

The effects of nutritional supplementation on body mass index and CD4 count among adult people living with HIV/AIDS on antiretroviral treatment in Conakry, Guinea

Sidikiba Sidibé,^{1,2}

Alexandre Delamou,^{1,2}

Mohamed Lamine Kaba,²

Aboubacar Sidiki Magassouba,^{1,2}

Amara Tabaoou Samake,^{1,2}

Yao Serge Arthur Dongo,²

Kadio Jean-Jacques Olivier Kadio,²

Sandouno Sah Dimio,²

Lansana Mady Camara,²

Stella Babalola³

¹National Center for Training and Rural Health Research, Maferinyah, Guinea;

²Faculty of Medicine, Pharmacy and Odonto-Stomatology, Gamal Abdel Nasser University, Conakry, Guinea;

³Johns Hopkins Center for Communication Programs, Johns Hopkins University, Baltimore, MD, USA

Abstract

Whereas the HIV prevalence in Guinea is among the lowest in Africa, many PLHIV in Guinea are malnourished. This study assessed the effect of a nutritional supplementation program on body mass index and CD4 count among adult PLHIV on ART. Study participants were PLHIV who came for consultation in the study sites between May and July 2016. The data came from two sources: retrospectively from participants' medical records and interviews at the time of recruitment into the study. About six months before they were recruited into the study, some of the PLHIV started to receive a monthly nutritional supplementation consisting of Corn-Soy Blend and oil. Analytic methods included bivariate and multivariable methods. The intervention increased the mean BMI by 7.4% and the average current CD4 count by 4.7% compared to non-intervention ($P < 0.001$). Programs in low resource settings should consider nutrition assistance as part of a comprehensive strategy to ensure optimal metabolic and immunological functions among PLHIV.

Introduction

The acquired immune deficiency syndrome (AIDS) is a public health problem in

many parts of Africa. The disease, caused by the human immunodeficiency virus (HIV), weakens the body's immune system and exposes the infected persons to opportunistic diseases. According to the 2012 Demographic and Health Survey, HIV prevalence rate was 1.7% in Guinea. As in most other African countries, women (2.1%) were almost twice as likely as men (1.2%) to be infected.¹

As HIV progresses to AIDS, nutritional requirements in terms of proteins, micronutrients, and energy increase.^{2,3} Unfortunately, malnutrition is a common problem among people living with HIV (PLHIV).³⁻⁶ The reasons for this are multiple including the fact that AIDS is often associated with loss of appetite, nausea and vomiting (often due to malabsorption of nutrients) and limited financial resources due to job loss and inability to HIV unable to procure adequate nutrition.^{3,7,8} Among PLHIV, not only do malnutrition and HIV tend to co-occur, the two problems tend to have synergistic effects in such a way as to aggravate outcomes for PLHIV.^{9,10} A healthy and balanced diet helps to compensate for energy deficits due to AIDS, strengthen the immune system, and improve metabolic processes and treatment outcomes.^{2,11} Furthermore, adequate nutrition helps to mitigate the pace of immune suppression in individuals infected with HIV and foster adherence to treatment.^{3,4} In contrast, inadequate nutrition and food insecurity tend to hasten disease progression and is associated with poorer treatment outcomes for PLHIV.¹⁰ For example, these conditions have been associated with lower CD4 counts and immune degradation,^{12,13} increased risk of transmission and metabolic syndrome,² increased risk of opportunity infections,⁵ increased risk of mortality,^{5,14} poor adherence to ART^{15,16} and reduced quality of life.⁶

Whereas the problem of malnutrition in HIV infected people is more common and severe in Africa, especially in countries without universal access to antiretroviral treatment, malnutrition continues to be a common problem in developed countries and in developing countries with widespread access to ART.^{12,14,17,18} In recent years, considerable improvements have been accomplished both in our understanding of the link between HIV and malnutrition and in the identification of effective strategies to improve the situation. Many of the studies that have contributed to this improved understanding come from African countries.^{5,14,19} The World Health Organization has long acknowledged the importance of adequate nutrition for PLHIV and made specific recommendations about increased calorie intake as the disease pro-

Correspondence: Sidibé Sidikiba, Faculty of Medicine, Gamal Abdel Nasser University of Conakry, Guinea.

Tel.: +224.628.993.899.

E-mail: layesidikiba@gmail.com

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Contributions: SS, AD, SDS, ATS and YSAD designed the study and developed the study protocol. ATS, YSAD, MLK, ASM, KADIO KJJO, AD and SS were involved in data collection. SS, AD and SB designed the analysis plan. SS and SB performed the data analyses, interpreted results and drafted the Manuscript with inputs from AD, ATS and YSAD. All authors critically revised and approved the final manuscript.

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gresses.²⁰ Nutrition-based interventions are becoming increasingly common in the care and support of PLHIV and have been found to be effective in Africa and other settings.^{3,8,19,21,22} For example, in their study in Abuja, Amlogu, Tewfik found that provision of a nutritional functional meal made from locally available ingredients increase CD4 count by 40.8 cells/mm³ compared to a decrease of 18.12 cells/mm³ in the control group after a period of six months. Similarly in a double-blinded randomized control trial

found an increase of 65 cells in the mean absolute CD4 count in the group that received micronutrient supplement compared to a decrease of 6 cells in the control group after 12 weeks of intervention.²³⁻²⁶

In Guinea, the number of PLHIV receiving ART have increased steadily over the years from 14,999 in 2009 to 27,792 in 2013.²⁴ This increase notwithstanding, malnutrition and weight loss continue to be a major concern among PLHIV in Guinea. According to the 2014 survey of nutritional status and vulnerability of PLHIV on ART in Conakry and six other cities revealed a prevalence of malnutrition of 24.3% at the onset of treatment.²⁵

The aim of this study was to assess the effect of nutritional supplementation on body mass index and CD4 count among adult PLHIV on antiretroviral therapy (ART) in Conakry Guinea.

Materials and Methods

Study population

Conakry, the capital of Guinea has the highest HIV prevalence rate in the country: 2.7%. With a population of 1.77 million, the city is by far the most populous and urbanized in the country. Conakry comprises five communes: Kaloum, Dixinn, Matam, Matoto and Ratoma. The study took place in the following health facilities: Centre Hospitalier Universitaire (CHU) Ignace Deen, CHU Donka, Centre Médical Communal (CMC) Matam, CMC les Flamboyants, Centre de Santé (CS) Gbessia Port 1, and CS Wanindara. These facilities are reference sites for HIV care and treatment in Conakry. The study targeted male and female PLHIV who obtained care from the study sites between April 2008 to January 2016. In parallel to the antiretroviral treatment, some of the participants were selected based on their BMI to receive a nutrition-based intervention. The intervention consisted of nutritional support. Specifically, underweight PLHIV (with BMI lower than 18.5) were provided with a monthly supply of a bag of fortified flour (Corn-Soya Blend) and five liters of vegetable oil for a period of six months. The duration of supplementation was six months for all patients who benefited the intervention. The duration of HAART depended on the time of diagnosis and HAART initiation.

Data collection

The data that we analyzed in this manuscript came from interviews with PLHIV

who received HIV care in the study sites between May and July 2016. PLHIV aged at least 15 years and having been on treatment for at least three months were eligible for participation in a cross-sectional survey. The data was collected during face to face interview with PLHIV and was completed by baseline demographic and clinical data collected directly from patients' medical records and covered the period from April 2008 to January 2016. The information extracted from the medical records included date diagnosed with HIV, date ART started, weight at the initiation of ART and CD4 count at the initiation of ART. Data were collected with a pretested survey tool that included questions on socio-demographic characteristics (sex, age, education level, marital status, and occupation); co-residence with another PLHIV, household size, prior and current experience with opportunistic infection, appetite-related problems, frequency of receiving nutritional supplementation, eating habits, and exposure to nutritional counseling at the health facility. Data collection also included obtaining the weight and height study participants and assessing their CD4 status. Participants were weighed with light clothing on using a high precision digital scale. Their height was measured using a measuring tape. The CD4 T cell count was based on an automated method (BD Bioscience, BD FACSCount™) using test strips.

Ethical and regulatory aspects

Ethical clearance for this study was obtained from the Scientific Committee of the Department of Public Health University of Conakry College of Medicine. Prior to conducting the interviews, field workers explained the objectives, procedures and associated risk and benefits of the study, and obtained informed consent from each respondent. Furthermore, the respondents were protected through individual face-to-face interviews without a third-party, assurance of confidentiality and voluntary participation.

Analysis

We started by examining the differences in the socio-demographic characteristics of the study participants that received nutritional supplementation and those that did not. We then performed both unadjusted and multivariable regression analysis. Prior to conducting the analysis, we checked for normality of the dependent variables by examining the Kurtosis and skewness. The results suggested that the variables were not normally distributed. We therefore performed log-transformation of the variables before using them in the regression models.

For the bivariate analysis, we examined the unadjusted relationship between the dependent variables and each of the independent variables using linear regression. The variables that were significant at 0.2 level were retained for inclusion in a multivariable linear regression. For the multivariable regression, we report both the regression coefficients and the beta weights. All analyses were performed in Statistical Package for Social Science (SPSS) version 24.²⁶

Results

Socio-demographic characteristics of study participants

The sample included 450 study participants; 138 of these were in the intervention group (that is, they received nutritional supplementation) while 312 were in the non-intervention group. The differences in the socio-demographic and baseline nutritional characteristics between the two groups are presented on Table 1. Overall, the sample included 26.9% men and 73.1% women; there were no significant differences in sex distribution between the intervention and non-intervention groups. Similarly, the two groups did not differ by marital status, education level or household size. Furthermore, the two groups did not differ by age, treatment duration, CD4 at initiation of treatment. In contrast, there were significant differences between the two groups in terms of exposure to nutritional counseling during facility visit. Specifically, the participants in the intervention group (61.6%) were more likely to have received nutritional counseling than their peers in the non-intervention group (45.2%). Similarly, the participants in the intervention group (57.2%) were more likely than their peers in the non-intervention group (44.2%) to have recently experienced an opportunistic infection. Problems with appetite were more prevalent in the non-intervention (25.3%) than in the intervention (16.7%) groups. Furthermore, the participants in the intervention group (39.1%) were more likely than their peers in the non-intervention group (25.3%) to have an income lower than 8175 Guinean Francs. Finally, the two groups differed significantly in terms of BMI at initiation of treatment; the average BMI was 16.63 in the intervention group and 20.95 in the non-intervention group.

Effects of nutritional supplementation on BMI

The median BMI increased by 4.7 between treatment initiation and end of the study among the intervention group com-

pared to 1.9 among the non-intervention ($P<0.001$). Results of the bivariate and multivariable linear regression models are presented on Table 2. The bivariate results show a negative association between exposure to the intervention and BMI at the end of the study. Specifically, the BMI was about 6% [$\exp(-0.06)-1$] smaller among intervention participants compared to the control. The relation of BMI at start of treatment and current BMI was strong and positive. Other variables positively associated with current BMI include being currently or previously married compared to never married, treatment duration in months and co-residence with another HIV-positive person. In contrast, being male, education level, recent episode of opportunistic infections, problems with appetite and poverty were negatively associated with current BMI. Household size and receiving nutritional

counseling during facility visits were not significantly associated with current BMI.

The multivariable logistic results show that the independent variables included in the model collectively predict 47.2% of the variance in current BMI. After controlling for BMI at treatment initiation and other variables that are likely to affect current BMI, the intervention has significant effects on current BMI. Specifically, compared to non-intervention, the intervention was associated with a 7.4% [$\exp(.0712328)-1$] increase in current BMI. A unit increase in baseline BMI increases the average current BMI by 3.1% while being male decreases the measure by 5.9% compared to being female. A one-year increase in age increases current BMI by 0.2%. In contrast, current recent episode of an opportunistic infection decreases the current BMI at end of study by 4.2% while problem with appetite

decreases it by 11.2%. The effects of treatment duration and education were only marginally significant whereas, marital status, poverty and co-residence with another HIV-positive person were not at all significant predictors. A look at the beta weights indicate that the strongest predictors of BMI at end of study are BMI at treatment initiation (a reflection of stability effects), problems with appetite, and the intervention.

Effects of nutritional supplementation on CD4 count

Between treatment initiation and end of the study, the median CD4 count increased by 266.5 cells/mm³ in the intervention group while the increase was 163 cells/mm³ in the non-intervention group ($P<0.001$) (Figure 1). Results of the bivariate analysis (unadjusted regression) indicate that the intervention has no significant effects on

Table 1. Baseline (at ART initiation) characteristics of intervention and non-intervention groups.

Independent Variable/Category	Intervention (n=138)		Non-Intervention (n=312)		P
	N.	% mean/median	N.	% mean/median	
Median BMI at treatment initiation	138	16.78	312	20.69	<0.001
Sex					
Male	32	23.2	89	28.5	0.239
Female	106	76.8	223	71.5	
Mean current age in years	138	35.8	312	37.3	0.118
Education level					
No education	85	61.6	177	56.7	0.566
Primary	17	12.3	40	12.8	
Middle School	16	11.6	32	10.3	
High School	14	10.1	37	11.8	
Tertiary	6	4.3	26	8.3	
Marital Status					
Polygynous marriage	62	44.9	116	37.2	0.401
Monogamous marriage	24	17.4	70	22.4	
Divorced/widowed	26	18.8	67	21.5	
Never Married	26	18.8	59	18.9	
Average treatment duration in months	138	42.0	312	43.9	0.257
Household size					
Five members or fewer	85	61.6	180	57.7	0.438
At least six members	53	38.4	132	42.3	
Nutrition counseling					
Did not receive	53	38.4	171	54.8	<0.001
Received	85	61.6	141	45.2	
Recent or current opportunistic infection					
Did not have	59	42.7	174	55.8	0.011
Had	79	57.3	138	44.2	
Recent or current appetite-related problems					
Did not have	115	83.3	233	74.7	0.043
Had	23	16.7	79	25.3	
Poverty					
Non-poor (Income at least 8175 Guinean Francs per day)	84	60.9	233	74.7	0.003
Poor (Income less than 8175 Guinean Francs per day)	54	39.1	79	25.3	
Another household member living with HIV					
No	95	68.8	214	68.6	0.958
Yes	43	31.2	98	31.4	

current CD4 count (Table 3). Similarly, current CD4 count was not significantly related to current age, education, marital status, household size, problems with appetite, and poverty. In contrast, CD4 count at treatment initiation, sex, treatment duration, recent or current experience with opportunistic infections, and exposure to nutrition counseling during facility visits were significantly associated with current CD4 count. The association of current CD4 count with co-residence with another HIV-positive person was only marginally significant.

The multivariate results show that the seven explanatory variables jointly explain 42.2% of the variance in current CD4 count. The results further show that the significant predictors of current CD4 count are CD4 count at treatment initiation, intervention participation, treatment duration, and exposure to nutrition counseling during facility visits. Specifically, the higher the CD4 at treatment initiation, the higher the current CD4 count is: a one-point increase in CD4 at treatment initiation increases current CD4 by 0.07%. The effect of the intervention is strong and positive such that being in the intervention group increases the average current CD4 count by 4.7% compared to the non-intervention group. The effects of nutrition counseling and length of time in treatment were positive. The beta coefficients reveal that the most important predic-

tors of current CD4 count were CD4 count at treatment initiation, nutrition counseling and the intervention.

Discussion

This manuscript examined the role of a nutrition-based intervention on current BMI and CD4 count among PLHIV on ART in

Conakry, Guinea. The results indicate that the intervention has net positive effects on both outcomes. This finding echoes what multiple other studies in Africa and elsewhere have found.^{3,8,19,21,23} This finding underscores the need for including nutritional assistance as part of a comprehensive strategy for promoting healthy outcomes among PLHIV on treatment. Another important finding from this study is that

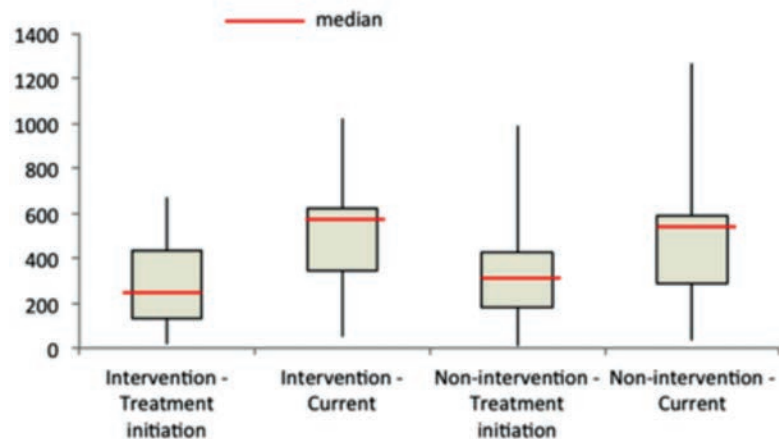


Figure 1. Change in CD4 count by intervention status, treatment initiation and end of study.

Table 2. Results of the regression of log-transformed BMI on lagged value of BMI, intervention participation status and other variables Conakry 2016.

Independent Variable/Category	Unadjusted Coefficient/SE ^{1,2}	Adjusted Coefficient/SE ^{2,3}	Beta
Received nutritional supplementation (RC = Did not receive)	-0.060** (0.020)	0.071*** (0.018)	0.166
BMI at treatment initiation	0.031*** (0.002)	0.031*** (0.002)	0.594
Male sex (RC = female sex)	-0.071*** (0.021)	-0.061*** (0.018)	-0.137
Current age	0.0024** (0.0009)	0.002** (0.0008)	0.105
Education level (RC = No education)			
Primary	0.001 (0.029)	0.009 (0.021)	0.015
Middle School	-0.080** (0.031)	-0.044§ (0.023)	-0.069
High School	-0.048 (0.030)	0.0009 (0.023)	0.001
Tertiary	-0.048 (0.037)	-0.003 (0.029)	-0.005
Marital Status (RC = Polygynous marriage)			
Monogamous marriage	-0.027 (0.024)	-0.024 (0.019)	-0.049
Divorced/widowed	-0.061* (0.025)	-0.026 (0.021)	-0.055
Never Married	-0.088*** (0.025)	-0.015 (0.021)	-0.029
Treatment duration in months	0.0008** (0.0003)	0.0004§ (0.0002)	0.064
Household size at least six members (RC = five members or fewer)	0.010 (0.019)	-	-
Received nutrition counselling (RC = Did not receive)	0.019 (0.019)	-	-
Recently or currently had an opportunistic infection (RC = Did not have)	-0.092*** (0.018)	-0.043** (0.014)	-0.109
Recently or currently had appetite-related problem (RC = Did not have)	-0.135*** (0.021)	-0.118*** (0.016)	-0.252
Poor (RC = non-poor)	-0.044* (0.020)	-0.021 (0.015)	-0.049
Another household member living with HIV (RC = No Other household member living with HIV)	0.054** (0.020)	0.010 (0.016)	0.024
Explained variance (R ²)	-	47.2%	-

¹Effects not adjusted for other covariates; ²the dependent variable is log-transformed; therefore the coefficients should be converted to percent change for better understanding and correct interpretation: Percent Change = (exp(Coefficient) - 1) * 100. ³Effects adjusted for other covariates. §P<0.1, *P<0.05, **P<0.01, ***P<0.001.

after controlling for intervention status and other variables associated with metabolic and immunological functions the lagged values of BMI and CD4 (at time of treatment initiation) are the strongest predictors of the current values. Substantively, this finding indicates the need to start treatment early before metabolic and immunologic functions are compromised, echoing suggestions from prior studies.^{27,28}

This study further found differences and commonalities among the predictors of current BMI and CD4 count. Both outcomes were sensitive to the intervention and lagged value of the outcome. Neither marital status nor education predicted current BMI or CD4. Current age, sex, opportunistic infections and appetite-related problems strongly predicted current BMI but not current CD4 count. In contrast, treatment duration and nutritional counseling were significantly associated with CD4 count but not with BMI. The reasons for these differences in predictors are not entirely clear. Nonetheless, it probably makes sense that opportunistic infections and appetite-related problems strongly predict current BMI, an outcome sensitive to short-term changes in health conditions. The positive relationship

of CD4 count with treatment duration makes intuitive sense since engagement in treatment is expected to lead to viral suppression and increased CD4 count, eventually.

Our study has several limitations including the fact that participants were not randomly allocated to intervention and non-intervention groups. Rather, the selection privilege those with lower income and lower BMI at treatment initiation. It is therefore prone to selection bias. Nonetheless, our results suggest that both income and BMI are good criteria for targeted nutritional supplementation programs in resource-constrained settings. Furthermore, data on treatment initiation and other baseline data were collected retrospectively, which might have led to missing values and limited the range of predictors that we could have included in the estimated models. For example, time to nutritional supplementation after treatment initiation and compliance with nutritional supplementation were not accounted for in the analyses. Finally, because the sampling was not stratified by municipality, the study does not allow comparison of the outcomes across municipalities. All the same, this

study, the first of its kind in Guinea, fills an existing gap and adds to the growing body of literature on the benefits of nutritional supplementation. The 2014/2015 Ebola outbreak has weakened the Guinean health system, decreased the performance of programs and services, and compromised community confidence in the health system.^{29,30} The findings can be used to support efforts designed to strengthen the health system and boost public confidence in the system.

Conclusions

This study demonstrated that nutritional supplementation has a beneficial effect on BMI and CD4 count among adults on anti-retroviral therapy (ART) in Conakry, Guinea. The positive effects of the nutritional supplement, comprising enriched flour (Corn-Soya Blend) and vegetable oil Programs, remained strong after controlling for other variables that are known to influence BMI and CD4 count. Programs in low resource settings should consider nutrition assistance as part of a comprehensive strategy to ensure optimal metabolic and immunological functions among PLHIV.

Table 3. Results of the regression of log-transformed CD4 count on lagged value of CD4 count, intervention participation status and other variables, Conakry 2016.

Independent Variable/Category	Unadjusted Coefficient/SE ^{1,2}	Adjusted Coefficient/SE ^{2,3}	Beta
Received nutritional supplementation (RC = Did not receive)	0.031 (0.022)	0.046** (0.017)	0.097
CD4 count at treatment initiation	0.001*** (0.00004)	0.0007*** (0.00004)	0.614
Male sex (RC = female sex)	-0.049* (0.023)	-0.003 (0.018)	-0.005
Current age	0.0007 (0.001)	-	-
Education level (RC = No education)			
Primary	-0.042 (0.032)	-	-
Middle School	-0.027 (0.034)	-	-
High School	-0.011 (0.034)	-	-
Tertiary	0.041 (0.041)	-	-
Marital Status (RC = Polygynous marriage)			
Monogamous marriage	-0.020 (0.028)	-	-
Divorced/widowed	-0.006 (0.028)	-	-
Never Married	-0.001 (0.029)	-	-
Treatment duration in months	0.001*** (0.0003)	0.0007** (0.0003)	0.094
Household size at least six members (RC = five members or fewer)	0.005 (0.021)	-	-
Received nutrition counseling (RC = Did not receive)	0.080*** (0.020)	0.048** (0.16)	0.111
Recently or currently had an opportunistic infection (RC = Did not have)	-0.063** (0.020)	-0.001 (0.016)	-0.002
Recently or currently had appetite-related problem (RC = Did not have)	-0.021 (0.025)	-	-
Poor (RC = non-poor)	-0.001 (0.023)	-	-
Another household member living with HIV (RC = No Other household member living with HIV)	0.039 [§] (0.022)	0.014 (0.017)	0.031
Explained variance (R ²)	-	42.2%	-

¹Effects not adjusted for other covariates; ²the dependent variable is log-transformed; therefore the coefficients should be converted to percent change for better understanding and correct interpretation: Percent Change = (exp(Coefficient) - 1) * 100. ³Effects adjusted for other covariates. [§]P < 0.1 *P < 0.05; **P < 0.01; ***P < 0.001.

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