



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

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

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Contributorship

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

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For peer review only

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3 1 Article Summary:
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6 2 1) Article Focus

- 7
8 3 a. What structural determinants are associated with food insufficiency, low
9 4 dietary diversity and low BMI in HIV-infected women in Rwanda?
10
11 5 b. What is the prevalence of food insufficiency, low dietary diversity and
12 6 low BMI in HIV-infected women in Rwanda and are they correlated with
13 7 each other?
14
15 8 c. Hypotheses
16
17 9 i. #1: Poverty, low educational status and alcohol use would be
18 10 associated with food insufficiency, low dietary diversity and low
19 11 BMI.
20 12 ii. #2 food insufficiency, low dietary diversity and low BMI would be
21 13 highly prevalent and would be correlated with one another.
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27 14 2) Key messages

- 28
29 15 a. Food insufficiency was found in 44% of the population and was
30 16 associated with low income and illiteracy and was strongly associated
31 17 with alcohol use.
32
33 18 b. BMI (body mass index, kg/m²) was not correlated with food insufficiency
34 19 or dietary diversity.
35
36 20 c. Significance: Food Insufficiency is highly prevalent in HIV-infected
37 21 women in Rwanda. Extreme poverty, low literacy and alcohol use may
38 22 useful indicators of food insufficiency in this population. Low BMI is not
39 23 an adequate screening tool for food insufficiency in HIV-infected
40 24 populations
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46 25 3) Strengths and limitations

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48 26 a. Strengths: Large cohort of HIV-infected women, very detailed tools
49 27 used for food insufficiency and dietary diversity
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51 28 b. Limitations: Cross sectional design, our measurement of food
52 29 insufficiency is solely by self report.
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32 Abstract

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

40 Study Design: cross-sectional analysis of a longitudinal cohort

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

43 Participants: 622 HIV-infected women

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

48 Results: Poverty and illiteracy were common (35% and 23%, respectively). Food
49 insufficiency was prevalent with 44% of women reporting "usually not" or "never" to
50 "Do you have enough food?" Food insufficiency was associated with low income
51 (adjusted Odds Ratio (aOR)=2.57), unemployment, (aOR=1.92) and illiteracy
52 (aOR=1.74). Alcohol use was strongly associated with being food insufficient
53 (aOR=4.89). Factors associated with low dietary diversity included low income
54 (aOR=8.72) and illiteracy (aOR=2.25). BMI (body mass index, kg/m²) was not
55 correlated with food insufficiency or dietary diversity, suggesting that low BMI in these

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2 56 women may not result from food insufficiency alone.
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4 57 Conclusions: HIV-infected Rwandan women experienced high rates of food
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6 58 insufficiency and low dietary diversity. HIV treatment programs in developing
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8 59 countries may consider extreme poverty, unemployment, illiteracy and alcohol use as
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10 60 indications to screen for and address food insufficiency and dietary diversity in HIV-
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12 61 infected populations. Additionally, low BMI is not an adequate screening tool for food
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14 62 insufficiency in HIV-infected populations.
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65 INTRODUCTION

66 Food insecurity, including insufficient access to adequate, safe, nutritionally diverse
67 food, affects an estimated 800 million people worldwide[1,2] In HIV-infected
68 individuals, food insufficiency and low dietary diversity are associated with poor
69 health[3-5]. Food insufficiency may be caused by structural factors: social, political,
70 economic structures or institutions that affect people's ability to control the conditions
71 of their lives and meet their basic needs. Structural determinants of health include
72 distribution of wealth, power and goods, access to education and schools, access to
73 health care, and housing and environment conditions. These structural determinants
74 play a major role in health inequities and greatly affect health status [6]
75 But structural factors associated with food insufficiency in HIV-infected Sub-Saharan
76 women, and how such factors may be addressed to mitigate food insufficiency in the
77 region is not well studied.

78 Food insufficiency (lack of adequate food to meet daily needs) is one aspect of
79 food insecurity, a complex phenomenon describing lack of access to sufficient
80 quantity and adequate quality of food, and anxiety in procuring food [2]. Over half of
81 all households in Rwanda are thought to be food insecure, many of which are
82 headed by women [7]. Rwanda has a significant number of female headed
83 households (31%), partly due to the high numbers of genocide-related widows, and
84 62% of female headed households live in poverty, compared to 54% of male-headed
85 households[8]. Especially in vulnerable populations, such as HIV-infected women,
86 gender disparities may prevent women from having control of family resources and
87 the discretionary income necessary for buying food [9]

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2 88 In HIV-infected women, food insufficiency may result in low body mass index
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4 89 (BMI), which adversely affects health outcomes [10]. In addition, consuming fewer
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6 90 distinct food groups or low dietary diversity, which contributes to poor health
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9 91 outcomes in African women and children [4], may reinforce malnutrition and
10
11 92 eventually result in poor health [11]. Many African diets consist of a single dominant
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13 93 carbohydrate group, such as cassava, potato or yam which provides calories that
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15 94 may maintain body weight, but often does not provide the micro and macronutrients
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17 95 needed for proper immune function[12] .
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21 96 In HIV+ patients, food insecurity has been associated with low CD4 counts,
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23 97 virologic failure and increased mortality[3,5] . Low BMI (<18.5 kg/m²) is a strong
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25 98 predictor for mortality in HIV+ patients starting ART, with higher mortality in patients
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27 99 who are both food insecure and underweight versus underweight but food secure[5] .
28
29 100 Although poverty is associated with poor health outcomes, income alone does not
30
31 101 always reflect the status of someone's "wealth." In populations with very low
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33 102 incomes, markers for disposable or discretionary income, defined as income after all
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35 103 essential items are paid for, may be more useful to define an individual's
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37 104 socioeconomic status. These may include access to electricity and ability to buy non-
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39 105 essential items such as alcohol. For women with HIV, it is unclear which structural
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41 106 factors most influence food insecurity, and therefore have the greatest impact on
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43 107 health outcomes.
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49 108 In order to understand structural determinants of food insufficiency and
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51 109 elucidate potential interventions to prevent food insufficiency and malnutrition in HIV+
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53 110 Rwandan women, we examined the prevalence and socio-demographic associations
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55 111 of food insufficiency and household dietary diversity in HIV+ women in Rwanda. We
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2 112 further examined the relationship between food insufficiency, low BMI and low dietary
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4 113 diversity in these women.
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9 115 **METHODS**

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11 116 Population and Setting: The Rwanda Women's Interassociation Study and
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14 117 Assessment (RWISA) (described in detail elsewhere [13]) is a prospective
15
16 118 observational cohort designed to assess the effectiveness and toxicity of antiretroviral
17
18 119 therapy (ART) in HIV-infected Rwandan women. In 2005, 710 HIV-infected and 226
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21 120 HIV-uninfected Rwandan women were recruited through community-based women's
22
23 121 organizations and clinical care sites for HIV-infected patients. Eligible women were
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25 122 25 years or older at study entry and willing to give informed consent. HIV-infected
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28 123 women were excluded if they had prior history of receiving antiretroviral treatment,
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30 124 except possibly single dose nevirapine to prevent mother to infant transmission of
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32
33 125 HIV. Women were compensated 2500 Rwandan francs for each visit. The Rwandan
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35 126 National Ethics Committee and the Institutional Review Board at Montefiore Medical
36
37 127 Center approved this study.

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40 128 At each study visit participants provided historical information. Trained
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42 129 research assistants collected socio-demographic data at study entry including age,
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44 130 income, education, literacy level, education, employment, access to electricity and
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46
47 131 alcohol use. At each visit participants had a focused physical examination and
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49 132 provided blood specimens for CD4 lymphocyte and complete blood counts. Standing
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51 133 height and weight were measured while the participant was wearing light clothing and
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54 134 no shoes. This analysis included all 622 HIV-positive women who completed socio-

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2 135 demographic and nutritional data at the fifth semi-annual visit, between July and
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4 136 December 2007.

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7 137 Measures:

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9 138 *Outcomes:* Between July and December 2007, food insufficiency was assessed
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11 139 using a single question, “Do you have enough food?” with the women answering
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13 140 “usually not” or “never” classified as food insecure [14,15]. Household dietary
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15 141 diversity was assessed using a modified Household Dietary Diversity Score (HDDS),
16
17 142 a validated tool measuring household food consumption over the previous 24 hours,
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19 143 giving one point for each food class (total 6 possible: 1) cereals and roots; 2)
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21 144 vegetables; 3) fruits; 4) meat protein [including meat, eggs, fish]; 5) vegetable protein
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23 145 [including legumes, beans, nuts]; 6) extras [including oil, fat, sugar, condiments]).
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25 146 Determination of “Low household dietary diversity” is described in detail elsewhere,
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27 147 [18] briefly, the sample was divided into income terciles with the mean HDDS for the
28
29 148 lowest income tercile (≤ 3) representing low dietary diversity [12,16,17].

30
31 149 Independent variables: Income categories were defined as 1) >35,000 Rwandan
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33 150 Francs (\$US 58), 2) 35,000-10,000, and 3) <10,000 RWF (\$US 17), per month.

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35 151 Electricity and alcohol were dichotomous variables with the presence of electricity in
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37 152 the participant’s home used as a proxy for the measurement of disposable income
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39 153 Alcohol use was queried as “Since the last visit have you had a drink containing
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41 154 alcohol?” Education was dichotomized to none vs. some (including some primary,
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43 155 completed primary and some secondary) for the analysis. Literacy was defined as
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45 156 “can read all, most, some or none,” and for the analysis was dichotomized to none
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47 157 vs. some, most or all. Employment was assessed with “Are you currently employed?”
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49 158 Antiretroviral use was assessed by self-report with verification of date of initiation and
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2 159 regimen by tracking cards provided to the participants by providers in the national
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4 160 treatment program. CD4 counts were determined with a FACS counter (Becton and
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7 161 Dickinson, Immunocytometry Systems, San Jose, CA, USA).

8
9 162 Data Analysis:

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11 163 BMI was calculated using weight divided by height-squared (kg/m^2) and dichotomized
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14 164 to ≤ 18.5 or > 18.5 for the analysis. Statistical analysis was performed using SAS
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16 165 (version 9.1.3, SAS Institute Inc., Cary, NC, USA). Univariate logistic regression
17
18 166 identified factors associated with food insecurity, low dietary diversity, and BMI.
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20 167 Multivariate logistic regression models were built using backward selection with a p-
21
22 168 value of 0.05 to stay in the model. Wilcoxon rank sum and Kappa statistics assessed
23
24 169 relationships between food insecurity, BMI and dietary diversity as continuous
25
26 170 variables and as dichotomous variables (food insecurity= answering “usually not” or
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28 171 “never” to “Do you have enough food”, HDDS ≤ 3 , BMI ≤ 18.5), respectively.
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34
35 173 **RESULTS**

36
37 174 The prevalence of poverty was high among the 622 women who met inclusion
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39 175 criteria; 35% reported a monthly income of less than <10K Rwandan Francs (FRW)
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41 176 (\$US 17). Illiteracy was as high as 23%, and 22% of women reported no formal
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43 177 education (Table 1). Mean CD4 counts among HIV positive women at Visit 5 were
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45 178 <350 cells/ μl in 53%; 70% of participants took antiretroviral therapy at this visit.

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49 179 Food insufficiency (Table 1) was highly prevalent with 44% of women reporting
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51 180 “usually not” or “never” to “Do you have enough food?” and another 45% reporting
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53 181 they “sometimes” did not have enough food. Almost half the population reported low
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2 182 dietary diversity (HDDS <3) and 12% of women met WHO criteria for malnutrition
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4 183 with a BMI<18.5 kg/m².

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6 184 In unadjusted analyses (Table 2), structural factors associated with food
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8 185 insufficiency included income <10,000 FRW (OR=2.96; CI 1.67-5.27), income
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10 186 >35,000 FRW vs. <10,000 FRW (OR=1.76; CI 1.01-3.07), no education (OR=2.02; CI
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12 187 1.05-3.88), illiteracy [(can read none: OR= 2.06; CI 1.29-3.30), (can read some:
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14 188 OR=1.48; CI 0.99-2.21)], unemployment (OR 1.99; CI 1.19-3.34), and alcohol use
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16 189 (OR=3.76; CI 2.08-6.78). Factors associated with low dietary diversity (HDDS<3)
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18 190 were income [(income <10,000 FRW: OR= 10.14;CI 4.90-21.01),],(income >35,000
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20 191 FRW vs. <10,000 FRW: OR=4.16; CI 2.04-8.46), education [(none: OR=3.42; CI 1.70-
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22 192 6.78), (some primary: OR =2.30; CI 1.19-4.42), illiteracy [(none: OR= 2.90; CI 1.79-
23
24 193 4.86) (some: OR=1.72; CI 1.14-2.59)], and unemployment (OR=2.13; CI 1.26-3.61).
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26 194 No variables had statistically significant (P < 0.05) associations with BMI.
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33 195 In the final stepwise multivariate model, food insufficiency was independently
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35 196 associated with low income {Adjusted Odds ratio (aOR) 2.57; 95% CI 1.39-4.74 for
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37 197 >35,000 FRW vs. <10,000 FRW}, unemployment (aOR=1.92; CI 1.09-3.38) and
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39 198 illiteracy (aOR=1.74; CI 1.06-2.85) (Table 2). Alcohol use (none vs. any use) was
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41 199 strongly independently associated with being food insecure (aOR=4.89; CI 2.57-
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43 200 9.29). Factors independently associated with low dietary diversity (HDDS <3.0)
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45 201 included low monthly income (aOR=8.72; CI 4.18-18.2 for income <10,000
46
47 202 vs. >35,000 FRW and aOR=3.77; CI 1.84-7.71 for income 10,000-35,000 FRW
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49 203 vs. >35,000 FRW) and illiteracy (aOR=2.25, CI 1.36-3.71).
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54 204 When analyzed as continuous variables, no significant correlations were found
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56 205 between self-reported food insufficiency and BMI (r=-0.05, p=0.29). A statistically
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2 206 significant but weak correlation was found between between dietary diversity and
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4 207 BMI $r=0.09$, $p=0.03$ and food insufficiency and dietary diversity: $r=0.14$, $p<0.001$.
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6 208 When analyzed as dichotomous variables, no significant correlations were found
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8 209 between food insufficiency and BMI, Kappa (K) =0.02, dietary diversity and BMI,
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10 210 K=0.02 or food insufficiency and dietary diversity, K=0.12.
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212 **DISCUSSION**

213 While HIV-infected Rwandan women experienced high rates of food insufficiency
214 (42.1%) and low dietary diversity (44.4%), only 12% of the women had low BMI.
215 Furthermore neither food insufficiency nor lack of dietary diversity was associated
216 with BMI, suggesting that low BMI in these women was not resulting from food
217 insufficiency alone. Still body weight may be maintainable on a low nutrient density
218 starchy diet that includes suboptimal protein and micronutrient consumption.

219 Structural factors including low income, illiteracy, and behavioral factors such as
220 alcohol use, were associated with food insufficiency and low dietary diversity. Our
221 findings highlight three important aspects useful in designing interventions to prevent
222 food insufficiency in vulnerable populations.

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

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2 230 potatoes or cassava root, common in Rwanda, that provide a sufficient yet minimally
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4 231 diverse diet. Additionally, if that single food group is cassava, it provides a much
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6 232 lower protein and micronutrient source than potato, yams or rice.
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9 233 Second, women who had incomes of <\$17 per month (equal to 10,000 RWF per
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11 234 month) or were unemployed were more likely to be food insecure when compared
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13 235 with women whose incomes were >\$60 monthly (equal to 35,000 RWF per month).
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15 236 The World Bank defines extreme poverty as <\$1.25/ day (~\$37/month) and moderate
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17 237 poverty at <\$2/day (~\$60/month): significant differences exist in health outcomes for
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19 238 these two groups[18] . This highlights a potentially important target for both ministries
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21 239 of health and international aid organizations and is consistent with the Millennium
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23 240 Development Goals to eradicate poverty[19] . HIV-infected women whose income is
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25 241 less than \$1.25/day may benefit from income supplementation programs to help
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27 242 prevent food insufficiency[20]. Alternatively, poverty reduction strategies, or job skills
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29 243 training programs, may be beneficial public health interventions for these women [21-
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31 244 23].
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37 245 Luxury items, such as alcohol, can be used as a marker for disposable income
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39 246 [24]. In our analysis, alcohol use was associated with higher rates of food
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41 247 insufficiency suggesting it reflected diversion of disposable income from food to
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43 248 alcohol. Data on alcohol misuse in Rwandan women are limited, with an estimated
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45 249 national pure alcohol use of 4.3 L per capita [25]; alcohol use may represent a
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47 250 valuable screening tool for food insufficiency in HIV+ women. Alcohol also serves as
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49 251 a predictor of inconsistent condom use in African women, further support that it
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51 252 represents an important point of intervention[14].
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2 253 Lastly, we found that illiteracy was independently associated with greater food
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4 254 insufficiency and low dietary diversity. This may be because low literacy is an
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6 255 important aspect of “income generating capacity,” which is critical to ability to obtain
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9 256 relevant dietary diversity and food security. Gender differences in educational and
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11 257 literacy attainment in Rwanda may lead to men procuring non-farm jobs with
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14 258 increased income potential which may increase the numbers of women left to
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16 259 manage the family agricultural plots[26]. Further studies need to be done to
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18 260 determine if literacy programs would benefit the level of food security and health
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21 261 status of HIV+ women. Improving land reform laws in Rwanda that strengthen
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23 262 women’s positions to own and farm their own land, and empower them with
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25 263 alternative farming techniques, may increase their food security in both urban and
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28 264 rural areas[27-29].

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30 265 Limitations of our study include its cross-sectional nature, which does not allow us
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32 266 to infer causality. Our measurement of food insufficiency is solely by self report. The
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34 267 question, “Do you have enough food?” does not address the quantity or quality of
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36 268 food, or the anxiety surrounding food procurement, although this question has been
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38 269 used in other food insufficiency analyses in Sub-Saharan Africa [14]. There was no
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40 270 explicit statement that this question would not alter a participant’s eligibility for food
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42 271 aid, which may have introduced bias. More complete information may be obtained
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44 272 with a different measurement tool [15, 17].

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49 273 Our findings suggest that extreme poverty, unemployment, illiteracy and alcohol
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51 274 use are associated with food insufficiency among HIV-infected women in Rwanda. .
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53 275 Addressing these structural factors through income generating activities, literacy
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55 276 programs, or perhaps most importantly, renewed health through improved access to
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2 277 ART, may help reduce the highly prevalent problem of food insufficiency in the Sub-
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4 278 Saharan region.

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8
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14
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37 292 Mutimura, M Cohen, K Anastos declare no conflicts of interest.
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Table 1. Demographic, Clinical and Dietary Characteristics of HIV-infected Women

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

¹ Reporting "Usually not" or "Never" to "Do you have enough food?"² Reporting "Sometimes" or "Always" to "Do you have enough food?"

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

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

P-value: a=0.01-0.05, b=0.001-0.01, c=<0.001

*N=504-513, # N=487-497

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

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

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

*Give information separately for exposed and unexposed groups.

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



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

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2 **Structural Determinants of Food Insufficiency, Low Dietary Diversity and BMI: a**
3 **Cross Sectional Study of HIV-infected and HIV negative Rwandan Women**
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3 1 Article Summary:
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6 2 1) Article Focus

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8 3 a. What structural determinants are associated with food insufficiency, low
9 dietary diversity and low **Body Mass Index (BMI) in HIV negative and**
10 **HIV-infected women** in Rwanda?
11 5
12 6 b. What is the prevalence of food insufficiency, low dietary diversity and
13 low BMI in **HIV negative and HIV-infected women** in Rwanda and are
14 these outcomes correlated with each other?
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16 8
17 9 c. Hypotheses
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19 i. #1: Poverty, **low literacy status** and alcohol use **are** associated
20 with food insufficiency, low dietary diversity and low BMI.
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22 ii. #2: Food insufficiency, low dietary diversity and low BMI **are**
23 highly prevalent and **are** correlated with one another.
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27 14 2) Key messages

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29 15 a. Food insufficiency and **low dietary diversity are highly prevalent (46%**
30 **and 43%, respectively)** and are associated with low income and
31 illiteracy and strongly associated with alcohol use.
32 17
33 18 b. BMI (body mass index, kg/m²) is not correlated with food insufficiency
34 or dietary diversity.
35 19
36 20 c. Significance: **Food Insufficiency and low dietary diversity, known**
37 **contributors to poor health, are highly prevalent in HIV negative and**
38 **HIV-infected women in Rwanda. Low BMI may not be an adequate**
39 **screening tool for food insufficiency.** Extreme poverty, low literacy and
40 alcohol use may contribute to food insufficiency and low dietary
41 diversity. **These structural factors may be useful targets to prevent the**
42 **adverse health effects of food insufficiency and low dietary diversity.**
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50 27 3) Strengths and limitations

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52 28 a. Strengths: Large cohort of **HIV negative and HIV-infected women**, very
53 detailed tools used for food insufficiency and dietary diversity
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55 30 b. Limitations: Cross sectional design, our measurement of food
56 insufficiency is solely by self report.
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1
2 32 Abstract

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4 33 Objectives: In Sub-Saharan Africa, the overlapping epidemics of undernutrition and
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6 34 HIV infection affect over 200 and 23 million people, respectively, and little is known
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8 35 about the combined prevalence and nutritional effects. We sought to determine
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10 36 which structural factors are associated with food insufficiency, low dietary diversity
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12 37 and low BMI in HIV negative and HIV-infected Sub-Saharan women.

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16 38 Study Design: cross-sectional analysis of a longitudinal cohort

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19 39 Setting: community-based women's organizations

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21 40 Participants: 161 HIV negative and 514 HIV-infected Rwandan women

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23 41 Primary and secondary outcome measures: Primary outcomes included food
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25 42 insufficiency (reporting "usually not" or "never" to "Do you have enough food?"), low
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27 43 household dietary diversity (Household Dietary Diversity Score ≤ 3) and BMI < 18.5
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29 44 (kg/m^2). We also measured structural and behavioral factors including: income,
30
31 45 household size, literacy, and alcohol use.

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35 46 Results: Food insufficiency was prevalent (46%) as was low dietary diversity (43%)
36
37 47 and low BMI (15%). Food insufficiency and dietary diversity were associated with low
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39 48 income [(aOR)=2.14 (95% CI 1.30, 3.52) $p < 0.01$], [aOR]=6.51 (CI 3.66, 11.57)
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41 49 $p < 0.001$], and illiteracy [aOR=2.00 (CI 1.31, 3.04) $p < 0.01$], [aOR]=2.10 (CI 1.37,
42
43 50 3.23) $p < 0.001$] and were not associated with HIV infection. Alcohol use was
44
45 51 strongly associated with food insufficiency [aOR=3.23 (CI 1.99, 5.24) $p < 0.001$].
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47 52 Low BMI was inversely associated with HIV infection [aOR ≈ 0.5] and was not
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49 53 correlated with food insufficiency or dietary diversity.

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54 54 Conclusions: Rwandan women experienced high rates of food insufficiency and low
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56 55 dietary diversity. Extreme poverty, illiteracy and alcohol use, not HIV infection alone,
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2 56 may contribute to food insufficiency in Rwandan women. Food insufficiency, dietary
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4 57 diversity and low do not correlate with one another; therefore, low BMI may not be an
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7 58 adequate screening tool for food insufficiency. Further studies are needed to
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9 59 understand the health effects of not having enough food, low food diversity and low
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11 60 weight in both HIV negative and HIV infected women.
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68 INTRODUCTION

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

84 Food insufficiency (lack of adequate food to meet daily needs) is one aspect of
85 food insecurity, a complex phenomenon describing lack of access to sufficient
86 quantity and adequate quality of food, and anxiety in procuring food [2]. Over half of
87 all households in Rwanda are thought to be food insecure, many of which are
88 headed by women [10]. Rwanda has a significant number of female headed
89 households (31%), partly due to the high numbers of genocide-related widows, and
90 62% of female headed households live in poverty, compared to 54% of male-headed
91 households [11]. Especially in vulnerable populations, such as HIV-infected women,

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2 92 gender disparities may prevent women from having control of family resources and
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4 93 the discretionary income necessary for buying food [12].
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6 94 In HIV-infected women, food insufficiency may result in low body mass index
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8 95 (BMI), which adversely affects health outcomes [13]. In addition, consuming fewer
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10 96 nutritionally distinct food groups (low dietary diversity), which contributes to poor
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12 97 health outcomes in African women and children [7], may reinforce malnutrition and
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14 98 eventually result in poor health [14]. Many African diets consist of a single dominant
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16 99 carbohydrate group, such as cassava, potato or yam which provides calories that
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18 100 may maintain body weight, but often does not provide the micro and macronutrients
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20 101 needed for proper immune function [15].
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25 102 In HIV-infected individuals, food insecurity has been associated with low CD4
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27 103 counts, virologic failure and increased mortality [6,8] . Low BMI ($<18.5 \text{ kg/m}^2$) is a
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29 104 strong predictor for mortality in HIV+ patients starting ART, with higher mortality in
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31 105 persons who are both food insecure and underweight versus underweight but food
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33 106 secure [8] . Although poverty is associated with poor health outcomes, income alone
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35 107 does not always reflect the status of someone's "wealth." In populations with very
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37 108 low incomes, markers for disposable or discretionary income, defined as income after
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39 109 all essential items are paid for, may be more useful to define an individual's
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41 110 socioeconomic status. These may include access to electricity and ability to buy non-
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43 111 essential items such as alcohol. For women with HIV, it is unclear which structural
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45 112 factors most influence food insecurity, and therefore have the greatest impact on
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47 113 health outcomes.
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52 114 In order to understand structural determinants of food insufficiency and
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54 115 elucidate potential interventions to prevent food insufficiency and malnutrition in HIV
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2 116 [negative and HIV-infected women](#), we examined the prevalence and socio-
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4 117 demographic associations of [food insufficiency, household dietary diversity and low](#)
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6 118 [BMI](#) in such women in Rwanda. [We were specifically interested in the relationship](#)
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8 119 [between poverty, low literacy, and alcohol use on food insufficiency, dietary diversity](#)
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10 120 [and low BMI. We further examined the relationship between food insufficiency, low](#)
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12 121 [BMI and low dietary diversity and whether these three outcomes were correlated with](#)
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14 122 [one another in these women.](#)
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21 124 **METHODS**

22
23 125 Population and Setting: The Rwanda Women's Interassociation Study and
24
25 126 Assessment (RWISA) (described in detail elsewhere [16]) is a prospective
26
27 127 observational cohort designed to assess the effectiveness and toxicity of antiretroviral
28
29 128 therapy (ART) in HIV-infected Rwandan women. In 2005, 710 HIV-infected and 226
30
31 129 HIV-uninfected Rwandan women were recruited through community-based women's
32
33 130 organizations and [HIV clinical care sites](#). Eligible women were 25 years or older at
34
35 131 study entry, willing to give informed consent and [were present in Rwanda during the](#)
36
37 132 [genocide](#). HIV-infected women were excluded if they had prior history of receiving
38
39 133 antiretroviral treatment, [except single dose nevirapine to prevent mother to infant](#)
40
41 134 [transmission of HIV](#). Women were compensated 2500 Rwandan francs for each
42
43 135 visit. The Rwandan National Ethics Committee and the Institutional Review Board at
44
45 136 Montefiore Medical Center approved this study.
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52 137 At each study visit participants provided historical information. Trained
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54 138 research assistants collected socio-demographic data at study entry including age,
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56 139 income, literacy level, [number of people in households](#), employment, access to
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1
2 140 electricity antiretroviral use (for HIV-infected women) and alcohol use. At each visit
3
4 141 participants had a physical examination and provided blood specimens for CD4
5
6 142 lymphocyte and complete blood counts. [This analysis included 161 HIV negative and](#)
7
8
9 143 [514 HIV-infected women](#) who completed socio-demographic and nutritional data at
10
11 144 the fifth semi-annual visit, between July and December 2007.

13
14 Measures:

15
16 146 *Primary Outcomes:* Food insufficiency was assessed using a single question, “Do
17
18 147 you have enough food?” with the women answering “usually not” or “never” classified
19
20
21 148 as food insecure [17,18]. Household dietary diversity was assessed using a modified
22
23 149 Household Dietary Diversity Score (HDDS), a validated tool measuring household
24
25 150 food consumption over the previous 24 hours, [giving one point each for having eaten](#)
26
27
28 151 [an item in the following food class \(total 6 points possible: Class-1\) cereals and roots;](#)
29
30 152 [Class-2\) vegetables; Class-3\) fruits; Class-4\) meat protein \[including meat, eggs,](#)
31
32 153 [fish\]; Class-5\) vegetable protein \[including legumes, beans, nuts\]; Class-6\) extras](#)
33
34 154 [\[including oil, fat, sugar, condiments\]\].](#) Determination of “Low household dietary
35
36 155 diversity” is described in detail elsewhere, [19] briefly, the sample was divided into
37
38 156 income terciles with the mean HDDS for the lowest income tercile (≤ 3) representing
39
40 157 low dietary diversity [15,19,20]. [Body mass index \(BMI\) was calculated using weight](#)
41
42 158 [divided by height-squared \(kg/m²\).](#) [Standing height and weight were measured](#)
43
44 159 [while the participant was wearing light clothing and no shoes. BMI was dichotomized](#)
45
46 160 [to \$\leq 18.5\$ or \$>18.5\$ for the analysis.](#)

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51 161 Independent variables: Income categories were defined as 1) >35,000 Rwandan
52
53 162 Francs (\$US 58), 2) 35,000-10,000, and 3) <10,000 RWF (\$US 17), per month.

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56 163 [Alcohol use was queried as “Since the last visit, have you had a drink containing](#)
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1
2 164 alcohol?" and was dichotomized to yes vs. no. Literacy was defined as "can read all,
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4 165 most, some or none," and for the analysis was dichotomized to none vs. some, most
5
6 166 or all. For HIV-infected women antiretroviral use at the current visit was assessed by
7
8
9 167 self-report with verification of date of initiation and regimen by tracking cards provided
10
11 168 to the participants by providers in the national treatment program. CD4 counts were
12
13
14 169 determined with a FACS counter (Becton and Dickinson, Immunocytometry Systems,
15
16 170 San Jose, CA, USA).

17 171 Data Analysis:

18
19 172 Categorical variables were compared using contingency tables with P-values from
20
21 173 exact tests. Univariate logistic regression identified factors associated with food
22
23 174 insecurity, low dietary diversity, and BMI. Multivariate logistic regression models were
24
25 175 built using backward selection with a p-value of 0.05 to stay in the model. Wilcoxon
26
27 176 rank sum and Kappa statistics assessed relationships between food insecurity, BMI
28
29 177 and dietary diversity as continuous variables and as dichotomous variables (food
30
31 178 insecurity= answering "usually not" or "never" to "Do you have enough food",
32
33 179 HDDS \leq 3, BMI \leq 18.5), respectively. Statistical analysis was performed using SAS
34
35 180 (version 9.1.3, SAS Institute Inc, Cary, NC USA).
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45 182 **RESULTS**

46
47 183 Overall food insufficiency (top row of Table 1) was highly prevalent with 46%
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49 184 of women reporting "usually not" or "never" to "Do you have enough food?" and
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51 185 another 45% reporting they "sometimes" did not have enough food (data not shown).
52
53 186 Almost half the population reported low dietary diversity (HDDS <3) and 15% of
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55 187 women met WHO criteria for malnutrition with a BMI <18.5 kg/m². The percentage of
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2 188 women reporting food insufficiency and low dietary diversity did not differ between
3
4 189 HIV negative and HIV-infected women. The percentage of women with BMI <18.5
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6 190 was higher in HIV negative women as compared to HIV infected women with
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9 191 CD4>350, 200-350, <200 (24%, vs. 11.8%, 12.4%, 14.9%, p=0.004), respectively.
10
11 192 Table 1 further breaks the food insecurity outcomes down by participant
12
13
14 193 characteristics. As the numbers in column 2 of Table 1, show, the prevalence of
15
16 194 poverty was high; 36% reported a monthly income of less than <10K Rwandan
17
18 195 Francs (FRW) (\$US 17). Illiteracy was present in one quarter of the population and
19
20
21 196 another 40% reported only reading “some”. Alcohol use was rare with 13% reporting
22
23 197 they had at least one drink in the last month. Of the HIV-infected women, almost one
24
25 198 third had CD4 counts over 350 and almost 70% of participants took antiretroviral
26
27 199 therapy at this visit.

30 200 Structural factors associated with food insufficiency included (Table 1): low
31
32 201 income, with 52.5% of those with monthly income <10,000 FRW, 43.6% of those with
33
34 202 monthly income 10,000 – 35,000 FRW and 31.8% of those with > 35,000 FRW
35
36 203 reporting food insufficiency, p=0.001; illiteracy with 57.1% of those who can't read,
37
38 204 44.5% of those with some literacy and 34.6% of those fully literate reporting food
39
40 205 insufficiency, p=0.0002; and alcohol use with 68.9% of users vs. 41.2% of nonusers
41
42 206 reporting food insufficiency, p<0.0001.

46 207 Structural factors associated with low dietary diversity (HDDS<3) were again;
47
48 208 low income with 58.9% of those with monthly income <10,000 FRW, 39.3% with
49
50 209 income 10,000–35,000 FRW and 16.2% of those with income >35,000 FRW having
51
52 210 low dietary diversity p<0.0001; illiteracy with 55.2%, 44.4% and 31.6% of those with
53
54 211 none, some and complete literacy having low dietary diversity, p<0.0001.
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2 212 Only HIV status had statistically significant associations with BMI. Surprisingly
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4 213 the association was in the opposite direction expected with 24.2% of HIV negatives
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6 214 compared to 11.8 – 14.9% of HIV positive women of all CD4 levels having BMI
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9 215 <18.5, p=0.004.

10
11 216 The univariate logistic regression models of Table 2 find the same unadjusted
12
13 217 associations of structural factors with outcomes just described for Table 1, here we
14
15 218 discuss the multivariate models. In the final stepwise multivariate model (Table 2),
16
17 219 food insufficiency was independently associated with low income [Adjusted Odds
18
19 220 ratio (aOR) 2.14; 95% CI 1.30-3.52 for >35,000 FRW vs. <10,000 FRW], and
20
21 221 illiteracy (aOR=2.00; CI 1.31-3.04) (Table 2). Alcohol use (none vs. any use) was
22
23 222 strongly independently associated with being food insufficient (aOR=3.23; CI 1.99-
24
25 223 5.24). Factors independently associated with low dietary diversity (HDDS <3.0)
26
27 224 included low monthly income (aOR=6.51; CI 3.36-11.57 for income <10,000
28
29 225 vs. >35,000 FRW and aOR=3.07; CI 1.76-5.37 for income 10,000-35,000 FRW
30
31 226 vs. >35,000 FRW) and illiteracy (aOR=2.10, CI 1.37-3.23). As in Table 1, HIV status
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33 227 had the only independent association with HIV positive women of all CD4 levels
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35 228 being *less* likely to have low BMI.
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45 230 When analyzed as continuous variables, no significant correlations were found
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47 231 between self-reported food insufficiency and BMI (r=-0.05, p=0.29). A statistically
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49 232 significant but weak correlation was found between dietary diversity and BMI r=0.09,
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51 233 p=0.03 and food insufficiency and dietary diversity: r=0.14, p<0.001. When analyzed
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53 234 as dichotomous variables, no significant correlations were found between food
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2 235 insufficiency and BMI, Kappa (K) =0.02, dietary diversity and BMI, K=0.02 or food
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4 236 insufficiency and dietary diversity, K=0.12.
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8 9 238 **DISCUSSION**

10
11 239 While HIV uninfected and HIV-infected Rwandan women experienced high rates of
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13 240 food insufficiency (46%) and low dietary diversity (43%), only 15% of the women had
14
15 241 low BMI. HIV status did not confer differences except in BMI, where the opposite of
16
17 242 what was expected was seen, a *higher* proportion of HIV uninfected women had BMI
18
19 243 <18.5. Furthermore neither food insufficiency nor lack of dietary diversity was
20
21 244 associated with BMI, suggesting that low BMI in these women was not resulting from
22
23 245 food insufficiency alone. Structural factors including low income and illiteracy were
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25 246 associated with food insufficiency and behavioral factors, such as alcohol use, was
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27 247 associated with low dietary diversity. Our findings highlight three important aspects
28
29 248 useful in the relationship between food insufficiency, dietary diversity and BMI in
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31 249 vulnerable populations.
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37 250 First, few women had low BMI (15%), while almost half were either food
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39 251 insufficient or had low dietary diversity. A higher percentage of HIV uninfected
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41 252 women had BMI <18.5 as compared to HIV infected women. This is likely explained
42
43 253 by food supplementation programs provided by community organizations that are
44
45 254 available exclusively to the HIV-infected women. These programs provide additional
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47 255 supply of the staple foods, which may provide enough calories to prevent
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49 256 malnutrition, but do not add to dietary diversity or change the perception of not
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51 257 having enough food. Additionally, BMI was not correlated with self-reported food
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53 258 insufficiency or dietary diversity. BMI is often measured in clinical settings and used
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1
2 259 to monitor people's nutritional status. Because of the known health effects of food
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4 260 insufficiency and low dietary diversity, separate from BMI [6,7,14], and the lack of
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6 261 correlation between the three outcomes, our results support that BMI should not be
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8 262 considered as a sole marker for food insufficiency in HIV uninfected or HIV-infected
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10 263 women. The weak association between self-reported food insufficiency and dietary
11
12 264 diversity may reflect an inexpensive, abundant single food group, such as potatoes or
13
14 265 cassava root, common in Rwanda, that provide a sufficient yet minimally diverse diet.
15
16 266 Body weight may be maintainable on a low nutrient density starchy diet that includes
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18 267 suboptimal protein and micronutrient consumption. Additionally, if that single food
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20 268 group is cassava, it provides a much lower protein and micronutrient source than
21
22 269 potato, yams or rice.

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28 270 Second, women who had incomes of <\$17 per month (equal to 10,000 RWF per
29
30 271 month) were more likely to be food insecure when compared with women whose
31
32 272 incomes were >\$60 monthly (equal to 35,000 RWF per month). The World Bank
33
34 273 defines extreme poverty as <\$1.25/ day (~\$37/month) and moderate poverty at
35
36 274 <\$2/day (~\$60/month): significant differences exist in health outcomes for these two
37
38 275 groups [21] . This highlights a potentially important target for both ministries of health
39
40 276 and international aid organizations and is consistent with the Millennium
41
42 277 Development Goals to eradicate poverty [22] . HIV negative and HIV-infected women
43
44 278 whose income is less than \$1.25/day may benefit from income supplementation
45
46 279 programs to help prevent food insufficiency and therefore the adverse health effects
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48 280 of food insufficiency and low dietary diversity [23]. Alternatively, poverty reduction
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50 281 strategies, or job skills training programs, may be beneficial public health
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52 282 interventions for these women [24-26].
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2 283 Alcohol use has known adverse health effects and is a known risk factor for HIV
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4 284 transmission [17]. Less is known about the relationship with alcohol use and food
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6 285 insufficiency. Alcohol can be used as a marker for disposable income, similar to
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8
9 286 other luxury items [27]. In our analysis, alcohol use was rare with only 13% of the
10
11 287 women stating they had at least one drink in the last month. This reflects that casual
12
13 288 alcohol drinking is not the social norm this population of Rwandan women, as
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15
16 289 compared to other nearby countries, such as Uganda, where drinking is considered a
17
18 290 socially acceptable activity. The Ugandan Health and Demographic survey found up
19
20
21 291 to one quarter of women reporting drinking in the last month and 18% stated they
22
23 292 drank alcohol daily [28,29]. Alcohol use was associated with higher rates of food
24
25 293 insufficiency, even when controlled for by income, suggesting it reflected diversion of
26
27
28 294 disposable income from food to alcohol, not just a reflection that more money is
29
30 295 available for alcohol purchase. Data on alcohol misuse in Rwandan women are
31
32
33 296 limited, with an estimated national pure alcohol use of 4.3 L per capita [30]. Our data
34
35 297 further supports the use of alcohol as an important point of intervention to help
36
37 298 prevent the adverse health effects of food insufficiency and low dietary diversity.

39
40 299 Lastly, we found that illiteracy was independently associated with greater food
41
42 300 insufficiency and low dietary diversity. This may be because low literacy is an
43
44 301 important aspect of “income generating capacity,” which is critical to ability to obtain
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46
47 302 relevant dietary diversity and food security. Gender differences in educational and
48
49 303 literacy attainment in Rwanda may lead to men procuring non-farm jobs with
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51 304 increased income potential which may increase the numbers of women left to
52
53 305 manage the family agricultural plots [31]. Further studies need to be done to
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56 306 determine if literacy programs would benefit the level of food security and health
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1
2 307 status of both [HIV negative and HIV-infected women](#). Improving land reform laws in
3
4 308 Rwanda that strengthen women's positions to own and farm their own land, and
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6 309 empower them with alternative farming techniques, may increase their food security
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9 310 in both urban and rural areas, [and therefore improve their health](#) [32-34].
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11 Limitations of our study include its cross-sectional nature, which does not allow us
12
13
14 312 to infer causality. Our measurement of food insufficiency is solely by self report. The
15
16 313 question, "Do you have enough food?" does not address the quantity or quality of
17
18 314 food, or the anxiety surrounding food procurement, although this question has been
19
20
21 315 used in other food insufficiency analyses in Sub-Saharan Africa [17]. [There was no](#)
22
23 316 [explicit statement that this question would not alter a participant's subsequent](#)
24
25 317 [eligibility for food aid, which may have introduced response bias. More complete](#)
26
27
28 318 [information may be obtained with a different measurement tool which would address](#)
29
30 319 [food insecurity \(insufficiency quantity, quality or anxiety in procuring food\), in addition](#)
31
32 320 [to food insufficiency \(not enough food\) \[18, 20\]. A longitudinal study design would be](#)
33
34
35 321 [helpful to determine the specific health effects of food insecurity on women over time.](#)
36

37
38 322 Our findings suggest that extreme poverty, illiteracy and alcohol use are
39
40 323 associated with food insufficiency among [HIV-infected and HIV negative](#) women in
41
42 324 Rwanda. [Addressing these structural factors through income generating activities,](#)
43
44 325 [literacy programs, substance abuse treatment,](#) or perhaps most importantly, renewed
45
46 326 health through improved access to ART for HIV-infected women, may help reduce
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49 327 the highly prevalent problem of food insufficiency in the Sub-Saharan region.
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54 329 Acknowledgments:
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3
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5
6 332 responsibility for the final content. All authors read and approved the final
7
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11 334
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16 336
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19
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23 339
24
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26
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Table 1. Demographic, Clinical and Dietary Characteristics of HIV negative and HIV infected women.

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

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

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

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

1. "Usually not" or "Never" to Do you have enough food?, N=302, 2. Household Dietary Diversity Score, N=186, 3. Body Mass Index (kg/m²), N=101, 4. Was not considered for multivariate models as it was only defined for HIV positive women and was never statistically significant in unadjusted models

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

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

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

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

*Give information separately for exposed and unexposed groups.

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