The correlates of dietary intake among HIV-positive adults[1–3]

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ABSTRACT

Background: Dietary adequacy, as distinct from weight loss, has not been examined thoroughly in a diverse cohort of HIV-infected individuals.

Objective: An analysis was undertaken to determine the correlates of inadequate dietary intake among HIV-infected adults.

Design: In a cross-sectional study of 463 men and 170 women (aged 21–70 y) with HIV infection, dietary adequacy was evaluated by using 3-d diet records.

Results: Among nondieting males, whites had higher energy intakes than did nonwhites. Injection drug users consumed less energy than did nonusers. Among nondieting females, only the absence of nausea and vomiting was marginally associated with higher energy intakes. Inadequate energy intake, which occurred in 38% of this population, was independently associated with female sex among nondieters. A significant proportion of the study cohort (52%) was consuming less than the recommended dietary allowance of vitamin A. Inadequate protein intake, found in 11% of the study population, occurred more often in females, those without a caregiving adult in the household, and individuals with reduced appetite. A considerable proportion of the participants (23%) reported that they were dieting to lose weight.

Conclusions: Dietary inadequacy was strongly correlated with being in the sociodemographic groups that are at heightened risk of adverse clinical outcomes. It may be worthwhile to study dietary intake as a potential determinant of the clinical outcomes of HIV infection. *Am J Clin Nutr* 2001;74:852–61.

KEY WORDS Diet, sociodemographics, AIDS, HIV, human immunodeficiency virus, wasting, nutrition, socioeconomics

INTRODUCTION

Since the AIDS epidemic began, the prevalence of HIV infection and AIDS has increased steadily in all demographic groups, yet the epidemiologic data indicate that minorities and lower-income populations are disproportionately affected by HIV disease (1–5). Lower-income populations have had higher rates of opportunistic infections and admissions to intensive care units and decreased survival times (6, 7). HIV wasting syndrome was found to occur more frequently in nonwhites and injection drug users than in whites and nonusers (8). Although unequal access to health care was considered the primary cause of the poorer prognosis of HIV disease in these populations, other causes related to sociodemographic attributes may be responsible for differential clinical outcomes (9). The social and biological mechanisms underlying the unfavorable epidemiologic profile in these communities have not been studied extensively.

Nutritional intake is an often-overlooked factor in the progression of HIV disease, although the relation between nutrition and immune function is well established. Even in populations not infected with HIV, poor nutritional status is known to impair immune response (10, 11). In HIV-infected individuals, poor nutritional status is a strong predictor of survival, even after controlling for CD4$^+$ cell counts (12, 13): a weight loss of >66% of ideal body weight was linked to the timing of death in AIDS patients (14). It was noted that HIV wasting syndrome was associated with decreased serum concentrations of vitamin A, folate, and carotene (11). Nutritional supplementation was shown to improve some of the immunologic symptoms associated with HIV disease (15, 16) and to increase immune function in healthy populations (17, 18). Given the evidence that malnutrition is a determinant of the development of AIDS and other adverse health outcomes (19), it is worthwhile to examine dietary adequacy in HIV-infected adults.

One objective of this study was to determine the correlates of reduced and inadequate nutrient intakes in a large, clinically and socioeconomically diverse cohort of HIV-infected adults. Previous nutritional studies focused on patients in the late stages of AIDS (14, 20, 21) or gay men who were socioeconomically advantaged relative to other HIV-infected groups (19, 22). Because a large number of individuals in this study cohort were in the early stages of their disease, we were able to examine the relations between diet and sociodemographic factors at a stage when eating habits are less affected by HIV-related symptoms.

We sought to determine the extent to which dietary inadequacy is correlated with clinical symptoms, economic inability to procure food, and lack of health awareness. We were also interested in exploring the effects of support for food acquisition

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and preparation as correlates of nutritional adequacy in HIV-infected adults. The findings may help health care providers develop nutritional guidelines and intervention strategies for patients at high risk of developing AIDS.

SUBJECTS AND METHODS

Subjects and study design

Nutrition for Healthy Living (NFHL) is a longitudinal study of wasting in HIV disease. From its inception in February 1995, this study has enrolled 679 HIV-positive participants from the greater Boston and Providence, RI, areas. To improve the generalizability of the study results to the HIV-infected population of the United States, the project sought to enroll large numbers of women, injection drug users, and people of lower socioeconomic status (SES) through recruitment practices and retention strategies that were sensitive to the needs of these individuals.

The study excluded potential participants at screening if they reported diabetes mellitus, current pregnancy, thyroid disease, active malignancy not related to HIV, an intent to move out of the area within 3 y, age < 18 y, or inability to be reached by telephone. Potential participants were also excluded if the staff determined that their English language proficiency was insufficient.

Data in this report were obtained from 2 baseline clinic visits per participant. These visits consisted of a physical examination, anthropometric measurements, and administration of several questionnaires on clinical status, physical activity, alternative health treatments, and quality of life. The details of the study design are outlined elsewhere (23, 24).

Measurement of dietary intake

At the first baseline visit, each participant was given a 3-d diet record that was to be returned at the second baseline visit. Three days of diet records were requested to obtain intake data for multiple days while minimizing the noncompliance associated with asking participants to keep diet records for longer periods of time. The study staff carefully instructed each participant on how to keep accurate diet records. The NFHL dietitian checked these diet records when they were collected at the second visit. Specially trained personnel entered the data from the diet records into the database. Nutrient calculations were performed by using the NUTRIENT DATA SYSTEM FOR RESEARCH software (version 4.0) developed by the Nutrition Coordinating Center, University of Minnesota, Minneapolis (Food and Nutrient Database 28) (25). If an analytic value was not available for a nutrient in a certain food, the value was calculated on the basis of the nutrient contents of the ingredients in the same food or the nutrient contents of similar foods (25).

We measured dietary intakes as absolute intakes (in kJ, g, or μg) and also as percentages of the US recommended dietary allowances (RDAs) (26). The RDAs published in 1989 rather than the updated RDAs were used to allow comparisons with the nutritional adequacy of other groups studied during the same time period. We included supplement use in all nutrient calculations because total nutrient intake was the variable of interest. We also determined the adequacy of energy intake by comparing each participant's energy intake with the energy needed to sustain minimal physical activity. Each participant's resting energy expenditure (REE) was measured with indirect calorimetry; we determined the participant's oxygen consumption and carbon dioxide production (27) for a duration of 20 min after ≥5 h of fasting. The indirect calorimetry module of the Sensormedic Vmax series spirometer (model 2130; Sensormedic Corp, Yorba Linda, CA) was used. REE was calculated by using the abbreviated Weir equation below (28):

$$\text{REE (kcal/24 h)} = 3.94 \times \dot{V}O_2 + 1.106\ \dot{V}CO_2 \text{ at standard temperature and pressure} \quad (1)$$

where $\dot{V}O_2$ (oxygen uptake) and $\dot{V}CO_2$ (carbon dioxide production) were measured in mL/min and REE was subsequently converted to kJ and MJ for statistical analysis.

We multiplied each participant's REE by an activity factor of 1.3 to represent a minimal (not bedridden) amount of physical activity (26). We chose this activity factor, which represents 10 h/d of rest and 14 h/d of very light activity (such as playing cards or watching television), to obtain conservative estimates of energy requirements, disregarding higher amounts of physical activity. This method of determining total energy expenditure was used instead of the conventional Harris-Benedict equation because the latter is derived from and thereby applicable to healthy persons with metabolisms that are not altered by underlying diseases such as HIV infection (29, 30).

Statistical analyses

To determine the independent correlates of absolute protein and energy intakes, we conducted multivariate linear regression analyses including all variables that were associated with a $P < 0.20$ in the unadjusted analyses (31). We examined the following variables in unadjusted analyses: age, $CD4^+$ cell count, nonwhite race, gay male lifestyle, history of injection drug use (compared with never using injection drugs), AIDS diagnosis, presence of nausea or vomiting, presence of a caregiving adult, presence of dependent children in the household, presence of diarrhea, presence of decreased appetite, educational attainment (an ordinal variable), household income (an ordinal variable), use of protease inhibitors or antiretroviral drugs, and dieting status (currently trying to lose weight or not). Individuals who were dieting to lose weight were excluded from the multivariate analyses.

We controlled for body size by including height instead of weight in the regression model of energy intake. This was done because many of the participants suffered from HIV wasting syndrome, which itself could lead to changes in energy intake. Preliminary analyses indicated that height was strongly and significantly correlated with energy intake, even though weight and body mass index (BMI; in kg/m^2) were not. We included alcohol consumption in all analyses of energy intake. The preliminary analysis of alcohol intake indicated that the median percentage of energy from alcohol was <1% for this cohort with an interquartile range of 0–0.3%. Alcohol contributed >15% of energy intake in only 2.5% of the participants. Moreover, alcohol intake was not significantly associated with the adequacy of energy intake; hence, we did not adjust for alcohol consumption in our analyses.

We present the results of the multivariate regression analyses along with the mean unadjusted intakes for each subgroup considered. We adjusted for energy intake in all regression analyses of protein intake to address the composition of the participants' diets, independent of absolute intake. We conducted influence diagnostics of the final results to ensure that the results were not unduly influenced by a few outlying measurements (32). The final regression coefficients were obtained after eliminating participants whose dfβ coefficients (33) for the covariates lay beyond 3 interquartile ranges from the median. Removal of influential points yielded more conservative models with fewer parameters that were statistically significant.

Correlates of dietary inadequacy (ie, intakes less than the RDA) were identified with preliminary unadjusted analyses by using linear models with a log link function and binomial distribution for the prevalence response variable (34). All variables that showed a *P* value <0.20 in the unadjusted analyses for energy, protein, vitamin A, and zinc intakes were included in a multivariate model (full model) (35). Any parameters with *P* values <0.20 were remodeled in a reduced model. In this article, we report the prevalence ratios and 95% CIs for each of the independent correlates of dietary inadequacy on the basis of binomial regression models with the log link function (35). All statistical analyses were conducted with SAS software, version 6.12 (36). $P < 0.05$ was considered statistically significant.

RESULTS

The characteristics of the NFHL Study population at baseline are shown in **Table 1**. The cohort included relatively large numbers of nonwhites (37.9%), females (26.9%), and persons who had not been diagnosed with AIDS (44%). There were several statistically significant differences between the male and female participants. Men tended to be slightly older and had a higher household income and higher educational attainment than did women. The largest racial category was white (70%) for men but was African American (42.9%) for women. Female participants were more likely to be living with children in their household (46.8% compared with 9.3% of men). Men tended to have more advanced disease, as shown by their lower mean $CD4^+$ cell counts and larger proportions of individuals with AIDS, diarrhea, and HIV wasting syndrome.

The baseline characteristics of the participants indicated that obesity is not uncommon among HIV-positive individuals. A greater percentage of women (20.6%) than of men (6.7%) met the clinical definition of obesity (BMI ≥30) (37). Fifty percent of the women were overweight (BMI >25). In the general population of women, the prevalence of overweight is also 50% (38). In contrast, there was a smaller percentage of overweight men in the NFHL Study than in the general population (41% and 59%, respectively) (38). Dieting status was self-reported on a questionnaire that asked whether the participant had actively attempted to reduce his or her weight during the past 6 mo. A considerable proportion of the participants (20.9% of men and 27.8% of women) reported that they were currently dieting to lose weight.

Certain clinical symptoms of HIV disease may interfere with adequate food consumption. Of these symptoms, reduced appetite and nausea and vomiting were relatively prevalent in this cohort, whereas diarrhea was reported by only 7.1% of the participants at baseline. Approximately 1 of 7 participants had been diagnosed with HIV wasting syndrome. A questionnaire item asked whether the participant had been clinically diagnosed with wasting related to HIV infection. When classifying participants as having or not having HIV wasting syndrome, we also considered self-reported weight changes in the 3 y before study enrollment. An involuntary weight loss of >10% of initial body weight or a sustained loss of >5% of body weight within the previous 6 mo was used as the definition of HIV wasting syndrome. About 25% of the participants reported a lack of assistance with food shopping and a similar proportion reported lack of assistance with food preparation. Almost 72% of the participants were using either a protease inhibitor or an antiretroviral drug at enrollment.

The variables that were correlated with energy and protein intakes at a significance of $P < 0.20$ in the unadjusted analysis are shown in **Table 2**. For each of these variables, the mean energy and protein intakes are shown. Because dieting was strongly associated with energy and protein intakes in the preliminary analyses, we eliminated all dieters from the multivariate analyses to uncover other relations. The *P* values shown for energy intake were obtained from models that adjusted for height to control for body size, and the *P* values for protein intake reflect adjustment for energy consumption to reduce the extraneous variation resulting from differences in energy intake. We also give the full multivariate adjusted results for all variables that had a $P < 0.20$ in the bivariate analyses.

Neither the $CD4^+$ cell count nor an AIDS diagnosis had a statistically significant association with macronutrient intakes, suggesting that food intake does not decrease with advanced HIV disease. Among male nondieters, only current injection drug use ($P < 0.05$) and white race ($P < 0.10$) were at least marginally associated with increased energy intake in the multivariate model. The energy-adjusted multivariate models of protein intake indicated that higher household income, not being a current injection drug user, having an adult caregiver present, presence of diarrhea symptoms, and absence of reduced appetite were at least marginally associated with higher protein intakes among the male nondieters. Among female nondieters, no variables were significantly correlated with energy intake and only a higher household income and the presence of diarrhea symptoms were marginally associated with increased protein intake in the final multivariate model.

Multivariate analyses of energy-adjusted fat and carbohydrate intakes indicated that sociodemographic parameters were the primary correlates of these macronutrient intakes. For males, history of injection drug use, low $CD4^+$ cell count, and the presence of children in the household were significantly associated with higher fat intakes. For females, the presence of children in the household was the only significant correlate of higher fat intake. For both men and women, the presence of children in the household was the only significant correlate of lower carbohydrate intake.

The correlates of inadequate intakes of energy, protein, niacin, folate, iron, zinc, and vitamins A, B-6, B-12, C, and E are shown in **Tables 3** and **4**. Intakes were considered inadequate if they were below the RDA. Energy intake was inadequate in 37.5% of the participants. Inadequate intakes of zinc, protein, and vitamin A were found in 41.6%, 11.0%, and 51.6% of participants, respectively.

Sociodemographic factors were strongly associated with adequacy of nutrient intakes. For every nutrient examined, a much higher percentage of women than of men had inadequate intakes. Educational status and annual household income showed strong trends in which higher income and education were associated with lower percentages of participants having inadequate intakes. Gay men were significantly more likely to meet the RDAs for nearly all nutrients studied than were participants who were not gay men. Injection drug users were significantly less likely to meet the RDAs for micronutrients and energy than were participants who had never used injection drugs. Participants living with a partner or other adult were more likely to meet the RDAs than were participants not living with an adult caregiver. Living with children in the home was associated with a greater likelihood of inadequate

TABLE 1
Characteristics of the Nutrition for Healthy Living (NFHL) Study population at enrollment[1]

	All subjects	Men	Women
Race (*n*)[2]	633	463	170
White (%)	62.1	70.0	41.2
African American (%)	25.9	19.7	42.9
Latino or Hispanic (%)	7.7	6.7	10.6
Other (%)	4.3	3.9	5.3
Education (*n*)[2]	633	463	170
Through grade 11 (%)	16.0	9.7	32.9
High school or GED (%)	25.4	22.7	32.9
Some college or technical school (%)	28.3	29.4	25.3
College degree or graduate school (%)	30.3	38.2	8.8
Annual household income ($) (*n*)[2]	611	449	162
<10000 (%)	45.7	37.6	67.9
10–20000 (%)	17.4	17.4	17.3
20–30000 (%)	10.3	12.0	5.6
30–40000 (%)	7.0	9.4	0.6
>40000 (%)	19.6	23.6	8.7
CDC risk category (*n*)[2]	619	452	167
Male-to-male sex only (%)	53.5	73.2	NA
Male-to-male sex + injection drug use (%)	3.0	4.2	NA
Injection drug use only (%)	21.7	14.4	41.3
Male-to-female sex (%)	19.1	6.0	54.5
All other risks (%)	2.7	2.2	4.2
Current illicit drug use (%)	25.3 [622][3]	27.2 [453]	20.0 [169]
AIDS diagnosis (%)[2]	56.4 [621]	61.0 [454]	44.0 [167]
Nausea or vomiting at baseline (%)	32.7 [586]	31.7 [427]	35.4 [159]
Diarrhea at baseline (%)[2]	7.1 [623]	8.2 [453]	4.3 [170]
Reduced appetite at baseline (%)	44.0 [589]	42.5 [429]	48.3 [160]
HIV-wasting syndrome at baseline (%)[2]	13.6 [624]	16.1 [454]	7.1 [170]
BMI (kg/m^2) (*n*)[2]	633	463	170
<20 (%)	7.8	6.9	10.0
≥20 but <25 (%)	48.7	52.0	40.0
≥25 but <30 (%)	33.1	34.4	29.4
≥30 (%)	10.4	6.7	20.6
Living with caregiving adult (%)	52.4 [630]	52.8 [460]	51.2 [170]
Living with dependent children (%)[2]	19.5 [622]	9.3 [453]	46.8 [169]
Absence of food shopping assistance (%)	25.3 [474]	22.7 [330]	31.2 [144]
Absence of food preparation assistance (%)[2]	27.1 [473]	26.4 [329]	28.5 [144]
Dieting to lose weight (%)[2]	23.0 [474]	20.9 [330]	27.8 [144]
Using protease inhibitors or antiretroviral drugs (%)	71.8 [613]	73.0 [448]	68.5 [165]
Year enrolled in the NFHL Study (*n*)	633	463	170
1995	17.4	19.7	11.2
1996	33.5	32.3	37.1
1997	34.5	34.6	34.1
1998	14.6	13.4	17.7
Age (y)[2]	39.0 ± 7.5 [633][4]	39 ± 7.6 [463]	37 ± 7.0 [170]
CD4$^+$ cell count (cells/mm^3)[2]	344 ± 251 [633]	323 ± 237 [463]	400 ± 279 [170]

[1] CDC, Centers for Disease Control and Prevention.
[2] Significant difference between men and women, $P < 0.05$.
[3] *n* in brackets.
[4] $\bar{x}$ ± SD.

intake for all the nutrients examined. Although assistance with food shopping and food preparation were both positively correlated with meeting nutrient requirements, a significant association was found in the unadjusted analysis only for iron intake.

Participants who were dieting to lose weight had consistently lower nutrient intakes than did nondieters. Of particular concern, dieting was significantly associated with a higher percentage of individuals not reaching the RDAs for vitamin A (64.2% compared with 47.7% of nondieters) and zinc (54.1% compared with 39.3% of nondieters).

We also compared the NFHL cohort to the general population of the northeastern United States regarding adequacy of nutrient intakes. For all the nutrients examined, a lower percentage of the NFHL cohort had inadequate intakes compared with the general population. This was found despite the fact that lower-SES participants were less successful at obtaining the RDAs for micronutrients than were higher-SES participants in the NFHL Study.

Of the clinical symptoms examined in this analysis (Table 4), only reduced appetite was consistently and significantly asso-

TABLE 2
Correlates of energy and protein intakes: means with bivariate *P* values and results of the multivariate regression models[1]

Variable	$\bar{x}$	*P*	Multivariate model *r*	Multivariate model SE	Multivariate model *P*
Energy intake among men (MJ/d)					
White race	12.5	0.03			
Nonwhite race	11.7				
Effect of white race	—	—	0.8	0.4	0.06
Current injection drug use	13.1	0.12			
Nonuser of injection drugs	12.5				
Effect of current injection drug use	—	—	1.7	0.8	0.04
Food preparation assistance	12.3	0.14			
No food preparation assistance	11.7				
Effect of food preparation assistance	—	—	0.5	0.5	0.28
Diarrhea	13.4	0.02			
No diarrhea	12.1				
Effect of diarrhea	—	—	0.8	0.5	0.14
Reduced appetite	11.7	0.03			
No reduced appetite	12.5				
Effect of reduced appetite	—	—	−0.6	0.4	0.12
Dieting to lose weight	11.0	0.003			
Not dieting	12.5				
Effect of dieting	—	—		Not applicable	
Energy intake among women (MJ/d)					
High school diploma or more	9.5	0.17			
Education through grade 11	8.6				
Effect of higher education level	—	—	0.5	0.4	0.23
Living with a caregiving adult	9.4	0.06			
Not living with a caregiving adult	8.4				
Effect of living with a caregiving adult	—	—	0.2	0.4	0.67
Food shopping assistance	8.5	0.06			
No food shopping assistance	9.6				
Effect of food shopping assistance	—	—	−0.6	0.5	0.21
Nausea or vomiting	8.2	0.15			
No nausea or vomiting	9.2				
Effect of nausea or vomiting	—	—	0.08	0.4	0.86
Protein intake among men (g/d)					
White race	109	0.06			
Nonwhite race	108				
Effect of white race	—	—	−1.1	2.6	0.67
Household income ≥$20000	114	0.05			
Household income <$20000	106				
Effect of household income ≥$20000	—	—	4.7	2.8	0.10
Current injection drug use	107	0.06			
Nonuser of injection drugs	109				
Effect of current injection drug use	—	—	−8.0	5.2	0.12
Living with a caregiving adult	109	0.17			
Not living with a caregiving adult	109				
Effect of living with a caregiving adult	—	—	6.3	2.5	0.01
Diarrhea	124	0.07			
No diarrhea	107				
Effect of diarrhea	—	—	9.2	5.3	0.09
Reduced appetite	102	0.02			
No reduced appetite	113				
Effect of reduced appetite	—	—	−5.7	2.6	0.03
Protein intake among women (g/d)					
College degree	88	0.04			
No college degree	75				
Effect of college degree	—	—	4.2	3.3	0.21
Household income ≥$20000	85	0.05			
Household income <$20000	75				
Effect of household income ≥$20000	—	—	4.9	3.1	0.11
Diarrhea	80	0.12			
No diarrhea	76				
Effect of diarrhea	—	—	8.7	4.9	0.08

[1] Energy intakes were adjusted for height, and protein intakes were adjusted for energy intakes. Multivariate models show only those study variables for which $P < 0.20$ in the unadjusted analyses. Only nondieters ($n = 99$ females and 245 males) were included in the multivariate models. Twelve and 4 influential points (outliers) were removed from the multivariate models for men and women, respectively.

TABLE 3

Percentages of individuals in the Nutrition for Healthy Living (NFHL) cohort with inadequate dietary intakes of micronutrients, protein, and energy in relation to sociodemographic and lifestyle variables

	Energy	Protein	Vitamin A	Niacin	Vitamin B-6	Vitamin B-12	Vitamin C	Vitamin E	Folate	Iron	Zinc
Comparison of populations											
P[1]	—	0.0001	0.44	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
General northeastern US (%)[2]	NA	19.0	51.7	22.0	52.0	19.1	30.0	68.8	30.5	35.3	73.8
NFHL cohort (*n* = 618) (%)	37.5	11.0	51.6	10.5	25.1	5.7	15.5	28.5	16.2	16.5	41.6
Sex (*n* = 618)											
P	0.16	0.0005[3]	0.07	0.0006	0.0008	0.0001[3]	0.0002[3]	0.0008	0.0002	0.0001[3]	0.0009
Male (%)	36.0	8.3	49.5	7.8	21.6	2.6	12.2	24.8	12.9	4.6	37.7
Female (%)	43.6	18.9	57.9	17.8	35.2	14.5	25.2	39.0	25.8	50.9	52.8
Age (*n* = 618)											
P[4]	0.03	0.13	0.001[3]	0.09	0.09	0.002[3]	0.03	0.07	0.006	0.0006	0.16
18–40 y (%)	40.9	11.9	55.5	11.6	27.5	7.3	18.1	31.5	19.1	19.1	42.1
>40 y (%)	32.7	9.7	45.8	9.0	21.5	3.2	11.7	23.9	11.7	12.6	40.9
Race (*n* = 618)											
P[5]	0.08	0.01	0.0001[3]	0.03	0.0003	0.16	0.07	0.0004	0.03	0.0001	0.04
African American (%)	42.0	13.9	63.3	12.4	31.7	8.2	19.6	36.7	22.2	26.0	50.6
Latino or Hispanic (%)	42.1	17.0	61.7	18.8	36.2	6.4	8.5	40.4	14.9	25.5	42.6
White (%)	34.7	8.5	44.7	8.4	20.2	4.7	13.4	23.5	13.7	11.6	38.5
Other (%)	45.0	19.2	65.4	14.8	38.5	3.9	34.6	30.8	19.2	15.4	30.8
Education (*n* = 618)											
P[6]	0.06	0.001	0.0001	0.0003[3]	0.0001[3]	0.0004	0.0001[3]	0.0001[3]	0.0001[3]	0.0001[3]	0.0001[3]
Through grade 11 (%)	46.5	19.4	61.2	22.2	41.8	12.2	29.6	50.0	32.7	37.8	57.1
High school or general equivalency diploma (%)	37.8	12.3	60.0	9.4	31.0	6.5	20.7	34.2	19.4	23.9	50.3
Some college or technical school (%)	38.4	10.2	50.3	9.6	24.3	5.7	14.1	27.1	13.0	14.1	37.9
College degree or graduate school (%)	32.8	6.4	41.0	6.3	12.2	1.6	5.3	13.8	8.0	1.6	29.8
Annual household income (*n* = 597) ($)											
P[6]	0.06	0.03	0.004	0.01	0.001	0.0001	0.002	0.0001	0.0001	0.0001	0.0001
<10000 ($)	42.6	13.7	57.9	14.1	30.6	8.5	20.7	35.8	21.0	25.5	50.2
10–20000 ($)	32.9	9.5	50.5	10.4	27.6	6.7	14.3	30.5	16.2	20.0	43.8
20–30000 ($)	28.3	13.1	49.2	6.5	16.4	3.3	11.5	21.3	18.0	6.6	26.2
30–40000 ($)	35.1	4.8	33.3	0.0	9.5	0.0	7.2	9.5	4.8	2.4	28.6
>40000 ($)	32.4	6.8	45.8	8.4	19.5	0.9	10.2	20.3	7.6	4.2	31.4
Risk category (*n* = 614)											
P[7]	0.04	0.02	0.02	0.002	0.003	0.0001	0.0001	0.0001	0.0003	0.0001	0.0001
Homosexual male (%)	33.8	8.2	47.6	7.0	20.0	2.3	10.4	21.1	11.3	3.9	34.1
Other (%)	43.5	14.5	57.4	14.7	31.6	10.6	22.3	38.3	22.7	34.0	51.6
P[7]	0.04	0.30	0.08	0.008	0.004	0.03	0.06	0.0006	0.02	0.0001	0.0003
Injection drug use (%)	43.9	13.0	57.1	14.8	33.2	8.7	19.6	38.6	20.7	27.7	53.3
Never injected drugs (%)	33.6	10.0	49.0	7.3	21.3	3.9	13.2	23.9	12.9	12.9	36.5
Living with caregiving adult? (*n* = 615)											
P[7]	0.12	0.009[3]	0.62	0.04	0.09	0.37	0.23	0.26	0.15	0.04	0.16
Yes (%)	35.0	8.2	49.1	8.2	23.4	5.3	11.7	26.3	12.3	14.0	37.4
No (%)	38.2	11.7	52.5	11.0	25.5	5.9	16.9	29.1	17.6	17.3	42.8
Living with children? (*n* = 609)											
P[7]	0.06	0.008	0.03	0.07	0.006	0.01	0.001	0.002	0.0002[3]	0.0001[3]	0.0003[3]
Yes (%)	47.4	18.0	60.7	15.0	35.0	11.1	25.6	40.2	28.2	41.0	56.4
No (%)	36.0	8.9	49.4	9.2	22.4	4.5	12.8	25.4	13.2	10.8	37.8
Food shopping assistance? (*n* = 463)											
P[7]	0.68	0.37	0.58	0.65	0.65	0.55	0.95	0.81	0.35	0.02	0.08
Yes (%)	36.3	12.2	50.9	9.4	26.5	5.2	15.7	29.1	14.8	15.1	40.4
No (%)	38.7	9.2	53.8	10.8	24.4	6.7	16.0	30.3	18.5	25.2	49.6
Food preparation assistance? (*n* = 462)											
P[7]	0.10	0.86	0.22	0.23	0.94	0.09	0.98	0.24	0.25	0.04[3]	0.29
Yes (%)	34.5	11.3	50.0	8.8	25.9	4.5	15.8	27.7	14.6	15.5	41.4
No (%)	43.7	11.9	56.4	12.5	26.2	8.7	15.9	33.3	19.1	23.8	46.8
Dieting to lose weight? (*n* = 463)											
P[7]	0.008	0.86	0.003[3]	0.62	0.009[3]	0.19	0.59	0.01[3]	0.005[3]	0.11	0.006[3]
Yes (%)	49.4	11.9	64.2	11.0	35.8	8.3	17.4	39.5	24.8	22.9	54.1
No (%)	33.3	11.3	47.7	9.4	22.9	4.8	15.3	26.3	13.0	16.1	39.3

[1] One-sample test of binomial proportions.
[2] Reference 39.
[3] Retained as an independent significant correlate in the stepwise multivariate regression model.
[4] Continuous predictor variable.
[5] Comparison of white (= 0) versus nonwhite (= 1).
[6] Test of trend for an ordinal predictor variable.
[7] No (= 0) versus yes (= 1).

ciated with inadequate dietary intakes in high percentages of participants. Neither CD4⁺ cell count nor the presence of the other clinical symptoms showed significant associations with any of the nutrient intakes studied. Although the difference was not significant, participants with an AIDS diagnosis were more successful at meeting their RDAs than were their counterparts without AIDS. Use of protease inhibitors or antiretroviral drugs was associated with higher nutrient intakes. Nevertheless, the use of these drugs was not associated with dietary adequacy in any of the multivariate models, with the exception of vitamin C intake.

The multivariate analyses of the correlates of inadequate energy, protein, vitamin A, and zinc intakes are shown in **Table 5**. A preliminary analysis showed that the only independent correlate of inadequate energy intake was dieting to lose weight. Likewise, dieting was independently associated with inadequate vitamin A and zinc intakes. When the multivariate analysis was rerun after excluding all participants who were dieting to lose weight, female sex was the only variable that entered the regression model for inadequate energy intake (prevalence ratio = 1.6; 95% CI: 1.1, 2.2). Inadequate protein intake was associated with lower educational attainment, absence of a caregiving adult in the household, and reduced appetite. Nonwhite race and younger age were the only independent correlates of inadequate vitamin A intake. Inadequate zinc consumption was independently associated with reduced appetite, lower educational attainment, the absence of an adult caregiver, and the presence of dependent children in the household. Adjusting for supplement use did not appreciably alter the results of the multivariate analyses.

DISCUSSION

The results of this study indicate that among HIV-infected persons, subgroups known to be at greater risk of adverse clinical outcomes are also likely to have reduced dietary intakes. Moreover, we found associations between lifestyle and behavioral factors (eg, dieting) and poorer nutrition in HIV-positive adults. These associations, which had not been explored previously, indicate that these lifestyle and behavioral factors should be considered in future analyses of food intake by persons with HIV disease.

Our analysis has several limitations. Because it was not feasible to conduct an exhaustive analysis of every nutrient in the human diet, we concentrated on nutrients known to affect immune function or known to be low in the serum of HIV-infected persons. Hence, we could have missed many important associations. The validity of self-reported dietary data, particularly data from less educated and obese individuals, has also been questioned (40). Nevertheless, diet records are the most accurate method of dietary analysis for studies that include many subjects of ethnic minorities; their intakes may not be reflected accurately by food-frequency questionnaires (41). Despite the day-to-day variations in food consumption, we believe that these data are an accurate representation of the group mean intakes because of the large sample size (41, 42) and because we elimi-

TABLE 4
Percentages of individuals in the Nutrition for Healthy Living Study Cohort with inadequate dietary intakes of micronutrients, protein, and energy in relation to clinical attributes

	Energy	Protein	Vitamin A	Niacin	Vitamin B-6	Vitamin B-12	Vitamin C	Vitamin E	Folate	Iron	Zinc
CD4⁺ count (*n* = 618)											
P[1]	0.58	0.33	0.14	0.25	0.19	0.17	0.12	0.33	0.22	0.36	0.34
$<0.2 \times 10^9$ cells/L (%)	31.9	10.9	46.7	9.2	21.2	3.8	12.5	26.6	12.5	13.0	37.5
0.2–0.499×10^9 cells/L (%)	43.1	9.9	53.0	11.2	26.0	6.1	15.7	27.1	16.8	17.9	42.8
$\geq 0.5 \times 10^9$ cells/L (%)	30.4	11.0	54.4	9.5	25.7	5.9	18.4	29.4	19.1	16.2	41.2
AIDS diagnosis (*n* = 609)											
P[2]	0.13	0.97	0.25	0.33	0.12	0.29	0.13	0.60	0.03	0.09	0.04
Yes (%)	34.6	10.6	48.7	9.1	22.4	4.9	13.5	27.6	13.5	14.4	37.6
No (%)	41.2	10.7	54.4	11.6	28.0	6.9	18.0	29.5	19.9	19.5	46.0
Reduced appetite? (*n* = 577)											
P[2]	0.05	0.0006[3]	0.23	0.0002	0.001[3]	0.01	0.05	0.03	0.001[3]	0.002[3]	0.0001[3]
Yes (%)	42.4	15.6	55.0	13.1	32.1	8.0	18.9	32.9	21.7	22.1	51.4
No (%)	33.6	6.7	50.0	6.9	18.6	3.4	12.8	24.7	11.6	12.2	34.2
Nausea or vomiting? (*n* = 574)[2]											
P[2]	0.43	0.29	0.98	0.19	0.95	0.74	0.29	0.26	0.43	0.35	0.99
Yes (%)	40.1	12.6	52.2	12.0	24.7	5.0	13.2	25.3	14.3	18.7	41.8
No (%)	36.3	9.7	52.3	8.5	24.5	5.6	16.6	30.0	16.8	15.6	41.8
Diarrhea at baseline? (*n* = 610)											
P[2]	0.17	0.30	0.40	0.11	0.37	0.66	0.64	0.29	0.28	0.26	0.20
Yes (%)	27.5	6.5	45.7	4.3	19.6	4.4	13.0	21.7	10.9	10.9	32.6
No (%)	38.3	11.2	52.1	10.8	25.4	5.9	15.6	28.9	16.7	17.1	42.2
Protease inhibitor or antiretroviral drug? (*n* = 600)											
P	0.41	0.25	0.35	0.06	0.04	0.30	0.0002[3]	0.63	0.002	0.68	0.28
Yes (%)	38.5	9.7	50.8	8.8	22.5	5.3	11.8	27.6	13.0	15.8	40.1
No (%)	34.5	13.0	55.0	14.0	30.8	6.5	24.3	30.0	23.7	17.2	45.0

[1] Continuous predictor variable.
[2] No (= 0) versus yes (= 1).
[3] Retained as an independent significant correlate in the stepwise multivariate regression model.

TABLE 5
Correlates of inadequate dietary intakes of key nutrients from multivariate analyses among nondieters[1]

	Full model[2]		Reduced model[3]	
Variable	PR (95% CI)	*P*	PR (95% CI)	*P*
Inadequate energy intake				
Female sex	1.6 (0.9, 2.6)	0.10	1.6 (1.1, 2.3)	0.007
Age ≤40 y	1.2 (0.8, 1.7)	0.35		
Nonwhite race	1.0 (0.7, 1.5)	0.95		
High school education or less	1.0 (0.6, 1.4)	0.82		
Household income <$20 000/y	1.0 (0.7, 1.6)	0.92		
Homosexual orientation	1.0 (0.7, 1.8)	0.96		
History of injection drug use	1.1 (0.7, 1.7)	0.62		
Absence of a caregiving adult in household	1.2 (0.9, 1.7)	0.30		
Living with dependent children	0.9 (0.6, 1.5)	0.79		
Assistance with food preparation	0.8 (0.6, 1.1)	0.25		
AIDS diagnosis	1.0 (0.7, 1.4)	0.97		
Reduced appetite	1.1 (0.8, 1.5)	0.63		
Diarrhea at baseline	0.7 (0.4, 1.5)	0.38		
Inadequate protein intake				
Female sex	1.9 (0.7, 5.6)	0.22		
Age ≤40 y	0.9 (0.5, 1.7)	0.81		
Nonwhite race	1.4 (0.7, 2.8)	0.29		
High school education or less	1.7 (0.8, 3.5)	0.15	2.2 (1.2, 4.1)	0.01
Household income <$20 000/y	0.9 (0.4, 2.0)	0.78		
Homosexual orientation	1.4 (0.4, 4.1)	0.59		
Absence of a caregiving adult in household	1.9 (1.0, 3.6)	0.05	2.0 (1.1, 3.7)	0.03
Living with dependent children	1.3 (0.7, 2.6)	0.43		
Reduced appetite	1.5 (0.8, 2.8)	0.16	1.6 (0.9, 2.9)	0.11
Inadequate vitamin A intake				
Female sex	1.0 (0.7, 1.4)	0.96		
Age ≤40 y	1.2 (0.9, 1.5)	0.17	1.2 (1.0, 1.5)	0.13
Nonwhite race	1.3 (1.02, 1.7)	0.03	1.5 (1.3, 1.8)	0.0008
High school education or less	1.2 (0.9, 1.5)	0.24		
Household income <$20 000/y	1.1 (0.8, 1.4)	0.63		
Homosexual orientation	1.02 (0.7, 1.5)	0.93		
History of injection drug use	1.0 (0.8, 1.3)	0.95		
Living with dependent children	1.1 (0.9, 1.4)	0.43		
$CD4^+$ count $<0.2 \times 10^9$ cells/L	0.9 (0.7, 1.2)	0.40		
Inadequate zinc intake				
Female sex	0.9 (0.6, 1.3)	0.47		
Age ≤40 y	0.9 (0.7, 1.2)	0.68		
Nonwhite race	1.0 (0.7, 1.3)	0.90		
High school education or less	1.5 (1.1, 2.0)	0.009	1.8 (1.4, 2.3)	0.0001
Household income <$20 000/y	1.2 (0.8, 1.8)	0.28		
Homosexual orientation	0.8 (0.5, 1.2)	0.23		
History of injection drug use	0.9 (0.7, 1.3)	0.67		
Absence of a caregiving adult in household	1.2 (0.9, 1.6)	0.19	1.4 (1.1, 1.8)	0.009
Living with dependent children	1.2 (0.9, 1.7)	0.18	1.4 (1.1, 1.8)	0.02
Lack of assistance with food shopping	0.9 (0.7, 1.3)	0.68		
AIDS diagnosis	0.8 (0.6, 1.1)	0.21		
Reduced appetite	1.5 (1.1, 1.9)	0.007	1.6 (1.3, 2.1)	0.0002

[1] PR, prevalence ratio. $n = 279$ for energy intake data, 344 for protein intake data, and 343 for zinc and vitamin A intake data.
[2] The adjusted analyses first controlled for all variables that showed an association with inadequate intake of the outcome variable at $P < 0.20$.
[3] Shows the variable coefficients and P values for those variables with $P < 0.20$ in the full model.

nated influential outliers from the regression analyses. A correlation previously found between dietary inadequacy and the presence of hunger in this cohort also supports the general validity of the dietary record data (23).

Finally, we cannot fully rule out the possibility of differential dietary underreporting. Previous studies reported conflicting results regarding the relations between SES and dietary underreporting (43–47). However, dieting and obesity have been consistently associated with dietary underreporting in the literature (43–46, 48). Because dieters were eliminated from the multivariate analyses altogether, dieting behavior could not have contributed to differential reporting of food intake in the data used in the multivariate analyses. Of the remaining participants, only 8% were clinically obese.

In the analysis of macronutrient intakes, many variables showed opposite trends for men and women. We speculate that these differences are attributable to greater health-consciousness in the male participants, who were better educated than their female counterparts. As their illness progresses, male participants appear to engage in compensatory eating behaviors. A previously conducted study of this cohort indicated that 55% of the men used vitamin supplements, whereas only 29% of the women took vitamins regularly (24). The female participants may not have the financial means, health consciousness, or social support to eat well as their health declines.

Although more members of this HIV-infected cohort met the RDAs for the various nutrients studied than in the general population of the northeastern United States (39), we cannot state unequivocally that dietary needs were better met in our study cohort. The burden of the disease would presumably necessitate increased nutrient intakes (49, 50), and therefore a direct comparison with the general population's dietary intakes would be unwise. In addition, differences in methodology, population composition, or both may account for the lower percentages of individuals with dietary inadequacy in our cohort. Because an HIV-negative control group was not included in our study, it is difficult to draw definitive conclusions.

The results of the multivariate analysis suggest that inability to meet the RDAs is largely a socioeconomic rather than a clinical phenomenon, because the only clinical symptom consistently associated with inability to meet the RDA was reduced appetite. Individuals with an AIDS diagnosis did not fare worse than participants who were still asymptomatic. Minorities, participants with dependent children, individuals without an adult caregiver, and those without food shopping assistance consistently had less adequate dietary intakes. Despite the noted side effects of protease inhibitors and antiretroviral drugs, we found that participants using these drugs were more successful at meeting their RDAs. Nevertheless, the use of these drugs was not associated with dietary adequacy in any of the multivariate models, except in the case of vitamin C intake. Hence, it can be assumed that the use of these medications (which is strongly correlated with higher educational attainment and having private insurance) is an indicator of SES that does not have independent effects on nutrient intakes once SES is accounted for. Likewise, the use of supplements, which is strongly associated with micronutrient adequacy, was also shown in a preliminary analysis to be significantly correlated with educational attainment.

Our data provide evidence that BMI can vary greatly in cohorts of individuals with HIV disease: >20% of the women in this study were obese, and 50% were overweight. We found that dieting behavior is correlated with high BMI. Of the obese participants, 47% said they were dieting, whereas 34% of individuals with a BMI between 25 and 30 were dieting. Only 13% of those with a BMI between 20 and 25 were voluntarily restricting their food intake. It is possible that overweight HIV-infected individuals are not aware of the potentially detrimental effects of dieting on their long-term prognosis, or that the social pressure to be thin prevails over their health concerns. No participant who was wasting reported attempts to lose weight, suggesting that dieting behavior is curtailed once the health effects of caloric restriction become observable.

BMI was inversely associated with risk of death on the basis of preliminary analyses of data from the 679 participants, 39 of whom have died since enrollment. Individuals with a baseline BMI >25 had a much lower risk of death than did those with a BMI <25 (OR = 0.4; 95% CI: 0.2, 0.8).

The behavioral and attitudinal aspects of dietary intake among HIV-infected adults have been largely overlooked by researchers. It may have been presumed that inadequate dietary intake is primarily involuntary, resulting from limited resources or clinical symptoms. Our results suggest that in HIV disease, dietary intake is a complex sociobehavioral phenomenon that reflects the confluence of attitudinal, economic, and lifestyle factors. Hence, clinicians and health care professionals should consider sociobehavioral models of dietary modification when designing intervention strategies for HIV-infected individuals. Public health practitioners should strive to understand the reasons underlying food choices, food procurement, and eating practices in this population, which includes disproportionate numbers of individuals who are drug abusers, indigent, disabled, and homeless. Given their limited resources, it is unclear how these individuals prioritize food procurement amid competing costs such as medical treatment, childcare, illegal drugs, and housing-related expenses. Future research should focus on longitudinal changes in food consumption patterns and the effects of dietary counseling and programmatic aid on nutritional intake.

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