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ORIGINAL COMMUNICATION

HIV status and sociodemographic correlates of maternal body size and wasting during pregnancy

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Objective: To examine HIV status and sociodemographic variables as correlates of body size (height, body mass index (BMI), and mid-upper-arm circumference (MUAC)) and wasting (MUAC <22 cm) in pregnant women.
Design: Cross-sectional study.
Setting: Four antenatal clinics in Dar es Salaam, Tanzania.
Subjects: Women presenting for first prenatal visit before the 23rd week of gestation, between April 1995 and July 1997 ($n=$ 13 760).
Results: Mean MUAC, BMI and height were 25.5 cm, 23.5 kg/m^2 and 155.1 cm, respectively. The prevalence of HIV infection was 13.1% and the overall prevalence of wasting was 4.7%. Wasting was 34% (95% CI = 3%, 73%) more prevalent among HIV-infected than in uninfected mothers, after adjusting for week of gestation, height and sociodemographic indicators. The risk of wasting associated with HIV infection was highest among women with low level of education or unable to contribute to the household income. From a multiple linear regression model, BMI was positively associated with mother's age, level of education and money spent on food, but not with HIV infection, after adjusting for week of gestation. In multivariate analysis, height increased monotonically by categories of maternal age and level of education, and was also positively correlated with the ability to contribute to household income, the amount of money spent on food per person per day, and having a professional partner.
Conclusion: HIV infection is a significant risk factor for wasting among pregnant women, particularly in groups of low socioeconomic status (SES). SES indicators are strongly correlated with maternal height and with BMI during the first and second trimesters of pregnancy independently of HIV status.
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Introduction

The anthropometric status of women before and during gestation is a strong predictor of the outcome of pregnancy. Short maternal stature and low pre-pregnancy weight are associated with increased risk of low birth weight (LBW), intra-uterine growth retardation (IUGR; World Health Organization, 1995), and preterm delivery (Ferraz *et al*, 1990; Kramer *et al*, 1995). Short stature is also related to increased risk of cephalopelvic disproportion, assisted delivery (Everett, 1975; Sokal *et al*, 1991; Thomson, 1959), and increased perinatal and infant mortality (Liljestrand *et al*, 1985; Martorell *et al*, 1981).

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Some specific determinants of chronic energy and protein deficiency, as reflected in small maternal body size, have been identified. In populations where malnutrition is highly prevalent, poor socioeconomic background is a strong predictor of short maternal stature and low body weight (Achadi *et al*, 1995; Ahmed *et al*, 1998; Baqui *et al*, 1994; Omar *et al*,

Table 1 Anthropometric characteristics of the study population

		Height (cm)		BMI[b] (kg/m^2)		MUAC[c] (cm)	
Variable	n[a]	*Mean*	*s.d.*	*Mean*	*s.d.*	*Mean*	*s.d.*
Overall	13760	155.2	6.0	23.5	3.4	25.5	2.7
Mother's age (y)							
15–19	3587	154.0	5.8	22.8	2.7	24.7	2.2
20–24	5417	155.2	5.9	23.3	3.2	25.3	2.5
25–29	2915	156.0	5.9	23.9	3.5	26.1	2.8
30–49	1835	156.0	6.1	25.0	4.2	26.8	3.1
Week of gestation							
≤12	644	154.2	6.0	22.7	3.2	25.4	2.7
13–16	3306	155.1	6.0	23.2	3.4	25.6	2.7
17–20	6359	155.2	5.9	23.5	3.3	25.5	2.7
21–23	3418	155.2	6.0	23.9	3.5	25.4	2.7
Mother's education[d]							
None/illiterate	1303	153.0	5.7	23.3	3.3	25.2	2.6
Low/literate	707	154.2	5.6	23.4	3.3	25.6	2.8
Elementary	10300	155.2	5.9	23.5	3.3	25.5	2.7
Secondary or higher	1450	157.4	6.1	24.0	3.7	25.7	2.9
Mother's occupation							
Housewife	10528	154.8	5.9	23.4	3.3	25.3	2.6
Public house	102	155.9	6.7	23.9	3.6	25.9	2.9
Petty trade	2061	156.1	6.0	23.7	3.6	26.0	2.8
Employed	530	156.6	6.0	24.2	4.0	26.0	2.8
Professional	305	157.8	6.2	24.5	3.8	26.4	3.2
Other	234	156.7	6.2	23.8	3.5	25.9	3.0
Mother contributes to household income[e]							
No	10629	154.8	5.9	23.4	3.3	25.3	2.6
Yes	3128	156.5	6.1	23.9	3.7	26.1	2.8
Money spent on food[f]							
Quintile 1 (233)	2248	155.0	5.9	23.4	3.4*	25.7	2.7
Quintile 2 (333)	2056	154.8	6.0	23.7	3.5	25.7	2.8
Quintile 3 (400)	1209	155.3	6.0	23.7	3.5	25.8	2.7
Quintile 4 (500)	3634	155.1	5.9	23.5	3.3	25.4	2.6
Quintile 5 (750)	2761	155.6	5.9	23.6	3.5	25.5	2.8
Mother's HIV status							
Uninfected	11950	155.1	6.0	23.5	3.4†	25.5	2.7†
Infected	1810	155.7	5.8	23.6	3.4	25.4	2.7
Mother's region of origin							
Coastal	5378	154.0	5.7	23.3	3.4	25.2	2.6
Southern Highlands	1134	155.7	5.5	24.2	3.3	26.3	2.7
West Lake	1542	158.1	6.1	23.6	3.5	25.8	2.7
Northern	1095	157.4	6.2	24.3	3.5	26.2	2.8
Southern	2782	154.0	5.7	23.3	3.3	25.3	2.6
Central	807	156.8	5.6	23.2	3.2	25.6	2.7
Other	115	156.2	6.1	24.2	3.9	25.9	2.8
Mother has partner							
No	1577	155.0	6.2†	23.1	3.1	24.8	2.6
Yes	12183	155.2	5.9	23.6	3.4	25.6	2.7
Partner's age[g]							
≤24	1199	153.9	5.8	22.6	2.6	24.5	2.2
25–29	2743	155.1	5.7	23.1	3.0	25.1	2.5
30–39	3690	156.0	5.9	23.8	3.6	25.8	2.8
≥40	1077	156.2	6.0	25.0	4.2	26.8	3.0
Partner's education[d,g]							
None/illiterate	190	153.4	6.4	23.3	3.5	25.6	2.7
Low/literate	434	154.7	6.2	23.7	3.4	25.9	2.9
Elementary	7673	154.7	5.8	23.4	3.3	25.4	2.7
Secondary or higher	2960	156.7	6.0	23.9	3.6	25.9	2.8

Table 1 cont.

Table 1 *continued.*

Variable	n[a]	Height (cm)		BMI[b] (kg/m²)		MUAC[c] (cm)	
		Mean	s.d.	Mean	s.d.	Mean	s.d.
Partner's occupation[g]							
Soldier	1075	157.5	6.1	23.7	3.6	26.4	2.8
Professional	623	157.1	6.2	23.9	3.5	26.0	2.7
Long distance driver	273	155.2	5.7	24.1	3.5	25.8	2.9
Driver	661	155.3	5.8	23.9	3.6	25.7	2.8
Employed	3055	154.8	5.7	23.5	3.4	25.5	2.6
Petty trade	4497	154.6	5.9	23.5	3.4	25.4	2.7
Public house	234	154.3	6.4	23.7	3.3	25.3	2.7
Farmer	116	153.8	5.9	22.8	3.2	25.0	2.2
Other	1333	155.3	5.8	23.3	3.4	25.4	2.7

[a]Totals may be less than 13 760 due to missing data.
[b]BMI, body mass index.
[c]MUAC, mid-upper-arm circumference.
[d]The category 'none/illiterate' includes mothers who are not able to read a sentence and did not attend formal schooling. Low education includes women who received 1–4 y of education and are able to read a sentence. Elementary and secondary education correspond to 5–8 and 9–12 y of formal schooling, respectively. Subjects with more than 13 y of education are classified in the 'secondary or higher' category.
[e]Mothers who contribute are those who provide part or all the household income themselves. Those who do not contribute are supported by another person.
[f]Money spent on food: quintiles of average household income (in Tanzanian shillings) spent on food per person per day, as estimated by dividing the total amount of money spent on food, by the number of household members. Median value for each quintile is presented in parentheses.
[g]Among mothers cohabiting with their partner.
Differences in anthropometric variable medians across categories of the covariates are all significant at $P \leq 0.01$, except $*P \leq 0.05$ and $^{\dagger}P > 0.05$ (Kruskal–Wallis test).

1994). In sub-Saharan Africa and South and South East-Asia, the nutritional status of women is additionally challenged by the rapid spread of the HIV-1 epidemic. Up to 15% of women attending prenatal care in Tanzania and as many as 35% in other African countries are estimated to be infected (UNAIDS, 2000). HIV infection is associated with wasting, a progressive loss of lean and fat body mass that increases the risk of mortality (Macallan, 1999).

Few studies have examined the relationship between HIV infection and maternal anthropometry. Whether socioeconomic factors interact with HIV infection in determining the maternal body size is also unknown. In this paper we examine HIV status and sociodemographic variables as correlates of maternal height, body mass index (BMI), and mid-upper-arm circumference (MUAC) among women presenting for the first prenatal visit in Dar es Salaam, Tanzania. We also examine the prevalence of wasting (MUAC < 22 cm) in relation to HIV infection.

Methods

Between April 1995 and July 1997, 14 040 pregnant women receiving prenatal care at four urban clinics in Dar es Salaam (Temeke, Ilala, Mwananyamala and Mwenge) were offered HIV-1 testing in order to determine eligibility for the Tanzania Vitamin Supplementation Trial (Fawzi *et al*, 1998). Consenting women ($n = 13\,845$, 98.6%) received pre-test counseling before a blood sample was drawn. Trained interviewers obtained data on mother's age, date of last menstrual period, literacy, level of education, occupation, marital status, partner's age, education and occupation, whether the mother contributes to the household income, money spent on food per day in the household, and number of people eating in the household. We also obtained information on the woman's tribal affiliation and used it to determine her region of origin. Anthropometric measurements including height, weight and MUAC were obtained by trained and standardized study staff, using calibrated instruments (Lohman *et al*, 1988). Height was measured to the nearest 0.1 cm. Weight was measured to the nearest 100 g, and left MUAC was obtained at the midpoint between the olecranon and the acromion process with a non-stretchable tape, to the nearest 0.1 cm. A complete clinical examination was also carried out. HIV-1 serostatus was tested by ELISA (Wellcozyme, Murex Biotech Ltd, Dartford, UK) and positive results confirmed by Western blot tests (Bio-Rad Laboratories Ltd, Hertfordshire, UK). Post-test counseling was provided and confidentiality of the results was strictly maintained.

Week of gestation was estimated from the date of last menstrual period. The amount of money spent on food per person per day was obtained by dividing the total amount spent for the household by the number of people eating in the household. BMI was calculated as the weight in kilograms divided by height in meters squared. Short stature was defined as height below 150 cm, and wasting as MUAC below 22 cm, according to previous reports that found similar cut-off points to be associated with adverse pregnancy outcomes (Sokal *et al*, 1991) and increased risk of death (Lindan *et al*, 1992), respectively, in African populations.

We conducted cross-sectional analyses of the relationships between three continuous anthropometric variables (height, BMI and MUAC) and independent predictors including HIV status and sociodemographic variables, eg age, education, occupation, marital status, region of origin and money spent on food per person/day in the household. Of the 13 845 women tested for HIV, those with indeterminate results ($n=47$), less than 15 y of age ($n=31$), and more than 23 weeks of gestation ($n=7$) were not included in the analyses. Means of anthropometric variables were estimated for categories of the independent predictors, and differences in their distributions were tested using the Kruskal–Wallis test (Rosner, 2000). A multiple linear regression model was then fitted for each of the three variables, introducing as covariates those that were significant predictors at $P<0.20$ in univariate analyses, and keeping in the final models those that remained significant at $P<0.05$. Robust estimators of variance (White, 1980) were used in the regression models.

The prevalence of short stature and wasting was estimated by categories of sociodemographic variables and HIV status. Multivariate adjusted prevalence ratios and 95% confidence intervals were estimated by binomial regression with the log link function (Wacholder, 1986). The likelihood ratio test was employed to examine whether the association between wasting and HIV status was modified by socioeconomic factors.

The study protocol was approved by the Research and Publications Committee of Muhimbili University College of Health Sciences, the Ethical Committee of the National AIDS Control Program of the Tanzanian Ministry of Health, and the Institutional Review Board of the Harvard School of Public Health.

Results

Mean age was 23.2 y (s.d. = 5.0), and the average week of gestation at first visit was 18.1 (s.d. = 3.1). Most women were housewives and had completed only elementary education. The average amount of money spent on food per person per day in the household was 492 Tanzanian shillings (s.d. = 262), about US $0.62 at the time of the study, and 77% of women did not contribute to the household income. The prevalence of HIV infection was 13.1%.

Anthropometric characteristics of the study population are presented in Table 1. Average maternal height, weight, BMI and MUAC at the initial visit were 155.1 cm (s.d. = 6.0), 56.6 kg (s.d. = 9.0), 23.5 kg/m^2 (s.d. = 3.4), and 25.5 cm (s.d. = 2.7), respectively.

Mid-upper-arm circumference

In univariate analysis (Table 1), MUAC was positively associated with mother's age, and socioeconomic status (SES) as reflected by education, occupation and the ability to contribute to household income. Among women cohabiting with a partner, MUAC was positively related to the partner's age, education and occupation. In multivariate analysis (Table 2), MUAC (95% CI) was 1.9 cm (1.8, 2.1) greater, on average, among women over 30 y of age as compared to those less than 20 y. Week of gestation and the mother's level of education were no longer associated with MUAC after controlling for age, height, HIV status, region of origin and socioeconomic variables. Mothers whose partner was a farmer had the lowest values of MUAC. HIV-infected mothers had a 0.2 cm (95% CI = −0.4, −0.1) lower mean MUAC than those who were uninfected, after controlling for potential confounders.

The overall prevalence of wasting (MUAC < 22 cm) was 4.7%. The prevalence (95% CI) was 36% (13%, 53%) lower among women older than 30 y compared to < 20 y (P for trend = 0.0001), after adjusting for week of gestation, height, indicators of SES, region of origin and HIV status in a binomial regression model (Table 3). Similarly, having a partner and contributing to the household income were associated with 47% (34%, 58%) and 38% (22%, 51%) lower risk (95% CI) of wasting, respectively. In the same model, the prevalence of wasting was higher among women in the highest category of money spent on food per person/day, and it was the lowest among women from the Southern Highlands region.

HIV-positive mothers had an adjusted 34% (3%, 73%) excess (95% CI) prevalence of wasting, compared with HIV-negatives. We further examined this association by levels of sociodemographic indicators, and found that HIV infection was related to a 50% (15%, 96%) excess prevalence of wasting among women who did not contribute to the household income but not so in women who contributed (prevalence ratio, PR = 0.62, 95% CI = 0.31, 1.25; P for interaction = 0.008). Similarly, there was a significantly increased prevalence of wasting associated with HIV infection among women with less than 4 y of education; this was not observed in women with more years of formal schooling (P for interaction = 0.05; Figure 1).

Body mass index

BMI was positively associated with maternal age, week of gestation and level of education in univariate analysis (Table 1). Mothers with a profession were significantly heavier than housewives, employed women or petty traders. Average BMI was slightly higher for mothers living with their partner and for those contributing to the household income. Mothers married to older and more educated men had higher BMI than those with younger and less educated partners, respectively. Mean BMI did not differ between HIV positive and negative women. In multivariate analysis

Table 2 Multivariate analysis of the correlates of height, body mass index and arm circumference at first prenatal care visit

	Height (cm)		BMI[b] (kg/m^2)		MUAC[c] (cm)	
Variable	*Diff*[a]	*95% CI*	*Diff*[a]	*95% CI*	*Diff*[a]	*95% CI*
Mother's age (y)						
15–19	Ref		Ref		Ref	
20–24	0.7	(0.5, 1.0)	0.4	(0.3, 0.5)	0.5	(0.4, 0.6)
25–29	1.3	(1.0, 1.6)	1.0	(0.9, 1.2)	1.2	(1.1, 1.3)
30–49	1.6*	(1.3, 2.0)	2.2*	(2.0, 2.4)	1.9*	(1.8, 2.1)
Week of gestation						
≤12	Ref		Ref		Ref	
13–16	0.8	(0.3, 1.3)	0.5	(0.2, 0.8)	0.2	(0.0, 0.4)
17–20	0.9	(0.4, 1.4)	0.8	(0.5, 1.1)	0.0	(−0.2, 0.2)
21–23	0.9*	(0.4, 1.4)	1.1*	(0.9, 1.4)	−0.1*	(−0.3, 0.1)
Mother's education						
None/illiterate	Ref		Ref		Ref	
Low/literate	1.0	(0.5, 1.5)	0.0	(−0.3, 0.3)	0.2	(−0.1, 0.4)
Elementary	1.5	(1.2, 1.9)	0.1	(−0.1, 0.3)	0.1	(−0.1, 0.2)
Secondary or higher	2.8*	(2.4, 3.3)	0.4‡	(0.1, 0.6)	−0.1§	(−0.3, 0.1)
Has partner						
No	Ref		Ref		Ref	
Yes	0.0	(−0.3, 0.4)	0.0	(−0.2, 0.2)	0.4	(0.2, 0.5)
Mother contributes to household income						
No	Ref		Ref		Ref	
Yes	0.7	(0.5, 1.0)	0.1	(−0.1, 0.2)	0.3	(0.2, 0.4)
Money spent on food (Tanzanian shillings)						
Quintile 1 (median 233)	Ref		Ref		Ref	
Quintile 2 (median 333)	−0.2	(−0.6, 0.1)	0.4	(0.2, 0.6)	0.1	(−0.1, 0.3)
Quintile 3 (median 400)	0.1	(−0.3, 0.5)	0.2	(0.0, 0.5)	0.1	(−0.1, 0.3)
Quintile 4 (median 500)	0.1	(−0.2, 0.4)	0.4	(0.2, 0.5)	0.0	(−0.1, 0.2)
Quintile 5 (median 750)	0.4*	(0.1, 0.7)	0.5*	(0.3, 0.7)	0.1§	(0.1, 0.3)
HIV status						
Uninfected	Ref		Ref		Ref	
Infected	0.2	(−0.2, 0.5)	−0.1	(−0.3, 0.1)	−0.2	(−0.4, −0.1)
Region						
Coastal	Ref		Ref		Ref	
Southern Highlands	1.3	(1.0, 1.7)	0.8	(0.6, 1.1)	1.0	(0.8, 1.2)
West Lake	3.6	(3.3, 4.0)	0.1	(−0.1, 0.3)	0.3	(0.2, 0.5)
Northern	2.6	(2.2, 3.0)	0.6	(0.4, 0.9)	0.7	(0.5, 0.9)
Southern	0.1	(−0.2, 0.3)	−0.1	(−0.2, 0.1)	0.1	(0.0, 0.3)
Central	2.6	(2.2, 3.0)	−0.2	(−0.4, 0.0)	0.2	(0.0, 0.4)
Other	1.9	(0.7, 3.0)	1.0	(0.1, 1.5)	0.6	(0.1, 1.1)
Partner's age (y)						
15–19	Ref		Ref		Ref	
20–24	0.7	(0.3, 1.1)	0.3	(0.1, 0.5)	0.4	(0.2, 0.5)
25–29	1.2	(0.8, 1.6)	0.7	(0.5, 0.9)	0.7	(0.5, 0.8)
30–49	1.5*	(0.9, 2.0)	1.4*	(1.0, 1.7)	1.2*	(1.0, 1.5)
Partner's occupation						
Farmer	−0.8	(−1.9, 0.3)	−0.9	(−1.4, −0.3)	−0.7	(−1.0, −0.3)
Professional	1.0	(0.5, 1.5)	0.0	(−0.3, 0.3)	0.1	(−0.1, 0.4)
Petty trade	−0.1	(−0.4, 0.2)	0.1	(−0.1, 0.2)	0.0	(−0.1, 0.1)
Employed	Ref		Ref		Ref	
Public house	−0.4	(−1.2, 0.4)	0.3	(−0.1, 0.8)	−0.1	(−0.4, 0.3)
Driver	0.4	(0.0, 0.9)	0.3	(0.1, 0.6)	0.2	(−0.1, 0.4)
Long distance driver	0.1	(−0.6, 0.8)	0.5	(0.1, 0.9)	0.2	(−0.1, 0.6)
Soldier	1.6	(1.2, 2.0)	−0.1	(−0.3, 0.2)	0.4	(0.2, 0.6)
Other	0.4	(0.1, 0.8)	−0.3	(−0.5, 0.0)	−0.2	(−0.3, 0.0)

[a]Multivariate adjusted mean difference between categories of the covariates and a reference category, based on one linear regression model for each anthropometric variable (dependent) with covariates introduced as indicator variables for: mother's age (three indicators), week of gestation (three indicators), education (three indicators), living with the partner, whether the mother contributes to household income, household income (Tanzanian shillings) spent on food per person per day (five indicators including one for missing information), HIV status, and region of origin (seven indicators including one for missing information). Partner's age and occupation were introduced each separately into the same multivariate model fitted in the subset of women with partner. 95% CI = 95% confidence interval.

[b]BMI, body mass index.

[c]MUAC, mid-upper-arm circumference. The model for MUAC also included five indicator variables for height.

**P*, test for trend, for the variable when introduced into the model as continuous ≤ 0.001; †*P*, test for trend < 0.01; ‡*P*, test for trend $= 0.02$; §*P*, test for trend > 0.05.

Table 3 Adjusted prevalence ratios for maternal stature < 150 cm and arm circumference < 22 cm

	Height < 150 cm			*MUAC[c] < 22 cm*		
Variable	*Prevalence (%)*	*PR[a]*	*95% CI[b]*	*Prevalence (%)*	*PR*	*95% CI*
Mother's age (y)						
15–19	18.9	1.00		6.5	1.00	
20–24	14.2	0.85	(0.77, 0.94)	4.9	0.86	(0.72, 1.02)
25–29	11.1	0.70	(0.61, 0.79)	3.2	0.61	(0.48, 0.78)
30–49	11.6	0.68*	(0.59, 0.79)	3.0	0.64*	(0.47, 0.87)
Week of gestation						
≤12	17.4	1.00		5.9	1.00	
13–16	14.6	0.86	(0.72, 1.04)	3.7	0.63	(0.45, 0.90)
17–20	14.2	0.85	(0.71, 1.01)	4.6	0.79	(0.57, 1.09)
21–23	14.2	0.84‡	(0.70, 1.01)	5.7	0.93‡	(0.66, 1.29)
Mother's education						
None/illiterate	24.2	1.00		5.7	1.00	
Low/literate	16.5	0.74	(0.61, 0.89)	4.0	0.77	(0.50, 1.18)
Elementary	14.0	0.68	(0.61, 0.76)	4.6	0.96	(0.76, 1.23)
Secondary or higher	7.6	0.45*	(0.36, 0.56)	5.1	1.39‡	(1.00, 1.93)
Has partner						
No	16.3	1.00		8.1	1.00	
Yes	14.2	0.89	(0.77, 1.02)	4.3	0.53	(0.42, 0.66)
Mother contributes to household income						
No	15.6	1.00		5.3	1.00	
Yes	10.4	0.84	(0.75, 0.94)	2.8	0.62	(0.49, 0.78)
Money spent on food						
Quintile 1 (median 233)	14.9	1.00		3.5	1.00	
Quintile 2 (median 333)	16.0	1.09	(0.95, 1.25)	4.8	1.32	(0.99, 1.77)
Quintile 3 (median 400)	14.2	1.02	(0.86, 1.21)	4.1	1.21	(0.85, 1.71)
Quintile 4 (median 500)	14.6	1.00	(0.88, 1.13)	4.8	1.31	(1.01, 1.72)
Quintile 5 (median 750)	12.6	0.91‡	(0.79, 1.05)	5.2	1.42†	(1.07, 1.87)
HIV status						
Uninfected	14.9	1.00		4.6	1.00	
Infected	11.4	0.82	(0.69, 0.97)	5.6	1.34	(1.03, 1.73)
Region						
Coastal	18.3	1.00		5.9	1.00	
Southern Highlands	10.6	0.65	(0.54, 0.78)	1.7	0.32	(0.20, 0.50)
West Lake	5.7	0.35	(0.28, 0.44)	3.0	0.65	(0.47, 0.88)
Northern	8.2	0.56	(0.45, 0.69)	3.1	0.64	(0.44, 0.91)
Southern	18.4	1.01	(0.92, 1.12)	5.2	0.90	(0.74, 1.09)
Central	8.2	0.48	(0.38, 0.61)	3.7	0.76	(0.53, 1.10)
Other	11.5	0.71	(0.42, 1.18)	2.6	0.47	(0.15, 1.45)

[a]PR, adjusted prevalence ratio from a binomial regression model in which outcome variable is 'stature < 150 cm'. The model includes indicator variables for all factors in the table.
[b]95% CI, confidence interval.
[c]MUAC, mid-upper-arm circumference. The binomial regression model for MUAC < 22 also included five indicator variables for mother's height.
**P*, test for trend, for the variable when introduced into the model as continuous < 0.001;
†*P*, test for trend = 0.04; ‡*P*, test for trend > 0.05.

(Table 2) age, week of gestation and education remained positively and significantly associated with maternal BMI. Increasing trends in BMI were observed across quintiles of money spent on food; mothers in the highest quintile had a BMI (95% CI) 0.5 (0.3, 0.7) units larger than those in the lowest quintile, after controlling for week of gestation, region of origin, HIV status and socioeconomic indicators. Women from the Southern Highlands and the Northern region were the heaviest. Having a partner, contributing to the household income, the mother's occupation and HIV status were not significantly associated with BMI in multivariate analysis.

Height

In univariate analysis (Table 1), maternal height was positively associated with age and indicators of SES including the level of maternal education, occupation, contribution to household income and money spent on food. Mothers married to spouses with higher levels of education were taller than those with illiterate partners. Average height was highest for women from the West Lake region of Tanzania, and lowest for mothers from the Coastal and Southern areas. Similar associations were observed in multivariate analysis (Table 2). Height did not differ significantly between HIV positives and negatives, after adjusting for sociodemo-

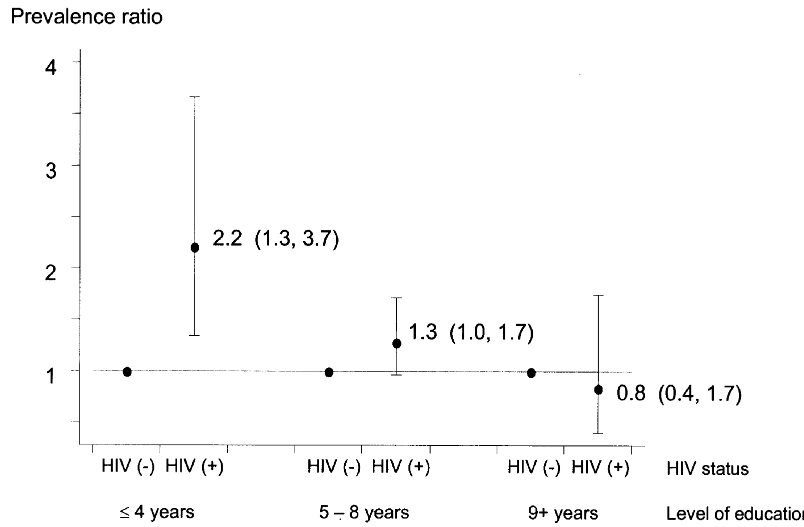

Figure 1 Prevalence ratios of wasting for HIV (+ve) women are presented in relation to HIV (−ve) (reference category) by levels of maternal education. 95% CIs for the PR are shown in parentheses. PRs were estimated from a bivariate regression model in which wasting is the outcome variable and predictors include interaction terms for each category of education with HIV status, plus indicator variables for the covariates presented in Table 3. *P* for interaction = 0.05

graphic variables. The prevalence of short stature (< 150 cm) was 14.4%. In multivariate analysis (Table 3), short stature was significantly less frequent among mothers above 30 y compared to those below 20 y (PR = 0.68, 95% CI = 0.59, 0.79), with secondary education (PR compared to no education = 0.45, 95% CI = 0.36, 0.56), contributing to the household income (PR = 0.84, 95% CI = 0.75, 0.94), and coming from the West Lake and Central regions. Cohabiting with a partner, the amount of money spent on food per person per day and HIV status were not significantly associated with the prevalence of short stature in this population. Among women living with a partner, the prevalence of short stature was inversely related to the spouse's age (PR for ≥ 30 y *vs* < 20 = 0.62; 95% CI = 0.47, 0.82; *P* for trend = 0.0001) and education (PR for secondary *vs* no education = 0.49; 95% CI = 0.34, 0.69; *P* for trend = 0.0001), after controlling for maternal age, education and other sociodemographic variables.

Discussion

Few studies have examined the associations between sociodemographic variables and maternal anthropometry in a setting where HIV infection poses new challenges to the nutritional status of the population. We have conducted cross-sectional analyses in a large community-based sample of mothers attending prenatal care in Dar es Salaam, Tanzania. In this population, HIV-infection was correlated with higher prevalence of wasting and indicators of low SES were significantly associated with poor nutritional status.

HIV infection is causally related to undernutrition in children and adults. HIV disease is associated with loss of lean (Kotler *et al*, 1985; Ott *et al*, 1993) and fat (Mulligan *et al*, 1997b; Sharpstone *et al*, 1996) body mass, as a result of opportunistic infections (Paton *et al*, 1997), metabolic (Melchior *et al*, 1991; Mulligan *et al*, 1997a) and hormonal (Strawford & Hellerstein, 1998) changes, decreased food intake and nutrient malabsorption (Kotler, 1998). In women, HIV-related weight loss occurs largely at the expense of body fat (Grinspoon *et al*, 1997; Kotler *et al*, 1999), and mean prepregnancy weight of HIV-positive women has been found to be lower than that of HIV-negatives in African settings (Castetbon *et al*, 1999). We did not observe significant differences in BMI between infected and uninfected mothers at their first visit of prenatal care. However, mean MUAC was significantly lower in HIV-infected mothers and the risk of wasting (MUAC < 22 cm) was 34% higher in HIV-positive compared to negative women, after controlling for SES, height, age and week of gestation. This suggests that MUAC could be a useful screening tool for HIV-related wasting during pregnancy. Additional studies are needed to test the validity of various MUAC cut-off points in the prediction of adverse maternal and gestational outcomes in populations with high prevalence of HIV infection. The association between HIV infection and wasting was strongly modified by SES indicators. We found that HIV was a significant risk factor for wasting primarily among women who were not able to contribute to the household income, and in those with low level of education. It is possible that women of poor SES were at more advanced stages of HIV disease. Women with independent purchasing power and higher level of education may have access to a more adequate diet and better health services (Terra de Souza *et al*, 1999), and may be empowered to make decisions for intra-household re-allocation of resources in the course of HIV infection. These factors could contribute to slower progression of the disease.

BMI was positively associated with maternal age, independent of week of gestation at first visit. This contrasts with findings from other poor settings, where older women seem to be at higher risk of low body weight and low BMI (Ahmed *et al*, 1998; Garner *et al*, 1994). We were unable to ascertain whether our finding was independent of parity (Rodrigues & Da Costa, 2001) due to lack of data on the women's obstetric history.

Poverty has been previously identified as a strong predictor of low weight and BMI in adult women from developing countries. We found that having no formal education and limited per person expenditure on food were predictive of low average BMI, independent of the maternal HIV status and week of gestation. Among Bangladeshi women of low SES, those with better education and housing were heavier than the poorest (Baqui *et al*, 1994). In a study from Indonesia, BMI and weight were higher for women who had selected possessions at home compared to women without (Achadi *et al*, 1995). BMI was also higher in women from rural Somalia who had a radio or gold in the household, owned a farm, or had a profession, in comparison to women of lower SES (Omar *et al*, 1994). Material deprivation in these settings is likely to be accompanied by strenuous work loads, diminished food availability (Pastore *et al*, 1993), and increased incidence of infectious diseases, which lead to loss or limited accretion of body tissue. Higher level of education could potentially be related to improved nutritional status independently of poverty (Islam *et al*, 1994), through mechanisms including enhanced hygienic practices, better knowledge of foods and food preparation, earlier identification and treatment of infections and more adequate management of household resources.

Average height in this group of mothers was 155.1 cm, slightly lower than the national average for adult women reported by the 1996 Tanzania Demographic and Health Survey (TDHS), 156.4 cm (Bureau of Statistics (Tanzania), 1997). We found a significantly increasing trend in maternal stature across categories of age; mothers above 30 y were 1.7 cm taller than those of less than 20 y. In the Tanzania Demographic and Health Survey, mothers between 30 and 34 y were 1.1 cm taller, on average, than those below 20 (Bureau of Statistics (Tanzania), 1997). Also, in studies from Nigeria (Adekolu-John, 1990), Bangladesh (Baqui *et al*, 1994), and Israel (Villamor *et al*, 1998) older women were taller than the youngest. In a study from India, however, no association was found (Srivastava *et al*, 1998), and in Papua New Guinea an inverse relationship between age and adult height was observed (Garner *et al*, 1994). In these cross-sectional studies, the variation in stature across age groups may reflect the effect of changing environmental conditions that have differentially affected successive birth cohorts. A positive relationship between year of birth and stature is consistent with a secular increase in average adult height, that for various populations has been estimated to range between 0.3 and 3 cm/decade (Hauspie *et al*, 1996), and has been associated with a relative improvement in living conditions over time. This may not be the case among Tanzanian women. An additional explanation for the strong cross-sectional association between age and height is that women could have extended their period of growth beyond adolescence. It has been shown that nutritionally deprived subjects with delays in skeletal and sexual maturation can exhibit complete catch-up growth after puberty (Dreizen *et al*, 1967; Kulin *et al*, 1982; Riley, 1994). Indicators of better SES, such as a higher level of education attained, the possibility of contributing to the household income, and greater amount of money spent on food per person per day were associated with higher average maternal height and lower prevalence of short stature. This is in agreement with previous reports from developing (Baqui *et al*, 1994) and developed countries (Bielicki & Waliszko, 1992; Meyer & Selmer, 1999; Villamor *et al*, 1998). The level of education of an adult women is likely to represent her parents' socioeconomic background and, indirectly, early influences in her growth process as poor SES is related to decreased availability of food and higher prevalence of infectious diseases (Bhuiya *et al*, 1986). Alternatively, women who were taller than average during childhood may have been selectively subjected to upward social mobility through gaining access to a higher level of education, as described in other population groups (Bielicki, 1983; Bielicki & Waliszko, 1992; Cernerud, 1995). Among mothers having a partner, those married to soldiers, drivers or professional men were taller, on average, than women married to farmers, after controlling for other indicators of the woman's SES. This could be partially explained by the fact that the woman's occupation may be correlated with her partner's. Also, taller women may have experienced selective upward social mobility by marriage to partners with more stable and better remunerated jobs. Ethnicity may have a plausible effect on body build in this population, and can be also related to the SES. Although the region of origin may partially represent the woman's ethnic background in this population, and it was introduced as a control variable in the model for height, residual confounding of the association between SES and stature by ethnicity cannot be ruled out. The effect of ethnicity on height, however, is likely to be substantially smaller than that attributable to environmental conditions, as described for most populations living under poverty (Floud *et al*, 1990).

This study has a number of limitations. First, its cross-sectional nature limits the possibility of establishing the temporal sequence of the associations found and therefore prevents us from making causal inferences. Second, we lacked information on some important predictors of maternal nutritional status such as the mother's reproductive history, prevalence of additional infectious diseases, and stage of HIV disease. These variables could have explained additional variability in the anthropometric outcomes. However, given the substantial strength of the associations observed between socioeconomic indicators, HIV infection and nutritional status, it is unlikely that confounding by unmeasured factors could have been considerable. In spite of these limitations, we are able to conclude that indicators of the past and present socioeconomic background of women are strongly predictive of their nutritional status at first prenatal visit, independent of their HIV status. Additionally, HIV infection is an important risk factor for wasting during pregnancy.

Our findings support the view that increasing the availability of food in the household among women of low SES and enhancing their capacity to allocate household resources could be related to improvements in their nutritional status. Prevention of HIV infection could be a key factor in decreasing the burden of malnutrition in Tanzanian women of childbearing age.

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