Structural Determinants of Food Insufficiency and Low Dietary Diversity: A Cross Sectional Study of HIV-positive Rwandan Women

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Structural Determinants of Food Insufficiency and Low Dietary Diversity a Cross Sectional Study of HIV-positive Rwandan Women

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Contributorship

K.A., E.M. and C.S. designed the research. N.S., Q.S., D.H., C.S. and K.A. analyzed the data. N.S. wrote the paper with input from all authors. N.S. had primary responsibility for the final content. All authors read and approved the final manuscript.

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Article Summary:

1) Article Focus
    a. What structural determinants are associated with food insufficiency, low dietary diversity and low BMI in HIV-infected women in Rwanda?
    b. What is the prevalence of food insufficiency, low dietary diversity and low BMI in HIV-infected women in Rwanda and are they correlated with each other?
    c. Hypotheses
        i. #1: Poverty, low educational status and alcohol use would be associated with food insufficiency, low dietary diversity and low BMI.
        ii. #2 food insufficiency, low dietary diversity and low BMI would be highly prevalent and would be correlated with one another.
2) Key messages
    a. Food insufficiency was found in 44% of the population and was associated with low income and illiteracy and was strongly associated with alcohol use.
    b. BMI (body mass index, kg/m^2) was not correlated with food insufficiency or dietary diversity.
    c. Significance: Food Insufficiency is highly prevalent in HIV-infected women in Rwanda. Extreme poverty, low literacy and alcohol use may useful indicators of food insufficiency in this population. Low BMI is not an adequate screening tool for food insufficiency in HIV-infected populations
3) Strengths and limitations
    a. Strengths: Large cohort of HIV-infected women, very detailed tools used for food insufficiency and dietary diversity
    b. Limitations: Cross sectional design, our measurement of food insufficiency is solely by self report.

Abstract

Objectives: Food insufficiency, low dietary diversity and low BMI affect millions of people worldwide and have negative effects on health. We sought to determine which structural factors are associated with food insufficiency, low dietary diversity and low BMI in HIV-infected Sub-Saharan women. We hypothesized that poverty, low education and alcohol use would be associated with food insufficiency, low dietary diversity and low BMI. We also hypothesized that food insufficiency would be correlated with low dietary diversity and low BMI.

Study Design: cross-sectional analysis of a longitudinal cohort

Setting: Community-based women's organizations and clinical care sites for HIV-infected patients in Rwanda

Participants: 622 HIV-infected women

Primary and secondary outcome measures: We measured structural and behavioral factors of HIV-infected women including: income, literacy, education level, electricity, and alcohol use. We also assessed for food insufficiency, household dietary diversity and body mass index.

Results: Poverty and illiteracy were common (35% and 23%, respectively). Food insufficiency was prevalent with 44% of women reporting "usually not" or "never" to "Do you have enough food?" Food insufficiency was associated with low income (adjusted Odds Ratio (aOR)=2.57), unemployment, (aOR=1.92) and illiteracy (aOR=1.74). Alcohol use was strongly associated with being food insufficient (aOR=4.89). Factors associated with low dietary diversity included low income (aOR=8.72) and illiteracy (aOR=2.25). BMI (body mass index, kg/m^2) was not correlated with food insufficiency or dietary diversity, suggesting that low BMI in these

women may not result from food insufficiency alone.

Conclusions: HIV-infected Rwandan women experienced high rates of food insufficiency and low dietary diversity. HIV treatment programs in developing countries may consider extreme poverty, unemployment, illiteracy and alcohol use as indications to screen for and address food insufficiency and dietary diversity in HIV-infected populations. Additionally, low BMI is not an adequate screening tool for food insufficiency in HIV-infected populations.

INTRODUCTION

Food insecurity, including insufficient access to adequate, safe, nutritionally diverse food, affects an estimated 800 million people worldwide[1,2] In HIV-infected individuals, food insufficiency and low dietary diversity are associated with poor health[3-5]. Food insufficiency may be caused by structural factors: social, political, economic structures or institutions that affect people's ability to control the conditions of their lives and meet their basic needs. Structural determinants of health include distribution of wealth, power and goods, access to education and schools, access to health care, and housing and environment conditions. These structural determinants play a major role in health inequities and greatly affect health status [6]

But structural factors associated with food insufficiency in HIV-infected Sub-Saharan women, and how such factors may be addressed to mitigate food insufficiency in the region is not well studied.

Food insufficiency (lack of adequate food to meet daily needs) is one aspect of food insecurity, a complex phenomenon describing lack of access to sufficient quantity and adequate quality of food, and anxiety in procuring food [2]. Over half of all households in Rwanda are thought to be food insecure, many of which are headed by women [7]. Rwanda has a significant number of female headed households (31%), partly due to the high numbers of genocide-related widows, and 62% of female headed households live in poverty, compared to 54% of male-headed households[8]. Especially in vulnerable populations, such as HIV-infected women, gender disparities may prevent women from having control of family resources and the discretionary income necessary for buying food [9]

In HIV-infected women, food insufficiency may result in low body mass index (BMI), which adversely affects health outcomes [10]. In addition, consuming fewer distinct food groups or low dietary diversity, which contributes to poor health outcomes in African women and children [4], may reinforce malnutrition and eventually result in poor health [11]. Many African diets consist of a single dominant carbohydrate group, such as cassava, potato or yam which provides calories that may maintain body weight, but often does not provide the micro and macronutrients needed for proper immune function[12] .

In HIV+ patients, food insecurity has been associated with low CD4 counts, virologic failure and increased mortality[3,5] . Low BMI (<18.5 kg/m^2) is a strong predictor for mortality in HIV+ patients starting ART, with higher mortality in patients who are both food insecure and underweight versus underweight but food secure[5] . Although poverty is associated with poor health outcomes, income alone does not always reflect the status of someone's "wealth." In populations with very low incomes, markers for disposable or discretionary income, defined as income after all essential items are paid for, may be more useful to define an individual's socioeconomic status. These may include access to electricity and ability to buy non-essential items such as alcohol. For women with HIV, it is unclear which structural factors most influence food insecurity, and therefore have the greatest impact on health outcomes.

In order to understand structural determinants of food insufficiency and elucidate potential interventions to prevent food insufficiency and malnutrition in HIV+ Rwandan women, we examined the prevalence and socio-demographic associations of food insufficiency and household dietary diversity in HIV+ women in Rwanda. We

further examined the relationship between food insufficiency, low BMI and low dietary diversity in these women.

METHODS

Population and Setting: The Rwanda Women's Interassociation Study and Assessment (RWISA) (described in detail elsewhere [13]) is a prospective observational cohort designed to assess the effectiveness and toxicity of antiretroviral therapy (ART) in HIV-infected Rwandan women. In 2005, 710 HIV-infected and 226 HIV-uninfected Rwandan women were recruited through community-based women's organizations and clinical care sites for HIV-infected patients. Eligible women were 25 years or older at study entry and willing to give informed consent. HIV-infected women were excluded if they had prior history of receiving antiretroviral treatment, except possibly single dose nevirapine to prevent mother to infant transmission of HIV. Women were compensated 2500 Rwandan francs for each visit. The Rwandan National Ethics Committee and the Institutional Review Board at Montefiore Medical Center approved this study.

At each study visit participants provided historical information. Trained research assistants collected socio-demographic data at study entry including age, income, education, literacy level, education, employment, access to electricity and alcohol use. At each visit participants had a focused physical examination and provided blood specimens for CD4 lymphocyte and complete blood counts. Standing height and weight were measured while the participant was wearing light clothing and no shoes. This analysis included all 622 HIV-positive women who completed socio-

demographic and nutritional data at the fifth semi-annual visit, between July and December 2007.

Measures:

Outcomes: Between July and December 2007, food insufficiency was assessed using a single question, “Do you have enough food?” with the women answering “usually not” or “never” classified as food insecure [14,15]. Household dietary diversity was assessed using a modified Household Dietary Diversity Score (HDDS), a validated tool measuring household food consumption over the previous 24 hours, giving one point for each food class (total 6 possible: 1) cereals and roots; 2) vegetables; 3) fruits; 4) meat protein [including meat, eggs, fish]; 5) vegetable protein [including legumes, beans, nuts]; 6) extras [including oil, fat, sugar, condiments]). Determination of “Low household dietary diversity” is described in detail elsewhere, [18] briefly, the sample was divided into income terciles with the mean HDDS for the lowest income tercile (≤3) representing low dietery diversity [12,16,17].

Independent variables: Income categories were defined as 1) >35,000 Rwandan Francs ($US 58), 2) 35,000-10,000, and 3) <10,000 RWF ($US 17), per month. Electricity and alcohol were dichotomous variables with the presence of electricity in the participant’s home used as a proxy for the measurement of disposable income Alcohol use was queried as “Since the last visit have you had a drink containing alcohol?” Education was dichotomized to none vs. some (including some primary, completed primary and some secondary) for the analysis. Literacy was defined as “can read all, most, some or none,” and for the analysis was dichotomized to none vs. some, most or all. Employment was assessed with “Are you currently employed?” Antiretroviral use was assessed by self-report with verification of date of initiation and

regimen by tracking cards provided to the participants by providers in the national treatment program. CD4 counts were determined with a FACS counter (Becton and Dickinson, Immunocytometry Systems, San Jose, CA, USA).

Data Analysis:

BMI was calculated using weight divided by height-squared (kg/m^2) and dichotomized to ≤18.5 or >18.5 for the analysis. Statistical analysis was performed using SAS (version 9.1.3, SAS Institute Inc., Cary, NC, USA). Univariate logistic regression identified factors associated with food insecurity, low dietary diversity, and BMI. Multivariate logistic regression models were built using backward selection with a p-value of 0.05 to stay in the model. Wilcoxon rank sum and Kappa statistics assessed relationships between food insecurity, BMI and dietary diversity as continuous variables and as dichotomous variables (food insecurity= answering “usually not” or “never” to “Do you have enough food”, HDDS≤3, BMI ≤18.5), respectively.

RESULTS

The prevalence of poverty was high among the 622 women who met inclusion criteria; 35% reported a monthly income of less than <10K Rwandan Francs (FRW) ($US 17). Illiteracy was as high as 23%, and 22% of women reported no formal education (Table 1). Mean CD4 counts among HIV positive women at Visit 5 were <350 cells/µl in 53%; 70% of participants took antiretroviral therapy at this visit.

Food insufficiency (Table 1) was highly prevalent with 44% of women reporting “usually not” or “never” to “Do you have enough food?” and another 45% reporting they “sometimes” did not have enough food. Almost half the population reported low

dietary diversity (HDDS <3) and 12% of women met WHO criteria for malnutrition with a BMI<18.5 kg/m^2.

In unadjusted analyses (Table 2), structural factors associated with food insufficiency included income <10,000 FRW (OR=2.96; CI 1.67-5.27), income >35,000 FRW vs. <10,000 FRW (OR=1.76; CI 1.01-3.07), no education (OR=2.02; CI 1.05-3.88), illiteracy [(can read none: OR= 2.06; CI 1.29-3.30), (can read some: OR=1.48; CI 0.99-2.21)], unemployment (OR 1.99; CI 1.19-3.34), and alcohol use (OR=3.76; CI 2.08-6.78). Factors associated with low dietary diversity (HDDS<3) were income [(income <10,000 FRW: OR= 10.14;CI 4.90-21.01),],(income >35,000 FRW vs. <10,000 FRW: OR-4.16; CI 2.04-8.46), education [(none: OR=3.42; CI 1.70-6.78), (some primary: OR =2.30; CI 1.19-4.42), illiteracy [(none: OR= 2.90; CI 1.79-4.86) (some: OR-1.72; CI 1.14-2.59)], and unemployment (OR=2.13; CI 1.26-3.61). No variables had statistically significant (P < 0.05) associations with BMI.

In the final stepwise multivariate model, food insufficiency was independently associated with low income {Adjusted Odds ratio (aOR) 2.57; 95% CI 1.39-4.74 for >35,000 FRW vs. <10,000 FRW], unemployment (aOR=1.92; CI 1.09-3.38) and illiteracy (aOR=1.74; CI 1.06-2.85) (Table 2). Alcohol use (none vs. any use) was strongly independently associated with being food insecure (aOR=4.89; CI 2.57-9.29). Factors independently associated with low dietary diversity (HDDS <3.0) included low monthly income (aOR=8.72; CI 4.18-18.2 for income <10,000 vs. >35,000 FRW and aOR=3.77; CI 1.84-7.71 for income10,000-35,000 FRW vs. >35,000 FRW) and illiteracy (aOR=2.25, CI 1.36-3.71).

When analyzed as continuous variables, no significant correlations were found between self-reported food insufficiency and BMI (r=-0.05, p=0.29). A statistically

significant but weak correlation was found between between dietary diversity and BMI r=0.09, p=0.03 and food insufficiency and dietary diversity: r=0.14, p<0.001. When analyzed as dichotomous variables, no significant correlations were found between food insufficiency and BMI, Kappa (K) =0.02, dietary diversity and BMI, K=0.02 or food insufficiency and dietary diversity, K=0.12.

DISCUSSION

While HIV-infected Rwandan women experienced high rates of food insufficiency (42.1%) and low dietary diversity (44.4%), only 12% of the women had low BMI. Furthermore neither food insufficiency nor lack of dietary diversity was associated with BMI, suggesting that low BMI in these women was not resulting from food insufficiency alone. Still body weight may be maintainable on a low nutrient density starchy diet that includes suboptimal protein and micronutrient consumption. Structural factors including low income, illiteracy, and behavioral factors such as alcohol use, were associated with food insufficiency and low dietary diversity. Our findings highlight three important aspects useful in designing interventions to prevent food insufficiency in vulnerable populations.

First, the few women had low BMI (12%), while almost half were either food insufficient or had low dietary diversity. Additionally, BMI was not correlated with self-reported food insufficiency or dietary diversity. Because of the known health effects of food insufficiency and low dietary diversity, separate from BMI [3,5,11], our results support that BMI should not be considered as a sole marker for food insufficiency in HIV-infected women. The weak association between self-reported food insufficiency and dietary diversity may reflect an inexpensive, abundant single food group, such as

potatoes or cassava root, common in Rwanda, that provide a sufficient yet minimally diverse diet. Additionally, if that single food group is cassava, it provides a much lower protein and micronutrient source than potato, yams or rice.

Second, women who had incomes of <$17 per month (equal to 10,000 RWF per month) or were unemployed were more likely to be food insecure when compared with women whose incomes were >$60 monthly (equal to 35,000 RWF per month). The World Bank defines extreme poverty as <$1.25/ day (~$37/month) and moderate poverty at <$2/day (~$60/month): significant differences exist in health outcomes for these two groups[18] . This highlights a potentially important target for both ministries of health and international aid organizations and is consistent with the Millennium Development Goals to eradicate poverty[19] . HIV-infected women whose income is less than $1.25/day may benefit from income supplementation programs to help prevent food insufficiency[20]. Alternatively, poverty reduction strategies, or job skills training programs, may be beneficial public health interventions for these women [21-23].

Luxury items, such as alcohol, can be used as a marker for disposable income [24]. In our analysis, alcohol use was associated with higher rates of food insufficiency suggesting it reflected diversion of disposable income from food to alcohol. Data on alcohol misuse in Rwandan women are limited, with an estimated national pure alcohol use of 4.3 L per capita [25]; alcohol use may represent a valuable screening tool for food insufficiency in HIV+ women. Alcohol also serves as a predictor of inconsistent condom use in African women, further support that it represents an important point of intervention[14].

Lastly, we found that illiteracy was independently associated with greater food insufficiency and low dietary diversity. This may be because low literacy is an important aspect of "income generating capacity," which is critical to ability to obtain relevant dietary diversity and food security. Gender differences in educational and literacy attainment in Rwanda may lead to men procuring non-farm jobs with increased income potential which may increase the numbers of women left to manage the family agricultural plots[26]. Further studies need to be done to determine if literacy programs would benefit the level of food security and health status of HIV+ women. Improving land reform laws in Rwanda that strengthen women's positions to own and farm their own land, and empower them with alternative farming techniques, may increase their food security in both urban and rural areas[27-29].

Limitations of our study include its cross-sectional nature, which does not allow us to infer causality. Our measurement of food insufficiency is solely by self report. The question, "Do you have enough food?" does not address the quantity or quality of food, or the anxiety surrounding food procurement, although this question has been used in other food insufficiency analyses in Sub-Saharan Africa [14]. There was no explicit statement that this question would not alter a participant's eligibility for food aid, which may have introduced bias. More complete information may be obtained with a different measurement tool [15, 17].

Our findings suggest that extreme poverty, unemployment, illiteracy and alcohol use are associated with food insufficiency among HIV-infected women in Rwanda. . Addressing these structural factors through income generating activities, literacy programs, or perhaps most importantly, renewed health through improved access to

ART, may help reduce the highly prevalent problem of food insufficiency in the Sub-Saharan region.

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K.A., E.M. and C.S. designed the research. N.S., Q.S., D.H., C.S. and K.A. analyzed the data. N.S. wrote the paper with input from all authors. N.S. had primary responsibility for the final content. All authors read and approved the final manuscript. We thank the patients and staff of RWISA.

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Table 1. Demographic, Clinical and Dietary Characteristics of HIV-infected Women

Variable	Food Insufficient[1] N=228 n (%)	Sufficient Food [2] N=285 n (%)	P-value
Age, *years* Mean (SD)	35.54 (7.11)	35.29 (6.95)	0.9211
Age, *years*			0.7275
< 30	42 (18.42)	60 (21.05)	
30-40	130 (57.02)	154 (54.04)	
> 40	56 (24.56)	71 (24.91)	
Income, *RWF month*			0.0004
Income <10,000	99 (43.42)	82 (28.77)	
10,000-35,000	107 (46.93)	149 (52.28)	
Income >35,000	22 (9.65)	54 (18.95)	
Education			0.0237
None	60 (26.55)	51 (18.21)	
Some primary school	91 (40.27)	101 (36.07)	
Completed primary school	56 (24.78)	97 (34.64)	
Some secondary or higher	19 (8.41)	31 (11.07)	
Literacy			0.0117
None	62 (27.43)	52 (18.57)	
Some	96 (42.48)	112 (40.00)	
Most and read all	68 (30.09)	116 (41.43)	
Employed			0.0091
No	203 (89.43)	229 (80.92)	
Yes	24 (10.57)	54 (19.08)	
Electricity			0.5039
No	199 (88.44)	240 (86.33)	
Yes	26 (11.56)	38 (13.67)	
Alcohol use			<0.0001
No	184 (80.70)	267 (94.01)	
Yes	44 (19.30)	17 (5.99)	
BMI, kg/m^2 Mean (SD)	22.30 (3.78)	22.42 (3.70)	0.8119
BMI, kg/m^2			0.4128
>= 18.5	190 (85.97)	244 (88.73)	
<18.5	31 (14.03)	31 (11.27)	
CD4 count, *cells/µL* Mean (SD)	355.1(146.5)	347.8 (141.1)	0.6634
CD4 count, *cells/µL*			0.1339
CD4 < 200	25 (10.96)	42 (14.74)	
CD4 200-350	102 (44.74)	104 (36.49)	
CD4 >350	101 (44.30)	139 (48.77)	
Antiretroviral Use			0.9227
No	69 (30.26)	84 (29.68)	
Yes	159 (69.74)	199 (70.32)	
Household Dietary Diversity Score			0.0052
> 3	116 (50.88)	181 (63.51)	
<= 3	112 (49.12)	104 (36.49)	

[1] Reporting “Usually not” or “Never” to “Do you have enough food?”
[2] Reporting “Sometimes” or “Always” to “Do you have enough food?”

Table 2. Univariate and Multivariate Analysis Factors associated with Food Insecurity, Household Dietary Diversity and BMI

Variable	Food Insufficiency "Usually not" or "Never" to Do you have enough food?*		Household Dietary Diversity HDDS≤3*		BMI ≤18.5#	
	Univariate OR (95% CI) p value	Multivariate OR (95% CI) p value	Univariate OR (95% CI) p value	Multivariate OR (95% CI) p value	Univariate OR (95% CI) p value	Multivariate OR (95% CI) p value
Age						
< 30 years	Reference		Reference		Reference	
31-40 yrs	1.21(0.76-1.91)		1.21 (0.76, 1.92)		1.33 (0.63,2.80)	
> 40yrs	1.13 (0.66-1.91)		1.27 (0.75, 2.17)		1.29 (0.56,2.99)	
CD4						
CD4 < 200 cells/µl	Reference		Reference		Reference	
CD4 200-350	1.65 (0.94, 2.90)		0.93 (0.53,1.63)		0.81 (0.37,1.79)	
CD4 > 350	1.22 (0.70, 2.13)		1.10 (0.64,1.91)		0.76 (0.35,1.67)	
Low Income, *RWF/year*						
<10,000	2.96 (1.67-5.27)[c]	2.27 (1.22, 4.22)[b]	10.14 (4.90,21.01)[c]	8.72 (4.18, 18.20)[c]	1.83 (0.72,4.68)	
<10,000-35 ,000	1.76 (1.01-3.07)[a]	1.45 (0.81, 2.61)	4.16 (2.04,8.46)[c]	3.77 (1.84, 7.71)[c]	1.56 (0.62,3.89)	
>35,000	Reference	Reference	Reference	Reference	Reference	
No Education						
None	2.02 (1.05, 3.88)[a]		3.42 (1.70,6.87)[c]		1.43 (0.49,4.20)	
Some primary vs.	1.54 (0.84, 2.84)		2.30 (1.19,4.42)[a]		1.09 (0.39,3.08)	
Completed primary	0.99 (0.53, 1.86)		1.53 (0.78,3.00)		1.83 (0.66,5.07)	
Some secondary	Reference		Reference		Reference	
Illiteracy: can read						
None	2.06 (1.29, 3.30)[b]	1.91 (1.16, 3.15)[a]	2.90 (1.79,4.68)[c]	2.25 (1.36, 3.71)[c]	0.92 (0.45,1.91)	
Some	1.48 (0.99, 2.21)	1.36 (0.89, 2.07)	1.72 (1.14,2.59)[b]	1.46 (0.95, 2.25)	1.02 (0.56,1.86)	
Most or All	Reference	Reference	Reference	Reference	Reference	
Unemployed						
No Employed vs. Employed	1.99 (1.19, 3.34)[b]	1.92 (1.09, 3.38)[a]	2.13 (1.26,3.61)[b]		1.06 (0.50,2.25)	
No Electricity						
No electricity vs. electricity	1.21 (0.71, 2.07)		1.54 (0.89,2.69)		1.33 (0.55,3.24)	
Alcohol use						
Any vs. none	3.76 (2.08-6.78)[c]	4.89 (2.57, 9.29)[c]	0.69 (0.39,1.20)		1.14 (0.51,2.53)	
ART						
ART vs. No ART	0.97 (0.66, 1.42)		1.18 (0.80,1.73)		0.64 (0.37,1.12)	

P-value: a=0.01-0.05, b=0.001-0.01, c=<0.001
*N=504-513, # N=487-497

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STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
Outcome data	15*	Report numbers of outcome events or summary measures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses

Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Structural Determinants of Food Insufficiency, Low Dietary Diversity and BMI: a Cross Sectional Study of HIV-infected and HIV negative Rwandan Women

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Structural Determinants of Food Insufficiency, Low Dietary Diversity and BMI: a Cross Sectional Study of HIV-infected and HIV negative Rwandan Women

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KEY WORDS: HIV, poverty, nutrition, international health

WORD COUNT: 2980. NUMBER OF FIGURES: 0. NUMBER OF TABLES: 2.

SUPPLEMENTARY MATERIAL: Online Supporting Material: 0.

Article Summary:

1) Article Focus
   a. What structural determinants are associated with food insufficiency, low dietary diversity and low Body Mass Index (BMI) in HIV negative and HIV-infected women in Rwanda?
   b. What is the prevalence of food insufficiency, low dietary diversity and low BMI in HIV negative and HIV-infected women in Rwanda and are these outcomes correlated with each other?
   c. Hypotheses
      i. #1: Poverty, low literacy status and alcohol use are associated with food insufficiency, low dietary diversity and low BMI.
      ii. #2: Food insufficiency, low dietary diversity and low BMI are highly prevalent and are correlated with one another.
2) Key messages
   a. Food insufficiency and low dietary diversity are highly prevalent (46% and 43%, respectively) and are associated with low income and illiteracy and strongly associated with alcohol use.
   b. BMI (body mass index, kg/m^2) is not correlated with food insufficiency or dietary diversity.
   c. Significance: Food Insufficiency and low dietary diversity, known contributors to poor health, are highly prevalent in HIV negative and HIV-infected women in Rwanda. Low BMI may not be an adequate screening tool for food insufficiency. Extreme poverty, low literacy and alcohol use may contribute to food insufficiency and low dietary diversity. These structural factors may be useful targets to prevent the adverse health effects of food insufficiency and low dietary diversity.
3) Strengths and limitations
   a. Strengths: Large cohort of HIV negative and HIV-infected women, very detailed tools used for food insufficiency and dietary diversity
   b. Limitations: Cross sectional design, our measurement of food insufficiency is solely by self report.

Abstract

Objectives: In Sub-Saharan Africa, the overlapping epidemics of undernutrition and HIV infection affect over 200 and 23 million people, respectively, and little is known about the combined prevalence and nutritional effects. We sought to determine which structural factors are associated with food insufficiency, low dietary diversity and low BMI in HIV negative and HIV-infected Sub-Saharan women.

Study Design: cross-sectional analysis of a longitudinal cohort

Setting: community-based women's organizations

Participants: 161 HIV negative and 514 HIV-infected Rwandan women

Primary and secondary outcome measures: Primary outcomes included food insufficiency (reporting "usually not" or "never" to "Do you have enough food?"), low household dietary diversity (Household Dietary Diversity Score ≤3) and BMI <18.5 (kg/m^2). We also measured structural and behavioral factors including: income, household size, literacy, and alcohol use.

Results: Food insufficiency was prevalent (46%) as was low dietary diversity (43%) and low BMI (15%). Food insufficiency and dietary diversity were associated with low income [(aOR)=2.14 (95% CI 1.30, 3.52) p=<0.01], [aOR=6.51 (CI 3.66, 11.57) p=<0.001], and illiteracy [aOR=2.00 (CI 1.31, 3.04) p=<0.01], [aOR=2.10 (CI 1.37, 3.23) p=<0.001] and were not associated with HIV infection. Alcohol use was strongly associated with food insufficiency [aOR=3.23 (CI 1.99, 5.24) p=<0.001]. Low BMI was inversely associated with HIV infection [aOR ≈ 0.5] and was not correlated with food insufficiency or dietary diversity.

Conclusions: Rwandan women experienced high rates of food insufficiency and low dietary diversity. Extreme poverty, illiteracy and alcohol use, not HIV infection alone,

may contribute to food insufficiency in Rwandan women. Food insufficiency, dietary diversity and low do not correlate with one another; therefore, low BMI may not be an adequate screening tool for food insufficiency. Further studies are needed to understand the health effects of not having enough food, low food diversity and low weight in both HIV negative and HIV infected women.

INTRODUCTION

Undernutrition, defined as the condition of people whose food consumption is continuously below a minimum dietary energy requirement for maintaining healthy life, affects over 850 million people worldwide and 200 million adults in Sub-Saharan Africa [1-4]. The effects of the overlap between undernutrition and HIV infection, which affects over 23 million in Sub-Saharan Africa, are not well understood [5]. In both HIV negative and HIV-infected individuals, undernutrition, food insufficiency and low dietary diversity are associated with poor health [5-8]. Food insufficiency may be caused by structural factors: social, political, economic structures or institutions that affect people's ability to control the conditions of their lives and meet their basic needs. Structural determinants of health include distribution of wealth, power and goods, access to education and schools, access to health care, and housing and environment conditions. These structural determinants play a major role in health inequities and greatly affect health status [9]. But structural factors associated with food insufficiency in Sub-Saharan women, and how such factors may be addressed to mitigate food insufficiency in the region is not well studied.

Food insufficiency (lack of adequate food to meet daily needs) is one aspect of food insecurity, a complex phenomenon describing lack of access to sufficient quantity and adequate quality of food, and anxiety in procuring food [2]. Over half of all households in Rwanda are thought to be food insecure, many of which are headed by women [10]. Rwanda has a significant number of female headed households (31%), partly due to the high numbers of genocide-related widows, and 62% of female headed households live in poverty, compared to 54% of male-headed households [11]. Especially in vulnerable populations, such as HIV-infected women,

gender disparities may prevent women from having control of family resources and the discretionary income necessary for buying food [12].

In HIV-infected women, food insufficiency may result in low body mass index (BMI), which adversely affects health outcomes [13]. In addition, consuming fewer nutritionally distinct food groups (low dietary diversity), which contributes to poor health outcomes in African women and children [7], may reinforce malnutrition and eventually result in poor health [14]. Many African diets consist of a single dominant carbohydrate group, such as cassava, potato or yam which provides calories that may maintain body weight, but often does not provide the micro and macronutrients needed for proper immune function [15].

In HIV-infected individuals, food insecurity has been associated with low CD4 counts, virologic failure and increased mortality [6,8] . Low BMI (<18.5 kg/m^2) is a strong predictor for mortality in HIV+ patients starting ART, with higher mortality in persons who are both food insecure and underweight versus underweight but food secure [8] . Although poverty is associated with poor health outcomes, income alone does not always reflect the status of someone's "wealth." In populations with very low incomes, markers for disposable or discretionary income, defined as income after all essential items are paid for, may be more useful to define an individual's socioeconomic status. These may include access to electricity and ability to buy non-essential items such as alcohol. For women with HIV, it is unclear which structural factors most influence food insecurity, and therefore have the greatest impact on health outcomes.

In order to understand structural determinants of food insufficiency and elucidate potential interventions to prevent food insufficiency and malnutrition in HIV

negative and HIV-infected women, we examined the prevalence and socio-demographic associations of food insufficiency, household dietary diversity and low BMI in such women in Rwanda. We were specifically interested in the relationship between poverty, low literacy, and alcohol use on food insufficiency, dietary diversity and low BMI. We further examined the relationship between food insufficiency, low BMI and low dietary diversity and whether these three outcomes were correlated with one another in these women.

METHODS

Population and Setting: The Rwanda Women's Interassociation Study and Assessment (RWISA) (described in detail elsewhere [16]) is a prospective observational cohort designed to assess the effectiveness and toxicity of antiretroviral therapy (ART) in HIV-infected Rwandan women. In 2005, 710 HIV-infected and 226 HIV-uninfected Rwandan women were recruited through community-based women's organizations and HIV clinical care sites. Eligible women were 25 years or older at study entry, willing to give informed consent and were present in Rwanda during the genocide. HIV-infected women were excluded if they had prior history of receiving antiretroviral treatment, except single dose nevirapine to prevent mother to infant transmission of HIV. Women were compensated 2500 Rwandan francs for each visit. The Rwandan National Ethics Committee and the Institutional Review Board at Montefiore Medical Center approved this study.

At each study visit participants provided historical information. Trained research assistants collected socio-demographic data at study entry including age, income, literacy level, number of people in households, employment, access to

electricity antiretroviral use (for HIV-infected women) and alcohol use. At each visit participants had a physical examination and provided blood specimens for CD4 lymphocyte and complete blood counts. This analysis included 161 HIV negative and 514 HIV-infected women who completed socio-demographic and nutritional data at the fifth semi-annual visit, between July and December 2007.

Measures:

Primary Outcomes: Food insufficiency was assessed using a single question, "Do you have enough food?" with the women answering "usually not" or "never" classified as food insecure [17,18]. Household dietary diversity was assessed using a modified Household Dietary Diversity Score (HDDS), a validated tool measuring household food consumption over the previous 24 hours, giving one point each for having eaten an item in the following food class (total 6 points possible: Class-1) cereals and roots; Class-2) vegetables; Class-3) fruits; Class-4) meat protein [including meat, eggs, fish]; Class-5) vegetable protein [including legumes, beans, nuts]; Class-6) extras [including oil, fat, sugar, condiments]). Determination of "Low household dietary diversity" is described in detail elsewhere, [19] briefly, the sample was divided into income terciles with the mean HDDS for the lowest income tercile ($\leq$3) representing low dietary diversity [15,19,20]. Body mass index (BMI) was calculated using weight divided by height-squared (kg/m^2). Standing height and weight were measured while the participant was wearing light clothing and no shoes. BMI was dichotomized to $\leq$18.5 or >18.5 for the analysis.

Independent variables: Income categories were defined as 1) >35,000 Rwandan Francs ($US 58), 2) 35,000-10,000, and 3) <10,000 RWF ($US 17), per month. Alcohol use was queried as "Since the last visit, have you had a drink containing

alcohol?" and was dichotomized to yes vs. no. Literacy was defined as "can read all, most, some or none," and for the analysis was dichotomized to none vs. some, most or all. For HIV-infected women antiretroviral use at the current visit was assessed by self-report with verification of date of initiation and regimen by tracking cards provided to the participants by providers in the national treatment program. CD4 counts were determined with a FACS counter (Becton and Dickinson, Immunocytometry Systems, San Jose, CA, USA).

Data Analysis:

Categorical variables were compared using contingency tables with P-values from exact tests. Univariate logistic regression identified factors associated with food insecurity, low dietary diversity, and BMI. Multivariate logistic regression models were built using backward selection with a p-value of 0.05 to stay in the model. Wilcoxon rank sum and Kappa statistics assessed relationships between food insecurity, BMI and dietary diversity as continuous variables and as dichotomous variables (food insecurity= answering "usually not" or "never" to "Do you have enough food", HDDS$\leq$3, BMI $\leq$18.5), respectively. Statistical analysis was performed using SAS (version 9.1.3, SAS Institute Inc, Cary, NC USA).

RESULTS

Overall food insufficiency (top row of Table 1) was highly prevalent with 46% of women reporting "usually not" or "never" to "Do you have enough food?" and another 45% reporting they "sometimes" did not have enough food (data not shown). Almost half the population reported low dietary diversity (HDDS <3) and 15% of women met WHO criteria for malnutrition with a BMI<18.5 kg/m^2. The percentage of

women reporting food insufficiency and low dietary diversity did not differ between HIV negative and HIV-infected women. The percentage of women with BMI <18.5 was higher in HIV negative women as compared to HIV infected women with CD4>350, 200-350, <200 (24%, vs. 11.8%, 12.4%, 14.9%, p=0.004), respectively. Table 1 further breaks the food insecurity outcomes down by participant characteristics. As the numbers in column 2 of Table 1, show, the prevalence of poverty was high; 36% reported a monthly income of less than <10K Rwandan Francs (FRW) ($US 17). Illiteracy was present in one quarter of the population and another 40% reported only reading "some". Alcohol use was rare with 13% reporting they had at least one drink in the last month. Of the HIV-infected women, almost one third had CD4 counts over 350 and almost 70% of participants took antiretroviral therapy at this visit.

Structural factors associated with food insufficiency included (Table 1): low income, with 52.5% of those with monthly income <10,000 FRW, 43.6% of those with monthly income 10,000 – 35,000 FRW and 31.8% of those with > 35,000 FRW reporting food insufficiency, p=0.001; illiteracy with 57.1% of those who can't read, 44.5% of those with some literacy and 34.6% of those fully literate reporting food insufficiency, p=0.0002; and alcohol use with 68.9% of users vs. 41.2% of nonusers reporting food insufficiency, p<0.0001.

Structural factors associated with low dietary diversity (HDDS<3) were again; low income with 58.9% of those with monthly income <10,000 FRW, 39.3% with income 10,000–35,000 FRW and 16.2% of those with income >35,000 FRW having low dietary diversity p<0.0001; illiteracy with 55.2%, 44.4% and 31.6% of those with none, some and complete literacy having low dietary diversity, p<0.0001.

Only HIV status had statistically significant associations with BMI. Surprisingly the association was in the opposite direction expected with 24.2% of HIV negatives compared to 11.8 – 14.9% of HIV positive women of all CD4 levels having BMI <18.5, p=0.004.

The univariate logistic regression models of Table 2 find the same unadjusted associations of structural factors with outcomes just described for Table 1, here we discuss the multivariate modes. In the final stepwise multivariate model (Table 2), food insufficiency was independently associated with low income [Adjusted Odds ratio (aOR) 2.14; 95% CI 1.30-3.52 for >35,000 FRW vs. <10,000 FRW], and illiteracy (aOR=2.00; CI 1.31-3.04) (Table 2). Alcohol use (none vs. any use) was strongly independently associated with being food insufficient (aOR=3.23; CI 1.99-5.24). Factors independently associated with low dietary diversity (HDDS <3.0) included low monthly income (aOR=6.51; CI 3.36-11.57 for income <10,000 vs. >35,000 FRW and aOR=3.07; CI 1.76-5.37 for income10,000-35,000 FRW vs. >35,000 FRW) and illiteracy (aOR=2.10, CI 1.37-3.23). As in Table 1, HIV status had the only independent association with HIV positive women of all CD4 levels being *less* likely to have low BMI.

When analyzed as continuous variables, no significant correlations were found between self-reported food insufficiency and BMI (r=-0.05, p=0.29). A statistically significant but weak correlation was found between dietary diversity and BMI r=0.09, p=0.03 and food insufficiency and dietary diversity: r=0.14, p<0.001. When analyzed as dichotomous variables, no significant correlations were found between food

insufficiency and BMI, Kappa (K) =0.02, dietary diversity and BMI, K=0.02 or food insufficiency and dietary diversity, K=0.12.

DISCUSSION

While HIV uninfected and HIV-infected Rwandan women experienced high rates of food insufficiency (46%) and low dietary diversity (43%), only 15% of the women had low BMI. HIV status did not confer differences except in BMI, where the opposite of what was expected was seen, a *higher* proportion of HIV uninfected women had BMI <18.5. Furthermore neither food insufficiency nor lack of dietary diversity was associated with BMI, suggesting that low BMI in these women was not resulting from food insufficiency alone. Structural factors including low income and illiteracy were associated with food insufficiency and behavioral factors, such as alcohol use, was associated with low dietary diversity. Our findings highlight three important aspects useful in the relationship between food insufficiency, dietary diversity and BMI in vulnerable populations.

First, few women had low BMI (15%), while almost half were either food insufficient or had low dietary diversity. A higher percentage of HIV uninfected women had BMI <18.5 as compared to HIV infected women. This is likely explained by food supplementation programs provided by community organizations that are available exclusively to the HIV-infected women. These programs provide additional supply of the staple foods, which may provide enough calories to prevent malnutrition, but do not add to dietary diversity or change the perception of not having enough food. Additionally, BMI was not correlated with self-reported food insufficiency or dietary diversity. BMI is often measured in clinical settings and used

to monitor people's nutritional status. Because of the known health effects of food insufficiency and low dietary diversity, separate from BMI [6,7,14], and the lack of correlation between the three outcomes, our results support that BMI should not be considered as a sole marker for food insufficiency in HIV uninfected or HIV-infected women. The weak association between self-reported food insufficiency and dietary diversity may reflect an inexpensive, abundant single food group, such as potatoes or cassava root, common in Rwanda, that provide a sufficient yet minimally diverse diet. Body weight may be maintainable on a low nutrient density starchy diet that includes suboptimal protein and micronutrient consumption. Additionally, if that single food group is cassava, it provides a much lower protein and micronutrient source than potato, yams or rice.

Second, women who had incomes of <$17 per month (equal to 10,000 RWF per month) were more likely to be food insecure when compared with women whose incomes were >$60 monthly (equal to 35,000 RWF per month). The World Bank defines extreme poverty as <$1.25/ day (~$37/month) and moderate poverty at <$2/day (~$60/month): significant differences exist in health outcomes for these two groups [21] . This highlights a potentially important target for both ministries of health and international aid organizations and is consistent with the Millennium Development Goals to eradicate poverty [22] . HIV negative and HIV-infected women whose income is less than $1.25/day may benefit from income supplementation programs to help prevent food insufficiency and therefore the adverse health effects of food insufficiency and low dietary diversity [23]. Alternatively, poverty reduction strategies, or job skills training programs, may be beneficial public health interventions for these women [24-26].

Alcohol use has known adverse health effects and is a known risk factor for HIV transmission [17]. Less is known about the relationship with alcohol use and food insufficiency. Alcohol can be used as a marker for disposable income, similar to other luxury items [27]. In our analysis, alcohol use was rare with only 13% of the women stating they had at least one drink in the last month. This reflects that casual alcohol drinking is not the social norm this population of Rwandan women, as compared to other nearby countries, such as Uganda, where drinking is considered a socially acceptable activity. The Ugandan Health and Demographic survey found up to one quarter of women reporting drinking in the last month and 18% stated they drank alcohol daily [28,29]. Alcohol use was associated with higher rates of food insufficiency, even when controlled for by income, suggesting it reflected diversion of disposable income from food to alcohol, not just a reflection that more money is available for alcohol purchase. Data on alcohol misuse in Rwandan women are limited, with an estimated national pure alcohol use of 4.3 L per capita [30]. Our data further supports the use of alcohol as an important point of intervention to help prevent the adverse health effects of food insufficiency and low dietary diversity.

Lastly, we found that illiteracy was independently associated with greater food insufficiency and low dietary diversity. This may be because low literacy is an important aspect of "income generating capacity," which is critical to ability to obtain relevant dietary diversity and food security. Gender differences in educational and literacy attainment in Rwanda may lead to men procuring non-farm jobs with increased income potential which may increase the numbers of women left to manage the family agricultural plots [31]. Further studies need to be done to determine if literacy programs would benefit the level of food security and health

status of both HIV negative and HIV-infected women. Improving land reform laws in Rwanda that strengthen women's positions to own and farm their own land, and empower them with alternative farming techniques, may increase their food security in both urban and rural areas, and therefore improve their health [32-34].

Limitations of our study include its cross-sectional nature, which does not allow us to infer causality. Our measurement of food insufficiency is solely by self report. The question, "Do you have enough food?" does not address the quantity or quality of food, or the anxiety surrounding food procurement, although this question has been used in other food insufficiency analyses in Sub-Saharan Africa [17]. There was no explicit statement that this question would not alter a participant's subsequent eligibility for food aid, which may have introduced response bias. More complete information may be obtained with a different measurement tool which would address food insecurity (insufficiency quantity, quality or anxiety in procuring food), in addition to food insufficiency (not enough food) [18, 20]. A longitudinal study design would be helpful to determine the specific health effects of food insecurity on women over time.

Our findings suggest that extreme poverty, illiteracy and alcohol use are associated with food insufficiency among HIV-infected and HIV negative women in Rwanda. Addressing these structural factors through income generating activities, literacy programs, substance abuse treatment, or perhaps most importantly, renewed health through improved access to ART for HIV-infected women, may help reduce the highly prevalent problem of food insufficiency in the Sub-Saharan region.

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K.A., E.M. and C.S. designed the research. N.S., Q.S., D.H., C.S. and K.A. analyzed the data. N.S. wrote the paper with input from all authors. N.S. had primary responsibility for the final content. All authors read and approved the final manuscript. We thank the patients and staff of RWISA.

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Competing interests: N Sirotin, DR Hoover, C Segal-Isaacson, Q Shi, A Adedimeji, E Mutimura, M Cohen, K Anastos declare no conflicts of interest.

Table 1. Demographic, Clinical and Dietary Characteristics of HIV negative and HIV infected women.

Participant Characteristic	Proportion of total population	Measure of Food Insufficiency by Participant Characteristic					
		Self-Reported Food Insufficient[1]		Self-Reported Low Dietary Diversity HDDS <=3[2]		Low Weight BMI <18.5[3]	
		Percent of Subgroup With Outcome	P-value	Percent of Subgroup With Outcome	P-value	Percent of Subgroup With Outcome	P-value
Total	N=675	45.9%		43.4%		15.3%	
HIV positive CD4 count, *cells/μL*			0.24		0.84		0.004
HIV Negative (N=161)	24.5%	46.3%		43.5%		24.2%	
HIV+ CD4>350 (N=240)	34.8%	42.1%		44.2%		11.8%	
HIV+ 200-350 (N=207)	30.6%	49.5%		40.1%		12.4%	
HIV+ CD4<200 (N=67)	10.2%	37.3%		41.8%		14.9%	
Antiretroviral Use*			0.89		0.41		0.12
No (N=154)	30.7%	45.1%		39.6%		15.8%	
Yes (N=358)	69.3%	44.4%		43.6%		10.8%	
Number of people in household			0.68		0.42		0.18
0-2 (N= 158)	24.5%	41.8%		41.1%		11.6%	
3-5 (N= 326)	50.3%	46.0%		43.9%		17.6%	
>5 (N= 167)	25.2%	44.8%		37.7%		13.1%	
Age, *years*			0.36		0.57		0.02
< 30 (N= 122)	17.9%	40.2%		38.5%		10.2%	
30-40(N= 321)	47.1%	44.4%		42.7%		13.6%	
> 40(N= 232)	35.0%	48.0%		44.4%		20.4%	
Income, *RWF month*			0.001		<0.0001		0.28
Income <10,000 (N= 241)	35.7%	52.5%		58.9%		17.0%	
10,000-35,000 (N= 323)	48.2%	43.6%		39.3%		15.8%	
Income >35,000 (N= 111)	16.1%	31.8%		16.2%		10.4%	
Literacy			0.0002		<0.0001		0.71
None (N=163)	24.9%	57.1%		55.2%		16.9%	
Some (N=266)	40.4%	44.5%		44.4%		15.8%	
Most and read all (N=231)	34.7%	36.1%		31.6%		13.9%	
Alcohol use			<0.0001		0.06		0.14
No (N=584)	86.8%	41.2%		44.0%		14.6%	
Yes (N=90)	13.2%	68.9%		33.3%		20.7%	

1. Reporting “Usually not” or “Never” to “Do you have enough food; 2. Household Dietary Diversity Score; 3.Body Mass Index (*kg/m²*)
*among HIV+ women

Table 2. Univariate and Multivariate Analysis Factors associated with Food Insecurity, Household Dietary Diversity and BMI

	Food Insufficiency[1]		Household Dietary Diversity Score ≤3[2]		BMI[3] ≤18.5	
Variable	**Univariate OR (95% CI) p value**	**Multivariate OR (95% CI) p value**	**Univariate OR (95% CI) p value**	**Multivariate OR (95% CI) p value**	**Univariate OR (95% CI) p value**	**Multivariate OR (95% CI) p value**
HIV negative	Reference		Reference		Reference	Reference
HIV positive, CD4	-		-		-	-
CD4 > 350 cells/µl	0.69 (0.39, 1.24)		0.93 (0.52, 1.66)		0.55 (0.26, 1.18)**	0.55 (0.26, 1.18)**
CD4 200-350	1.14 (0.75, 1.72)		0.87 (0.57, 1.32)		0.44 (0.26, 0.77)**	0.44 (0.26, 0.77)**
CD4 < 200	0.84 (0.56, 1.26)		1.03 (0.69, 1.54)		0.42 (0.24, 0.72)**	0.42 (0.24, 0.72)**
ART use[4]	0.97 (0.66, 1.42)		1.18 (0.80, 1.73)		0.64 (0.37, 1.12)	
Number of people in household						
0-2	Reference		Reference		Reference	
3-5	1.19 (0.81, 1.74)		1.12 (0.76, 1.64)		1.62 (0.92, 2.86)	
>5	1.13 (0.73, 1.76)		0.87 (0.56, 1.35)		1.15 (0.59, 2.25)	
Age						
< 30 years	Reference		Reference		Reference	
31-40 yrs	1.19 (0.78, 1.82)		1.19 (0.78, 1.82)		1.38 (0.70, 2.73)	
> 40yrs	1.38 (0.88, 2.15)		1.27 (0.81, 1.99)		2.27 (1.15, 4.47)	
Low Income, *RWF/year*						
<10,000	2.37 (1.47, 3.81)***	2.14 (1.30, 3.52)**	7.41 (4.21, 13.05)***	6.51 3.66, 11.57)***	1.77 (0.87, 3.61)	
<10,000-35 ,000	1.66 (1.05, 2.62)*	1.52 (0.94, 2.44)	3.35 (1.93, 5.81)***	3.07 (1.76, 5.37)***	1.62 (0.81, 3.24)	
>35,000	Reference	Reference	Reference	Reference	Reference	
Illiteracy: can read						
None	2.25 (1.50, 3.37)***	2.00 (1.31, 3.04)**	2.61 (1.73, 3.92)***	2.10 (1.37, 3.23)***	1.26 (0.73, 2.19)	
Some	1.36 (0.95, 1.94)	1.24 (0.86, 1.79)	1.69 (1.17, 2.42)**	1.48 (1.01, 2.16)*	1.16 (0.71, 1.91)	
Most or All	Reference	Reference	Reference	Reference	Reference	
Alcohol use						
Any vs. none	3.15 (1.96, 5.08)***	3.23 (1.99, 5.24)***	0.64 (0.40, 1.02)	0.60 (0.37, 0.98)	1.53 (0.87, 2.70)	

1. "Usually not" or "Never" to Do you have enough food?, N=302, 2. Household Dietary Diversity Score, N=186, 3. Body Mass Index (kg/m^2), N=101, 4. Was not considered for multivariate models as it was only defined for HIV positive women and was never statistically significant in unadjusted models

P-value: **=0.001-0.01, ***=<0.001

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STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
Outcome data	15*	Report numbers of outcome events or summary measures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses

Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.