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Socioeconomic correlates of dietary diversity and its association with adherence and psychosocial functioning of people living with HIV in rural Zambia

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Abstract

Background: The intersection of nutrition and HIV underscores the importance of adequate food and a diverse diet. In communities with high prevalence of food insecurity and HIV, there is a substantial co-occurrence of low dietary diversity, undernutrition, and adverse health outcomes. **Aim:** The aim of this study was to identify correlates of individual dietary diversity (IDD) and its association with health outcomes for people living with HIV (PLHIV) in rural Zambia. **Methods:** The study used a cross-sectional design using data from 101 PLHIV. We calculated IDD using a composite score based on dietary diversity, food frequency, and the relative nutritional importance of different food groups. Adherence was measured using the visual analog scale. Psychosocial functioning was measured using the Structural Barriers to Medication-taking Scale and the Perceived Stress Scale. Data were analyzed using linear and logistic regressions. Multiple imputation was conducted to address missing data. **Results:** Staples were the most commonly consumed food group. Income and household size were negatively associated with IDD scores. Assets were positively associated with IDD scores. Residing in Lundazi and having a poor or fair self-rated health were associated with lower IDD scores. IDD was also associated, albeit not significant, with desirable health outcomes, including adherence and lower levels of perceived barriers to pill taking and stress. **Conclusions:** Findings suggest a heterogeneous effect of socioeconomic variables on IDD. Understanding this heterogeneity is important for the design of interventions. Interventions that combine opportunities to generate economic resources with food and nutrition coaching may be appropriate and effective.

Keywords

Dietary diversity, assets, income, psychosocial functioning, adherence, HIV, barriers to pill taking, perceived stress, Zambia

Introduction

The intersection of nutrition and HIV underscores the importance of adequate food and a diverse diet. The types of food people living with HIV (PLHIV) eat are vital to prevent malnutrition, extend periods of asymptomatic infection, boost immune system, fight opportunistic infections, support recovery from infections, and slow disease progression (De Pee and Semba, 2010; Ivers et al., 2009; Kadiyala and Rawat, 2013). Furthermore, food is critical to improve efficacy of antiretroviral therapy (ART), optimize treatment outcomes, regain energy and strength, maintain body weight, and minimize adverse side effects of antiretroviral (ARV) drugs (Drain et al., 2007; McDermott et al., 2003; Salomon et al., 2002; Seume-Fosso et al., 2004). Alternatively, a less diverse diet heightens risk of mortality (De Pee and Semba, 2010; Rawat et al., 2013) and increases efficiency of HIV transmissions (Hadgu et al., 2013; Weiser et al., 2011).

In communities with high prevalence of poverty and HIV, there is a substantial overlap of food insecurity, defined as limited access to food, and HIV (Mamlin et al., 2009; Masa et al., 2017; Musumari et al., 2014; Tsai et al.,

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2011). In turn, inadequate food access contributes to consumption patterns that are less diverse and nutritious (Faber et al., 2017; Na et al., 2016; Ntwenya et al., 2015; Rebick et al., 2016). Unsurprisingly, the state of diet and food consumption of PLHIV in low-resource settings are marginal and require improvement (Duran et al., 2008; Hadgu et al., 2013). Similarly, low dietary diversity is more common in HIV-positive populations compared with HIV-negative populations in sub-Saharan Africa (SSA) (Mpontshane et al., 2008; Oketch et al., 2011; Onyango et al., 2009; Sunguya et al., 2014). As a result, undernutrition is highly prevalent among PLHIV (Hadgu et al., 2013; Sunguya et al., 2014).

Although a nutritious diverse diet is crucial in all stages of HIV infection, we know little about the correlates of individual dietary diversity (IDD) among PLHIV. In contrast, a growing number of studies have examined factors associated with food access among HIV-positive populations in low-resource countries (Masa et al., 2017; Nagata et al., 2012; Tiyou et al., 2012; Tsai et al., 2011). Given current gaps in knowledge, this study aims to examine correlates of IDD in a sample of treatment-experienced PLHIV, that is, HIV+ persons who are receiving ART, in rural Zambia. Our study may help identify modifiable factors that can be altered by food and nutrition interventions for PLHIV. Additionally, we intend to expand empirical evidence pertaining to the association between dietary diversity and health outcomes for PLHIV. Beyond nutrition and physiological health, prior research indicates wide-ranging effects of dietary diversity on health, including adherence (Bahwere et al., 2011; Berhe et al., 2013; Gebrezgabher et al., 2017), access to HIV treatment (Chileshe and Bond, 2010), and mental health (Palermo et al., 2013). In this study, we examined the association between dietary diversity and medication adherence, perceived barriers to pill taking, and perceived stress. To our knowledge, this study is one of the first to examine correlates of dietary diversity and its association with health outcomes for treatment-experienced PLHIV in rural Zambia and similar communities in southern Africa.

Methods

Study design and sample

This study used a cross-sectional design. We analyzed baseline data that were collected, between December 2014 and January 2015, from 101 treatment-experienced PLHIV who were participating in an integrated HIV and livelihood intervention. The sample size was determined by the requirements of the main intervention outcome, treatment adherence. Thus, the aim was to recruit 100 treatment-experienced PLHIV (Teare et al., 2014). In addition, at the time of data collection, all respondents were receiving outpatient care either at Lundazi District (LDH) or Lumezi Mission Hospital (LMH). All study respondents were between 18 and 50 years old, economically poor (defined as living below the Zambian national poverty threshold of approximately $90 USD per month (Zambia Central Statistical Office, 2012a), not pregnant, and not experiencing rapid weight loss at the time of recruitment. The study protocol was approved by the Institutional Review Board at the University of North Carolina at Chapel Hill and the University of Zambia. Informed consent was obtained from all individual participants included in the study.

Study setting

The study was conducted in Lundazi District, Eastern Province. Lundazi District was selected because the original intervention study aimed to test an integrated HIV and livelihood program in a rural setting with high prevalence of HIV and with substantial proportion of smallholder farmers. Lundazi District is predominantly rural, with more than 90% of the 314,281 residents living in rural areas (Zambia Central Statistical Office, 2012b). Lundazi District also has a high HIV prevalence, estimated at 15% in 2010 (Zambia National AIDS Council, 2014). The district is one of the highest producers of maize, cotton, groundnuts, and tobacco. Most of the district's annual agricultural output is produced by an estimated 68,000 small-scale farmers (Zimba, 2015). Within Lundazi District, two health facilities were selected as study sites. The two health facilities were in Lundazi (LDH) and Lumezi (LMH).

Variables and measures

Individual dietary diversity. Consistent with the literature, we defined IDD as the number of food or food groups consumed by the respondent (not the entire household) over a given reference period (Ruel, 2003). We measured IDD by using a four-point Likert scale (*never*, *rarely*, *sometimes*, or *often*) that asked respondents, at the time of data collection, how frequently they had eaten the following six food groups: staples, meat, fish, beans, seeds and nuts, and vegetables in the past seven days. For each food group, we listed food items that are relevant and familiar to the respondents and their local communities. We calculated IDD using a composite score based on consumption of foods or food groups, frequency of consumption, and the relative nutritional importance of each food group. We calculated each respondent's score by using this formula: $\text{IDD} = A_{\text{staples}}X_{\text{staples}} + A_{\text{meat}}X_{\text{meat}} + A_{\text{fish}}X_{\text{fish}} + A_{\text{beans}}X_{\text{beans}} + A_{\text{seeds/nuts}}X_{\text{seeds/nuts}} + A_{\text{vegetables}}X_{\text{vegetables}}$, where X_{i} is the frequency of food consumption in the past seven days and A_i is the weight of the food group i. Frequency of food consumption was based on the four-point Likert scale and was coded as: 0 = *never*; 1 = *rarely*; 2 = *sometimes*; and 3 = *often*. Based on their energy, protein, and micronutrient densities, we applied the following weights for each food group: (a) two for main staples; (b) three for pulses such as beans and nuts; (c) one for vegetables; and (d) four for meat and fish (World Food Programme, 2008). Higher scores signify a more diverse

diet. We also categorized IDD scores as follows: 0–21 = poor; 21.5–35 = borderline; and >35 = acceptable. These procedures for calculating IDD scores were based on measurement tools that had been validated in similar settings in SSA (Nsabuwera et al., 2016; Ruel, 2003; World Food Programme, 2008).

Adherence and psychosocial functioning. We used three health indicators as outcome variables. First, *adherence* was measured using a visual analog scale (VAS), which had been used in prior research in Zambia (Haberer et al., 2011; Hampanda et al., 2017). The VAS assessed ART adherence during the past 30 days. Despite limitations, prior studies have found no evidence of significant overestimation when using patient self-assessments of ART adherence compared with other adherence measures such as pharmacy records (Kabore et al., 2015; Simoni et al., 2014). Second, *perceived barriers to pill taking* referred to the extent to which different structural barriers to pill or medication taking applied to respondents' own situations in the past 30 days. This outcome variable was measured using the 11-item Structural Barriers to Medication-taking Scale, which was developed and validated in South Africa (Coetzee and Kagee, 2013). Items were aggregated to obtain the barrier to pill taking scores. A higher score indicates presence of numerous barriers to medication adherence. Third, *perceived stress* referred to the degree to which respondents assessed their life situations as stressful and their ability to manage the same life events in the last four weeks. Perceived stress was measured using the 10-item perceived stress scale (PSS) (Cohen and Williamson, 1988; Cohen et al., 1983). Consistent with prior research (Cohen and Williamson, 1988; Leung et al., 2010), we used a two-factor PSS. The first factor was a 4-item measure of perceived coping strategies. The second factor was a six-item measure of perceived mental distress. Item responses were aggregated to obtain scores for each factor. A higher score on the coping factor indicates ability to manage stressful events, whereas a higher score on the perceived distress factor suggests inability to deal with stressful situations. The PSS had been validated and used in previous research in Zambia (Hjelm et al., 2017) and similar low-resource settings (Dao-Tran et al., 2017; Hannan et al., 2016).

Covariates. Covariates of IDD included occupation (farming or non-farming), household size (total number of people living in respondent's household at the time of data collection), place of residence (Lundazi or Lumezi), monthly household income (measured in four categories: 0–20 Zambian kwacha (Zk), 21–50 Zk, 51–500 Zk, and ≥501 Zk), frequency of saving (*never*, *sometimes*, or *usually/always*), asset ownership (household possessions and livestock), food access, and self-rated health (*poor/fair* or *good/very good/excellent*). Asset ownership included two types of assets: livestock and household possessions. For both asset variables, we created two distinct asset indices using methods recommended in the literature (Filmer and Scott, 2012). A high index value indicates ownership of more assets. Livestock comprised ownership of chickens, pigs, goats, cattle, donkeys, and sheep. Household possessions included ownership of a radio, electric or gas stove, charcoal brazier, electric iron, charcoal iron, refrigerator, television, cellular phone, and land phone. Food access was measured using an adaptation of the Household Food Insecurity Access Scale (HFIAS) (Coates et al., 2007). HFIAS consists of nine items that ask respondents the frequency of experiencing different conditions and degrees of food insecurity, defined as inadequate access to food, within the past four weeks. We obtained a continuous measure of food access by summing the scores for all HFIAS items. Higher HFIAS scores indicate worsening access to food. Additionally, we used the following variables as covariates of adherence and psychosocial functioning: gender (male or female), marital status (married or not married), head of household status (yes or no), debt (owed or did not owe money), self-rated health, and food access.

Analysis

We conducted bivariable and multivariable analyses to examine the correlates of dietary diversity and its association with adherence and psychosocial functioning. We used linear regression with ordinary least squares method to identify the correlates of IDD and to examine the association between IDD and three continuous-level outcomes, perceived barriers to pill taking and the two-factor structure of perceived stress (coping and distress). We used logistic regression to examine the relationship between IDD and a binary adherence variable. Significance level was set at $p < .05$.

Additionally, we performed multiple imputation (MI) to address potential issues associated with missing data. Missing data analysis using MI included several steps, each undertaken separately. First, although there is no established cutoff regarding an acceptable proportion of missing data for valid statistical inferences (Dong and Peng, 2013), we examined missing-data patterns. Missing values included 12% of adherence and 32% of IDD. Second, we conducted diagnostic tests to explore missing-data mechanisms. Results suggested that the missing at random (MAR) assumption may be reasonable. Third, we built an imputation model based on best practices suggested in the literature (Allison, 2002; Enders, 2010; Graham, 2009; White et al., 2011). For example, all variables in the MI model were at least minimally associated with the variables containing the missing values. We also created a more general imputation model compared with a specific analytical model to capture more associations between the variables (Enders et al., 2006; Graham, 2009). Fourth, MI datasets were created by imputation using the chained equations approach (Van Buuren, 2007; White et al., 2011). Last, we created our primary MI model with 100 imputed data sets to yield accurate statistical results and improve

Table 1. Sample characteristics and correlates of individual dietary diversity scores.

Variables	% or M (SD)[a]	Dietary Diversity Scores[b]		
		β	p	95% CI
Dependent variable				
Individual dietary diversity	23.99 (10.43)	-	-	-
Independent variables				
Occupation		−4.04	.28	−11.51, 3.43
Farming*	75%			
Non-farming	25%			
Household size	5.99 (3.60)	−0.95	.02	−1.73, −0.16
Place of residence		10.12	.02	2.07, 18.18
Lundazi*	50%			
Lumezi	50%			
Household income		−6.14	.01	−10.38, −1.89
Zk 0–20	45%			
Zk 21–50	25%			
Zk 51–500	15%			
>Zk 501	15%			
Frequency of saving				
Never*	36%			
Sometimes	50%	2.70	.31	−2.52, 7.91
Usually or always	14%	2.20	.58	−5.74, 10.15
Inadequate access to food	14.43 (7.86)	−0.15	.36	−0.47, 0.18
Household possessions index	0.64 (0.81)	6.39	.00	2.46, 10.31
Livestock index	1.37 (2.99)	1.02	.05	−0.01, 2.04
Self-rated health		7.17	.04	0.29, 14.05
Poor/fair*	19%			
Good/very good/excellent	81%			

M = mean, SD = standard deviation; β = regression coefficient; CI = confidence interval; Zk = Zambian kwacha.
[a]M (SD) for continuous variables and percentage distribution (%) for categorical variables.
[b]Results were based on multiple imputation with 100 multiply imputed datasets.
* = reference group.

power (Enders, 2010; Graham et al., 2007). We tested the sensitivity of results to the number of imputations by generating an additional model with 50 multiply imputed datasets. We also compared the results based on complete-case analysis and MI. Results were similar. In all analytical models, the direction of associations did not change when using either complete-case analysis or MI method. However, complete case results had larger coefficient sizes and smaller robust standard errors compared to MI results.

Using multiply imputed data sets, we estimated five multivariable models. Model 1 examined correlates of IDD. In model 1, we treated the ordinal household income variable as an interval variable. Likelihood ratio test results indicated that treating household income as an interval variable did not lead to loss of information about the association of this variable with dietary diversity score (Long and Freese, 2006). The remaining four models examined associations between dietary diversity and treatment adherence (model 2), perceived barriers to pill taking (model 3), perceived coping strategies (model 4), and perceived mental distress (model 5). In model 2, we created a binary adherence variable using the VAS. We defined adherence as $\geq$95% of scheduled doses taken (Ickovics and Meade, 2002; Paterson et al., 2000). Respondents were adherent if they took $\geq$95% of prescribed doses, and non-adherent if they took <95% of prescribed doses. All analyses were conducted by the first author using Stata 14 (StataCorp, 2015).

Results

Sample characteristics and individual dietary diversity

Table 1 lists respondents' characteristics that were included as correlates of IDD. The sample also included more women (56%) than men, married (75%) than not married, and heads of household (65%) than non-heads of household. The study also had fewer respondents with monetary debt (24%) compared to those without debts. More than 90% of respondents reported having inadequate access to food. Inadequate food access might have influenced dietary diversity. Food consumption levels were classified as predominantly borderline (45%) or poor (42%). Only 13% of respondents had acceptable food consumption levels (World Food Programme, 2008). Table 2 lists the frequency

Table 2. Frequency of consuming various food groups in the past seven days.

Food group	Never	Rarely	Sometimes	Often
Staples	15%	8%	21%	56%
Meat	35%	32%	31%	2%
Fish	29%	32%	35%	4%
Beans	14%	41%	37%	8%
Seeds and nuts	15%	34%	31%	20%
Vegetables	12%	11%	22%	55%

Never = 0 times in the past seven days; rarely = once or twice; sometimes = three or four times; and often = five times or more.

of consuming food items from six different food groups. Staples and vegetables were the most frequently consumed food groups. Alternatively, meat (such as beef and chicken) was the least frequently consumed food group.

Correlates of individual dietary diversity

Table 1 (last three columns) lists correlates of IDD. Multivariable findings indicated significant associations between socioeconomic variables and IDD. Significant correlates ($p \leq .05$) included asset ownership, income, household size, place of residence, and self-rated health. Ownership of livestock or household possessions was positively associated with IDD scores. However, income was negatively associated with IDD scores. Household size was also negatively associated with IDD scores. Residing in Lumezi and having a good or better self-rating of one's health were positively associated with IDD scores. In addition, having an occupation other than farming and inadequate access to food were associated with a less diverse diet, while, being able to save was associated with a more diverse diet. However, these relationships were not statistically significant. Additionally, sensitivity model results supported findings based on the primary MI model.

Individual dietary diversity and health outcomes

Table 3 lists the multivariable associations of IDD scores and the four health outcomes. Overall, results indicated desirable associations between dietary diversity and adherence and psychosocial functioning of treatment-experienced PLHIV.

Self-reported adherence. In contrast with a less diverse diet, a more diverse diet was associated with ART adherence. As illustrated in Table 3, primary and sensitivity MI models produced identical results. However, this association was not statistically significant.

Perceived barriers to pill taking. Respondents who reported consuming a more diverse diet scored lower on the perceived barriers to pill taking scale compared with their peers who reported consuming a less diverse diet. In other words, respondents with a more diverse diet reported fewer barriers to pill taking compared to respondents with a less diverse diet. Primary and sensitivity MI models produced identical results. However, this association was not statistically significant.

Perceived stress. Consumption of a more diverse diet was associated with higher level of perceived coping strategies. This positive association approached statistical significance in the primary model ($p < .10$), and was statistically significant in the sensitivity model ($p = .05$). Furthermore, dietary diversity was associated with lower level of perceived mental distress. However, this association was not significant in both MI models.

Discussion

The most commonly consumed food group was staples, which are high in carbohydrates. The frequent consumption of carbohydrate sources is consistent with previous studies in the region. In Kenya (Onyango et al., 2009) and Tanzania (Barnett and Rugalema, 2000), HIV-affected households tend to consume mainly starchy food; a pattern that is attributed to low socioeconomic status. However, as our findings illustrate, the role of income and other indicators of socioeconomic status on dietary diversity appears to be heterogeneous. A key example is the contradicting associations of income and assets on dietary diversity. Assets, particularly ownership of livestock or household possessions, were positively associated with dietary diversity. In contrast, income was negatively associated with dietary diversity. This heterogeneity suggests that the effect on dietary diversity appears to be a function of the socioeconomic variable.

First, the beneficial effect of asset ownership on dietary diversity may be explained by the (tangible) direct or indirect influence on consumption. For example, livestock provides a direct and immediate source of various food items, such as eggs, milk, meat, or other animal source foods. The tangible indirect effect can be attributed to assets' ability to generate income or to increase efficient time use. For example, livestock can be sold for cash, which in turn, increases available financial resources to purchase various foods. Additionally, household possessions such as electric or gas stoves may reduce time spent in the kitchen preparing and cooking food, while refrigerators ensure that food lasts longer. The time saved can be allocated for extra work or longer working hours, which in turn, can generate additional resources.

Unlike income, assets may have an intangible influence on dietary diversity. Assets create welfare effects beyond consumption, including increased personal efficacy, motivation, and future orientation (Sherraden, 1991). Evidence from SSA suggests that asset ownership is positively associated with future orientation, or the ability to engage in future thinking (Chowa and Masa, 2015). In other words, owning assets help individuals imagine their possible selves (i.e., the selves an individual would like to be or is

Table 3. Multivariable associations of dietary diversity and adherence, perceived barriers to pill taking, and perceived stress.

	Health outcomes											
	Adherence[a]			Perceived barriers to pill taking			Perceived stress					
							Coping strategies			Mental distress		
Variables	OR	*p*	95% CI	β	*p*	95% CI	β	*p*	95% CI	β	*p*	95% CI
m = 100												
Key predictor variable												
Individual dietary diversity	1.02	.59	0.96, 1.07	−0.05	.56	−0.23, 0.12	0.08	.07	−0.01, 0.17	−0.03	.62	−0.14, 0.08
Covariates												
Gender (reference is female)	0.74	.62	0.22, 2.44	−0.62	.68	−3.56, 2.33	−0.34	.75	−2.49, 1.80	−1.00	.38	−3.27, 1.27
Marital status (reference is not married)	0.74	.62	0.22, 1.44	0.62	.59	−1.64, 2.87	0.23	.81	−1.75, 2.19	−0.02	.98	−2.19, 2.14
Head of household status (reference is no head of household)	0.93	.90	0.27, 3.18	1.61	.21	−0.94, 4.17	−0.01	.99	−1.97, 1.94	0.78	.49	−1.46, 3.02
Debt (reference is no debt)	1.45	.55	0.43, 4.89	0.48	.78	−2.88, 3.84	−0.13	.90	−2.12, 1.86	−0.38	.70	−2.38, 1.61
Food access	0.99	.87	0.93, 1.06	0.06	.39	−0.08, 0.20	−0.03	.61	−0.16, 0.09	0.20	.00	0.10, 0.30
Self-rated health (reference is poor/fair)	1.93	.31	0.55, 6.84	−5.55	.09	−11.90, 0.80	0.56	.87	−1.36, 2.48	−3.08	.00	−5.21, −0.94
m = 50												
Key predictor variable												
Individual dietary diversity	1.02	.59	0.95, 1.08	−0.05	.54	−0.23, 0.12	0.09	.05	0.00, 0.18	−0.03	.60	−0.13, 0.08
Covariates												
Gender (reference is female)	0.76	.66	0.23, 2.53	−0.63	.67	−3.56, 2.31	−0.31	.77	−2.44, 1.81	−0.99	.39	−3.25, 1.28
Marital status (reference is not married)	0.75	.63	0.23, 2.44	0.64	.58	−1.62, 2.90	0.19	.84	−1.75, 2.14	−0.02	.98	−2.20, 2.14
Head of household status (reference is not head of household)	0.94	.91	0.28, 3.16	1.63	.21	−0.94, 4.20	−0.05	.96	−1.98, 1.87	0.77	.50	−1.47, 3.01
Debt (reference is no debt)	1.35	.63	0.40, 4.46	0.50	.77	−2.86, 3.86	−0.14	.89	−2.09, 1.82	−0.35	.72	−2.33, 1.62
Food access	0.99	.84	0.93, 1.06	0.06	.38	−0.08, 0.20	−0.03	.60	−0.16, 0.09	0.20	.00	0.10, 0.30
Self-rated health (reference is poor/fair)	1.99	.28	0.57, 7.00	−5.51	.09	−11.88, 0.86	0.50	.61	−1.42, 2.41	−3.05	.01	−5.20, −0.90

OR = odds ratio, CI = confidence interval, β = regression coefficient.
[a]Reference for adherence variable is not optimally adherent.

afraid of becoming) that function as incentives and disincentives for certain behaviors through the projection of desired or undesired end states (Markus and Nurius, 1986). When PLHIV see themselves in a healthy future state, they may be likely to follow treatment guidelines (e.g., taking medications as prescribed or consuming a diverse diet to ensure adequate nutrition) and to avoid behaviors that jeopardize their future selves (e.g., consuming a suboptimal diet that minimizes treatment efficacy).

Second, the negative association between income and dietary diversity, though counter-intuitive, may reveal underlying mechanisms that may explain the observed relationship. Intuitively, it seems reasonable that as income increases, individuals would tend to diversify their diet and consume various food items, largely because they can afford to buy a greater variety of food. However, our finding indicates that higher income does not translate into consumption of a diverse diet. In contrast to assets, income, which is what people receive as a return on their labor, is mostly spent on current consumption (Shefrin and Thaler, 1988). Although income can be set aside as savings, many people in low-resource communities, including the study setting, have incomes that are irregular, seasonal, and/or obtained in lump sum. Given the variability, income may not be regularly set aside for future needs. It is also possible that, unlike assets, income may not have welfare effects beyond consumption. When incomes are variable, individuals may not have the ability or motivation to think about their futures or to imagine their possible selves (Haushofer and Fehr, 2014). As a result, income may not function as an incentive for certain behaviors (e.g., consuming a diverse diet) that enable one's desired future self.

Furthermore, expensive food items can generate more appetizing and pleasant diets. In contrast, a monotonous

diet (e.g., comprising staples and beans) may be unenjoyable and unsavory. Evidence indicates a "flight to quality" in food consumption (i.e., as income increases, individuals do not necessarily consume more of the same food and maximize the intake of calories or nutrients) in low-resource communities outside SSA (Banerjee and Duflo, 2011; Jensen and Miller, 2008; Popkin et al., 2001). In fact, when incomes are higher, individuals tend to spend the extra money on better-tasting and more expensive food items (Deaton and Drèze, 2009; Jensen and Miller, 2008), which are not necessarily rich in nutrients or high in calories. Previous experience with food assistance programs for PLHIV also indicate preference and satisfaction with flavorful foods (Ndirangu et al., 2014; Posse and Baltussen, 2013; Rodas-Moya et al., 2016). In other words, people may be motivated to spend their income in ways that are physiologically and psychosocially satisfying.

Beyond assets and income, our findings suggest an important role of place of residence, household size, and self-perceived health on dietary diversity. Respondents living in Lundazi had significantly lower IDD scores compared to respondents living in Lumezi. One plausible explanation is the availability of more food choices and expensive food items in Lundazi. Lundazi is the district's economic center, where most trading activities occur. It is likely that access to a constant supply and availability of various and expensive food items are more consistent in Lundazi than Lumezi. Furthermore, household size was negatively associated with dietary diversity. Respondents from larger-sized households reported consuming a less diverse diet than smaller-sized households. Larger households generally allocate food to more people than households with fewer members. In turn, food allocation may be in smaller portions and may result in a less diverse diet.

Self-perceived health was significantly associated with dietary diversity. PLHIV who rated their health as good or better had higher IDD scores compared with their peers with poor or fair self-rated health. Although a subjective measure, self-rated health is influenced by the larger social and economic environment. When an individual assesses his or her own health, the same individual reviews available information (e.g., medical and nutritional) and resources (such as assets and social capital) to determine which response best describes his or her health status (Giordano and Lindstrom, 2010; Jylhä, 2009). It is plausible that a good or better self-rating indicates a higher socioeconomic status (characterized by tangible and intangible resources) and recognition of the importance of nutrition on HIV and ART. In turn, a higher socioeconomic standing and better appreciation of the role of nutrition on health allows PLHIV with good or better self-rated health to afford and to recognize the importance of a diverse and nutritious diet. We also examined the relationship between inadequate food access and dietary diversity. Our findings suggest that as access becomes less secure, dietary diversity diminishes, albeit minimally. This inverse association is consistent with prior research (Faber et al., 2017; Ntwenya et al., 2015; Rebick et al., 2016). However, our finding was not statistically significant.

Our motivation for identifying modifiable correlates of dietary diversity is its wide-ranging effects on the health of PLHIV. Our findings add to the growing evidence pertaining to the adverse effects of poor dietary diversity. In contrast with PLHIV with lower dietary diversity scores, we found that PLHIV with higher dietary diversity scores were more likely to take their medications as prescribed, less likely to perceive more barriers to pill taking, more likely to manage stressful life events, and less likely to experience mental distress. Although most relationships were not statistically significant, the consistent positive correlations across various health indicators suggest that dietary diversity may be a critical component for ensuring that PLHIV thrive physically and mentally.

Implications

Our findings have relevant implications. First, findings suggest a heterogeneous role of income and assets on dietary diversity. Understanding these heterogeneous relationships is important for appropriate design of food and nutrition programs for PLHIV. Programs may benefit from incorporating behavioral prompts or "nudges" that remind PLHIV of the importance of adequate food and proper nutrition, particularly as individual or household economic resources increase. It may also be essential to advise PLHIV of various ways to prepare and cook diverse, nutrient-rich foods that have better tastes. Second, our study identifies malleable correlates of dietary diversity that can be altered through purposeful programs. Programs should also take into consideration other factors that heighten risk of poor diet. For example, PLHIV from larger households may not regularly receive a diverse diet. Also, it is possible that in communities such as Lundazi, the combination of higher income, limited information on food and nutrition, and availability of more food choices may drive them to choose foods that are appetizing but less diverse or with little nutritional benefit. Behavioral prompts that are incorporated with HIV treatment may fill the gaps in information and motivation to consume a diverse diet. Last, a two-pronged strategy that: (a) builds economic assets to afford a diverse diet and (b) coaches consumption of a diverse diet may tackle both the need to increase tangible resources and an additional programming for higher income PLHIV to maintain intake of a diverse diet. For example, economic strengthening programs can be combined with life-skills sessions that encourage and inform PLHIV or their treatment supporters about the importance of food and nutrition.

Limitations

Study results should be interpreted in the context of the following limitations. First, the food consumption questionnaire did not include food groups included in other

model questionnaires. For example, our questionnaire did not include milk, sugar, oil, and fruit. Similarly, we did not use the standard 7-day food frequency. Second, our study included one dimension of dietary quality. Because we did not assess other dimensions, including adequacy, balance, and moderation, our assessment of dietary diversity does not equate to dietary quality or consumption of a healthy and nutrient-rich diet. Third, our study design was cross sectional. Cross-sectional design does not eliminate reverse causality and may alter the true direction of observed relationships. Fourth, although we reviewed the literature to identify relevant indicators, our covariates were limited to variables measured in the study and were not exhaustive. Fifth, the small sample size might affect statistical power, which may result in overestimation of coefficient sizes and inability to detect true relationships. However, MI could have helped increase statistical power (Enders, 2010). Sixth, omission of important variables in the MI model might bias study findings. To minimize bias, we created an imputation model that included auxiliary variables to capture more associations between variables (Enders et al., 2006; Graham, 2009). Future research should address these limitations.

Conclusions

The intersection of nutrition and HIV underscores the importance of dietary diversity. Additionally, the adverse effects on physical and mental health of PLHIV draw attention to why identifying modifiable factors associated with dietary diversity is crucial, particularly in the development of appropriate interventions. Our findings indicate a heterogeneous role of similar modifiable factors on dietary diversity. Household economic variables, such as assets and income, influence dietary diversity in opposing ways. This heterogeneity indicates meaningful differences with distinct implications for development of effective interventions. Improving dietary diversity through economic strengthening programs alone may not be sufficient. Economic interventions, or those that provide opportunities to generate resources to access food, may be more effective if they are combined with food and nutrition coaching that reminds PLHIV to follow dietary guidelines for managing HIV and ART, particularly in the context of increasing household economic resources.

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Availability of data and materials

The dataset used in the current study are available from the corresponding author (RM) on reasonable request.

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References

Allison PD (2002) *Missing Data Series: Quantitative Applications in the Social Sciences*. Thousand Oaks, CA: Sage Publications.

Bahwere P, Deconinck H, Banda T, et al. (2011) Impact of household food insecurity on the nutritional status and the response to therapeutic feeding of people living with human immunodeficiency virus. *Patient Preference and Adherence* 5: 619–627.

Banerjee AV and Duflo E (2011) *Poor Economics: A Radical Rethinking of the Way to Fight Global Poverty*. New York: Public Affairs.

Barnett T and Rugalema G (2000) *HIV/AIDS and the Crisis of Rural Livelihood: A Case Study of a Buhaya Village, Bukoba, Tanzania*. New York: United Nations Development Programme.

Berhe N, Tegabu D and Alemayehu M (2013) Effect of nutritional factors on adherence to antiretroviral therapy among HIV-infected adults: a case control study in Northern Ethiopia. *BMC Infectious Diseases* 13: 233.

Chileshe M and Bond VA (2010) Barriers and outcomes: TB patients co-infected with HIV accessing antiretroviral therapy in rural Zambia. *AIDS Care* 22(Supplement 1): 51–59.

Chowa GA and Masa RD (2015) Asset ownership and future orientation of youth and their parents: evidence from Ghana. *Child & Youth Services* 36(2): 173–200.

Coates J, Swindale A and Bilinsky P (2007) *Household Food Insecurity Access Scale (HFIAS) for Measurement of Food Access: Indicator Guide*. Washington, DC: Food and Nutrition Technical Assistance Project, Academy for Educational Development.

Coetzee B and Kagee A (2013) The development of an inventory to assess the structural barriers to clinic attendance and pill-taking amongst users of antiretroviral therapy. *AIDS and Behavior* 17(1): 319–328.

Cohen S and Williamson G (1988) Perceived stress in a probability sample of the US. In: Spacapam S and Oskamp S (eds) *The*

Social Psychology of Health: Claremont Symposium on Applied Social Psychology. Thousand Oaks, CA: Sage Publications, pp.31–67.

Cohen S, Kamarck T and Mermelstein R (1983) A global measure of perceived stress. *Journal of Health and Social Behavior* 24(4): 385–396.

Dao-Tran TH, Anderson D and Seib C (2017) The Vietnamese version of the Perceived Stress Scales (PSS-10): translation equivalence and psychometric properties among older women. *BMC Psychiatry* 17(1): 53.

Deaton A and Drèze J (2009) Food and nutrition in India: facts and interpretations. *Economic and Political Weekly* 44(7): 42–65.

De Pee S and Semba RD (2010) Role of nutrition in HIV infection: review of evidence for more effective programming in resource-limited settings. *Food and Nutrition Bulletin* 31(4): S313–S344.

Dong Y and Peng CYJ (2013) Principled missing data methods for researchers. *SpringerPlus* 2(1): 222.

Drain PK, Kupka R, Mugusi F, et al. (2007) Micronutrients in HIV-positive persons receiving highly active antiretroviral therapy. *The American Journal of Clinical Nutrition* 85(2): 333–345.

Duran AC, Almeida LB, Segurado AA, et al. (2008) Diet quality of persons living with HIV/AIDS on highly active antiretroviral therapy. *Journal of Human Nutrition and Dietetics* 21(4): 346–350.

Enders C, Dietz S, Montague M, et al. (2006) Modern alternatives for dealing with missing data in special education research. *Advances in Learning and Behavioral Disorders* 19: 101–130.

Enders CK (2010) *Applied Missing Data Analysis*. New York: Guilford Press.

Faber M, Wenhold FA and Laurie SM (2017) Dietary diversity and vegetable and fruit consumption of households in a resource-poor peri-urban South Africa community differ by food security status. *Ecology of Food and Nutrition* 56(1): 62–80.

Filmer D and Scott K (2012) Assessing asset indices. *Demography* 49(1): 359–392.

Gebrezgabher BB, Kebede Y, Kindie M, et al. (2017) Determinants to antiretroviral treatment non-adherence among adult HIV/AIDS patients in northern Ethiopia. *AIDS Research and Therapy* 14: 16.

Giordano GN and Lindstrom M (2010) The impact of changes in different aspects of social capital and material conditions on self-rated health over time: a longitudinal cohort study. *Social Science & Medicine* 70(5): 700–710.

Graham JW (2009) Missing data analysis: making it work in the real world. *Annual Review of Psychology* 60: 549–576.

Graham JW, Olchowski AE and Gilreath TD (2007) How many imputations are really needed? Some practical clarifications of multiple imputation theory. *Prevention Science* 8(3): 206–213.

Haberer JE, Cook A, Walker AS, et al. (2011) Excellent adherence to antiretrovirals in HIV+ Zambian children is compromised by disrupted routine, HIV nondisclosure, and paradoxical income effects. *PLoS One* 6(4): e18505.

Hadgu TH, Worku W, Tetemke D, et al. (2013) Undernutrition among HIV positive women in Humera hospital, Tigray, Ethiopia, 2013: antiretroviral therapy alone is not enough, cross sectional study. *BMC Public Health* 13: 943.

Hampanda KM, Abougi LL and Ahmed Y (2017) HIV-positive women taking lifelong antiretroviral therapy report better adherence than women taking short-course prophylaxis during and after pregnancy under PMTCT program Option A in Lusaka, Zambia. *International Journal of MCH and AIDS* 6(1): 27–35.

Hannan J, Diaz G, Valcourt M, et al. (2016) Psychometric properties of newly translated Creole perceived stress scale and daily hassles scale. *Journal of Nursing Measurement* 24(2): 190–201.

Haushofer J and Fehr E (2014) On the psychology of poverty. *Science* 344(6186): 862–867.

Hjelm L, Handa S, de Hoop J, et al. (2017) Poverty and perceived stress: evidence from two unconditional cash transfer programs in Zambia. *Social Science & Medicine* 177: 110–117.

Ickovics JR and Meade CS (2002) Adherence to HAART among patients with HIV: breakthroughs and barriers. *AIDS Care* 14(3): 309–318.

Ivers LC, Cullen KA, Freedberg KA, et al. (2009) HIV/AIDS, undernutrition, and food insecurity. *Clinical Infectious Diseases* 49(7): 1096–1102.

Jensen RT and Miller NH (2008) Giffen behavior and subsistence consumption. *The American Economic Review* 98(4): 1553–1577.

Jylhä M (2009) What is self-rated health and why does it predict mortality? Towards a unified conceptual model. *Social Science & Medicine* 69(3): 307–316.

Kabore L, Muntner P, Chamot E, et al. (2015) Self-report measures in the assessment of antiretroviral medication adherence: comparison with medication possession ratio and HIV viral load. *Journal of the International Association of Providers of AIDS Care* 14(2): 156–162.

Kadiyala S and Rawat R (2013) Food access and diet quality independently predict nutritional status among people living with HIV in Uganda. *Public Health Nutrition* 16(1): 164–170.

Leung DYP, Lam T and Chan SSC (2010) Three versions of Perceived Stress Scale: validation in a sample of Chinese cardiac patients who smoke. *BMC Public Health* 10(1): 1–7.

Long JS and Freese J (2006) *Regression Models for Categorical Dependent Variables Using Stata*. College Station, TX: Stata Press.

Mamlin J, Kimaiyo S, Lewis S, et al. (2009) Integrating nutrition support for food-insecure patients and their dependents into an HIV care and treatment program in Western Kenya. *American Journal of Public Health* 99(2): 215–221.

Markus H and Nurius P (1986) Possible selves. *American Psychologist* 41(9): 954.

Masa R, Chowa G and Nyirenda V (2017) Prevalence and predictors of food insecurity among people living with HIV enrolled in antiretroviral therapy and livelihood programs in two rural Zambian hospitals. *Ecology of Food and Nutrition* 56(3): 256–276.

McDermott AY, Shevitz A, Must A, et al. (2003) Nutrition treatment for HIV wasting: a prescription for food as medicine. *Nutrition in Clinical Practice* 18(1): 86–94.

Mpontshane N, Broeck JV den, Chhagan M, et al. (2008) HIV infection is associated with decreased dietary diversity in South African children. *The Journal of Nutrition* 138(9): 1705–1711.

Musumari PM, Wouters E, Kayembe PK, et al. (2014) Food insecurity is associated with increased risk of non-adherence to antiretroviral therapy among HIV-infected adults in the Democratic Republic of Congo: a cross-sectional study. *PLoS One* 9(1): e85327.

Na M, Mehra S, Christian P, et al. (2016) Maternal dietary diversity decreases with household food insecurity in rural Bangladesh: a longitudinal analysis. *The Journal of Nutrition* 146(10): 2109–2116.

Nagata JM, Magerenge RO, Young SL, et al. (2012) Social determinants, lived experiences, and consequences of household food insecurity among persons living with HIV/AIDS on the shore of Lake Victoria, Kenya. *AIDS Care* 24(6): 728–736.

Ndirangu M, Sztam K, Sheriff M, et al. (2014) Perceptions of food-insecure HIV-positive adults participating in a food supplementation program in central Kenya. *Journal of Health Care for the Poor and Underserved* 25(4): 1763–1783.

Nsabuwera V, Hedt-Gauthier B, Khogali M, et al. (2016) Making progress towards food security: evidence from an intervention in three rural districts of Rwanda. *Public Health Nutrition* 19(7): 1296–1304.

Ntwenya JE, Kinabo J, Msuya J, et al. (2015) Dietary patterns and household food insecurity in rural populations of Kilosa district, Tanzania. *PLoS One* 10(5): e0126038.

Oketch JA, Paterson M, Maunder EW, et al. (2011) Too little, too late: comparison of nutritional status and quality of life of nutrition care and support recipient and non-recipients among HIV-positive adults in KwaZulu-Natal, South Africa. *Health Policy* 99(3): 267–276.

Onyango AC, Walingo MK and Othuon L (2009) Food consumption patterns, diversity of food nutrients and mean nutrient intake in relation to HIV/AIDS status in Kisumu district Kenya. *African Journal of AIDS Research* 8(3): 359–366.

Palermo T, Rawat R, Weiser SD, et al. (2013) Food access and diet quality are associated with quality of life outcomes among HIV-infected individuals in Uganda. *PLoS One* 8(4): e62353.

Paterson DL, Swindells S, Mohr J, et al. (2000) Adherence to protease inhibitor therapy and outcomes in patients with HIV infection. *Annals of Internal Medicine* 133(1): 21–30.

Popkin BM, Horton S, Kim S, et al. (2001) Trends in diet, nutritional status, and diet-related noncommunicable diseases in China and India: the economic costs of the nutrition transition. *Nutrition Reviews* 59(12): 379–390.

Posse M and Baltussen R (2013) HIV/AIDS patient satisfaction with a food assistance programme in Sofala province, Mozambique. *African Journal of AIDS Research* 12(4): 203–210.

Rawat R, McCoy SI and Kadiyala S (2013) Poor diet quality is associated with low CD4 count and anemia and predicts mortality among antiretroviral therapy-naive HIV-positive adults in Uganda. *Journal of Acquired Immune Deficiency Syndromes* 62(2): 246–253.

Rebick GW, Franke MF, Teng JE, et al. (2016) Food insecurity, dietary diversity, and body mass index of HIV-infected individuals on antiretroviral therapy in rural Haiti. *AIDS and Behavior* 20(5): 1116–1122.

Rodas-Moya S, Kodish S, Manary M, et al. (2016) Preferences for food and nutritional supplements among adult people living with HIV in Malawi. *Public Health Nutrition* 19(4): 693–702.

Ruel MT (2003) Operationalizing dietary diversity: a review of measurement issues and research priorities. *The Journal of Nutrition* 133(11 Supplement 2): 3911S–3926S.

Salomon J, De Truchis P and Melchior JC (2002) Nutrition and HIV infection. *The British Journal of Nutrition* 87(Supplement 1): S111–S119.

Seume-Fosso E, Rajabiun S and Cogill B (2004) *HIV/AIDS: A Guide for Nutritional Care and Support*. Washington, DC: Food and Nutrition Technical Assistance, Academy for Educational Development.

Shefrin HM and Thaler RH (1988) The behavioral life-cycle hypothesis. *Economic Inquiry* 26(4): 609–643.

Sherraden M (1991) Assets and the poor: a new American welfare policy. *Armonk*, NY: M.E. Sharpe.

Simoni JM, Huh D, Wang Y, et al. (2014) The validity of self-reported medication adherence as an outcome in clinical trials of adherence-promotion interventions: findings from the MACH14 study. *AIDS and Behavior* 18(12): 2285–2290.

StataCorp (2015) *Stata Statistical Software: Release 14*. College Station, TX: StataCorp.

Sunguya BF, Poudel KC, Mlunde LB, et al. (2014) Poor nutrition status and associated feeding practices among HIV-positive children in a food secure region in Tanzania: a call for tailored nutrition training. *PLoS One* 9(5): e98308.

Teare MD, Dimairo M, Shephard N, et al. (2014) Sample size requirements to estimate key design parameters from external pilot randomised controlled trials: a simulation study.*Trials*. 5: 264.

Tiyou A, Belachew T, Alemseged F, et al. (2012) Food insecurity and associated factors among HIV-infected individuals receiving highly active antiretroviral therapy in Jimma zone Southwest Ethiopia. *Nutrition Journal* 11: 51.

Tsai AC, Bangsberg DR, Emenyonu N, et al. (2011) The social context of food insecurity among persons living with HIV/AIDS in rural Uganda. *Social Science & Medicine* 73(12): 1717–1724.

Van Buuren S (2007) Multiple imputation of discrete and continuous data by fully conditional specification. *Statistical Methods in Medical Research* 16(3): 219–242.

Weiser SD, Young SL, Cohen CR, et al. (2011) Conceptual framework for understanding the bidirectional links between food insecurity and HIV/AIDS. *The American Journal of Clinical Nutrition* 94(6): 1729S–1739S.

White IR, Royston P and Wood AM (2011) Multiple imputation using chained equations: issues and guidance for practice. *Statistics in Medicine* 30(4): 377–399.

World Food Programme (2008) *Food Consumption Analysis. Calculation and Use of the Food Consumption Score in Food Security Analysis*. Rome: World Food Programme, Vulnerability Analysis and Mapping Branch.

Zambia Central Statistical Office (2012a) *2010 Census of Population and Housing. Population Summary Report*. Lusaka, Zambia: Central Statistical Office.

Zambia Central Statistical Office (2012b) *2010 Census of Population and Housing (Volume 11 National Descriptive Tables)*. Lusaka, Zambia: Central Statistical Office.

Zambia National AIDS Council (2014) *Zambia Country Report: Monitoring the Declaration of Commitment on HIV and AIDS and the Universal Access*. Lusaka, Zambia: National AIDS Council, Ministry of Health.

Zimba J (2015) Lundazi: small town with big dreams. *Zambia Daily Mail Limited*, 25 February. Available at: www.daily-mail.co.zm/lundazi-small-town-big-dreams/ (accessed August 4, 2017).