Food insecurity and HIV medication adherence among people living with HIV in rural South-Africa

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Layman Summary

Treatment adherence is crucial for people living with HIV to prevent suppression of the immune system and drug resistance. However, adherence is not always optimal and is influenced by many factors. There are social, psychological and biological reasons for not adhering to a treatment regimen. Food insecurity may increase immune suppression and is associated with worse health behaviors. We conducted this research to assess whether food insecurity is related to poor treatment adherence among people living with HIV in rural South Africa.

We found that in women food insecurity is related to poor treatment adherence, but this was not observed for men. This involved both moderate and severe food insecurity. Therefore, this gender inequality regarding food insecurity should be addressed. Women had lower income, more depressive symptoms, were more often unemployed, less likely to have a stable relationship and less likely to be on treatment. This lower socio-economic status compared to men indicates that women should be empowered in order to mitigate this difference. More research is needed to address these differentials in food security and ART adherence between men and women. Additionally, further qualitative research should focus on reasons for non-adhering to treatment.

Abstract

Background

For people living with HIV (PLHIV), antiretroviral therapy (ART) adherence is crucial to prevent viral mutation, opportunistic infections and drug resistance. ART adherence is influenced by many factors. However, it remains unclear if food insecurity is associated with ART adherence in rural Sub-Saharan Africa.

Methods

The Ndlovu Cohort Study in South Africa is a prospective study in a rural setting. 1927 participants were enrolled, of which 887 were HIV-positive. 145 newly diagnosed PLHIV were excluded from analysis. Food insecurity was measured using a score based on answers to a questionnaire, which was then categorized as food secure, moderately food insecure and severely food insecure. ART adherence was classified as good adherence (<50 copies/mL) and poor adherence (>50 copies/mL), based on plasma HIV-RNA. A multivariable logistic regression was performed to estimate odds ratios and corresponding 95% confidence intervals. Individual factors were assessed using the likelihood ratio test, using a stepwise backward approach.

Results

On average, PLHIV (n=742) had been diagnosed five years prior to the study and 16% were ART naïve. 60% of PLHIV were female, 73.3% of PLHIV had undetectable HIV viral load. 25.2% reported moderate food insecurity and 19.9% reported severe food insecurity in the past year. In women, after adjusting for age and line of ART, both moderate (OR: 2.10, 95% CI: 1.06-4.21) and severe (OR: 2.97, 95% CI: 1.46-6.14) food insecurity were significantly associated with poor adherence. In men, food insecurity was not associated with poor adherence.

Interpretation

In women, both moderate and severe food insecurity were significantly associated with poor adherence. Women reported lower educational attainment and lower employment opportunities, suggesting that investment and in education and income generation may mitigate gender inequality regarding food insecurity. Further studies are needed to identify specific determinants of food insecurity and long-term direction and association between food insecurity and ART adherence.

Background

People living with HIV (PLHIV) are at risk of low CD4 cell counts and high HIV RNA viral load, which may lead to unfavorable clinical outcomes (1). Antiretroviral therapy (ART) is effective in suppressing viral multiplication and prevents the weakening of the immune system. Early initiation of ART may prevent a decline in immune function or restore CD4 cell counts when already dropped. Adequate adherence to treatment is crucial as it prevents viral mutation, opportunistic infections, and drug resistance.

Studies suggest that food insecurity in people living with HIV (PLHIV) poses health risks and may increase immune suppression resulting from the infection (2-6). Food insecurity has been defined as having access to sufficient, safe, nutritious food to maintain a healthy and active life (7). Food insecurity may contribute to malnutrition and almost one in four people is undernourished in this region (8). It is suggested that the negative clinical outcomes are partially caused by lower adherence to ART (9, 10). In addition, food insecurity is associated with worse health behaviors and HIV transmission behaviors (4, 8, 11). Reversely, HIV may lead to decreased productivity and consumption of household resources due to health-care related expenses, increasing food insecurity (12). Another mechanism through which PLHIV are disproportionally affected is that food security worsens when the social network is not reliable and that this occurs through possible stigma that PLHIV may suffer from (4).

In Sub-Saharan Africa (SSA), food insecurity affects 239 million people and is related to various social determinants and is more prevalent among PLHIV (13). (14). In SSA, almost half of the population lives below the poverty line (15). There is an increasing inequality between consumption, nutrition and food availability at regional, household and individual levels (15). In rural areas, this may be an even greater problem. Low socio-economic status (lower education, limited income, fewer assets and unemployment) is associated with food insecurity (16). Food insecurity is also linked with structural factors at the community level such as food availability, because demands for food may compete with resources needed to procure medicines and often PLHIV struggle to afford both food, household expenses, medications and travel costs to the clinic (6). Studies also suggest that nausea and vomiting caused by taking ART without food and increased hunger due to ART may contribute to non-adherence (17, 18).

Studies on the association between ART adherence and food insecurity are limited (9) and there are gaps in the understanding of the context and specific determinants of food insecurity. It remains unclear if food insecurity is associated to ART adherence in rural Sub-Saharan Africa and through which mechanisms food insecurity influences HIV transmission, mortality and other clinical outcomes.

This research aims to assess the relation of food insecurity with HIV medication adherence among PLHIV in rural South-Africa. The outcomes may give direction to the development of effective nutrition interventions and food assistance.

Methods

Study design

The Ndlovu Cohort Study is a prospective cohort study in the Moutse area, Limpopo Province, South Africa. Details of the study have been previously described (19). This cohort was originally designed with the aim of providing insight into the burden of cardiovascular risk factors and disease and the contribution of HIV infection to cardiovascular disease in rural South Africa. The study was approved by the Human Research Ethics Committee at the University of Pretoria, Pretoria, South Africa, and the Limpopo Department of Health Ethics Committee, and written informed consent was obtained from all participants before study participation.

Participants

1927 patients were included in the cohort, of which 887 were HIV-positive, recruited from the Ndlovu Medical Centre or from outreach testing programs (20). Enrolment started in November 2014 and was completed in February 2017. All participants were tested for HIV prior to enrolment. Inclusion criteria were age 18 years or older, able to provide written, informed consent and committed to long-term follow-up. Reason for exclusion was the inability to undergo the study procedures for any reason.

Data collection

At baseline, a questionnaire was filled in and physical measurements were collected. Physical measurements that were taken included anthropometric, blood pressure and cardiovascular measurements. Additionally, blood was drawn to obtain information on lipids, glucose, c-reactive protein and for HIV-related measurements such as viral load and CD4 cells. The questionnaire included questions on HIV-related matters such as time to diagnosis, time on ART, line of treatment. It also included questions on socio-economic status, stigma, family, mental health, food security and ART adherence. Questions regarding food security were based on the South African National Health and Nutrition Examination Survey (SANHANES). Data on ART treatment status collected through the questionnaire was complemented with data from an electronic HIV registry (TIER.net). Questions on ART adherence included reasons for skipping medication, frequency of missing medication, beliefs on the efficacy of ART.
Comorbidities were also registered. Hypertension was defined as a systolic BP >140 mm Hg and/or diastolic BP >90 mm Hg and/or use of antihypertensive drugs. Diabetes mellitus was defined as random glucose >11 mmol/L or glycated hemoglobin >6.4 mmol/L or the use of blood glucose-lowering medication. Obesity was defined as having a BMI ≥ 30. More detailed information has been published previously (19).

Exposure

Food insecurity was measured using the answers of the baseline questionnaire based on methods described by the Household Food Insecurity Access Scale (HFIAS) (21). For each question on food insecurity in the past year one point was assigned for the answer ‘yes’ and zero points for the answer ‘no’, answers ‘unknown’ were excluded. A total score

was then calculated for each participant between zero and five. The outcome food insecurity was then categorized as food secure (0), moderate food insecurity (1-3) and severe food insecurity (>3) in the past year.

Main outcome

ART adherence was dichotomized, using plasma HIV-RNA as a proxy measure (22). Undetectable (<50 copies/ml) viral load was classified as good adherence and detectable (>50 copies/ml) viral load as poor adherence. Since newly diagnosed PLHIV were likely to have high viral loads regardless of ART adherence, they were excluded from the analysis.

Covariates

Potential confounding factors were included in the model (11). Age was included as a continuous variable. Highest level of education was categorized as primary, secondary and matric, and college and university. Employment was classified as yes, no or other (student, retired, volunteer). Income per person per month was divided into three categories (in ZAR, <648, 648-992, >992)(23). Depressive symptoms were dichotomized, based on a score using the Patient Health Questionnaire (PHQ)-9. For each one out of nine questions, points (0-3) were obtained (not at all = 0, several days = 1, more than half the days = 2, nearly every day = 3), leading to a total score of 27. A score of nine or lower was classified as absence of depressive symptoms and above nine as displaying depressive symptoms. Smoking and alcohol use were included as dichotomous variables (yes, no), both ever and current smoking, respectively alcohol consumption were assessed. Physical activity was assessed using the International Physical Activity Questionnaire (24), categorized as low, moderate or high. Being in a stable relationship was included as a categorical variable, defined as being married, having a life partner or cohabitating (yes/no). BMI was divided into four categories (<18.5, 18.5-24.9, 25.0-29.9, >29.9).

Data analysis

Descriptive data were presented in table 1 for all the HIV-positive participants in the Ndlovu cohort. Mean (SD), median (interquartile range), count (percentage) were reported where appropriate. Factors associated with socio-economic status were reported, such as: highest level of education (none, primary, secondary and matric, college and university), employment (unemployed, self-employed, other), income stable partnership (yes/no). Factors related to health behaviors were described, such as: physical activity (moderate/high), smoking status (ever, current), alcohol use (ever, in the past 30 days) comorbidities (obesity, hypercholesterolemia, type 2 diabetes mellitus, hypertension), depressive symptoms (in the last two weeks; yes/no). Lastly, HIV-related factors were reported in this table, such as: ART status (first-line, second-line), CD4 cell count, plasma HIV-RNA (< 50, 50-1000, >1000 copies/ml).

145 newly diagnosed (being diagnosed with HIV at a maximum of 8 weeks before inclusion) participants were excluded from analysis on adherence, since HIV plasma RNA could not be used as a proxy measure.

Men and women are unequally affected by food insecurity, suggesting to assess effect modification through a stratified analysis (4). In case of effect modification being present, results will be reported separately for each sex.

Statistical methods

A multivariable logistic regression was performed to estimate odds ratios and corresponding 95% confidence intervals. A two-sided α of 0.05 was used to assess significance. Individual factors were assessed using the likelihood ratio test, using a stepwise backward approach. It was analyzed whether food insecurity was associated with ART-adherence. The model was adjusted for confounding factors. Age and highest education were kept in the model, because of considerable relevance. All analyses were performed using R (version R-4.0.3) (25).

Results

In total, after exclusion of those newly diagnosed, 742 PLHIV were included in this analysis with a mean age of 42 years (SD: 10.0) (**table 1)**. Most participants were unemployed and living under the poverty line. On average, PLHIV had been diagnosed five years prior to the study and 16% were ART naïve. 60% of PLHIV were female. 73.3% of PLHIV had undetectable HIV viral load. 82.5% was on first-line ART and 10.4% was on second-line ART. 54.9% reported being food secure, 25.2% reported moderate food insecurity and 19.9% reported severe food insecurity. Compared to men, women had higher educational attainment, but were more often unemployed. Women also had a lower income and reported more frequently to suffer from depressive symptoms. Men were more often in a stable relationship and on ART than women. Women were more likely to have viral load suppression, which suggests that men are more often non-adherent.

37.5% of PLHIV reported running out of money to buy food in the past 12 months and 32.6% reported cutting the size of meals because there was not enough food in the house **(table 2, figure 1).** Women reported relatively more food insecurity than men. Food insecurity was highest in the months January, February and generally during the winter season in June, July and August.

Overall, in all PLHIV, univariable logistic regression showed a significant association between poor ART adherence and moderate physical activity and being on second line of ART, but not with food insecurity **(table 3)**. After adjusting for age and income, severe food insecurity but not moderate food insecurity was significantly associated with poor ART adherence (OR: 1.69, 95% CI: 1.00-2.83) and being on second line of ART (OR: 2.84, 95% CI: 1.66-4.80).

In men, food insecurity was not associated with poor adherence in both univariable and adjusted analysis. However, we found a significant effect between being on second line of ART and poor adherence in both univariable (OR: 5.69, 95% CI: 2.50-13.35) and multivariable analysis (OR: 5.58, 95% CI: 2.50-12.81).

In women, univariable analysis showed a significant inverse association between poor ART adherence and both age (OR: 0.95, 95% CI: 0.92-0.99) and moderate physical activity (OR: 0.50, 95% CI: 0.25-1.00). Women experiencing moderate food insecurity were 2.04 (95% CI: 1.01-4.18) times more likely to poorly adhere to ART and those reporting severe food insecurity were 2.45 (95% CI: 1.16-5.25) times more likely to poorly adhere. After adjusting for age and line of ART, both moderate (OR: 2.10, 95% CI: 1.06-4.21) and severe (OR: 2.97, 95% CI: 1.46-6.14) food insecurity was

significantly associated with poor adherence. In adjusted analysis, those with moderate physical activity were significantly less likely to poorly adhere to ART compared to those with light physical activity (OR: 0.48, 95% CI: 0.24-0.93).

Discussion

This study found that PLHIV experiencing severe food insecurity were significantly more likely to poorly adhere to ART regimens. Women were more likely to experience both moderate and severe food insecurity than men. Adherence was mostly associated with being on 2nd line of ART.

Severe food insecurity was significantly associated with ART association, but this was not the case for moderate food insecurity. This general association between food insecurity and ART-adherence is seen in multiple other studies (26-31). In contrast to other studies, we did not find financial factors, such as income per person per month, and highest level of education to be significantly associated with ART adherence. This may suggest that food insecurity is related to and affects adherence more than poverty alone and that there may be more complex layers. However, the population was rather poor, so this may explain our different result. A systematic review and meta-analysis published in 2017 showed that nearly all quantitative studies showed that non-adherent PLHIV were less likely to obtain complete viral suppression (32). However, most studies did not distinguish between moderate or severe food insecurity. Another study also found that only severe and not moderate food insecurity was linked to medication adherence (33). Differences in the outcomes of studies may be because of study designs and of different measuring methods for food insecurity and ART adherence. Additionally, our results show a different effect for moderate and severe food insecurity. Moreover, not all studies adjusted for newly diagnosed PLHIV. Comparing our results to other studies from Sub-Saharan Africa, we found the same direction and association between ART adherence and food insecurity (2, 31, 34-41). Two studies, however, did not find a significant or an inverse association between food insecurity and ART adherence (37, 42). In the first study, carried out in rural Zambia, in the qualitative part of the research, food insufficiency was named as one of the main reasons for missing a dose (37). The fact that this study was performed in newly diagnosed PLHIV and the strict measurement of full adherence may explain the different outcome. This suggests that the link between food insufficiency and adherence may be due to enhanced social support targeting people living in extreme poverty. Food insufficiency was also only reported by a single question on the survey. Several other studies observed food insecurity to be related to incomplete HIV RNA suppression (39, 43-45).

In our study, women were more affected by food insecurity. This is in line with previous work (4, 46, 47). We also found that women reported lower socio-economic status. They were less likely to be in a stable relationship, had lower income and were more often unemployed. It is suggested that economic or social dependency may lead them to HIV-risk behaviors such as transactional or commercial sex to obtain resources and food for themselves and their families, even more so in low- and middle-income countries (11, 48). However, it remains unclear if there is a relationship between HIV transmission and food insecurity longitudinally. Gender inequality may be the reason for the difference in

this association. In qualitative studies, women reported economic instability and enacted stigma in the labor and social domains as drivers of food insecurity (49). Stigma may lead to isolation from economic resources, food and other support as women are more likely to be blamed for spreading HIV (50). Gender norms that privilege men's control over women may prevent safer sex, and reproductive decisions. Opposed to our results, the study carried out in rural Zambia in newly diagnosed PLHIV found that full-adherence (defined as never missing medication) was associated with being female (37). The authors suggest that females may be more adherent because of more opportunities to start treatment at early stages, through the participation in prevention of mother-to-child transmission programs. Food insecurity also increases the risk of intimate partner violence (51). A study from Cameroon found that men were more likely to be non-adherent (42). The authors suggest this is because men have more difficulties accepting their HIV status and entering long-term care. More research is needed to address differentials in food security and ART adherence between men and women and to identify the reasons for this. It also remains unclear what the exact reasons of non-adherence are as results are limited and mostly quantitative. Qualitative research on this topic is lacking, whereas this could potentially guide future interventions.

We found that poor ART adherence is significantly associated with being on second-line ART, but there were no significant differences between those on first-line compared to those on second line ART. This may be because they are switched to another regimen because of low adherence, or a failure of the first regimen. Adherence to first-line ART is an important predictor of adherence to second-line ART (52). One study on food insecurity and ART adherence showed results similar to ours (36), but another one found no significant effect for being on first-line ART (42). More research is needed to explore this association and identifying potential solutions for improving ART adherence on different ART regimens.

Not many studies have investigated the association between food insecurity and ART adherence. Furthermore, the majority of those who did, were cross-sectional and of small size. Our study had almost no missing data, sample size was large using baseline data of a prospective cohort study. Given similar demographics regarding sex, income, stable relationships, and education levels, it is probable that our results can be generalized for PLHIV in rural South Africa. However, in our study a larger proportion was unemployed, and we observed a large proportion being food insecure compared to other studies from Sub-Saharan Africa (2, 31, 34-41).

Studies that found that food insecurity was positively associated with good ART adherence suggested that this might be because of enhanced social support (37). This may be reason to believe that nutrition programs and strengthening the social network of PLHIV may be beneficial to mitigating food insecurity (8, 11, 53, 54). This may hold especially true regarding women. As we found a large difference between men and women in food security and socio-economic status, empowering women may improve their food security status.

Study limitations

This study has several limitations. Firstly, ART adherence is very difficult to reliably measure. We chose to use a proxy measure, namely plasma HIV-RNA (22) not affected by recall bias or subjective interpretation compared to questionnaires. In addition to being a proxy measure of ART adherence, plasma HIV-RNA also measures efficacy which may be the most clinically relevant and it is more reliable than self-reported adherence or pill counts (56).

Although we adjusted for many covariates linked to food insecurity or ART adherence, we were not able to adjust for ART side effects, which may be related to ART regimen and adherence. Neither were we able to give an indication of the direction of the association. From these results, it is not clear whether poor ART adherence is a cause or consequence of food insecurity. Follow-up data over a longer period are needed to draw such a conclusion.

A small monetary reimbursement was given to participants and through the study they received a free health check-up, which may have led to self-selection bias. However, this was minimized by the fact that most participants were already registered for the Ndlovu cohort. People with or without HIV didn't differ significantly with regard to food insecurity. Those who were newly diagnosed with HIV didn't differ greatly in food insecurity either. Recall bias regarding food insecurity may also have been present, as a questionnaire about the past year was used.

Conclusions

Severe food insecurity was observed to be associated with poor adherence to ART regimens. Food insecure PLHIV may need more attention and focus from health care workers. Women are especially affected by this association. Since they are more likely to have lower SES and potentially engage in risk behavior, empowering them may mitigate this gender inequality regarding food insecurity. Further studies are needed to identify specific determinants of food insecurity and long-term direction and association between food insecurity and ART adherence. Also, it should be qualitatively researched what drives PLHIV to non-adhere, meaning the beliefs, thoughts and fears concerning both food insecurity and ART medication.

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Table 1: Baseline descriptive characteristics of PLHIV in the Ndlovu Cohort (n=742)

	Total (n=742)	Men (n=297)	Women (n=445)
Age (years), mean (SD)	42.3 (10.0)	45.3 (10.0)	40.4 (9.5)
Highest level of education			
None	37 (5.0%)	15 (5.1%)	22 (4.9%)
Primary	163 (22.0%)	87 (29.3%)	76 (17.1%)
Secondary and matric	495 (66.7%)	184 (62.0%)	311 (69.9%)
College and University	47 (6.3%)	11 (3.7%)	36 (8.1%)
Employment			
Unemployed	503 (67.8%)	177 (59.6%)	326 (73.3%)
Employed	214 (28.8%)	108 (36.4%)	106 (23.8%)
Other (student, retired, volunteer)	25 (3.4%)	12 (4.0%)	13 (2.9%)
Income per person per month in ZAR*			
<648	436 (58.8%)	151 (50.8%)	285 (64.0%)
648-992	54 (7.3%)	12 (4.0%)	42 (9.4%)
>992	210 (28.3%)	100 (33.7%)	110 (24.7%)
Stable relationship (married, life partner, cohabiting), (yes), n(%)	414 (55.8%)	193 (65.0%)	221 (49.7%)
Depressive symptoms in the last 2 weeks			
yes	101 (13.6%)	34 (11.4%)	67 (15.1%)
no	636 (85.7%)	262 (88.2%)	374 (84.0%)
Physical activity, MET-min/wk**			
Moderate	226 (30.5%)	71 (23.9%)	155 (34.8%)
High	158 (21.3%)	74 (24.9%)	84 (18.9%)
Current smoker (yes), n(%)			
Never	480 (64.7%)	115 (38.7%)	365 (82.0%)
Ever	261 (35.2%)	182 (61.3%)	79 (17.8%)
Current	157 (21.2%)	121 (40.7%)	36 (8.1%)
Alcohol use (yes), n(%)			
Ever	468 (63.1%)	224 (75.4%)	244 (54.8%)
In the past 30 days	194 (26.1%)	122 (41.1%)	72 (16.2%)
Weight (kg), median (IQR)	63 (54-74)	60 (53-70)	65 (55-76)
Height (cm), mean (SD)	166 (8.3)	171 (6.8)	162 (7.2)
BMI, median (IQR)	22.8 (19.6-26.7)	20.6 (18.5-23.7)	24.2 (21.1-28.5)
Waist circumference (cm), mean (SD)	85.2 (12.7)	83.1 (11.0)	86.6 (13.5)
Hip circumference (cm), mean (SD)	100.0 (13.8)	93.5 (10.7)	104.3 (14.0)
Chronic illnesses or conditions, n(%)			
Obesity	125 (14.1%)	16 (4.5%)	109 (20.6%)
Hypercholesterolemia	191 (21.5%)	56 (15.6%)	135 (25.5%)
Type 2 Diabetes Mellitus	30 (3.4%)	15 (4.2%)	15 (2.8%)
Hypertension	128 (14.4%)	64 (17.9%)	64 (12.1%)
ART (yes), n (%)	689 (92.9%)	285 (96.0%)	404 (90.8%)
First-Line	612 (82.5%)	251 (84.5%)	361 (81.1%)
Second-Line	77 (10.4%)	34 (11.4%)	43 (9.7%)
CD4 count, cells/mL, median (IQR)	491 (336-675)	429 (280-602)	518 (378-714)
HIV RNA, copies/mL			
< 50	544 (73.2%)	210 (70.7%)	334 (75.1%)
50-1000	69 (9.3%)	33 (11.1%)	36 (8.1%)
>1000	116 (15.6%)	50 (16.8%)	66 (14.8%)
Food secure	407 (54.9%)	195 (65.7%)	212 (47.6%)
Moderate food insecurity	187 (25.2%)	58 (19.5%)	129 (29.0%)
Severe food insecurity	148 (19.9%)	44 (14.8%)	104 (23.4%)

*Lower bound poverty line: <648, upper bound poverty line: >992 [23]

** MET-min-wk are calculated as duration x frequency x MET intensity; low is defined as not meeting criteria for categories 2 and 3; moderate is defined as any of the following 3 criteria: 1) 3 or more days of vigorous activity at least 20 minutes per day OR 2) 5 or more days of moderate-intensity activity or walking of at least 30 minutes per day or 3) 5 or more days of any combination of walking, moderate-intensity or vigorous-intensity activities achieving a minimum of at least 600 MET-min/week; high is defined as any of the following 2 criteria: 1) vigorous-intensity activity on at least 3 days and accumulating at least 1500 MET-minutes/week OR 2) 7 or more days of any combination of walking, moderate-intensity or vigorous intensity activities achieving a minimum of at least 3000 MET-minutes/week.

Table 1: Baseline response to questionnaire related to food insecurity among PLHIV in the Ndlovu Cohort Study (n=742)

Question	Response options	Baseline response		
		Total, N (%) (n=742)	Men, N (%) (n=297)	Women, N (%) (n=445)
Did your household run out of money to buy food during the past 12 months?	Yes	278 (37.5%)	88 (29.6%)	190 (42.7%)
	No	463 (62.4%)	209 (70.4%)	254 (57.1%)
	Don't know	1 (0.1%)	-	1 (0.2%)
Has it happened in the past 30 days?	Yes	192 (25.9%)	62 (20.9%)	130 (29.2%)
	No	87 (11.7%)	26 (8.8%)	61 (13.7%)
	Don't know	1 (0.1%)	-	1 (0.2%)
Has it happened 5 or more days in the past 30 days?	Yes	128 (17.3%)	40 (13.5%)	88 (19.8%)
	No	67 (9.0%)	23 (7.7%)	44 (9.9%)
	Don't know	1 (0.1%)	-	1 (0.2%)
In the past 12 months, were there times when members of your household went hungry because there was not enough food in the house to eat?	Yes	179 (24.1%)	54 (18.2%)	125 (28.1%)
	No	562 (75.7%)	242 (81.5%)	320 (71.9%)
	Don't know	1 (0.1%)	1 (0.3%)	-
Did you cut the size of meals during the past 12 months because there was not enough food in the house?	Yes	242 (32.6%)	69 (23.2%)	173 (38.9%)
	No	499 (67.3%)	228 (76.8%)	271 (60.9%)
	Don't know	1 (0.1%)	-	1 (0.2%)
Has it happened 5 or more days in the past 30 days?	Yes	168 (22.6%)	50 (16.8%)	118 (26.5%)
	No	76 (10.2%)	19 (6.4%)	57 (12.8%)
	Don't know	1 (0.1%)	-	1 (0.2%)
Did you skip any meals during the past 12 months because there was not enough food in the house?	Yes	150 (20.2%)	45 (15.2%)	105 (23.6%)
	No	592 (79.8%)	252 (84.5%)	340 (76.4%)
	Don't know			
Has it happened 5 or more days in the past 30 days?	Yes	116 (15.6%)	32 (10.8%)	84 (18.9%)
	No	35 (4.7%)	13 (4.4%)	22 (4.9%)
	Don't know			
Did you eat smaller variety of foods during the past 12 months than you would have liked to, because there was not enough food in the house?	Yes	226 (30.5%)	68 (22.9%)	158 (35.5%)
	No	516 (69.5%)	229 (77.1%)	287 (64.5%)
	Don't know			
Has it happened 5 or more days in the past 30 days?	Yes	150 (20.2%)	41 (13.8%)	109 (24.5%)
	No	75 (10.1%)	26 (8.8%)	49 (11.0%)
	Don't know	2 (0.3%)	1 (0.3%)	1 (0.2%)

Table 3: Factors associated with poor ART adherence among PLHIV in the Ndlovu Cohort Study (n=742), 1 year

Baseline characteristic	Total (742)				Men (297)				Women (445)			
	Unadjusted OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value	Unadjusted OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value	Unadjusted OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
Food insecurity (insecure)												
Moderate	1.31 (0.79-2.14)	0.29	1.40 (0.86-2.26)	0.17	0.76 (0.31-1.74)	0.52	0.79 (0.34-1.72)	0.56	2.04 (1.01-4.18)	0.05	2.10 (1.06-4.21)	0.03
Severe	1.50 (0.86-2.60)	0.15	1.69 (1.00-2.83)	0.05	0.65 (0.23-1.74)	0.41	0.79 (0.30-1.93)	0.62	2.45 (1.16-5.25)	0.02	2.97 (1.46-6.14)	<0.001
Covariates												
Age	0.98 (0.95-1.00)	0.06	0.99 (0.97-1.01)	0.24	1.00 (0.96-1.04)	0.85	0.99 (0.96-1.02)	0.43	0.95 (0.92-0.99)	0.01	0.97 (0.94-1.00)	0.06
Highest level of education												
Primary	0.93 (0.36-2.63)	0.89			2.11 (0.43-16.16)	0.40			0.61 (0.17-2.43)	0.47		
Secondary and matric	0.69 (0.27-1.97)	0.46			2.35 (0.46-18.58)	0.35			0.34 (0.09-1.33)	0.11		
College and University	0.40 (0.09-1.63)	0.20			1.79 (0.14-22.68)	0.64			0.20 (0.03-1.20)	0.08		
Employed												
Unemployed	1.02 (0.60-1.74)	0.96			1.00 (0.43-2.34)	1.00			1.16 (0.53-2.63)	0.71		
Other	1.42 (0.42-4.16)	0.54			2.42 (0.49-11.35)	0.26			0.59 (0.03-3.72)	0.63		
Income per person per month in ZAR *												
648-992	0.70 (0.27-1.58)	0.42	0.65 (0.26-1.44)	0.32	0.53 (0.07-2.48)	0.46	0.57 (0.08-2.45)	0.50	0.79 (0.24-2.16)	0.67	0.76 (0.24-1.98)	0.60
>992	1.11 (0.67-1.85)	0.68	1.04 (0.65-1.64)	0.86	0.75 (0.32-1.70)	0.50	0.79 (0.40-1.53)	0.48	1.35 (0.66-2.74)	0.41	1.21 (0.61-2.36)	0.57
Stable partnership (yes)	1.02 (0.67-1.55)	0.93			0.86 (0.43-1.74)	0.67			1.06 (0.59-1.90)	0.84		
Depressive symptoms in the last 2 weeks (yes)	1.10 (0.61-1.94)	0.74			1.08 (0.38-2.81)	0.88			1.12 (0.51-2.32)	0.78		
Smoking												
Ever	1.09 (0.58-2.01)	0.78			0.98 (0.37-2.57)	0.96			0.80 (0.34-1.75)	0.59		
Current	1.01 (0.51-2.03)	0.97							0.83 (0.20-3.25)	0.80		
Physical activity**												
Moderate	0.57 (0.34-0.92)	0.02			0.92 (0.41-1.99)	0.84			0.50 (0.25-1.00)	0.05	0.48 (0.24-0.93)	0.03
High	0.98 (0.55-1.70)	0.94			1.57 (0.69-3.55)	0.28			0.97 (0.41-2.22)	0.93	0.83 (0.40-1.68)	0.62
Alcohol consumption												
Ever	1.23 (0.74-2.04)	0.42			1.31 (0.49-3.55)	0.59			1.11 (0.59-2.08)	0.75		
In the past 30 days	0.88 (0.51-1.51)	0.66			0.73 (0.34-1.58)	0.43			1.03 (0.41-2.46)	0.95		
ART line												
2nd	2.93 (1.69-5.03)	<0.001	2.84 (1.66-4.80)	<0.001	5.69 (2.50-13.35)	<0.001	5.58 (2.50-12.81)	<0.001	1.72 (0.72-3.85)	0.20	1.78 (0.76-3.92)	0.16

*Lower bound poverty line: <648, upper bound poverty line: >992(23)

** MET-min-wk are calculated as duration x frequency x MET intensity; low is defined as not meeting criteria for categories 2 and 3; moderate is defined as any of the following 3 criteria: 1) 3 or more days of vigorous activity at least 20 minutes per day OR 2) 5 or more days of moderate-intensity activity or walking of at least 30 minutes per day or 3) 5 or more days of any combination of walking, moderate-intensity or vigorous-intensity activities achieving a minimum of at least 600 MET-min/week; high is defined as any of the following 2 criteria: 1) vigorous-intensity activity on at least 3 days and accumulating at least 1500 MET-minutes/week OR 2) 7 or more days of any combination of walking, moderate-intensity or vigorous intensity activities achieving a minimum of at least 3000 MET-minutes/week.

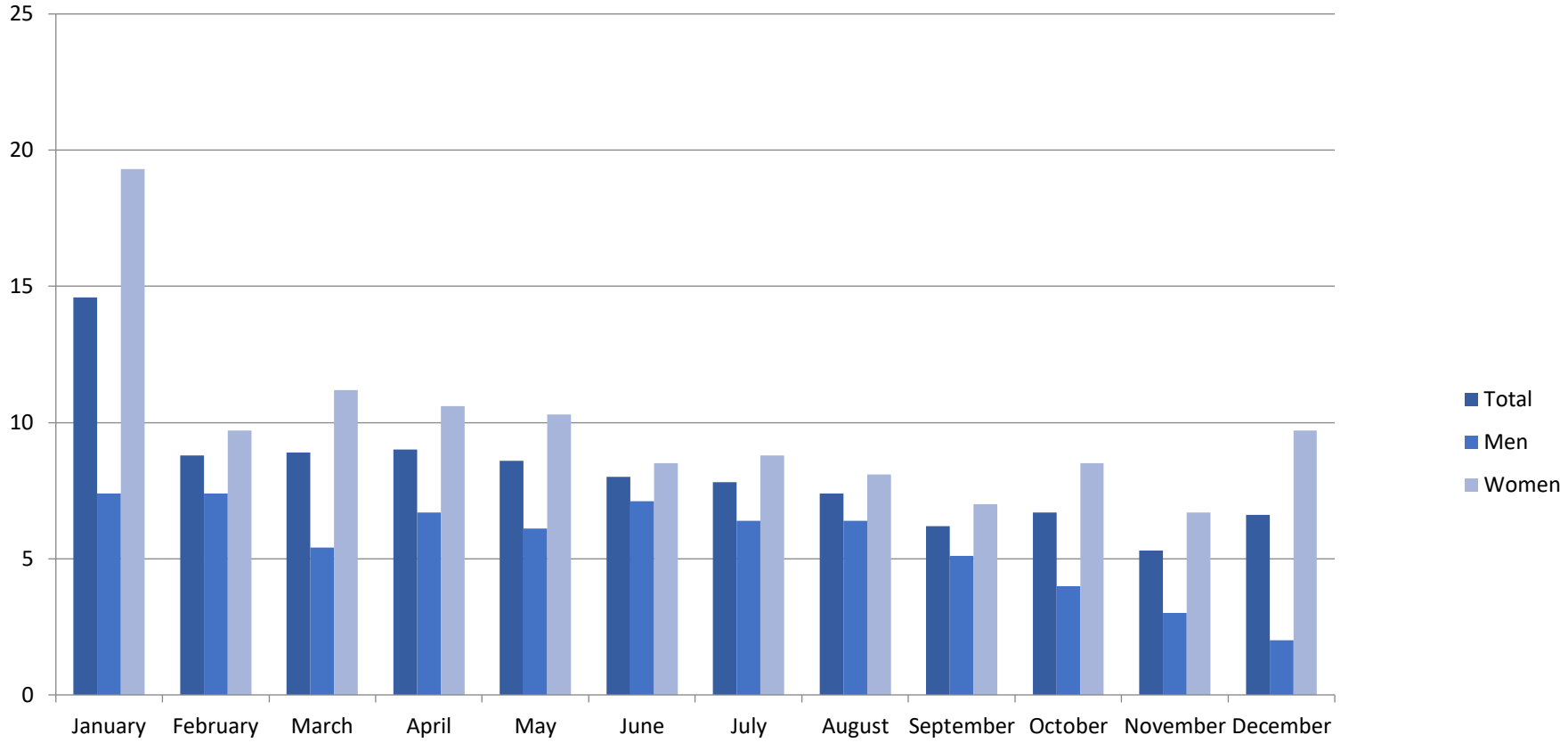

Figure 1: Percentage of PLHIV that went hungry in the past 12 months (n=742)