Food insecurity, diet quality and body composition: data from the Healthy Life Trajectories Initiative pilot survey in urban Soweto, South Africa

Abstract

Objective: To determine whether food security, diet diversity and diet quality are associated with anthropometric measurements and body composition among women of reproductive age. The association between food security and anaemia prevalence was also tested.

Design: Secondary analysis of cross-sectional data from the Healthy Life Trajectories Initiative (HeLTI) study. Food security and dietary data were collected by an interviewer-administered questionnaire. Haemoglobin levels were measured using a HemoCue and anaemia was classified as an altitude-adjusted haemoglobin level <12.5 g/dL. Body size and composition were assessed using anthropometry and dual energy x-ray absorptiometry.

Setting: The urban township of Soweto, Johannesburg, South Africa

Participants: Non-pregnant women aged 18-25 years (n=1534)

Results: Almost half of the women were overweight or obese (44%) and 9% were underweight. Almost a third of women were anaemic (30%). The prevalence rates of anaemia and food insecurity, were similar across BMI categories. Food insecure women had the least diverse diets and food security was negatively associated with diet quality (food security category vs. diet quality score: B= -0.35, 95% CI: -0.70, -0.01, p=0.049). Significant univariate associations were observed between food security and total lean mass. However, there were no associations between food security and body size or composition variables in multivariate models.

Conclusions**:** Our data indicate that food security is an important determinant of diet quality in this urban-poor, highly-transitioned setting. Interventions to improve maternal and child nutrition should recognise both food security and the food environment as critical elements within their developmental phases.

Introduction

Being overweight or obese prior to, and during, pregnancy can have adverse consequences for women and their babies [1]. Among women, the risks include reduced fertility, gestational diabetes or impaired glucose tolerance, lipid disorders, hypertension and pre-eclampsia [1,2]. Among the offspring, there are risks of fetal macrosomia and obesity in the short and longer term respectively, as well as of developing cardiometabolic disorders during adolescence and adulthood [2]. Rates of overweight and obesity among women of reproductive age are increasing globally and particularly in middle- and upper middle-income countries [3]. In South Africa, there has been an increase in female obesity from approximately 33% in 2005 to 38% in 2014 [3]. In Soweto, the combined prevalence of overweight and obesity has been estimated at approximately two thirds [4]. A recent Lancet series reported the double burden of malnutrition as a public health problem which has emerged in South Africa since the 1990s [5]. Specifically, a large proportion of women who are currently of reproductive age would have been stunted, wasted or underweight in childhood, and are now susceptible to, or experiencing overweight and obesity. This early undernutrition, followed by over nutrition in adult life, is the least favourable trajectory for cardiometabolic disease risk across the life course [6].

A food security-obesity paradox has been described in the USA whereby both food insecurity and obesity have been increasing since 1999, particularly among women [7]. The term 'food insecurity' is often understood to mean 'insufficient access to food' or 'hunger' [8]. However, it is also possible to consume sufficient, or even excess, calories yet be unable to consume a diverse, high quality diet due to lack of availability, access, or affordability of healthier foods, as well as a lack of time and resources to prepare them. This lack of access to a healthy, diverse diet is sometimes termed 'nutrition insecurity' and is characterised by a double burden of overnutrition (overweight and obesity) alongside persisting micronutrient deficiencies such as anaemia [9].

In low- and middle-income countries, the likelihood that food insecurity will lead to obesity, rather than undernutrition, is driven by the interplay of several complex mechanisms, including the quantity and diversity of food consumed, as well as the affordability of high energy, processed foods and the level of access to nutritious food [10]. Thus, the relevance of the food security-obesity paradox to low- and middle-income settings, where the capacity of health systems is least equipped to respond to the consequences, requires further investigation [10].

Central to the growing burden of obesity in middle-income settings including South Africa, is the nutrition transition; whereby traditional, indigenous diets are replaced with frequent consumption of processed high fat, salt and sugar foods and drinks [5,11–14]. Such foods are often cheaper and more accessible than healthier foods such as fruit, vegetables, dairy foods, pulses, fish, lean meats, nuts and seeds. Also, they often require less time and resources for preparation.

In terms of the measurement of overweight and obesity, these are typically assessed using body mass index (BMI). This approach is convenient in large scale studies, but does not consider the distribution of fat, or differentiate between fat and lean mass. For example, a waist circumference ≥80cm can be indicative of central adiposity whereby fat is stored around the abdominal organs and is associated with cardiometabolic risk [15]. Alternatively, a person with a high proportion of lean mass could also have a high BMI, for example an athlete. Metabolically and functionally the consequences of either of these would be very different, which is why BMI is limited. The proportion of an individual's adiposity and lean mass is also associated with disease risk [16].

The objective of the present study was to determine whether food security, diet diversity and diet quality are associated with anthropometric measurements and body composition among non-pregnant women of reproductive age enrolled in the Healthy Life Trajectories Initiative (HeLTI) study in Soweto, South Africa [17]. The association between food security and anaemia prevalence in these women was also tested.

Methods

Study Setting

The HeLTI study was initiated in 2016 in South Africa, Canada, China and India in response to the need for preconception interventions in low- and middle-income countries (LMICs). It aims to implement interventions during preconception, pregnancy, infancy and childhood, to optimise women's physical and mental health, reduce childhood obesity and the risk for cardiometabolic disease, and improve child development [18].

The HeLTI site in South Africa is in Soweto, Johannesburg. Soweto is a large urban area situated in the mining belt of Johannesburg, consisting of both formal and informal housing (shacks). The population was 1.27 million in 2011 with a population density of 6357 people per km^2 [19]. Over the past decade, economic change and a rapid emergence of fast food outlets have transformed the landscape of food availability and choice.

Participants

Non-pregnant women aged 18-25 years were recruited between June 2018 and June 2019 from randomly selected clusters in Soweto through home visits conducted by trained fieldwork teams. Women with a medical history of type 1 diabetes, cancer or epilepsy were not eligible for the study.

Data Collection

The present study uses data from the Soweto Young Women's Health Survey which was the screening and baseline data collection tool for the HeLTI study in Soweto. Household level data collection was conducted in participants' homes. The young women were then invited for individual level data collection at the South African Medical Research Council (SAMRC)/Wits Developmental Pathways for Health Research Unit, located within the Chris Hani Baragwanath Academic Hospital in Soweto (the largest hospital in the Southern Hemisphere). Food security and dietary data were collected by an interviewer-administered questionnaire. Body size and composition data were collected using anthropometry and DXA. Anthropometric data collection followed World Health Organization (WHO) anthropometry standards, and all research assistants were trained by trainers from WHO. Haemoglobin levels (g/dl) were assessed using a HemoCue and anaemia was classified as a haemoglobin level of <12.5 g/dL based on the WHO's altitude-adjusted threshold [20,21].

Food Security

Food security was assessed using a questionnaire based on the tool developed by the Community Childhood Hunger Identification Project which has been described in detail elsewhere [22–24]. Specifically, three questions were asked regarding whether the respondent's household ever experienced any occurrence of being unable to buy food as follows:

1. "Does your household ever run out of money to buy food?"

2. "Do you ever cut the size of meals or skip meals because there is not enough money for food?"

3. “Do you go to bed hungry because there is not enough money to buy food?”

Women who answered ‘no’ to all three questions were categorised as ‘food secure’. If a woman answered ‘yes’ to one of these three questions they were categorised as ‘at risk’ and if they answered yes to two or more of the three questions they were categorised as ‘food insecure’.

Diet diversity and diet quality

Diet diversity and quality were assessed using a dietary practices questionnaire. This questionnaire asked women about the occurrence and frequency of consumption of specified food or beverage groups during the previous day and month respectively. Specifically, diet diversity was assessed by asking whether the women consumed foods from the following 14 groups on the day before the interview (grains, orange vegetables, white roots and tubers, dark green leafy vegetables, orange fruit, other fruit, other vegetables, organ meat, other meat or poultry, eggs, fish or seafood, beans or peas, nuts or seeds, milk or milk products). Food groups were based on the Minimum Dietary Diversity Score for Women produced by the Food and Agriculture Organization (FAO) and USAID’s Food and Nutrition Technical Assistance III Project (FANTA), which is designed primarily to derive a diet diversity score as an indicator of dietary macro- and micronutrient adequacy [25]. While this document is based on 10 mutually exclusive food groups, the food group list was adapted into 14 food groups for this population in order to consider context-specific characteristics as recommended by the FAO [26] and more accurately capture diversity within core food groups. For example, extensive research in this setting using quantitative food frequency questionnaires shows that intake of refined grains is common, while availability and intake of vitamin-A rich vegetables and white roots and tubers is less so [4,27,28]. Thus, distinguishing between these categories is important in describing dietary diversity and micronutrient adequacy in this setting. All items consumed on the previous day were coded ‘1’, with a code of ‘0’ given for all items that had not been consumed. A diet diversity score was then calculated by summing the responses [29]. A maximum score of 14 indicated maximum diet diversity and women were divided into tertiles based on their diet diversity score.

Diet quality was assessed according to the frequency of consumption of the above 14 food and beverage groups during the past month. In addition, women were asked about the frequency of consumption of processed meat, fried snacks, savoury snacks, bakery items, sweets, fizzy drinks and condiments. The possible responses for frequency of consumption were: ‘every day’, ‘2-4 times per week’, ‘5-6 times per week’, ‘once per week’, ‘less than once per week’, ‘never’. A diet quality score was created based on the method described by Imamura et al. [30]. Briefly, we computed frequency scores based on responses to 18 of the food items. For the following ‘healthy’ foods, more frequent intakes scored more highly: orange vegetables, dark green leafy vegetables, orange fruit, other fruit, other vegetables, organ meat, other meat or poultry, eggs, fish or seafood, beans or peas, nuts or seeds, milk or milk products. For the ‘unhealthy’ foods, more frequent intakes scored low: processed meat, fried snacks, savoury snacks, bakery items, sweets and fizzy drinks. The maximum diet quality score of 126 would be achieved if a woman consumed all of the ‘healthy’ foods on a daily basis and none of the ‘unhealthy’ foods. If a woman consumed all of the ‘unhealthy’ foods on a daily basis and consumed the healthy foods less than once per week, she would have a score of 0. For data analysis, the diet quality score was used as a continuous variable.

Body size and composition

All measurements were taken by trained members of research staff. Height was measured to the nearest 0.1 cm using a Holtain wall-mounted stadiometer (Holtain Ltd, Crymych, Wales) and weight was measured to the nearest 100g using SECA scales (SECA, Hamburg, Germany). BMI was calculated as: weight (kg)/height (m^2). Measurement equipment was calibrated daily. Mid-upper arm circumference was measured half way between the shoulder (acromion) and elbow (olecranon) and waist circumference was measured halfway between the iliac crest in the mid-axillary plane and the lowest rib margin according to standard protocols. All measurements were taken in triplicate and the mean values were calculated for use in analyses. Fat and lean mass were measured using DXA whole body scans (Hologic Inc, Marlborough, Massachusetts) and were analysed as ‘whole body less head’. DXA scanning was conducted by trained radiographers on a Hologic machine and following daily quality control procedures. Fat % was calculated using the DXA values in kgs divided by total weight. Fat mass index (FMI) and lean mass index (LMI) were calculated by dividing the mass in kgs by height in metres squared.

Covariates

Socio-demographic data on age, duration of education in years, parity (number of live births) and household socio-economic status were collected by questionnaire. Socio-economic status was assessed using an asset score which summed the number of assets owned in the household from the following options: TV, car, washing machine, fridge, phone, radio, microwave, cell phone, DVD/Video, DSTV (cable channel), computer, internet access, and medical aid. This asset score was based on standard measures used in the Demographic and Health Surveys household questionnaire (available at: www.measuredhs.com) and has been extensively utilised in this setting [31,32].

Data Analysis

Variables that were not normally distributed were log transformed (weight, BMI, waist circumference, fat mass, lean mass, fat %, FFSTM %, FMI, LMI) for analysis. These were all dependent variables and therefore the results relating to these variables in regression models should be interpreted in terms of percentage points. Descriptive statistics were computed for participant characteristics and dietary intakes. Food security and diet diversity scores were derived and categorised. A diet quality index was constructed and analysed as a continuous variable. The relationships between food security and diet diversity were examined using chi squared tests, and the associations between food security and diet quality using univariate linear regression. Associations between food security category and body composition outcomes, as well as between diet quality and body composition outcomes, were examined by creating dummy variables and using univariate and multivariate linear regression models, the latter adjusted for age, parity, education status and socio-economic status. Analyses were completed using SPSS v25 (IBM Corp) and StataSE version 16.0 (StataCorp, College Station, TX, USA).

Results

Table 1 presents the characteristics of women included in the analysis. The flow of participants through the study to reach the final sample size is depicted in Supplementary Figure 1. The median duration of women's education was 12 years. Of the 13 assets used to assess socio-economic status, the median score was 8. The median BMI was within the normal range, but approximately 44% of women were overweight or obese, and almost 9% were underweight. The median (IQR) fat % of normal weight women was 38 (35, 42) % compared to 32 (29, 34) % in underweight, 46 (43, 48) % in overweight and 51 (48, 53) % in obese women (data not shown). Half of the women were nulliparous and approximately 30% were anaemic.

Table 2 presents data on the percentage of women who consumed any item from each of the food groups on the day before the interview, as well as data on the frequency of consumption over the past month. The majority of women reported consuming grains on the previous day. Approximately two thirds of women consumed “other than vitamin-A rich” fruit, milk and fizzy drinks, and about half of the women ate orange vegetables, tubers, other vegetables, processed meat, fried snacks, savoury snacks and sweets on the previous day. The median (IQR) diet diversity score was 6 (4, 9) with the maximum score being 14.

The majority of women ate grains and condiments on a daily basis. Approximately half of the women consumed orange fruit, beans and fish/seafood less than once per week, and two thirds consumed nuts and seeds less than once per week. The majority ate non-processed and processed meat at least twice per week. Organ meat was consumed at least once per week by over two thirds of the women and approximately one third of women consumed fizzy drinks at least once per day. The median (IQR) diet quality score was 48.0 (44.0, 52.0); where a score of 126 would be the maximum.

Table 3 shows that women who were classified as food insecure and at risk of food insecurity tended to consume less diverse diets (i.e. have diet diversity scores in the lowest tertile). In addition, based on a univariate linear regression model, food security category was positively associated with diet quality score; i.e. food insecure women had the lowest quality diets and food secure women had the highest quality diets; (B= -0.35, 95% CI: -0.70, -0.01, p=0.049; data not shown).

The relationships between anaemia and food insecurity prevalence rates according to BMI categories are presented in Table 4. While the prevalence of anaemia was highest in underweight women (34%) and lowest in obese women (28%), there were no significant differences in anaemia prevalence according to BMI status. Irrespective of their nutritional status, over half of the women were either at risk of, or experiencing, food insecurity in their household.

Table 5 presents the associations between food security category and body size and composition using log regression models. The coefficients should be interpreted in terms of percentage points. Food security was not associated with measures of size including weight, MUAC and waist circumference. During univariate analyses, there was a significant association between food security and lean mass, such that women who were at risk of food insecurity had a lower absolute lean mass than those who were food secure. However, relative fat mass was not associated with food security nor were indices of fat mass. There was a borderline association between food security and lean mass index such that women at risk of food insecurity had a lower LMI than those who were food secure. There were no associations between food security and BMI, FMI or LMI in the adjusted multivariate models (adjusted for age, parity, education status and socio-economic status) (data not shown).

There were no statistically significant associations between either diet diversity score or diet quality score and measures of body size or composition in the univariate analyses (data not shown). In addition, multivariate models (adjusted for age, parity, education status and socio-economic status) showed no association between diet quality and body size or composition outcomes (BMI, FMI or LMI).

Discussion

The present study aimed to investigate associations between food security, diet diversity and diet quality and anthropometric measurements and body composition among women of reproductive age in the urban township of Soweto, South Africa. The association between food security and anaemia prevalence was also tested. We found that women who were the least food secure had the least diverse diets; with 46% of food insecure women consuming diets in the lowest tertile of dietary diversity compared to 39% of those who were food secure. Food insecurity was also associated with lower diet quality. Irrespective of their BMI, food insecurity and anaemia affected approximately a third of women. In addition, women who were the least food secure had a lower absolute lean mass, but there were no associations between food security or diet and measures of adiposity in models adjusted for socio-demographic factors.

To date there has been little research in urban South Africa on the links between food security and diet quality [33]. However, there is evidence that in poorer settings both adults and children consume monotonous diets mainly comprised of processed cereals and lacking in fruit, vegetables and other nutritious foods [27,34–36]. The paradox is that these diets are often high in energy, refined carbohydrates and sugar, and therefore may be linked with obesity, pregnancy disorders such as gestational diabetes and long term cardiometabolic risk among women and their children [37]. Furthermore, in some settings, there are issues around intra-household allocation of food with women and girls having reduced access to any nutrient-rich foods that are available [38]. Our study shows that women of reproductive age in Soweto consume poor quality diets with grains likely to comprise a dietary staple for most households due to their affordability and wide availability. Findings also indicate a tendency towards frequent consumption of highly processed high sugar and fat foods, as well as low intakes of nutrient- and protein-rich foods such as vegetables, fruit, seafood, pulses and nuts/seeds.

Our data also suggest that underweight and obesity may have common underlying causes; both resulting from the consumption of poor-quality diets and often co-existing with micronutrient deficiencies and conditions such as anaemia. While undernutrition may be the outcome of energy- and nutrient-inadequate diets, obesity is likely caused by high intakes of inexpensive, energy-dense, but micronutrient-poor, foods. Both of these scenarios are the result of poverty and limited financial resources which restrict the ability to afford a healthy and diverse diet. This provides the potential for introducing common interventions, such as those focused on improved diet quality, irrespective of body weight. However, while poverty and unstable incomes are likely to play a large part in the link between food security and diet diversity and quality, there may be other confounding factors among those who are food insecure. These could include: time and resources available to prepare food; increased convenience and availability of ultra-processed foods; taste preference, particularly if any ‘healthier’ options such as fruit and vegetables are not fresh or have been poorly stored; marketing and advertising of ultra-processed foods; or an unhealthy food environment [39,40] (Ersze et al, Public Health Nutrition, in press). The food environment in settings such as Soweto has to date been under-studied and will be a focus of our future research. However, a previous qualitative study in this setting showed that young women living in Soweto feel that, while unhealthy, energy dense foods are easily accessible, affordability and availability limit their access to healthier food items [41].

In terms of the link between food security and body size and composition, our findings were somewhat unexpected. Our data indicated that food security may be associated with greater lean mass; however, these associations were no longer evident after accounting for overall body size. In addition, there was no association between diet quality and any of the outcomes. Previous research findings are inconsistent which may be explained by the extent of the nutrition transition in different settings [42–44]. For example, in lower income settings where the quantity of calories is inadequate, it is more likely that chronic energy deficiency will result from food insecurity. In contrast, in higher income settings where calories are plentiful, but nutrition security may be an issue, overweight and obesity are more likely to be a problem. A cross-sectional study in Connecticut, USA among parents and children found that 50% of households were food insecure, and adults in these households were more likely to be obese than those who were food secure. In addition, having an obese parent in the household significantly increased the risk of being an overweight child – suggesting that the relationships between food insecurity and obesity may track into the next generation [45]. In South Africa, where two thirds of women enter pregnancy overweight or obese, targeting this intergenerational cycle of obesity through improving household level food and nutrition security and optimising body size and composition prior to conception is critical.

In order to assess cardiometabolic risk, it is important to study longitudinal associations between food security and body size and composition [7]. While not possible from our cross-sectional data, a previous NHANES study in the USA assessed food security and followed participants up for one year. Women who were food insecure were more likely to be obese at baseline than those who were food secure. In addition, women in food insecure households were more likely to gain approximately 4.5kg more weight than those from food secure households [46]. This highlights the need to understand how the observed relationships between food security and diet track over time, as well as how these factors may be associated with body size and composition in the longer term.

Strengths and Limitations

A major strength of our approach was our access to a large, high quality dataset. The availability of detailed body size and composition measurements enabled us to study body size, composition and distribution of body fat as outcomes. This level of detail is limited in large scale studies and is likely to be important in understanding the mechanisms associated with cardiometabolic disease in transitioning societies. However, the data we analysed were cross-sectional and thus it is not possible to determine the direction of the associations between the exposure and outcome variables in this study. It will be of interest to determine whether there are longitudinal associations between food security, diet and body composition outcomes in the future and the HeLTI study platform provides an opportunity to do so. The age range in this study was relatively narrow with women recruited between 18 and 25 years. Although almost half of the women were overweight, the variability in body composition outcomes is likely to be lower than among the full range of reproductive age, since age is positively associated with adiposity.

In future research, it would be beneficial to collect more detailed quantitative dietary data in order to calculate energy and nutrient intakes. In addition assessing other elements of diet, for example calculating a dietary inflammatory index, may be useful in assessing the associations between diet and cardiometabolic risk [47].

Public Health Implications and Future Research

It has been previously estimated that over a quarter of South African households are at risk of food insecurity [48]. Specifically, research suggests a shift in poverty and poor nutrition from rural to urban areas, with greater prevalence of food insecurity in urban settings [34]. In the recently published Lancet series on the Double Burden of Malnutrition, it appears that the prevalence of undernutrition has declined in South Africa but that of overweight and obesity is increasing. The authors argue that it is important to understand where the burden of overweight is occurring and how it is likely to affect the health of those living in poverty now and in the future. Particularly in South Africa, the proportion of women and children who are undernourished has reduced in the past 20 years, but maternal overweight and obesity is a major public health problem [33]. Given the link between food security and diet diversity and quality, strategies aimed at improving household food security in urban areas such as South Africa may be important in establishing healthier dietary habits, as well as nutritional and metabolic profiles in the long term. Food environments in particular should benefit from public policies aimed at restricting the availability and affordability of energy-dense, ultra-processed foods and increase access to minimally processed and fresh foods, especially in low-income areas such as Soweto. In addition, it is important to understand how other aspects of lifestyle – for example women's changing roles which require them to work outside the home and place greater demands on their time - influence demands for ultra-processed energy-dense foods [5].

Future research aimed at reducing the burden of cardiometabolic disease in LMICs would benefit from focusing on the link between food security and diet and aiming to fully understand the determinants of dietary diversity and diet quality. Complex long-term interventions that are both nutrition-specific and sensitive are likely required to improve maternal and child health outcomes.

Table 1 Characteristics of non-pregnant women of reproductive age enrolled in the Healthy Life Trajectories Initiative (HeLTI) study

Characteristic	Mean/ Median	SD/ IQR
Age (years)	21.0	19.0, 23.0
Education (years)	12.0	12.0,13.0
Socio-economic status (asset score *)	8	7, 10
Height (cm) **	159.4	6.0
Weight (kg)	61.3	53.4, 72.6
BMI (kg/m^2)	24.2	21.1, 28.7
MUAC (cm) **	28.4	4.5
Waist circumference (cm)	76.2	68.6, 85.4
Fat mass (kg) ***	22.9	17.0, 30.6
Lean mass (kg) ***	33.3	30.1, 37.0
% Fat mass	42.1	36.4, 47.4
FMI (kg/m^2)	9.0	6.7, 12.1
LMI (kg/m^2)	12.5	11.4, 13.8
BMI categories	**N**	**%**
Underweight (BMI <18.5 kg/m^2)	132	8.6
Normal weight (BMI 18.5-24.9 kg/m^2)	726	47.3
Overweight (BMI 25.0-29.9 kg/m^2)	366	23.9
Obese (BMI ≥30.0 kg/m^2)	310	20.2
Parity (live births)		
0	774	50.5
1	630	41.1
>1	130	8.4
Food Security		
Food secure	707	46.1
At risk of food insecurity	319	20.8
Food insecure	508	33.1
Anaemia (Hb <12.5 g/dL) [n=1519]		
No	1059	69.7
Yes	460	30.3

Abbreviations: BMI, body mass index; FMI, fat mass index; Hb, haemoglobin; IQR, interquartile range; LMI, lean mass index; MUAC, mid-upper arm circumference; SD, standard deviation; *Asset score out of a maximum of 13 items; ** Indicates those variables described as mean (SD); *** Whole body less head

Table 2 Dietary intake, diversity and quality of study participants

Food group	Consumed yesterday (%)	Frequency of consumption / week (%)				
		<1	1	2-4	5-6	≥7
Grains	95.4	1.4	3.2	16.6	7.9	70.4
Condiments	78.6	10.4	5.6	16.6	9.3	57.6
Other (non-processed) meat	74.6	4.7	8.8	35.9	18.4	32.0
Fizzy drinks	70.3	9.9	12.8	31.8	12.6	32.8
Other fruit	67.1	19.9	16.5	36.6	9.8	17.3
Milk	65.7	14.3	15.7	32.0	11.3	26.7
Fried snacks	57.1	15.3	17.9	36.4	11.8	18.5
Processed meat	52.7	22.2	19.4	33.2	9.6	15.7
Other veg	50.9	22.3	23.5	27.8	7.8	18.5
Sweets	50.7	24.9	15.9	20.8	9.1	29.3
Savoury snacks	50.5	22.7	20.2	28.7	9.9	18.5
White roots/ tubers	47.7	17.5	22.2	39.4	9.2	11.7
Orange vegetables	47.5	20.2	28.3	35.6	6.7	9.2
Bakery items	44.1	27.2	25.0	31.0	6.9	9.9
Eggs	41.1	23.4	18.4	34.0	11.0	13.2
Green leafy vegetables	37.5	33.5	27.2	30.0	5.3	4.0
Organ meat	36.6	31.8	28.5	28.9	7.2	3.6
Beans/ peas	28.5	44.2	28.1	21.9	4.2	1.6
Orange fruit	28.4	47.5	20.9	21.6	4.5	5.5
Seafood	23.6	50.2	29.6	15.1	3.6	1.6
Nuts/ seeds	18.8	67.0	17.6	10.1	2.1	3.2
Median (interquartile range) diet diversity score	6.0 (4.0, 9.0)					
Median (interquartile range) diet quality score	48.0 (44.0, 52.0)					

Table 3 Diet diversity scores according to food security categories

	Diet diversity score (%)			P*
Food security category	**≤5**	**5-8**	**≥8**	
Food secure	38.5	31.9	29.6	0.015
At risk of food insecurity	48.3	27.9	23.8	
Food insecure	46.2	26.6	27.2	

*P value relates to chi-square test for difference between diet diversity groups.

Table 4 Anaemia and household food insecurity prevalence rates according to BMI categories

	BMI category (%)				P **
	Underweight (N=132)	**Normal weight (N=726)**	**Overweight (N=366)**	**Obese (N=310)**	
Anaemia prevalence *	34.4	30.6	30.1	27.9	0.596
Household food insecurity prevalence					
At risk of food insecurity	28.8	20.0	18.3	22.3	0.193
Food insecure	28.8	34.9	33.3	30.7	

Abbreviations: BMI, body mass index; underweight, BMI <18.5 kg/m^2; normal weight, BMI 18.5-24.9 kg/m^2; overweight, BMI 25.0-29.9 kg/m^2; obese, ≥30.0 kg/m^2; *Includes mild to severe anaemia; n=1513; **P value relates to chi-square test for difference between BMI categories.

Table 5 Univariate associations between food security category* and measures of body size and composition

	Food Security Category (reference: Food Secure)	**B**	**95% CI**	**P**
Weight (kg)†	At risk	-0.02	-0.05, 0.01	0.119
	Food insecure	-0.02	-0.04, 0.01	0.264
BMI (kg/m^2) †	At risk	-0.01	-0.04, 0.02	0.329
	Food insecure	-0.01	-0.03, 0.02	0.582
MUAC (cm)	At risk	-0.29	-0.89, 0.31	0.336
	Food insecure	-0.31	-0.82, 0.21	0.244
Waist circumference (cm) †	At risk	-0.02	-0.04, 0.01	0.126
	Food insecure	-0.01	-0.02, 0.01	0.474
Fat mass** (kg) †	At risk	-0.03	-0.08, 0.03	0.306
	Food insecure	-0.02	-0.06, 0.03	0.516
Lean mass** (kg) †	At risk	-0.03	-0.05, -0.01	**0.010**
	Food insecure	-0.02	-0.04, 0.00	**0.057**
% Fat mass†	At risk	-0.00	-0.03, 0.02	0.915
	Food insecure	-0.00	-0.02, 0.02	0.995
% Lean mass†	At risk	-0.00	-0.02, 0.02	0.922
	Food insecure	-0.00	-0.02, 0.01	0.776
FMI (kg/m^2) †	At risk	-0.02	-0.07, 0.04	0.498
	Food insecure	-0.01	-0.05, 0.04	0.748
LMI (kg/m^2) †	At risk	-0.02	-0.04, 0.00	**0.055**
	Food insecure	-0.01	-0.03,0.01	0.227

Abbreviations: BMI, body mass index; FMI, fat mass index; LMI, lean mass index; MUAC, mid-upper arm circumference; *Independent variable was food security in 3 categories, the reference category was 'food secure' **Whole body less head. †Coefficients represent associations with log transformed variables and should therefore be interpreted in terms of percentage points

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