partner, education, home ownership, household size, dwelling floor type, asset index (quartiles), per capita expenditures (quartiles), acres of land, land ownership, and ever being a beneficiary of the voucher program. In this model, regular sexual partner was excluded due to multicollinearity. The model for women in male-headed household is adjusted for age category, marital status, education, dwelling floor type, asset index (quartiles), per capita expenditures (quartiles), acres of land, land ownership, and ever being a beneficiary of the voucher program. In this model, the following covariates were excluded due to multicollinearity: whether there is an adult male in the household, regular sexual partner, home ownership, and household size

households. In contrast, in male-headed households, food security was associated with assets, flooring material, and land ownership but not expenditures, possibly indicating that FI is a consequence of poverty in the longer-term and not a reflection of a short-term economic shock, which might instead be reflected by recent per capita household expenditures. Thus, although previous studies have also reported that FI can exist even in economically secure households, [22–24] our findings suggest that these relationships may vary by the sex of the household head. This heterogeneity was unexpected and is critical to assess in future studies.

The second objective of our study was to examine the relationship between household food security and HIV-related risk behavior and relationship power. Among female heads of household, there was not a strong association between FI and women's sexual risk behavior or relationship power, before or after adjustment for indicators of SES and other covariates. However, among the women in male-headed households, household FI was

associated with an increased likelihood of entering into or staying in a relationship because of material goods as well as not being able to ask the regular sexual partner to use a condom. These data are consistent with previous studies that have demonstrated the independent effect of FI on HIV-related risk behavior even after adjustment for dimensions of SES [6, 18]. In contrast, FI was not strongly associated with relationship power among women in male-headed households.

An important consideration is that in male-headed households, household food security was reported by the male household head. Thus, the food security status of women in these households may be misclassified if men are less knowledgeable about a household's food situation than women, given that women are more likely to be responsible for a household's food supply and preparation. The most plausible misclassification scenario would be if a woman in a male-headed household was herself food insecure but the male household head reported that the household was food secure. This type of exposure

Table 4 Relationship between FI and sexual relationship power among women in sexual relationships, stratified by sex of the household head, Tanzania, 2010

Characteristic	N	Relationship power score				
		Mean (SD)	Unadjusted ^a		Adjusted ^b	
			β (SE)	<i>p</i>	β (SE)	<i>p</i>
Female heads of household (<i>N</i> = 237) ^c						
Food security status						
Food secure	200	2.48 (0.35)	1		1	
Some FI	37	2.35 (0.33)	−0.14 (0.06)	0.07	−0.10 (0.07)	0.22
Severe FI	58	2.49 (0.36)	0.01 (0.08)		0.03 (0.08)	
Women in male-headed households (<i>N</i> = 295)						
Food security status						
Food secure	157	2.53 (0.40)	1		1	
Some FI	47	2.47 (0.28)	−0.05 (0.05)	0.05	−0.01 (0.06)	0.17
Severe FI	33	2.41 (0.27)	−0.11 (0.05)		−0.10 (0.06)	

SD standard deviation, SE standard error

^a OLS linear regression with the sexual relationship power score as the dependent variable and robust standard errors to account for clustering within village

^b Model adjusted for age category, marital status, education, regular sexual partner, home ownership, dwelling floor type, asset index (quartiles), per capita expenditures (quartiles), acres of land, type of land ownership, and ever being a beneficiary of the voucher program. Whether there is an adult male in the household was excluded from the model due to multicollinearity

^c Analysis limited to the 522 women (237 female heads of household and 295 women in male-headed households) who were currently in a sexual relationship with a regular or steady partner

misclassification could bias our estimates of effect either towards the null if it is not related to the outcome or in either direction if misclassification is differential by outcome groups [49]. Understanding whether male and female reports of FI differ within the same household would shed light on this issue, and also add to our understanding of intra-household allocation of food. Despite this limitation, our data imply that the effects of household FI in male-headed households may extend to multiple domains of a woman's life, including her sexual behavior.

Together, our findings suggest that the association between FI and HIV risk behavior may differ depending on the physical presence of a male household head (although half of female household heads in our study were married, male spouses/partners were often living away from the household). The pattern of heterogeneity we observed was unanticipated given that female heads of household are often thought to be the *most* vulnerable to the effects of economic insecurity. In particular, widows are thought to bear the worst of the “entangled crisis” [50] of FI, poverty, and HIV/AIDS—they may be evicted from their land, deprived of their livelihood, and stigmatized if their husband died of HIV infection—resulting in widows being at a heightened risk for HIV acquisition, if not already infected [7, 51, 52]. If this were true among the women in our sample, we would have expected FI to be strongly

associated with risk behavior and relationship power among female heads of household, contrary to what we observe.

There are several possible explanations for these divergent findings. First, the sample had few widows (5 %) and a relatively young study population (average age of 37 years), likely due to restriction of the study sample to women in sexual relationships. Thus, our sample of female household heads may be different than the typical female household head in Tanzania. Another possibility is that female household heads are more autonomous by virtue of their status as head of household than women in male-headed households. For example, despite our data suggesting that female-headed households are economically disadvantaged compared to male-headed households, they may have more control over their sexual behavior, even if they are food insecure. A third possibility is that we may have found different results if we would have had a sample large enough to distinguish between different types of female-headed households. For example, some of the female household heads in our sample may have been the wives of migrants (“de facto” female headed households who may be receiving remittance), different from “de jure” female headed-households, in which a woman is considered the legal and customary head of household [53]. We were unable to explore this type of variability in-depth

among female-headed households. However, a post hoc sensitivity analysis among female heads of household using binary indicators for food security (any versus none) and marital status (married/informal union versus unmarried) did not reveal statistical heterogeneity in any of the three relationships of interest (p values of all interaction terms >0.05 , data not shown).

Our analysis has important limitations. We used cross-sectional data and we therefore cannot make inferences about the direction of effect (i.e., temporality) or causation. In addition, the households in the evaluation met the eligibility criteria for the subsidy program and are therefore not representative of all farming households in Tanzania. Likewise, although the sample of female-headed households was generated with probability sampling, we used a convenience sample of women in male-headed households. If the women in male-headed households who were included in the survey were systematically different from those that did not participate (e.g., these women were more likely to be home because they had smaller farms or they were more likely to have young children), our sample would be biased. In this case, our results would not be generalizable to all male-headed farming households in Tanzania or in Eastern Africa more broadly. Further, if the factors related to study participation were also related to sexual behavior and/or relationship power, the relationships we have described would be biased. For example, if having young children affects the probability of being interviewed and is also associated with being food insecure and/or remaining in a partnership due to financial support, the association we have described may be different from the true relationship in the target population.

Another limitation is that there may be unmeasured confounders and endogeneity of food security in our models that would bias our estimates of effect; this must be considered when interpreting the results. Although we have controlled for the most important confounders in our data, there is the unlikely possibility that other unmeasured factors, like market characteristics or drought, are associated with FI and are also indirectly associated with sexual behavior and empowerment. These factors were unmeasured and therefore excluded from the analysis. Further, due to interview time constraints, food security was not measured using the full HFIAS, a validated scale which would have bolstered our confidence in the classification of food security. Thus, our findings may be sensitive to alternative parameterizations of food security. For example, a small sample size precluded the inclusion of a category limited to those households that experienced hunger alone, as opposed to our chosen category of hunger and/or often worrying about food supply or food quality. Finally, we selected four dimensions of SES to explore in the analysis; given that SES is a multidimensional construct,

other measures like education and occupation may also be associated with food security and should be considered in future analyses [30].

In spite of these caveats, our study also has important strengths, including a unique community-based sample of women in farming households and an explicit goal to describe and clarify the relationship between FI and SES, a key confounder of the relationship of interest. Our study lends support to previously postulated relationships, confirms that food security and socioeconomic position are distinct constructs, uses a validated scale of relationship power, and highlights the importance of stratifying by household type in future studies of this relationship, a new contribution of this study. Our results describe the complex interplay between dimensions of socioeconomic position, FI, and sexual risk behavior among women living in farming households in Tanzania. These results may be generalizable to other women living in farming households in Eastern Africa where there are similar generalized HIV epidemics.

Although our findings add to the growing evidence base of observational data linking food and economic insecurity to sexual and reproductive health, few interventions in this area have been prospectively evaluated [13, 14]. The global momentum to rigorously evaluate social protection and economic development programs, [54–57] including agricultural programs that may directly enhance household food security, [25] presents a prime opportunity to measure sexual and reproductive health outcomes in addition to dimensions of household welfare and nutrition. Our data suggest that multisectoral programs that simultaneously influence multiple pathways that can lead to poor health, like FI, may hold future promise. Such programs may represent new tools in our arsenal of proven interventions to prevent sexually transmitted infections and improve women's reproductive health more broadly.

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