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The Association of Material Hardship with Medication Adherence and Perceived Stress Among People Living with HIV in Rural Zambia

Rainier Masa^{1,2,3}, Gina Chowa^{1,2,3}

¹School of Social Work, University of North Carolina, Chapel Hill, NC, USA

²Global Social Development Innovations, University of North Carolina, Chapel Hill, NC, USA

³Centre for Social Development in Africa, University of Johannesburg, Auckland Park, South Africa

Abstract

The intersection of poverty and HIV/AIDS has exacerbated socioeconomic inequalities in Zambia. For example, the downstream consequences of HIV/AIDS are likely to be severe among the poor. Current research has relied on multidimensional indicators of poverty, which encompass various forms of deprivation, including material. Although comprehensive measures help us understand what constitutes poverty and deprivation, their complexity and scope may hinder the development of appropriate and feasible interventions. These limitations prompted us to examine whether material hardship, a more practicable, modifiable aspect of poverty, is associated with medication adherence and perceived stress among people living with HIV (PLHIV) in Zambia. We used cross-sectional data from 101 PLHIV in Lundazi District, Eastern Province. Data were collected using a questionnaire and hospital records. Material hardship was measured using a five-item scale. Perceived stress was measured using the ten-item perceived stress scale. Adherence was a binary variable measured using a visual analog scale and medication possession ratio (MPR) obtained from pharmacy data. We analyzed the data with multivariable linear and logistic regressions using multiply imputed datasets. Results indicated that greater material hardship was significantly associated with MPR nonadherence (odds ratio = 0.83) and higher levels of perceived mental distress ($\beta = 0.34$). Our findings provide one of the first evidence on the association of material hardship with treatment and mental health outcomes among PLHIV. The findings also draw attention to the importance of economic opportunities for PLHIV and their implications for reducing material hardship and improving adherence and mental health status.

[✉]Rainier Masa, rmasa@email.unc.edu.

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

Keywords

Poverty; Material hardship; Medication adherence; Perceived stress; HIV/AIDS; Zambia

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Introduction

In low-resource communities in Zambia and sub-Saharan Africa (SSA), the intersection of poverty and HIV/AIDS has exacerbated the already substantial social, economic, and health inequalities caused by poverty (Drimie and Casale 2009; Franco et al. 2009; Misselhorn 2005; de Waal and Whiteside 2003). Although research suggests that poverty is not associated with a higher risk of HIV exposure and infection in SSA (Fox 2012; Gillespie et al. 2007; Mishra et al. 2007; Wojcicki 2005), the downstream consequences of HIV/AIDS are likely to be severe and punitive for poor individuals and households (Bachmann and Booyesen 2003; Collins and Leibbrandt 2007; Tekola et al. 2008). For example, reduced or loss of income due to missed work days and limited productivity because of HIV-related illnesses creates greater material hardship for the poor compared with their affluent peers who may have more assets and other income sources that buffer against income and health shocks (Bachmann and Booyesen 2004; Fox et al. 2004; Larson et al. 2013). In turn, material hardship (defined as not having enough money to pay for basic and essential needs) in poor HIV-affected households may worsen the economic gaps and health disparities between wealthy and poor individuals living with HIV (Goldberg and Short 2016; Marinescu 2014; Short and Goldberg 2015). For example, material hardship in HIV-affected households exacerbates food insecurity (Bukusuba et al. 2007; McCoy et al. 2014), impedes regular access to health care (Braathen et al. 2016; Cornelius et al. 2017), and harmfully affects physical and mental health of household members (Braathen et al. 2016; Short and Goldberg 2015).

The consequences of material hardship (e.g., inadequate food and limited health care access) heighten the risk of adverse treatment and health outcomes in people living with HIV (PLHIV). Prior studies have shown that material hardship is associated with undernutrition (Aberman et al. 2014; Kadiyala and Rawat 2013), more opportunistic infections (Weiser et al. 2012), poor quality of life and mental health status (Choi et al. 2015; Heylen et al. 2015), and elevated risk of mortality (Koethe et al. 2013; Rawat et al. 2013). Material hardship is also associated with sexual risk taking, particularly among women, as a strategy to obtain access to food (Kamndaya et al. 2014; Matovu and Ssebadduka 2014; Miller et al. 2011). Material hardship adversely affects HIV treatment outcomes, resulting in lower rate of voluntary HIV testing (Kim et al. 2016), delayed or non-initiation of HIV treatment (Hardon et al. 2007; Nabukeera-Barungi et al. 2015), poor retention or engagement in care (Bezabhe et al. 2014), delayed or late pickup of prescription refills (Semvua et al. 2017), missed clinic appointments (Tuller et al. 2010), medication non-adherence (Singer et al. 2015; Young et al. 2014), and non-use of novel health technologies (such as cell phone and text messaging service) to improve adherence and health outcomes (Madhvani et al. 2015; Norton et al. 2014). In turn, material hardship or lack of financial resources (for example, to afford medical services and ancillary HIV care) may heighten risk of treatment failure, which is

characterized by low CD4 count and incomplete viral suppression resulting in rapid progression to AIDS and death (Chi et al. 2009; Stringer et al. 2006).

Despite the increasing number of studies that point to an adverse association of material hardship with treatment and health outcomes for PLHIV in low-resource settings, many prior studies have relied on composite measures of poverty, a multidimensional construct that encompasses material hardship, capability deprivation, social exclusion, and deprivation of both tangible and intangible resources (Sen 1999). Global poverty or deprivation measures can be valuable in basic research as a way to better understand what constitutes poverty and deprivation (Guio et al. 2016; Gordon et al. 2000; Mohanty et al. 2017). Although these measures may capture a more valid and universal representation of deprivation, they do not take into account that other poverty domains (e.g., social exclusion and capability deprivation) may result from or may be exacerbated by material hardship, albeit not solely (Sen 1997, 1999). Furthermore, the scope and complexity of comprehensive poverty and deprivation measures may hinder our ability to develop appropriate and feasible solutions. From an intervention development angle, it can be unwieldy and costly to create and test a program that addresses multiple domains of deprivation, including capability (e.g., limited education and lack of access to health care), material (e.g., low income and limited assets), and social (e.g., biased gender norms, stigma, and discrimination). Similarly, evaluation of complex programs can lead to identification and assessment of inaccurate and unrealistic outcomes. Thus, the evidence generated from the evaluation may be biased and may not accurately illustrate program effectiveness. It is also possible that the same evidence may influence policymakers to disregard identical policy prescriptions. This domino effect underscores the importance of suitable and relevant instrumentation because of its implications for research, practice, and policy.

These issues and implications prompted us to focus on material hardship, instead of a broader conceptualization of poverty and deprivation. In this study, we examined whether material hardship, defined as not having enough money to meet various household needs, is associated with medication adherence and perceived stress in a sample of PLHIV who are receiving antiretroviral therapy (ART) in two hospitals in Lundazi District, Eastern Province, Zambia. Similarly, theoretical and empirical work on hierarchy of needs lends support to the primacy of tackling material hardship (or the inability to satisfy basic needs) (Kenrick et al. 2010; Maslow 1943). Disentangling lack of financial resources (as a key measure of material hardship and a predictor of treatment and health outcomes for PLHIV) from other poverty domains may help practitioners and policy makers to propose and implement solutions that are manageable, pertinent to local conditions, and feasible given resource constraints. To our knowledge, this study is also one of the first to examine whether material hardship is associated with perceived stress and medication adherence among PLHIV in Zambia.

Methods

Study Design and Sample

We used a cross-sectional design. We analyzed the baseline data that were collected from 101 ART patients who were participating in an integrated HIV and livelihood intervention. The sample size of 101 was determined by the requirements of the main intervention

outcome, medication adherence (Teare et al. 2014). Thus, our aim was to recruit 100 HIV-positive individuals who were on ART. Other inclusion criteria were as follows: (a) at least 18 years old, (b) economically poor, (c) receiving outpatient medical care at either Lundazi District Hospital (LDH) or Lumezi Mission Hospital (LMH), and (d) able to participate in the intervention activities. Economically poor refers to individuals who are living below the country's national poverty threshold. At the time of baseline data collection, the national poverty line was approximately 90 USD per month (Central Statistical Office 2012).

The study protocol received institutional review board approvals from the University of Zambia Biomedical Research Ethics Committee and the University of North Carolina at Chapel Hill Institutional Review Board. We obtained permission to implement our research activities from the Ministry of Health and the Office of the District Medical Officer in Lundazi District. Study participation was voluntary. Informed consent was obtained from all study participants.

Study Setting

The study was conducted in Lundazi District, Eastern Province. Lundazi District was selected as the study site because the main intervention study aimed to evaluate an integrated HIV and livelihood program in a rural setting with high prevalence of HIV and presence of smallholder farmers. Lundazi District is predominantly rural, with more than 90% of the population living in rural areas (CSO 2012). In 2010, Lundazi District had a population of 314,281 (CSO 2011). In 2010, HIV prevalence was estimated at 15%, higher than the overall prevalence rates in the province and the country (National AIDS Council [NAC] 2014). Agriculture is the most common occupation, and the district is one of the country's highest producers of maize, cotton, groundnuts, and tobacco.

Data Collection Methods

Data were collected using two methods: interviewer-administered survey questionnaire and abstraction of medical and pharmacy records. The survey, conducted between December 2014 and January 2015, collected demographic, economic, psychosocial, and health characteristics of respondents and their households. Medical and pharmacy records were reviewed to obtain ART-related information (such as treatment start date, treatment duration, treatment regimen, and timing of pharmacy refill pickup) and physical health and clinical data (e.g., weight, body mass index, and CD4 count). Medical and pharmacy data abstraction occurred between January and March 2015.

Variables and Measures

Medication Adherence—Medication adherence was measured using two methods: self-assessment and pharmacy refill information. Self-assessment was collected using a visual analog scale (VAS). Respondents were asked to place an "X" inside the box above the point showing their best guess about the proportion of their antiretroviral (ARV) medications the respondents consumed in the past 30 days. Despite overreporting, self-assessments of medication adherence have been shown to perform well (i.e., no evidence of significant overestimation) in comparison with more objective adherence measures such as pharmacy

records (Kabore et al. 2015; Simoni et al. 2014). Prior studies in Zambia have used VAS to measure medication adherence (Haberer et al. 2011; Hampanda et al. 2017).

Given limitations of self-reported adherence, we used another measure of adherence using pharmacy records. Pharmacy records have been shown to be highly associated with biological markers of adherence (Henegar et al. 2015; Rougemont et al. 2009) and to outperform self-reported methods in predicting treatment outcomes (McMahon et al. 2011; Sangeda et al. 2014). Based on pharmacy records, the timing of ARV prescription refills is used to estimate adherence. If refills are not obtained in a timely manner, it is assumed that patients are not taking their medications between refills or are missing doses that allow medications to last longer than it should (Steiner and Prochazka 1997). In this study, the pharmacy adherence measure was a variation of the medication possession ratio (MPR), which is defined as the proportion of days a patient possessed his or her medications relative to the total amount of time between two scheduled prescription pickups (McMahon et al. 2011). Consistent with prior studies (Hong et al. 2013; Musumari et al. 2014), MPR was calculated as follows: $1 - (\text{number of days late for ARV pickup} / \text{total number of days between the two most recent ARV pickups})$, expressed as a percentage. We calculated MPR based on pharmacy records from the first and second quarters of 2015.

We created two binary adherence variables: one based on VAS and the other based on MPR. For both binary variables, we defined adherence primarily as 95% of scheduled doses taken (Ickovics and Meade 2002; Musumari et al. 2014). Respondents were adherent if they took 95% of prescribed doses and non-adherent if they took < 95% of prescribed doses.

Material Hardship—Material hardship referred to the frequency of not meeting basic and essential needs due to lack of money (Beverly 2001; Isaacs et al. 2004). Material hardship was measured using a five-item, five-point Likert-type scale that asked respondents how often, in the past 30 days, did they not have enough money to satisfy the following needs: food, medical care, clothing, shelter, and other household needs (e.g., cooking fuel). Response options included *never* (or zero times in the last 30 days), *rarely* (once or twice), *sometimes* (three to ten times), *often* (more than ten times), and *always* (every day in the past 30 days). Responses to each item were summed to obtain an overall material hardship score. A higher score indicated greater material hardship, i.e., frequent inability to satisfy needs due to lack of money. Factor analysis results indicated adequate fit of the measure ($\chi^2(5) = 14.329$, $p = .014$; CFI = .0922; SRMR = 0.073; composite reliability = 0.717) (Cho 2016; Hu and Bentler 1999; Raykov 1997).

Perceived Stress—Perceived stress, or the degree to which respondents assessed their life situations as stressful and their ability to manage stressful situations, was measured using the ten-item perceived stress scale (PSS) (Cohen et al. 1983). We used a two-factor PSS, consistent with prior research in nonWestern settings (Leung et al. 2010; Reis, Hino & Rodriguez-Añez). The first factor was a four-item measure of perceived coping. The second factor was a six-item measure of perceived mental distress. Items on both factors included the same five response options: *never* (0), *almost never* (1), *sometimes* (2), *fairly often* (3), and *very often* (4). Responses to each item were summed to obtain separate scores for perceived coping and perceived distress. We reverse coded the four items that comprised the

perceived coping factor. Thus, a higher score on the perceived coping factor indicated lower ability to cope with stressful events (i.e., lower perceived coping). A higher score on the perceived distress factor implied lower ability to deal with stressful situations (i.e., higher perceived distress).

Covariates—We included the following covariates in all analytical models: age (in years), gender (female or male), marital status (married or not married), education level (primary education or secondary education and higher), head of household (yes or no), household size (total number of people living in respondent's household at the time of data collection), place of residence (Lundazi or Lumezi), household financial situation (worse or stayed the same/better than the last 2 years), asset ownership, debt (owed money or did not owe money), length of HIV treatment (in months), and access to health care. Asset ownership included two types of assets: livestock and transportation. Both asset variables were measured using indices (Filmer and Scott 2012). A high index value indicated ownership of more assets. Transportation assets included bicycles, motorcycles, ox carts, and other motor vehicles (e.g., cars and trucks), whereas livestock comprised chicken, pigs, goats, cattle, donkeys, and sheep. Access to health care was measured using two variables: distance to the nearest health facility (in kilometers) and travel time to the nearest health facility (in minutes).

Analysis

Multivariable analyses were conducted to examine the association between (a) material hardship and treatment adherence and (b) material hardship and perceived coping and mental distress. We used logistic regression for binary outcome variables (adherence based on VAS and MPR) and linear regression using the ordinary least squares method for continuous outcome variables (perceived coping and perceived distress). Significance level was set at $p = .05$, two-tailed test.

Additionally, we performed multiple imputation (MI) to address potential missing data issues. Missing data analysis using MI included several steps, each undertaken separately. First, we examined missing data patterns. Although there is no established cutoff regarding an acceptable proportion of missing data for valid statistical inferences (Dong and Peng 2013), study variables with missing values included VAS (12%), MPR (2%), and material hardship (2%). 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; 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). Fourth, MI datasets were created by imputation using the chained equations approach (White et al. 2011). Last, we created our primary MI model with 100 imputed datasets to yield accurate statistical results and improve power (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, and results were similar. In all analytical

models, the direction of associations did not change when using either complete-case analysis or MI method. Coefficient sizes and standard errors were comparable between methods.

Using multiply imputed datasets, we estimated four main multivariable models (based on $m = 100$), one for each outcome measure. Model 1 estimated the association between material hardship and medication adherence based on VAS. Model 2 measured the association between material hardship and medication adherence based on MPR. Model 3 evaluated the association between material hardship and perceived coping, whereas model 4 estimated the association of material hardship with perceived mental distress. We reran the same four multivariable models using 50 multiply imputed datasets. All analyses were conducted using Stata 15 (Stata 2017).

Results

Sample Characteristics and Frequency of Material Hardship

The sample included more women (56%) than men, married (75%) than not married, and heads of household (65%) than non-heads of household. Mean age of respondents was 38 (standard deviation (SD) = 7.39; range = 18–51). An equal proportion (50%) of respondents was from Lundazi or Lumezi. Thirty-five percent had a secondary education or higher. There were fewer respondents with monetary debts (24%) compared to those without debts. Eighty-two percent classified their household financial situation as worse than the last 2 years. Mean household size was six members (SD = 3.60). Mean treatment duration was 26 months (median = 19; SD = 20.64). Mean distance to the nearest health facility was 11.42 km, whereas mean travel time to the nearest health facility was 110 min. The proportion of adherent respondents was 75 and 67% based on VAS and MPR, respectively. The two adherence measures were not significantly different. Respondents reported low levels (i.e., mean scores were above the median of possible scores) of perceived coping ($M_{\text{perceived coping}} = 9.44$; SD = 4.24; range = 0–16) and high levels (i.e., mean scores were above the median of possible scores) of perceived mental distress ($M_{\text{perceived distress}} = 7.44$; SD = 4.64; range = 0–18).

Table 1 lists the frequency of experiencing material hardship, defined as not having enough money for basic needs in the past 30 days. A substantial proportion of respondents did not have enough money for food, medical care, clothing, and other household needs. In contrast, 86% of respondents met their shelter needs every day in the past 30 days.

Material Hardship and Medication Adherence

Table 2 lists the multivariable associations of material hardship and medication adherence. The top half of Table 2 presents results based on 100 multiply imputed datasets. Overall, material hardship was associated with decreased likelihood of medication adherence. For every unit increase in material hardship, the probability of medication adherence decreased by 14% when measured with VAS and by 17% when measured using MPR. However, only the relationship between material hardship and MPR was statistically significant ($p = .041$).

Other significant correlates of medication adherence included ownership of transport-related assets (VAS) and distance and travel time to the nearest health facility (MPR).

These results were consistent with the findings based on 50 multiply imputed datasets as illustrated in the bottom half of Table 2.

Material Hardship and Perceived Stress

Table 2 also lists the multivariable relationships between material hardship and perceived stress. The top half of Table 2 presents results based on 100 multiply imputed datasets. For each multivariable model with a perceived stress factor as an outcome, we included the other factor as a covariate. Overall, material hardship was significantly associated with lower perceived coping and with higher perceived mental distress. For every unit increase in material hardship, perceived coping and perceived distress scores increased by 0.22 ($p = .077$) and 0.34 ($p = .017$), respectively. Higher scores on the perceived coping subscale indicated having fewer strategies to manage stressful events. Higher scores on the perceived mental distress subscale implied higher levels of stress and lower ability to deal with stressful situations. Other significant results included (a) the association of perceived coping with place of residence, travel time to the nearest health facility, and perceived mental distress and (b) the association of perceived mental distress with place of residence and perceived coping. These results were consistent with the findings based on 50 multiply imputed datasets as presented in the bottom half of Table 2.

Discussion

Our objective was to examine whether material hardship is associated with medication adherence, perceived coping, and perceived mental distress in a sample of Zambian ART patients. Study findings suggest that ART patients who experienced material hardship were less likely to take their medications as prescribed. Material hardship was also associated with lower perceived coping and higher perceived mental distress. These findings are consistent with evidence from other studies that link material hardship with adverse HIV treatment and health outcomes. For example, food, housing, and transportation insecurity are consistently associated with poor ART adherence in low-, middle-, and high-income countries (Chop et al. 2017; Coetzee et al. 2015; Cornelius et al. 2017; Ehlers and Tshisuyi 2015; Holtzman et al. 2015; Kalichman et al. 2014; Shubber et al. 2016; Siefried et al. 2017).

The inverse relationship between material hardship and medication adherence underscores the importance of having adequate financial resources to cushion against income or health shocks associated with HIV/AIDS. The likelihood of experiencing material hardship among PLHIV and their households may be heightened by diminished capacity to earn income because of decreased labor productivity (e.g., missing more work days due to illness) or caregiving responsibilities (e.g., taking care of a household member who is HIV positive takes time away from work). Material hardship, characterized by lack of money for food, medical care, housing, and other household needs, may affect medication adherence in several ways. First, insufficient money for food may signify that PLHIV and their households find it difficult to afford food on a regular basis. PLHIV and other household

members may resort to limiting the frequency, variety, and size of their meals. Some households may spend whole days and nights without eating. In turn, access to inadequate food may influence ART patients' ability to take their medications as prescribed. Food insecurity may interrupt adherence because (a) PLHIV may believe that adequate food should be eaten to optimize treatment efficacy, (b) hunger may become severe due to increased appetite from being on ART, (c) ARV drug side effects can be worse when taken without adequate food, and (d) competing household demands (e.g., to either put food on the table or pay for other household needs or ancillary treatment costs) may compel PLHIV to interrupt or give up treatment (Singer et al. 2015; Weiser et al. 2010; Young et al. 2014). When there is no adequate food, these beliefs and fears (real or perceived) may discourage PLHIV to take their medications as prescribed or stop their treatment until adequate food becomes available.

Second, insufficient money for medical care may indicate that PLHIV and their households cannot afford fee-based medical services and their ancillary costs. For example, ART patients may need to pay for medications to treat opportunistic infections and other illnesses (communicable or non-communicable) that are exacerbated by HIV. Although antiretroviral therapy is provided free of charge in the study hospitals, ART patients need money to pay for transportation that will take them to the hospital for regular checkups, medication refills, laboratory tests, and other health services. Transportation costs are a major health care-related expense and a common barrier to medication adherence (Tuller et al. 2010). Transportation is a basic need for ART patients who live far from the hospitals. In our study, the average distance from respondents' homes to the nearest health facility is 11 km, with an average travel time of 110 min. Furthermore, ancillary HIV care, such as case management, mental health treatment and counseling, and treatment supporter/buddy, when available, may not be provided for free. Although ancillary services help meet non-medical needs of ART patients, failure to meet these needs is negatively associated with PLHIV's ability to access medical care (Ashman et al. 2002; Evans 2006). Unaffordability of essential medical and ancillary HIV care may discourage PLHIV to adhere to their treatment.

Third, insufficient money for shelter may suggest an unstable housing situation. Housing instability may deprive ART patients of a permanent residence and its health benefits (e.g., better social relationships and improved psychosocial functioning) (Hamoudi and Dowd 2014; Thomson et al. 2013). Alternatively, housing stability may facilitate ART adherence by getting patients linked to care, engaged in care, and create a routine for taking ARV medications. In contrast, housing instability, characterized by constant moving, may increase the likelihood of forgetting or (unintentionally) leaving medications, not getting transferred to a new health facility, not being linked to treatment, and not being engaged or retained in care (Aidala et al. 2016). Last, insufficient money for clothing and other household needs may indicate competing demands that may compel PLHIV to make difficult decisions by prioritizing some needs and ignoring others. It is possible that these competing demands may lead PLHIV to default from treatment (e.g., some may stretch their medications beyond scheduled refill dates to forego or delay going to the pharmacy) so other critical household needs can be satisfied (e.g., buying cooking fuel or paying for children's school fees).

Furthermore, our findings suggest that greater material hardship is significantly associated with higher levels of perceived mental distress. This association represents another pathway, albeit indirect, in which material hardship may negatively influence medication adherence. Lack of financial resources heightens stress level because it inhibits one's ability to satisfy needs (Hobfoll 1989). Evidence suggests that the need to find money for regular hospital visits is a constant source of mental distress and anxiety among PLHIV (Tuller et al. 2010). In turn, mental distress and anxiety are negatively associated with treatment adherence (Mutumba et al. 2016; Shacham et al. 2017; Shubber et al. 2016). Alternatively, having adequate money alleviates stress associated with finding money to pay for clinic visits (Czaicki et al. 2017). Perceived mental distress due to material hardship may also negatively affect self-efficacy, motivation, and other personality traits that facilitate adherence (Langebeek et al. 2014).

In sum, the adverse association of material hardship with medication adherence and perceived mental distress may be explained by various direct and indirect pathways. Although prior studies have shown that material deprivation or being poor is not associated with a higher risk of HIV exposure and infection (Fox 2012; Mishra et al. 2007), our findings suggest that material hardship is associated with poor treatment and mental health outcomes among those who are living with HIV. Poor PLHIV are likely to be more susceptible to adverse outcomes because they may not have enough financial resources, compared with their affluent peers, to cushion against income and health shocks.

Implications

Study findings have implications for practice and policy. First, material hardship is a modifiable risk factor that can be altered through appropriate, feasible, and evidence-based household-economic-strengthening interventions. We distinguished material hardship from a broader conceptualization of deprivation and poverty because there are more appropriate and feasible interventions for improving household financial resources within a reasonable length of time. In contrast, tackling poverty (which constitutes multiple, interrelated dimensions such as material hardship, capability deprivation, and social exclusion) can be unfeasible and costly and require macro-level policy solutions that may not promptly result in tangible benefits for PLHIV. Furthermore, although the distinction between poverty and material hardship was done to inform sound and more targeted program prescriptions, our definition of material hardship recognizes that the person living with HIV and other individuals living in the same household have various needs (e.g., food, shelter, medical care, clothing, and other household needs). This conceptualization was purposeful to differentiate between interventions with a primary aim of addressing one component of material hardship (e.g., food assistance to address food insecurity, or transportation voucher to cover transport costs) and multifaceted programs that tackle the interrelated dimensions of material hardship by increasing income and promoting long-term financial security.

A relevant and promising intervention is the graduation approach, which recognizes an interrelated and hierarchical nature of individual and household needs. The graduation approach aims to understand how various program inputs can be sequenced to create effective pathways out of poverty and into sustainable livelihoods (Hashemi and

Montesquiou 2011). A multi-country experiment of the graduation approach showed positive effects on income, consumption, food access, savings, and asset ownership (Banerjee et al. 2015). To our knowledge, the graduation model has not been implemented and evaluated in a sample of ART patients. Another relevant intervention is a livelihood approach integrated with HIV treatment. Using similar features of the graduation approach (e.g., cash/asset transfer, skills training, and financial protection), this integrated program transfers tangible and intangible resources to help PLHIV create sustainable livelihoods, which can provide resources to achieve treatment success (Yager et al. 2011). Integrated HIV and livelihood programs (IHLs) are increasingly being tested in SSA. Evaluations of IHLs in Kenya (Weiser et al. 2015) and Zambia (Masa et al. 2018) showed positive effects on income, food access, health, and treatment outcomes.

Second, although alleviating material hardship is important to adherence and health, financial resources represent only one facilitator of behavior change. Increasing household financial resources should be done, considering other noneconomic-strengthening adherence interventions. Economic-strengthening programs, when integrated with other programs that address multilevel barriers to adherence may result in robust and sustainable effects on adherence and other health outcomes. For example, lack of knowledge about the necessity of medication adherence combined with not having the desire to change health behaviors is a critical barrier that needs to be overcome.

Limitations

Although study findings expand what we know about the association of material hardship with treatment and health outcomes in a sample of rural Zambian ART patients, findings should be interpreted in view of study limitations. First, our small sample size may not be representative of ART patients in the country, which limits the generalizability of results. However, as a result of the original study's inclusion criteria, our sample may be representative of financially poor ART patients in Lundazi District. Second, small sample size may affect statistical power, whereas missing data may result in biased findings. We conducted multiple imputation to minimize potential bias in findings due to sample size reduction and to increase statistical power. Third, cross-sectional and correlational studies provide weak causal evidence. Lack of temporal order may also alter true direction of the relationship. Fourth, measurement bias may affect study findings. For example, self-reported adherence is susceptible to recall and social desirability bias. In view of this limitation, we used another adherence measure (pharmacy records) that is less prone to subjective reporting. However, our adherence measure using pharmacy records does not indicate actual intake of the medications and may remain susceptible to bias. Nonetheless, both measures are commonly used in HIV adherence research in resource-limited settings. Furthermore, we measured previous history of material hardship. Forward-looking measures may be needed to identify and assist PLHIV before they experience or reexperience material hardship. Similarly, our examples of basic needs are limited. Although we included medical care as an essential need for PLHIV, the addition of context-specific indicators to assess material hardship in diverse HIV-positive populations may improve construct validity.

Conclusions

Although poverty is not associated with a higher risk of HIV exposure and infection, poor PLHIV are likely to be severely affected by consequences of HIV. These consequences are wide ranging and include reduced income and lower labor productivity, which may exacerbate current financial difficulty and material hardship in poor HIV-affected households. In this sample of ART patients in rural Zambia, greater material hardship is associated with poor medication adherence and higher perceived mental distress. In turn, poor mental health and medication nonadherence may increase risk of treatment failure leading to rapid progression to AIDS and mortality. These interrelationships illustrate pathways that can be interrupted by appropriate and effective interventions. The graduation approach and integrated HIV and livelihood programs offer promising strategies to reduce material hardship and to improve adherence and psychosocial health of PLHIV.

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References

- Aberman NL, Rawat R, Drimie S, Claros JM, & Kadiyala S (2014). Food security and nutrition interventions in response to the AIDS epidemic: assessing global action and evidence. *AIDS and Behavior*, 18(Suppl 5), S554–S565. 10.1007/s10461-014-0822-z. [PubMed: 24943352]
- Aidala AA, Wilson MG, Shubert V, Gogolishvili D, Globerman J, Rueda S, Bozack AK, Caban M, & Rourke SB (2016). Housing status, medical care, and health outcomes among people living with HIV/AIDS: a systematic review. *American Journal of Public Health*, 106(1), e1–e23. 10.2105/AJPH.2015.302905.
- Allison PD (2002). *Missing data series: quantitative applications in the social sciences*. Thousand Oaks: Sage.
- Ashman JJ, Conviser R, & Pounds MB (2002). Associations between HIV-positive individuals' receipt of ancillary services and medical care receipt and retention. *AIDS Care*, 14(Suppl 1), S109–S118. 10.1080/09540120220149993a. [PubMed: 12204145]
- Bachmann MO, & Booyesen FLR (2003). Health and economic impact of HIV/AIDS on South African households: a cohort study. *BMC Public Health* 3(1), 14. [PubMed: 12667263]
- Bachmann MO, & Booyesen FLR (2004). Relationships between HIV/AIDS, income and expenditure over time in deprived South African households. *AIDS Care*, 16(7), 817–826. 10.1080/09540120412331290220. [PubMed: 15385236]
- Banerjee A, Duflo E, Goldberg N, Karlan D, Osei R, Parienté W, ... Udry C (2015). A multifaceted program causes lasting progress for the very poor: evidence from six countries. *Science*, 348(6236), 1260799 10.1126/science.1260799. [PubMed: 25977558]
- Beverly SG (2001). Measures of material hardship. *Journal of Poverty*, 5(1), 23–41. 10.1300/J134v05n01_02.
- Bezabhe WM, Chalmers L, Bereznicki LR, Peterson GM, Bimirew MA, & Kassie DM (2014). Barriers and facilitators of adherence to antiretroviral drug therapy and retention in care among adult HIV-positive patients: a qualitative study from Ethiopia. *PLoS One*, 9(5), e97353 10.1371/journal.pone.0097353. [PubMed: 24828585]
- Braathén SH, Sanudi L, Swartz L, Jürgens T, Banda HT, & Eide AH (2016). A household perspective on access to health care in the context of HIV and disability: a qualitative case study from Malawi. *BMC International Health and Human Rights*, 16(1), 12 10.1186/s12914-016-0087-x. [PubMed: 27036489]

- Bukusuba J, Kikafunda JK, & Whitehead RG (2007). Food security status in households of people living with HIV/AIDS (PLWHA) in a Ugandan urban setting. *The British Journal of Nutrition*, 98(1), 211–217.
- Central Statistical Office. (2012). 2010 census of population and housing (volume 11 national descriptive tables). Lusaka, Zambia: CSO Retrieved from <http://www.zamstats.gov.zm/report/Census/2010/National/Zambia%20National%20Descriptive%20Population%20Tables.pdf>.
- Central Statistical Office [CSO]. (2011). Zambia 2010 census of population and housing: preliminary population figures. Lusaka, Zambia: CSO Retrieved from http://unstats.un.org/unsd/demographic/sources/census/2010_phc/Zambia/PreliminaryReport.pdf.
- Chi BH, Giganti M, Mulenga PL, Limbada M, Reid SE, Mutale W, & Stringer JS (2009). CD4+ response and subsequent risk of death among patients on antiretroviral therapy in Lusaka, Zambia. *Journal of Acquired Immune Deficiency Syndromes*, 52(1), 125–131. 10.1097/QAI.0b013e3181ab6d8b. [PubMed: 19546812]
- Cho E (2016). Making reliability reliable: a systematic approach to reliability coefficients. *Organizational Research Methods*, 19(4), 651–682. 10.1177/1094428116656239.
- Choi SKY, Fielden S, Globerman J, Koornstra JJJ, Hambly K, Walker G, ... Healthy Places Team, T. P. S. (2015). Food insufficiency, housing and health-related quality of life: results from the Positive Spaces, Healthy Places Study. *AIDS Care*, 27(9), 1183–1190. 10.1080/09540121.2015.1036725. [PubMed: 25964996]
- Chop E, Duggaraju A, Malley A, Burke V, Caldas S, Yeh PT, Narasimhan M, Amin A, & Kennedy CE (2017). Food insecurity, sexual risk behavior, and adherence to antiretroviral therapy among women living with HIV: a systematic review. *Health Care for Women International*, 38(9), 927–944. 10.1080/07399332.2017.1337774. [PubMed: 28586273]
- Coetzee B, Kagee A, & Bland R (2015). Barriers and facilitators to paediatric adherence to antiretroviral therapy in rural South Africa: a multi-stakeholder perspective. *AIDS Care*, 27(3), 315–321. 10.1080/09540121.2014.967658. [PubMed: 25355176]
- Cohen S, Kamarck T, & Mermelstein R (1983). A global measure of perceived stress. *Journal of Health and Social Behavior*, 24(4), 385–396. [PubMed: 6668417]
- Collins DL, & Leibbrandt M (2007). The financial impact of HIV/AIDS on poor households in South Africa. *AIDS*, 21 (Suppl 7), S75–S81. 10.1097/01.aids.0000300538.28096.1c. [PubMed: 18040168]
- Cornelius T, Jones M, Merly C, Welles B, Kalichman MO, & Kalichman SC (2017). Impact of food, housing, and transportation insecurity on ART adherence: a hierarchical resources approach. *AIDS Care*, 29(4), 449–457. 10.1080/09540121.2016.1258451. [PubMed: 27846730]
- Czaicki NL, Mnyippembe A, Blodgett M, Njau P, & McCoy SI (2017). It helps me live, sends my children to school, and feeds me: a qualitative study of how food and cash incentives may improve adherence to treatment and care among adults living with HIV in Tanzania. *AIDS Care*, 29(7), 1–9. 10.1080/09540121.2017.1287340. [PubMed: 27410058]
- de Waal A, & Whiteside A (2003). New variant famine: AIDS and food crisis in Southern Africa. *Lancet*, 362(9391), 1234–1237. [PubMed: 14568749]
- Dong Y, & Peng C-YJ (2013). Principled missing data methods for researchers. *SpringerPlus*, 2(1), 222. 10.1186/2193-1801-2-222. [PubMed: 23853744]
- Drimie S, & Casale M (2009). Multiple stressors in Southern Africa: the link between HIV/AIDS, food insecurity, poverty and children's vulnerability now and in the future. *AIDS Care*, 21(Suppl 1), 28–33. 10.1080/09540120902942931. [PubMed: 22380976]
- Ehlers VJ, & Tshisuyi ET (2015). Adherence to antiretroviral treatment by adults in a rural area of Botswana. *Curationis*, 38(1), 10.4102/10.4102/curationis.v38i1.1255.
- Enders CK (2010). *Applied missing data analysis*. New York: Guilford.
- Enders C, Dietz S, Montague M, & Dixon J (2006). Modern alternatives for dealing with missing data in special education research. *Advances in Learning and Behavioral Disorders*, 19, 101–130.
- Evans KR (2006). Ancillary services for individuals living with HIV/AIDS. *The Nursing Clinics of North America*, 41(3), 383–393. <https://doi.org/10.1016/j.cnur.2006.05.005>. [PubMed: 16908231]
- Filmer D, & Scott K (2012). Assessing asset indices. *Demography*, 49(1), 359–392. [PubMed: 22135117]

- Fox AM (2012). The HIV-poverty thesis re-examined: poverty, wealth or inequality as a social determinant of HIV infection in Sub-Saharan Africa? *Journal of Biosocial Science*, 44(4), 459–480. 10.1017/S0021932011000745. [PubMed: 22273351]
- Fox MP, Rosen S, MacLeod WB, Wasunna M, Bii M, Foglia G, & Simon JL (2004). The impact of HIV/AIDS on labour productivity in Kenya. *Tropical Medicine & International Health*, 9(3), 318–324. [PubMed: 14996359]
- Franco LM, Burkhalter B, de Wagt A, Jennings L, Kelley AG, & Hammink M-E (2009). Evidence base for children affected by HIV and AIDS in low prevalence and concentrated epidemic countries: applicability to programming guidance from high prevalence countries. *AIDS Care*, 21(Suppl 1), 49–59. 10.1080/09540120902923089. [PubMed: 22380979]
- Gillespie S, Kadiyala S, & Greener R (2007). Is poverty or wealth driving HIV transmission? *AIDS*, 21(Suppl 7), S5–S16. 10.1097/01.aids.0000300531.74730.72.
- Goldberg RE, & Short SE (2016). What do we know about children living with HIV-infected or AIDS-ill adults in Sub-Saharan Africa? A systematic review of the literature. *AIDS Care*, 28(Suppl 2), 130–141. 10.1080/09540121.2016.1176684. [PubMed: 27392008]
- Gordon D, Adelman A, Ashworth K, Bradshaw J, Levitas R, Middleton S, ... Williams J (2000). *Poverty and social exclusion in Britain*. York: Joseph Rowntree Foundation.
- Graham JW, Olchowski AE, & Gilreath TD (2007). How many imputations are really needed? Some practical clarifications of multiple imputation theory. *Prevention Science*, 8(3), 206–213. [PubMed: 17549635]
- Guio AC, Marlier E, Gordon D, Fahmy E, Nandy S, & Pomati M (2016). Improving the measurement of material deprivation at the European Union level. *Journal of European Social Policy*, 26(3), 219–333. 10.1177/0958928716642947.
- Haberer JE, Cook A, Walker AS, Ngambi M, Ferrier A, Mulenga V, Kityo C, Thomason M, Kabamba D, Chintu C, Gibb DM, & Bangsberg DR (2011). Excellent adherence to antiretrovirals in HIV+ Zambian children is compromised by disrupted routine, HIV nondisclosure, and paradoxical income effects. *PLoSOne*, 6(4), e18505 10.1371/journal.pone.0018505.
- Hamoudi A, & Dowd JB (2014). Housing wealth, psychological wellbeing, and cognitive functioning of older Americans. *The Journals of Gerontology. Series B, Psychological Sciences and Social Sciences*, 69(2), 253–262. 10.1093/geronb/gbt114.
- Hampanda KM, Abuogi LL, & 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. 10.21106/ijma.164.
- Hardon AP, Akurut D, Comoro C, Ekezie C, Irunde HF, Gerrits T, Kglatwane J, Kinsman J, Kwasa R, Maridadi J, Moroka TM, Moyo S, Nakiyemba A, Nsimba S, Ogenyi R, Oyabba T, Temu F, & Laing R (2007). Hunger, waiting time and transport costs: time to confront challenges to ART adherence in Africa. *AIDS Care*, 19(5), 658–665. [PubMed: 17505927]
- Hashemi S, & Montesquiou AD (2011). Reaching the poorest: lessons from the graduation model. *Focus Note*, 69, 1–15.
- Henegar CE, Westreich D, Maskew M, Brookhart MA, Miller WC, Majuba P, & Rie AV (2015). Comparison of pharmacy-based measures of adherence to antiretroviral therapy as predictors of virological failure. *AIDS and Behavior*, 19(4), 612–618. 10.1007/s10461-014-0953-2. [PubMed: 25433652]
- Heylen E, Panicker ST, Chandy S, Steward WT, & Ekstrand ML (2015). Food insecurity and its relation to psychological well-being among south Indian people living with HIV. *AIDS and Behavior*, 19(8), 1548–1558. 10.1007/s10461-014-0966-x. [PubMed: 25488171]
- Hobfoll SE (1989). Conservation of resources. A new attempt at conceptualizing stress. *The American Psychologist*, 44(3), 513–524. [PubMed: 2648906]
- Holtzman CW, Shea JA, Glanz K, Jacobs LM, Gross R, Hines J, Mounzer K, Samuel R, Metlay JP, & Yehia BR (2015). Mapping patient-identified barriers and facilitators to retention in HIV care and antiretroviral therapy adherence to Andersen's behavioral model. *AIDS Care*, 27(7), 817–828. 10.1080/09540121.2015.1009362. [PubMed: 25671515]

- Hong SY, Jerger L, Jonas A, Badi A, Cohen S, Nachega JB, Parienti JJ, Tang AM, Wanke C, Terrin N, Pereko D, Blom A, Trotter AB, & Jordan MR (2013). Medication possession ratio associated with short-term virologic response in individuals initiating antiretroviral therapy in Namibia. *PLoS One*, 8(2), e56307. 10.1371/journal.pone.0056307. [PubMed: 23509605]
- Hu L, & Bentler PM (1999). Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. *Structural Equation Modeling*, 6(1), 1–5. 10.1080/10705519909540118.
- Ickovics JR, & Meade CS (2002). Adherence to antiretroviral therapy among patients with HIV: a critical link between behavioral and biomedical sciences. *Journal of Acquired Immune Deficiency Syndromes*, 31(Suppl 3), S98–S102. [PubMed: 12562029]
- Isaacs J, Ouellette T, Burstein N, Long D, & Beecroft E (2004). Measures of material hardship Final report. Washington, D.C.: U.S. Department of Health and Human Services Retrieved from <https://aspe.hhs.gov/system/files/pdf/73366/report.pdf>
- Kabore L, Muntner P, Chamot E, Zinski A, Burkholder G, & Mugavero MJ (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. 10.1177/2325957414557263. [PubMed: 25421930]
- Kadiyala S, & 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. 10.1017/S136898001200050X. [PubMed: 22348289]
- Kalichman SC, Hernandez D, Cherry C, Kalichman MO, Washington C, & Grebler T (2014). Food insecurity and other poverty indicators among people living with HIV/AIDS: effects on treatment and health outcomes. *Journal of Community Health*, 39(6), 1133–1139. 10.1007/s10900-014-9868-0. [PubMed: 24705680]
- Kamndaya M, Thomas L, Vearey J, Sartorius B, & Kazembe L (2014). Material deprivation affects high sexual risk behavior among young people in urban slums, South Africa. *Journal of Urban Health*, 91(3), 581–591. 10.1007/s11524-013-9856-1. [PubMed: 24481587]
- Kenrick DT, Griskevicius V, Neuberg SL, & Schaller M (2010). Renovating the pyramid of needs: contemporary extensions built upon ancient foundations. *Perspectives on Psychological Science*, 5(3), 292–314. 10.1177/1745691610369469. [PubMed: 21874133]
- Kim SW, Skordis-Worrall J, Haghighparast-Bidgoli H, & Pulkki-Brannstrom A-M (2016). Socio-economic inequity in HIV testing in Malawi. *Global Health Action*, 9(1), 31730. [PubMed: 27790970]
- Koethe JR, Blevins M, Bosire C, Nyirenda C, Kabagambe EK, Mwango A, Kasongo W, Zulu I, Shepherd BE, & Heimbarger DC (2013). Self-reported dietary intake and appetite predict early treatment outcome among low-BMI adults initiating HIV treatment in Sub-Saharan Africa. *Public Health Nutrition*, 16(3), 549–558. 10.1017/S1368980012002960. [PubMed: 22691872]
- Langebeek N, Gisolf EH, Reiss P, Vervoort SC, Hafsteinsdottir TB, Richter C, ... Nieuwkerk PT (2014). Predictors and correlates of adherence to combination antiretroviral therapy (ART) for chronic HIV infection: a meta-analysis. *BMC Medicine*, 12(1), 142. 10.1186/PREACCEPT-1453408941291432. [PubMed: 25145556]
- Larson BA, Fox MP, Bii M, Rosen S, Rohr J, Shaffer D, Sawe F, Wasunna M, & Simon JL (2013). Antiretroviral therapy, labor productivity, and sex: a longitudinal cohort study of tea pluckers in Kenya. *AIDS*, 27(1), 115–123. 10.1097/QAD.0b013e32835a5b12. [PubMed: 23014516]
- Leung DYP, Lam T, & 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. 10.1186/1471-2458-10-513. [PubMed: 20043862]
- Madhvani N, Longinetti E, Santacatterina M, Forsberg BC, & El-Khatib Z (2015). Correlates of mobile phone use in HIV care: results from a cross-sectional study in South Africa. *Preventive Medicine Reports*, 2, 512–516. <https://doi.org/10.1016/j.pmedr.2015.06.010>. [PubMed: 26844111]
- Marinescu I (2014). HIV, wages, and the skill premium. *Journal of Health Economics*, 37, 181–197. 10.1016/j.jhealeco.2014.06.010. [PubMed: 25019957]

- Masa R, Chowa G, & Nyirenda V (2018). Chuma na Uchizi: a livelihood intervention to increase food security of people living with HIV in rural Zambia. *Journal of Health Care for the Poor and Underserved*, 29(1), 349–372. 10.1353/hpu.2018.0024. [PubMed: 29503305]
- Maslow A (1943). A theory of human motivation. *Psychological Review*, 50(4), 370–396.
- Matovu JKB, & Ssebadduka NB (2014). Knowledge, attitudes & barriers to condom use among female sex workers and truck drivers in Uganda: a mixed-methods study. *African Health Sciences*, 13(4), 1027–1033.
- McCoy SI, Ralph LJ, Njau PF, Msolla MM, & Padian NS (2014). Food insecurity, socioeconomic status, and HIV-related risk behavior among women in farming households in Tanzania. *AIDS and Behavior*, 18(7), 1224–1236. 10.1007/s10461-013-0629-3. [PubMed: 24097335]
- McMahon JH, Jordan MR, Kelley K, Bertagnolio S, Hong SY, Wanke CA, Lewin SR, & Elliott JH (2011). Pharmacy adherence measures to assess adherence to antiretroviral therapy: review of the literature and implications for treatment monitoring. *Clinical Infectious Diseases*, 52(4), 493–506. 10.1093/cid/ciq167. [PubMed: 21245156]
- Miller CL, Bangsberg DR, Tuller DM, Senkungu J, Kawuma A, Frongillo EA, & Weiser SD (2011). Food insecurity and sexual risk in an HIV endemic community in Uganda. *AIDS and Behavior*, 15(7), 1512–1519. 10.1007/s10461-010-9693-0. [PubMed: 20405316]
- Mishra V, Assche SB-V, Greener R, Vaessen M, Hong R, Ghys PD, Boerma JT, van Assche A, Khan S, & Rutstein S (2007). HIV infection does not disproportionately affect the poorer in Sub-Saharan Africa. *AIDS*, 21(Suppl 7), S17–S28. 10.1097/01.aids.0000300532.51860.2a. [PubMed: 18040161]
- Misselhorn AA (2005). What drives food insecurity in Southern Africa? A meta-analysis of household economy studies. *Global Environmental Change*, 15(1), 33–43.
- Mohanty SK, Agrawal NK, Mahapatra B, Choudhury D, Tuladhar S, & Holmgren EV (2017). Multidimensional poverty and catastrophic health spending in the mountainous regions of Myanmar, Nepal and India. *International Journal for Equity in Health*, 16(1), 21 10.1186/s12939-016-0514-6. [PubMed: 28100226]
- Musumari PM, Wouters E, Kayembe PK, Nzita MK, Mbikayi SM, Suguimoto SP, ... Kihara M (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 10.1371/journal.pone.0085327. [PubMed: 24454841]
- Mutumba M, Musiime V, Lepkwoski JM, Harper GW, Snow RC, Resnicow K, & Bauermeister JA (2016). Examining the relationship between psychological distress and adherence to antiretroviral therapy among Ugandan adolescents living with HIV. *AIDS Care*, 28(7), 807–815. 10.1080/09540121.2015.1131966. [PubMed: 27294696]
- Nabukeera-Barungi N, Elyanu P, Asire B, Katureebe C, Lukabwe I, Namusoke E, Musinguzi J, Atuyambe L, & Tumwesigye N (2015). Adherence to antiretroviral therapy and retention in care for adolescents living with HIV from 10 districts in Uganda. *BMC Infectious Diseases*, 15(1), 520 10.1186/s12879-015-1265-5. [PubMed: 26573923]
- National AIDS Council [NAC]. (2014). National HIV/AIDS strategic framework 2014–2016: a nation free from the threat of HIV and AIDS. Lusaka, Zambia: NAC Retrieved from <http://www.nac.org.zm/content/revised-national-hiv-and-aids-strategic-framework-r-nasf-2014-2016>.
- Norton BL, Person AK, Castillo C, Pastrana C, Subramanian M, & Stout JE (2014). Barriers to using text message appointment reminders in an HIV clinic. *Telemedicine Journal and E-Health*, 20(1), 86–89. 10.1089/tmj.2012.0275. [PubMed: 24160900]
- Rawat R, McCoy SI, & Kadiyala S (2013). Poor diet quality is associated with low CD4 count and anemia and predicts mortality among antiretroviral therapy-naïve HIV-positive adults in Uganda. *Journal of Acquired Immune Deficiency Syndromes*, 62(2), 246–253. 10.1097/QAI.0b013e3182797363. [PubMed: 23117502]
- Raykov T (1997). Estimation of composite reliability for congeneric measures. *Applied Psychological Measurement*, 21(2), 173–184. 10.1177/01466216970212006.
- Rougemont M, Stoll BE, Elia N, & Ngang P (2009). Antiretroviral treatment adherence and its determinants in Sub-Saharan Africa: a prospective study at Yaounde Central Hospital, Cameroon. *AIDS Research and Therapy*, 6(1), 21 10.1186/1742-6405-6-21. [PubMed: 19821997]

- Sangeda RZ, Mosha F, Prosperi M, Aboud S, Vercauteren J, Camacho RJ, Lyamuya EF, van Wijngaerden E, & Vandamme AM (2014). Pharmacy refill adherence outperforms self-reported methods in predicting HIV therapy outcome in resource-limited settings. *BMC Public Health*, 14(1), 1035 10.1186/1471-2458-14-1035. [PubMed: 25280535]
- Semvua SK, Orrell C, Mmbaga BT, Semvua HH, Bartlett JA, & Boulle AA (2017). Predictors of non-adherence to antiretroviral therapy among HIV infected patients in Northern Tanzania. *PLoS One*, 12(12), e0189460 10.1371/journal.pone.0189460. [PubMed: 29252984]
- Sen A (1997). *On economic inequality*. New York: Oxford University Press.
- Sen A (1999). *Development as freedom* (1st ed.). New York: Knopf.
- Shacham E, Estlund AL, Tanner AE, & Presti R (2017). Challenges to HIV management among youth engaged in HIV care. *AIDS Care*, 29(2), 189–196. 10.1080/09540121.2016.1204422. [PubMed: 27397139]
- Short SE, & Goldberg RE (2015). Children living with HIV-infected adults: estimates for 23 countries in Sub-Saharan Africa. *PLoS One*, 10(11), e0142580 10.1371/journal.pone.0142580. [PubMed: 26575484]
- Shubber Z, Mills EJ, Nachega JB, Vreeman R, Freitas M, Bock P, Nsanzimana S, Penazzato M, Appolo T, Doherty M, & Ford N (2016). Patient-reported barriers to adherence to antiretroviral therapy: a systematic review and meta-analysis. *PLoS Medicine*, 13(11), e1002183 10.1371/journal.pmed.1002183. [PubMed: 27898679]
- Siefried KJ, Mao L, Kerr S, Cysique LA, Gates TM, McAllister J, ... PAART study investigators. (2017). Socioeconomic factors explain suboptimal adherence to antiretroviral therapy among HIV-infected Australian adults with viral suppression. *PLoS One*, 12(4), e0174613 10.1371/journal.pone.0174613. [PubMed: 28369066]
- Simoni JM, Huh D, Wang Y, Wilson IB, Reynolds NR, Remien RH, Goggin K, Gross R, Rosen MI, Schneiderman N, Arnsten J, Golin CE, Erlen JA, Bangsberg DR, & Liu H (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. 10.1007/s10461-014-0905-x. [PubMed: 25280447]
- Singer AW, Weiser SD, & McCoy SI (2015). Does food insecurity undermine adherence to antiretroviral therapy? A systematic review. *AIDS and Behavior*, 19(8), 1510–1526. 10.1007/s10461-014-0873-1. [PubMed: 25096896]
- Stata. (2017). *Stata statistical software: release 15*. College Station: StataCorp LLC.
- Steiner JF, & Prochazka AV (1997). The assessment of refill compliance using pharmacy records: methods, validity, and applications. *Journal of Clinical Epidemiology*, 50(1), 105–116. 10.1016/S0895-4356(96)00268-5. [PubMed: 9048695]
- Stringer JS, Zulu I, Levy J, Stringer EM, Mwango A, Chi BH, ... Sinkala M (2006). Rapid scale-up of antiretroviral therapy at primary care sites in Zambia: feasibility and early outcomes. *JAMA*, 296(7), 782–793. [PubMed: 16905784]
- Teare MD, Dimairo M, Shephard N, Hayman A, Whitehead A, & Walters SJ (2014). Sample size requirements to estimate key design parameters from external pilot randomised controlled trials: a simulation study. *Trials*, 15(1), 264 10.1186/1745-6215-15-264. [PubMed: 24993581]
- Tekola F, Reniers G, Haile Mariam D, Araya T, & Davey G (2008). The economic impact of HIV/AIDS morbidity and mortality on households in Addis Ababa, Ethiopia. *AIDS Care*, 20(8), 995–1001. 10.1080/09540120701777256. [PubMed: 18777224]
- Thomson H, Thomas S, Sellstrom E, & Petticrew M (2013). Housing improvements for health and associated socio-economic outcomes. *The Cochrane Database of Systematic Reviews*, 2, CD008657 10.1002/14651858.CD008657.pub2.
- Tuller DM, Bangsberg DR, Senkungu J, Ware NC, Emenyonu N, & Weiser SD (2010). Transportation costs impede sustained adherence and access to HAART in a clinic population in southwestern Uganda: a qualitative study. *AIDS and Behavior*, 14(4), 778–784. 10.1007/s10461-009-9533-2. [PubMed: 19283464]
- Weiser SD, Tuller DM, Frongillo EA, Senkungu J, Mukiibi N, & Bangsberg DR (2010). Food insecurity as a barrier to sustained antiretroviral therapy adherence in Uganda. *PLoS One*, 5(4), e10340 10.1371/journal.pone.0010340. [PubMed: 20442769]

- Weiser SD, Tsai AC, Gupta R, Frongillo EA, Kawuma A, Senkungu J, Hunt PW, Emenyonu NI, Mattson JE, Martin JN, & Bangsberg DR (2012). Food insecurity is associated with morbidity and patterns of healthcare utilization among HIV-infected individuals in a resource-poor setting. *AIDS*, 26(1), 67–75. 10.1097/QAD.0b013e32834cad37. [PubMed: 21904186]
- Weiser SD, Bukusi EA, Steinfeld RL, Frongillo EA, Weke E, Dworkin SL, Pusateri K, Shiboski S, Scow K, Butler LM, & Cohen CR (2015). Shamba Maisha: randomized controlled trial of an agricultural and finance intervention to improve HIV health outcomes. *AIDS*, 29(14), 1889–1894. 10.1097/QAD.0000000000000781. [PubMed: 26214684]
- White IR, Royston P, & Wood AM (2011). Multiple imputation using chained equations: issues and guidance for practice. *Statistics in Medicine*, 30(4), 377–399. [PubMed: 21225900]
- Wojcicki JM (2005). Socioeconomic status as a risk factor for HIV infection in women in East, Central and Southern Africa: a systematic review. *Journal of Biosocial Science*, 37(1), 1–36. [PubMed: 15688569]
- Yager JE, Kadiyala S, & Weiser SD (2011). HIV/AIDS, food supplementation and livelihood programs in Uganda: a way forward? *PLoS One*, 6(10), e26117 10.1371/journal.pone.0026117. [PubMed: 22022530]
- Young S, Wheeler AC, McCoy SI, & Weiser SD (2014). A review of the role of food insecurity in adherence to care and treatment among adult and pediatric populations living with HIV and AIDS. *AIDS and Behavior*, 18(Suppl 5), S505–S515. 10.1007/s10461-013-0547-4. [PubMed: 23842717]

Table 1

Frequency of experiencing material hardship in the past 30 days

Frequency of not having enough money in the past 30 days to pay for	Never (%)	Rarely (%)	Sometimes (%)	Often (%)	Always (%)
Food	10	7	36	38	9
Medical care	3	2	13	34	48
Clothing	5	9	29	48	9
Shelter	86	2	3	4	5
Other household needs	0	9	17	39	35

Never = 0 times in the past 30 days, *rarely* = once or twice, *sometimes* = three to ten times, *often* = more than ten times, and *always* = every day in the past 30 days

Table 2

Variables		Outcomes											
		Medication adherence						Perceived stress					
		95% based on VAS		95% based on MPR		Perceived coping		Perceived mental distress					
OR	p	95% CI	OR	p	95% CI	β	p	95% CI	β	p	95% CI		
m = 100													
Key predictor variable													
Material hardship													
Covariates													
Age	0.86	.13	0.70, 1.05	0.83	.04	0.70, 0.99	0.22	.08	-0.02, 0.47	0.34	.02	0.06, 0.62	
Gender (reference is female)	0.99	.80	0.91, 1.07	1.04	.27	0.97, 1.13	0.06	.34	-0.06, 0.18	-0.01	.83	-0.14, 0.12	
Marital status (reference is not married)	0.71	.61	0.19, 2.62	1.74	.38	0.51, 5.90	-0.50	.58	-2.32, 1.31	-0.82	.44	-2.92, 1.28	
Education level (reference is primary education)	0.58	.42	0.15, 2.21	0.65	.50	0.19, 2.22	1.03	.23	-0.66, 2.72	0.19	.85	-1.79, 2.16	
Head of household status (reference is no head of household)	0.64	.51	0.17, 2.43	0.47	.22	0.14, 1.56	-0.28	.77	-2.15, 1.59	-0.70	.52	-2.85, 1.44	
Household size	1.00	1.00	0.22, 4.64	0.38	.20	0.09, 1.65	-0.33	.76	-2.44, 1.78	0.84	.47	-1.46, 3.14	
Household financial situation (reference is worse)	0.93	.49	0.75, 1.15	0.95	.44	0.81, 1.10	-0.07	.58	-0.30, 0.17	0.02	.89	-0.30, 0.35	
Transportation asset index	1.13	.88	0.23, 5.60	0.54	.42	0.12, 2.43	-0.31	.76	-2.29, 1.67	-1.73	.14	-4.04, 0.57	
Livestock index	0.12	.03	0.02, 0.80	0.34	.29	0.05, 2.47	1.39	.27	-1.08, 3.86	0.69	.64	-2.20, 3.57	
Debt (reference is no debt)	1.16	.28	0.89, 1.50	1.04	.77	0.82, 1.30	-0.05	.79	-0.45, 0.35	0.11	.59	-0.30, 0.52	
Place of residence (reference is Lundazi)	0.82	.74	0.26, 2.59	0.45	.20	0.13, 1.53	0.33	.71	-1.45, 2.11	-0.88	.30	-2.58, 0.81	
Treatment duration	0.50	.29	0.14, 1.81	0.32	.11	0.08, 1.29	3.04	.01	0.69, 5.39	-3.60	.00	-5.82, -1.38	
Distance to the nearest health facility	1.01	.68	0.98, 1.04	0.99	.26	0.96, 1.01	-0.01	.77	-0.06, 0.04	-0.02	.28	-0.07, 0.02	
Travel time to the nearest health facility	1.01	.82	0.96, 1.06	0.93	.04	0.86, 0.99	-0.03	.39	-0.09, 0.04	0.06	.11	-0.01, 0.13	
Perceived coping	1.00	.65	0.99, 1.01	1.01	.05	1.00, 1.02	0.01	.03	0.00, 0.02	0.00	.57	-0.01, 0.01	
Perceived mental distress										-0.32	.01	-0.54, -0.10	
m = 50													
Key predictor variable													
Material hardship													
Covariates													
Age	0.85	.11	0.70, 1.04	0.84	.04	0.70, 0.99	0.22	.08	-0.02, 0.47	0.35	.02	0.07, 0.63	
	0.99	.78	0.91, 1.07	1.04	.26	0.97, 1.13	0.06	.37	-0.07, 0.18	-0.02	.82	-0.14, 0.11	

Variables	Outcomes											
	Medication adherence						Perceived stress					
	95% based on VAS			95% based on MPR			Perceived coping			Perceived mental distress		
	OR	p	95% CI	OR	p	95% CI	β	p	95% CI	β	p	95% CI
Gender (reference is female)	0.74	.65	0.19, 2.79	1.75	.37	0.52, 5.89	-0.54	.56	-2.38, 1.31	-0.82	.44	-2.93, 1.28
Marital status (reference is not married)	0.57	.41	0.15, 2.15	0.65	.48	0.19, 2.19	1.05	.22	-0.66, 2.77	0.20	.84	-1.77, 2.17
Education level (reference is primary education)	0.67	.56	0.17, 2.59	0.48	.23	0.15, 1.58	-0.29	.76	-2.17, 1.58	-0.71	.51	-2.85, 1.44
Head of household status (reference is no head of household)	1.01	.99	0.22, 4.63	0.38	.20	0.09, 1.65	-0.29	.79	-2.43, 1.85	0.85	.46	-1.45, 3.16
Household size	0.92	.43	0.75, 1.13	0.94	.45	0.81, 1.10	-0.06	.60	-0.30, 0.17	0.03	.87	-0.30, 0.35
Household financial situation (reference is worse)	1.06	.95	0.22, 5.18	0.54	.42	0.12, 2.42	-0.30	.76	-2.29, 1.68	-1.70	.14	-4.00, 0.60
Transportation asset index	0.13	.04	0.02, 0.87	0.35	.30	0.05, 2.52	1.39	.27	-1.08, 3.86	0.69	.63	-2.18, 3.57
Livestock index	1.15	.30	0.89, 1.49	1.03	.78	0.82, 1.30	-0.05	.79	-0.45, 0.34	0.11	.59	-0.30, 0.51
Debt (reference is no debt)	0.83	.75	0.26, 2.63	0.46	.21	0.13, 1.56	0.32	.72	-1.46, 2.10	-0.89	.30	-2.58, 0.81
Place of residence (reference is Lundazi)	0.54	.35	0.15, 1.98	0.33	.12	0.08, 1.31	3.05	.01	0.69, 5.41	-3.62	.00	-5.84, -1.40
Treatment duration	1.01	.71	0.98, 1.03	0.99	.26	0.96, 1.01	-0.01	.81	-0.06, 0.04	-0.02	.29	-0.07, 0.02
Distance to the nearest health facility	1.00	.85	0.96, 1.06	0.93	.04	0.86, 0.99	-0.03	.38	-0.09, 0.04	0.06	.11	-0.01, 0.13
Travel time to the nearest health facility	1.00	.68	0.99, 1.01	1.01	.05	1.00, 1.02	0.01	.03	0.00, 0.02	0.00	.57	-0.01, 0.01
Perceived coping										-0.32	.01	-0.54, -0.09
Perceived mental distress							-0.28	.01	-0.51, -0.06			

β = regression coefficient

OR odds ratio, CI confidence interval