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Adolescents' dietary patterns, their drivers and association with double burden of malnutrition in adolescents: a cross-sectional study in Kenya's urban slums

Milkah N Wanjohi[1,4*], Elizabeth Wambui Kimani-Murage[1], Gershim Asiki[2], Michelle Holdsworth[3], Rebecca Pradeilles[3], Nelson Langat[1], Dickson A. Amugsi[1], Calistus Wilunda[1] and Kerstin Klipstein-Grobusch[4,5]

Abstract

Background The double burden of malnutrition (DBM) during adolescence is associated with growth and developmental impairment and risk of non-communicable diseases. There is limited evidence on adolescent's dietary patterns (DPs), and how they contribute to DBM in urban low income contexts in sub Saharan Africa. This study assessed DPs of adolescents, their drivers and association with DBM in Kenya's urban slums.

Methods Anthropometric, socio-demographic and dietary-intake data were collected through a cross-sectional survey of 621 adolescents from three major urban slums in Nairobi, Kenya. DPs were derived using principal component analysis. Multinomial-logistic-regression was used to assess the association between the DPs, individual and environmental factors and DBM.

Results Two DPs were identified: traditional DP (whole grains/cereals, rice, fruits, legumes/nuts, and water) and transitioning DP (refined cereals (maize/wheat), vegetables, meat, tea/coffee, sweet ultra-processed/deep fried snacks). Adolescents from Mathare (the largest slum) were more likely to adhere to the traditional DP (RRR = 3.43; 95% CI 1.85–6.37). Cultural background (Luo) had a positive association (RRR = 4.28; 95% CI 1.97–9.32), while longer residency in the slum (> 10 years) had a negative association (RRR = 0.47; 95% CI 0.25–0.90) with transitioning DP. The transitioning DP had a positive (non-linear) association with overweight/obesity in girls (RRR = 2.79; 95% CI 1.16–6.71). The DPs were not associated with thinness or stunting.

Conclusion The DPs indicate various stages of nutrition transition of adolescent diets, which are influenced by cultural background, neighbourhood and duration of stay in the slum. Transitioning DP may expose adolescents to the risks of overweight/obesity in the long-term.

Keywords Dietary patterns, Adolescents, Double burden of malnutrition, Overweight/obesity, Nutrition transition, Undernutrition, Urban, Slums, Kenya

*Correspondence:
Milkah N Wanjohi
mwanjohi@aphrc.org
Full list of author information is available at the end of the article

Background

Poor nutrition, including overweight/obesity and undernutrition during adolescence has adverse and intergenerational consequences such as growth and developmental impairment and increased risk of diet-related non-communicable diseases in adulthood [1]. The double burden of malnutrition (DBM), characterised by the co-existence of both overweight/obesity and undernutrition at individual, household or population level, is a growing concern among adolescents globally [1]. A review of the nutritional status of adolescents in various regions, including in sub-Saharan Africa (SSA), revealed persistent undernutrition and increasing trends in overweight and obesity [2]. This is also evident in Kenya, with increasing overweight/obesity alongside undernutrition among adolescents [3]. Unhealthy diets that are calorie dense and poor in nutrients are among the causes of DBM [2].

Urbanisation is associated with nutritional transition characterised by changes in dietary behaviour from traditional plant based diets such as whole grains, pulses/legumes, fruits and vegetables to increased intake of less healthy diets that are refined and low in fibre, highly processed, high in sugar, fat, salt, calories and animal source proteins [4]. Some of the drivers of the nutrition transition in SSA include the growth of super and hypermarkets in urban areas which is associated with increased availability, purchase and consumption of refined, processed and calorie dense foods; coupled with the proliferation of cheap and ready-to-eat ultra-processed food or deep fried street foods supplied by informal and street food vendors in urban low-income areas [5–9]. About 50% of global population is urban, and projected to grow to about 70% by 2050 [10]. SSA, is one of the world's fastest urbanizing regions, but poor urban planning and management has led to an increase of informal urban settlements (slums), about half of SSA urban population lives in slums [11]. In Kenya, about a third of the population is urban, with projections for the growth of urban population up to 50% by 2025 [12]. The increasing rate of urbanisation in the country has led to proliferation of urban informal settlements (slums) [13]. Half of urban dwellers in Kenya live in slums [14], characterised by limited provision of government services such as health, education, water and sanitation; poor and congested living conditions and high rates of poverty and food insecurity, which may impact their dietary behaviour and nutritional outcomes. Indeed, urban slum dwelling is a global problem, representing about a quarter of urban dwellers globally, which translates to over a billion people living in slums globally [15].

Establishing healthy dietary behaviours and reduction of harmful exposures such as poor diet during adolescence will help reduce the risk of DBM, morbidity, disability and premature mortality later in adulthood [16]. Understanding adolescents' dietary patterns (DPs), the factors driving them and how they are associated with DBM is a first step in the development of interventions to enhance the healthiness of their dietary patterns, as a strategy to address DBM. Assessment of overall dietary patterns (DPs) may be more predictive of health outcomes than single foods or nutrients [17]. Characterising DPs also allows the linkage and effects of overall diet to be examined, rather than specific individual foods or nutrients whose association with health outcomes may be difficult to identify. Factor and cluster analysis are some of the data driven approaches used in DP assessment [18]. Principal component analysis (PCA), is an a posteriori factor analysis that describes actual intake patterns, by deriving linear combinations of foods or food groups, based on their interrelations [19]. There is a documented dearth of adolescent specific nutrition evidence and programming in Kenya [20], with a call for action to address adolescent nutrition needs [21]. In addition, few studies have examined actual adolescents' DP using a posteriori methods in Kenya. The majority of published studies are limited to a *priori* methods, such as assessment of dietary diversity or food group consumption [20]. This study therefore assesses the DPs of adolescents, their drivers and association with the DBM in Kenya's major urban slums using PCA method.

Methods

Study design and settings

A cross-sectional household survey was conducted between August and December 2021, among adolescents aged 10–19 years living in major urban slums in Nairobi city, Kenya (Mathare, Korogocho, and Viwandani). This study was nested within the Nairobi Urban Health and Demographic Surveillance System (NUHDSS) [22] and a larger Healthy Food Africa (HFA) project [23]. The African Population and Health Research Center operates the NUHDSS in Korogocho and Viwandani slums, through which health and demographic data are collected routinely from about 79,000 individuals (aged 0–105 years) living in 25,000 households [22]. The HFA is a research and innovations project aimed at creating sustainable, equitable and resilient food systems in African cities [23]. The NUHDSS formed the sampling frame for adolescents in Korogocho and Viwandani, while the HFA project's baseline household listing formed the sampling frame for adolescents in Mathare. The three slums represent different urban slum contexts. Mathare slum is one of the oldest and is the second largest slum in Nairobi and Kenya. Korogocho and Viwandani are smaller slums, Korogocho has a more stable population with longer slum residency (14 years) and higher levels of chronic poverty compared

to Viwandani. Viwandani is located in the industrial area of Nairobi city, has a more mobile population with shorter slum residency (8 years) and a relatively higher social economic status compared to Korogocho [22, 24].

Study design and settings

Sample size was calculated using Cochran's formula for estimating sample size for proportions, using the documented prevalence of overweight/obesity among school going adolescents (14 to 19 years) in Nairobi as 17.6% [25] and taking into account a level of precision of 5%, with 95% confidence level. Adjusting for a 20% non-response rate yielded a sample size of n=327 (~330) adolescents. Two age strata of younger (10-14 years) and older (15-19 years) adolescents were powered independently. A total sample size of 660 for both age groups was therefore estimated. A list of all households with eligible adolescents was obtained from the NUHDSS data for Korogocho and Viwandani and the HFA project from Mathare. Random sampling was used to select a sample of 660 adolescents, proportionate to the number of eligible adolescents in each slum.

Data collection

Anthropometric measurements to assess DBM

Anthropometric measurements (height and weight) were taken using standardised procedures, barefoot with minimum clothing [26]. Weight was measured using a portable Seca 874dr (seca corp) weighing scale to the nearest 0.1 kg, while height was measured using a portable Seca 217 (seca corp) stadiometer to the nearest 0.1 cm. Two measurements were taken for both height and weight and the average obtained.

Double burden of malnutrition (DBM)

The main outcome was population level DBM, defined as the co-existence of both overweight/obesity and undernutrition (thinness and stunting) among sampled adolescents in the three slums. Height-for-age (HAZ), and BMI-for- age Z-scores (BMIAZ) were first computed using the WHO anthros stata macros (2007) [27]. The Z-scores were then classified as thin (BMIAZ < -2), overweight (BMIAZ > +1 and < +2), obese (BMIAZ > +2 BMI) and stunted (HAZ < -2SD), based on the WHO 2007 growth reference [27]. In this study, we used combined overweight/obesity as one group because of small numbers in the obesity group.

Dietary intake (to derive dietary patterns)

Dietary data were obtained through quantitative multiple 24-h open recall interviews. To capture intra-individual variability in dietary intake, two 24-h recalls were conducted on two non-consecutive days, representing one weekday and one weekend, within a period of one month. Multiple pass method/steps were followed for dietary data collection [28]. On each visit, adolescents were asked to list all the foods they had consumed the previous day from the morning (when they woke up) to the end of the day (when they went to sleep), with probes on foods that are easily forgotten (e.g. water, beverages, snacks). Information on each of the food items listed including the eating time and details of the food item (food type, ingredients of mixed dishes and brand names of commercially produced foods, method of cooking) and amount consumed was collected, after which a final probe on foods that may have been missed in the listing was undertaken. The food portion sizes and amounts consumed were estimated with the aid of the Kenya adolescent photographic food atlas [29], which contains photographic estimates of household measures, quantities and weights of foods that are commonly consumed by adolescents in urban settings in Kenya. The Kenya food composition tables [30] were subsequently used to establish the energy content of the foods consumed. The mean quantity of each food item and mean energy intake were computed as an average of the two days. Participants with energy intakes > 4000 and < 500 kcal per day, indicating implausible energy intake and potential misreporting, were excluded from analysis [31].

Dietary patterns

Principal component analysis (PCA) was used to identify the DPs from the food items consumed by the adolescents. The 153 foods items reported were categorised into 18 broad food groups based on the food and nutritional characteristics, national (Kenyan) key messages for healthy eating and existing literature [32] (additional file 1). Food group intakes (mean daily intake in g) were obtained by summing up the amount of food items consumed in each group. The food group intakes were then standardised, by creating Z-scores, to account for variation in the portion sizes consumed and used as the input variables in the PCA model. Kaiser Criterion (Eigen values > 1), and the breakpoint in the scree plot were used to identify the components (patterns) to be retained. Varimax orthogonal rotation was applied to enhance interpretability of the components and to ensure the independence of the derived factors. Food groups with factor loadings of ≥|0.2| were considered to contribute to the patterns based on existing literature [33]. The retained patterns were then defined/labelled based on the types of the foods/food groups that constituted them. Scores of the retained patterns were computed and stratified into quartiles for use in subsequent analysis.

Individual and environmental factors

A structured interviewer administered questionnaire was used to collect the adolescents' socio-demographic information, such as age, sex, education level, cultural background (ethnicity), neighbourhood of residence (Mathare, Korogocho and Viwandani) and duration of residence in the slum. Household level information including household food expenditure and asset ownership was obtained from the adolescent's primary caregiver. Average monthly household food expenditure reported by the caregivers was categorised into two groups: < 500 > 500 Kenya shillings. Household wealth index was computed from the reported household asset ownership using PCA and categorised into quintiles [34].

Story et al.'s [35] conceptual model of drivers of adolescents dietary behaviour categorises the drivers into individual (biological and behavioural), social environment (family, peers) and physical environment (community setting) and macro level factors. Based on this conceptual model, the adolescent's socio-demographic characteristics were categorised into individual level factors (age, sex, education level, meal skipping and energy intake), social environment factors (ethnicity, household wealth index and household food budget) and physical environment factors (neighbourhood, duration of residence in the slum) in the subsequent analysis.

Physical activity

Physical activity data were collected for use as an adjustment variable in the relationship between DP and DBM. The WHO STEPs survey questionnaire [36] was used for physical activity data collection, and categorised into low (< 420 min of moderate to vigorous activity per week), moderate (≥ 420 min of moderate to vigorous activity per week) and high (≥ 420 min of moderate to vigorous activity and ≥ 180 min per week of vigorous activities). This categorisation was based on WHO guidelines for physical activity and sedentary behaviour, for children and adolescents [37].

Statistical analysis

Data analysis was conducted using Stata version 17. Chi-squared tests were used to compare adolescent characteristics by sex. Multinomial logistic regression models were used to determine the association between adolescents' individual level factors (age, sex, education level, meal skipping, energy intake), social environment factors (ethnicity, household wealth index and household food budget) and physical environment factors (neighbourhood, duration of residence in the slum) and the DPs. Factors with p-value < 0.20 in the bivariate model were selected for inclusion in the multivariate logistic regression. Multinomial logistic regression models were used to assess the association between DPs and each of the adolescent DBM indicators (overweight/obesity, thinness or stunting). Model 1 adjusted for variables; age, ethnicity, education level, slum of residence, duration of residency in the slum and meal skipping. Model 2 adjusted in addition to the variables in model 1 for energy intake and physical activity. Factors with a p-value < 0.20 in the bivariate model were selected for inclusion in the multivariate logistic regression models since more traditional level p-values such as 0.05 used to select variables may not identify important variables [38].

Results

Out of the 660 adolescents sampled for the study, n = 621 participated in the two 24 h recall interviews. Thirty-nine were unavailable for at least one round of dietary data collection due to relocation out of the study area or to boarding school. Of the n = 621, n = 14 were excluded due to implausible energy intake, whereby n = 12 reported a very low energy intake (< 500 kcal per day) while n = 2 reported a very high energy intake (> 4000 kcal/day), resulting into an overall n = 607 participants for the current analysis.

Adolescents' individual level, social and physical environment characteristics

Almost two-thirds (63.9%) of participants were younger adolescents (10–14 years), and the majority were girls (60%). About half of the adolescents were upper primary school level (grades 4–8).

Kikuyu (30%) and Luo (20%) were the most prominent cultural backgrounds. Up to 90% of the adolescents' households spent ≤ Ksh 500 (approx. 4 USD) per day on food on average (Table 1). Majority of the adolescents were from Mathare slum and nearly three-quarters (72%) of them had lived in their slum area for > 10 years. (Table 1).

About a third of the adolescents reported to have skipped at least one meal per day. The mean (SD) estimated energy intake was 1604 (550) Kcals; boys 1636 (511) Kcal, girls 1581 (574) Kcal. Differences in energy intake between girls and boys were not significant (Table 1).

Anthropometric measurements/DBM

About 13% of the adolescents were overweight/obese, 6% were thin and 13% were stunted. A significantly higher proportion of girls were overweight/obese compared to boys, while stunting and thinness were significantly higher in boys compared to girls (Table 1).

Table 1 Adolescents' individual level, social and physical environment characterisitcs by sex

Characterisitcs		Total (N = 607)	Male (N = 243)	Female (N = 364)	*P*-value
Individual level characteristics					
Age	10–14 years	388 (63.9)	163 (67.1)	225 (61.8)	0.19
	15–19 years	219 (36.1)	80 (32.9)	139 (38.2)	
Education level	0–4 years	142 (23.4)	64 (26.3)	78 (21.4)	0.37
	4–8 years	321 (52.9)	124 (51.0)	197 (54.1)	
	≥ 8 years	144 (23.7)	55 (22.6)	89 (24.5)	
Meal skipping/day	0 meals	448 (73.8)	193 (79.4)	255 (70.1)	0.01
	≥ 1 meal	159 (26.2)	50 (20.6)	109 (29.9)	
Energy intake (Kcal/day)	Mean (SD)	1604 (550)	1636 (511)	1581 (574)	0.15
Social environment characteristics					
Ethnicity	Kikuyu	185 (30.5)	82 (33.7)	103 (28.3)	0.16
	Luo	124 (20.4)	41 (16.9)	83 (22.8)	
	Luhya	97 (16.0)	34 (14.0)	63 (17.3)	
	Kamba	118 (19.4)	54 (22.2)	64 (17.6)	
	Other (Specify)	83 (13.7)	32 (13.2)	51 (14.0)	
Household wealth index	Poorest	119 (19.7)	44 (18.1)	75 (20.7)	0.16
	Poorer	123 (20.3)	46 (18.9)	77 (21.3)	
	Middle	124 (20.5)	62 (25.5)	62 (17.1)	
	Richer	115 (19.0)	42 (17.3)	73 (20.2)	
	Richest	124 (20.5)	49 (20.2)	75 (20.7)	
Household average daily food expenditure (Ksh)	≤ 100	24 (4.0)	7 (2.9)	17 (4.7)	0.026
	101–500	547 (90.4)	229 (94.2)	318 (87.8)	
	> 500	34 (5.6)	7 (2.9)	27 (7.5)	
Physical environment characteristics					
Slum of residence	Korogocho	179 (29.5)	74 (30.5)	105 (28.8)	0.7
	Viwandani	179 (29.5)	67 (27.6)	112 (30.8)	
	Mathare	249 (41.0)	102 (42.0)	147 (40.4)	
Duration in slum	≤ 10 years	168 (27.7)	62 (25.5)	106 (29.1)	0.33
	> 10 years	439 (72.3)	181 (74.5)	258 (70.9)	
Anthropometric measurements/DBM status					
DBM status	Thin	38 (6.26)	25 (10.3)	13 (3.57)	0.01
	Overweight/obese	81 (13.34)	16 (6.58)	65 (17.86)	0.00
	Stunted	81 (13.34)	42 (17.28)	39 (10.71)	0.02
Physical activity level					
Physical activity	Low	205 (33.8)	66 (27.1)	139 (38.2)	< 0.001
	Moderate	207 (34.1)	74 (30.5)	133 (36.5)	
	High	195 (32.1)	103 (42.4)	92 (25.3)	

Physical activity: low (< 420 min/week, moderate(≥ 420 min/week), high (≥ 420 min/week + 180 min/week vigorous activity)

Dietary patterns

Eight components explaining a variance of 60%, were generated though the Kaiser Criterion method (Eigen value > 1). The scree plot break point method suggested two components which explained a variance of 21.8% and were more meaningful and interpretable compared to the eight components identified through the Kaiser Criterion method, which had few food items loading in each component and therefore difficult to interpret. The spider plot in Fig. 1 represents the factor loadings of all the food groups on the two DPs identified through the scree plot. Overall, it indicates two distinct DPs, one pattern with predominantly plant source minimally processed food groups and one with predominantly refined cereals, animal source foods, sweet and savoury snacks (ultra processed or deep-fried) and vegetables.

Table 2 further indicates food groups with at least |0.2| factor loading on the two DPs. Pattern 1 had a high positive loading on plant source, minimally processed foods, including whole grains, rice, fruits,

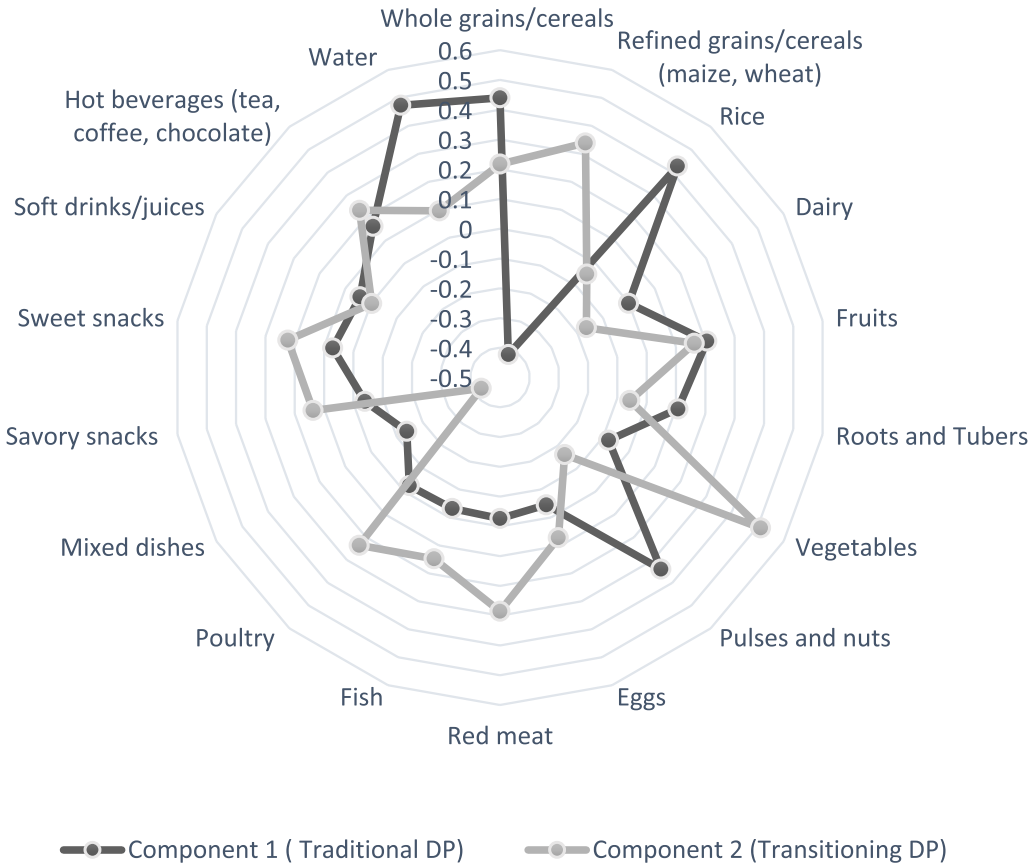

Fig. 1 Factor loadings of the 17 food groups on the traditional and transitioning DPs

Table 2 Rotated components (food groups) with at least 0.2 factor loadings on either of the two DPs

Food group	Traditional DP	Transitioning DP
Whole grains/cereals	**0.464**	0.159
Refined grains/cereals (Maize, wheat)	**−0.371**	**0.390**
Rice	**0.418**	−0.101
Dairy	−0.022	−0.163
Fruits	**0.205**	0.173
Roots and tubers	0.099	−0.070
Vegetables	−0.013	**0.516**
Legumes and nuts	**0.317**	**−0.205**
Eggs	−0.035	0.078
Red meat	0.010	**0.286**
Fish	−0.012	0.151
Poultry	0.004	**0.237**
Mixed dishes	−0.192	**−0.406**
Savoury (Ultra processed/deep fried) snacks	−0.022	0.141
Sweet (Ultra processed/deep fried) snacks	0.099	**0.213**
Soft drinks and juices	0.042	−0.008
Hot beverages (Tea, coffee, chocolate)	0.192	**0.211**
Water	**0.482**	0.035

legumes and nuts, and water and a negative loading on refined cereals. It was therefore labelled as the traditional DP. The second pattern had a high positive loading mainly on refined cereals, vegetables, meat (red meat, poultry) and sweet ultra-processed or deep-fried snacks (e.g. biscuits, cakes, sweets, and ice cream, *mandazi* (African doughnut)), hot beverages (tea, coffee, chocolate) and negative loading on legumes/nuts and mixed dishes. It was labelled as the transitioning DP (Table 2).

Individual level, social and physical environment factors associated with adolescent's DPs.

At the individual level, meal skipping was inversely associated with adherence to the traditional DP (RRR = 0.52; 95% CI 0.28–0.94). At the social environment, cultural background was associated with adolescent DPs whereby adolescents from Luo cultural background (RRR = 4.28; 95% CI 1.97–9.32) were more likely to adhere to the transitioning DP compared to those from the Kikuyu cultural background. At the physical environment, slum area and duration of residency in the slum were associated with the adolescents DPs. Adolescents from Mathare (largest slum) were more likely to adhere to the traditional DP (RRR = 3.43; 95% CI 1.85–6.37) compared to those from the Korogocho, while those who had lived in the slum for a longer period (> 10 years) (RRR = 0.47; 95% CI 0.25–0.90) were less likely to adhere to the transitioning DP compared those who had lived in the slum for a shorter duration (≤ 10 years) (Table 3).

Association between dietary patterns and DBM

Sex was associated with all indicators of nutritional status (thinness, stunting, and overweight/obesity); therefore, sex-specific analysis was undertaken in addition to the main analysis.

In the main analysis (overall model) no association was observed between the traditional and transitioning DP and DBM (Table 4).

In the sex specific analysis, a positive non-linear association was observed between transitioning DP and overweight/obesity in girls, which was sustained after adjusting for energy intake and physical activity. Girls with a higher adherence to the transitioning DP (quartile 3) were more likely to be overweight/obese compared to those with a lower adherence (quartile 1) (OR = 2.79; 95% CI 1.16–6.71). An inverse association was also observed between the traditional DP and stunting in girls in the crude model (OR = 0.16, 95% CI 0.04–0.64), but adjustment for energy intake and physical activity attenuated the association (Table 4).

Discussion

This study investigated the DPs of adolescents, their drivers and association with the DBM in Kenya's major slums. The DBM was observed among the adolescents with a higher prevalence of overweight/obesity compared to thinness. There were significant sex differences; overweight/obesity was more pronounced in girls while undernutrition was more pronounced in boys. This finding aligns with those of the recent Demographic and Health Survey in Kenya [3] and other SSA countries [39]. Sex differences in nutritional status have been attributed to a complex interplay of biological, social, cultural and environmental factors [40]. In this study, girls were more sedentary compared to boys, while an assessment of gender differences in adolescent's diets, physical activity and nutritional status in eight SSA countries observed that girls had a higher dietary diversity and consumption of animal source foods compared to boys who on the other hand were more physically active compared to girls [41]. Furthermore, in a qualitative study in the study area (Wanjohi., et al., unpublished), adolescent girls were perceived to be less physically active, ate more meals/more often than boys as they held the cooking responsibilities and were given preferential treatment in cases of inadequate food in the context of high levels of food insecurity in urban slums. These gender and sex differences in diet and physical activity that may contribute to sex differences the nutritional status of adolescent boys and girls in the long-term.

Two DPs were identified, the traditional DP was characterised mainly by consumption of plant source and minimally refined/processed foods while the transitioning DP was characterised by consumption of refined cereals, meat, ultra-processed /deep-fried snacks and vegetables. Popkin et al. posits that nutritional transition occurs in various stages; the pre-transition or early stage of transition is characterised by consumption of plant based, traditional foods (e.g. cereals and starchy staples) that are minimally processed and high in fibre, and water, while the mid to late stage of nutritional transition is characterised by consumption of refined carbohydrates, processed foods that are high in fat, sugar and salt, animal source foods and sweetened beverages [42]. As such, the two DPs reflect the various stages of nutrition transition of adolescent diets, in urban slums [42]. The traditional DP is indicative of a sub-population that is in the pre transition or early stages of nutrition transition. The transitioning DP reflects a sub-group that is already in the mid to late stage of transition [42].

A previous analysis of dietary patterns of young adolescents in Nairobi identified three patterns including (i) *a plant source and dairy* pattern which resembles the *traditional dietary pattern* in this study and (ii)

Table 3 Factors associated with adherence to traditional and transitioning dietary patterns (Multinomial regression model)

Q1 (Ref)	Traditional dietary pattern								
	Q2			Q3			Q4		
	RRR**	95% CI		RRR	95% CI		RRR	95% CI	
Individual level factors									
Sex *(ref: Male)*									
Female	1.35	0.84	2.17	1.21	0.76	1.94	1.03	0.63	1.67
Age	0.94	0.81	1.09	1.02	0.89	1.18	1.05	0.90	1.22
Education *(ref: Lower primary)*									
upper primary	0.90	0.45	1.82	0.84	0.42	1.69	0.61	0.30	1.25
≥ secondary	1.54	0.51	4.64	1.13	0.39	3.32	0.56	0.18	1.75
Meal skipping *(ref: no meal skipped)*									
≥ l meal skipped	0.72	0.41	1.24	0.52	0.30	0.92	0.52	0.28	0.94*
Energy intake	1.00	0.99	1.00	0.99	0.99	1.00	1.00	0.99	1.00
Social environment factors									
Ethnicity *(ref: Kikuyu)*									
Luo	1.59	0.82	3.09	0.72	0.35	1.46	0.63	0.31	1.28
Luhya	0.81	0.39	1.69	0.76	0.38	1.54	0.68	0.33	1.40
Kamba	1.22	0.62	2.39	0.82	0.42	1.61	0.54	0.27	1.11
Others	0.62	0.27	1.40	1.05	0.53	2.11	0.63	0.29	1.38
Physical environment factors									
Slum*(ref: Korogocho)*									
Viwandani	0.61	0.33	1.14	0.90	0.49	1.66	0.50	0.24	1.03
Mathare	1.10	0.61	1.99	1.37	0.74	2.51	3.43	1.85	6.37****
Duration in slum *(ref: ≤ 10 years)*									
> 10 years	0.80	0.44	1.44	0.85	0.47	1.54	0.68	0.37	1.25
Q1 (Ref)	**Transitioning dietary pattern**								
	Q2			Q3			Q4		
	RRR	95% CI		RRR	95% CI		RRR	95% CI	
Individual level factors									
Sex *(ref: Male)*									
Female	1.64	1.01	2.66	1.05	0.65	1.69	1.24	0.74	2.09
Age	1.02	0.88	1.18	1.12	0.96	1.30	1.07	0.91	1.27
Education *(ref: Lower primary)*									
upper primary	0.94	0.46	1.89	0.68	0.33	1.40	0.97	0.45	2.06
≥ secondary	0.78	0.26	2.31	0.65	0.22	1.96	0.68	0.20	2.30
Meal skipping *(ref: no meal skipped)*									
≥ l meal skipped	1.23	0.71	2.14	1.07	0.60	1.89	0.67	0.34	1.32
Energy intake	1.00	0.99	1.00	1.00	1.00	0.35	1.00	1.00	1.00
Social environment factors									
Ethnicity *(ref: Kikuyu)*									
Luo	2.41	1.16	5.03	3.43	1.65	7.14	4.28	1.97	9.32*
Luhya	2.49	1.20	5.17	2.91	1.38	6.15	2.15	0.92	5.02
Kamba	1.29	0.65	2.53	1.63	0.83	3.21	1.83	0.88	3.77
Others	0.79	0.39	1.60	0.66	0.31	1.41	0.69	0.31	1.54
Physical environment factors									
Slum*(ref: Korogocho)*									
Viwandani	1.33	0.70	2.53	1.44	0.74	2.78	1.11	0.55	2.26
Mathare	1.26	0.70	2.26	1.38	0.76	2.51	0.83	0.43	1.59
Duration in slum *(ref: ≤ 10 years)*									
> 10 years	0.62	0.34	1.14	0.75	0.40	1.38	0.47	0.25	0.90*

Table 3 (continued)

*$p < 0.05$

**RRR—Relative risk ratio

refined grains and vegetables; (iii) *animal source and fastfoods/snacks patterns*, which resemble the *transitioning pattern* identified in this study [43]. For other SSA countries at different levels of nutrition transition, so called 'western' dietary patterns in the southern region of SSA and a combination of both western and traditional dietary patterns in other parts of the SSA region were observed [44].

In line with the traditional DP observed in the current study, a review of school going children and adolescents' diets reported a predominantly plant based diet that was, low in fruit, vegetables and animal source protein [45]. Other studies have reported a high consumption of whole grains/cereals and plant source proteins among school going children and adolescents in Nairobi [46], and low vegetable and animal source food consumption by adolescents in African countries, including Kenya [47, 48]. The plant based pattern observed in our study may also be a reflection of aspects of the school meal programme in Kenya, which typically includes cereals (maize/rice) and pulses/legumes [49], as most adolescents in Kenya spend a majority of their time in schools. In urban slums, the low consumption of animal source foods could be due to their perceived high cost [50].

The transitioning DP reveals the growing transition of adolescent diets, from traditional, plant based diets to more refined and processed foods. It aligns with literature from various continents, including Africa, showing a general transition of adolescent diets towards processed energy dense and nutrient poor foods [45, 51], with urbanisation as a major driver of the nutrition transition [42]. In support of the transitioning pattern, previous studies in urban low income settings have documented high preference and consumption of ultra-processed and deep fried snacks among school children and adolescents [52], widespread consumption of sweetened tea (including chocolate/ coffee etc.) among adolescents and adults [53], and widespread consumption of low cost types of meat which are more affordable in these settings [50]. In addition, deep fried and processed foods and beverages are largely available in these settings, provided mainly by local vendors as cheap ready-to-eat street foods [50] and preferred by residents as a time, money and water saving strategy because they require minimum preparation or cooking [50]. The high loading of vegetables in the transitioning diets may be a reflection of common Kenyan cuisines, in which refined corn/wheat meals are commonly consumed with vegetable accompaniments [54, 55], as shown in an earlier study of young adolescents in Nairobi [43].

In contrast to other studies that clearly derived healthy and unhealthy DP in adolescents [56], each of the two DP derived in the current study possess both positive (healthy) and negative (unhealthy) dietary aspects. For instance, the traditional DP aligns with most of Kenya's healthy diet key messages, such as the consumption of whole or minimally processed foods, plant protein, fruits and water. However, it is limited in vegetable and animal source proteins, which are rich sources of iron and micronutrients. This is of concern in the long-term, as it may expose adolescent to risks of nutritional deficiencies and stunted growth, which are chronic nutritional challenges in the sub-Saharan region [57]. In the transitioning DP, vegetable consumption is positive, while the consumption of refined, ultra processed or deep fried foods and snacks may have detrimental effects in the long-term, since foods that are high in sugar, calories and poor in nutrients increase the risks of DBM and non-communicable diseases in the long term [4]. Interventions to address the impact of nutrition transition should therefore focus on identifying, and promoting the positive and curbing the negative aspects of diets of urban dwellers including adolescents.

Dietary behaviours, are informed and influenced by various factors within the individual, physical and social environment. In the current study, cultural background (ethnicity) was identified as a factor in the social environment that influenced adherence to the DPs. Unique differences in the foods commonly consumed by different cultural groups and communities in the country have been previously described [55]. For instance, among the Luo community, corn meal (*e.g.ugali* – commonly made from refined maize flour in urban areas), accompanied by fish and vegetables is one of the most popular dishes in this community. Among the Kikuyu community, meals made from cereals (maize), pulses (beans) and tubers (potatoes) (*e.g.githeri, mukimo*) are more popular [55]. This may explain the higher adherence of adolescents from Luo community to the transitioning DP with animal source foods, refined grains and vegetables, compared to those from the Kikuyu community in this study. A qualitative study among adolescents in the study community (Wanjohi et al., unpublished) showed cultural influences in their food consumption: Luo ethnic community was perceived to be more likely to consume fish and *ugali* (corn meal), and less likely to consume rice as they are

Table 4 Association between the traditional and transitioning DP and anthropometric/DBM status (Multinomial logistic regression models)

Q1 (Ref)	Traditional DP									
	Q2			Q3			Q4			*p* trend
	RRR	95% CI		RRR	95% CI		RRR	95% CI		
Overweight and obesity										
Overall sample										
Model 1	0.63	0.31	1.29	1.14	0.59	2.20	1.35	0.67	2.72	0.22
Model 2	0.66	0.32	1.36	1.16	0.60	2.25	1.34	0.66	2.71	0.26
Girls										
Model 1	0.51	0.22	1.19	0.99	0.45	2.14	1.35	0.59	3.09	0.14
Model 2	0.56	0.24	1.31	1.00	0.46	2.19	1.31	0.57	3.03	0.20
Boys										
Model 1	0.84	0.17	4.09	1.02	0.21	5.05	2.14	0.41	11.22	0.87
Model 2	0.84	0.17	4.14	1.01	0.20	5.03	2.16	0.41	11.45	0.86
Thinness										
Overall Sample										
model 1	0.51	0.17	1.58	1.49	0.63	3.56	0.94	0.35	2.56	0.70
model 2	0.52	0.17	1.59	1.49	0.62	3.57	0.95	0.35	2.59	0.69
Girls										
Model 1	0.25	0.02	2.59	1.01	0.20	5.21	2.62	0.48	14.44	0.17
Model 2	0.23	0.02	2.48	1.00	0.19	5.28	2.68	0.47	15.38	0.20
Boys										
Model 1	0.60	0.15	2.44	1.55	0.49	4.93	0.40	0.10	1.61	0.38
Model 2	0.62	0.15	2.53	1.53	0.48	4.91	0.41	0.10	1.67	0.41
Stunting										
Overall sample										
model 1	0.79	0.38	1.61	0.93	0.47	1.84	1.07	0.53	2.15	0.71
model 2	0.81	0.39	1.66	0.95	0.48	1.88	1.09	0.54	2.19	0.73
Girls										
Model 1	0.16	0.04	0.64*	0.66	0.26	1.67	0.72	0.27	1.91	0.89
Model 2	0.17	0.04	0.65	0.66	0.26	1.69	0.71	0.26	1.91	0.81
Boys										
Model 1	2.20	0.76	6.39	1.48	0.49	4.41	1.45	0.48	4.34	0.63
Model 2	2.24	0.77	6.53	1.56	0.52	4.73	1.51	0.50	4.58	0.60
	Transitioning DP									
Q1 (Ref)	**Q2**			**Q3**			**Q4**			***p* trend**
	RRR	**95% CI**		**RRR**	**95% CI**		**RRR**	**95%CI**		
Overweight and obesity										
Overall sample										
Model 1	1.01	0.49	2.08	1.48	0.73	3.00	1.51	0.73	3.13	0.58
Model 2	1.02	0.49	2.10	1.41	0.69	2.87	1.25	0.58	2.72	0.87
Girls										
Model 1	1.32	0.55	3.14	2.97	1.25	7.10*	2.18	0.88	5.42	0.13
Model 2	1.42	0.59	3.40	2.79	1.16	6.71*	1.75	0.68	4.55	0.49
Boys										
Model 1	0.43	0.08	2.30	0.29	0.05	1.82	1.96	0.42	9.11	0.77
Model 2	0.48	0.09	2.61	0.31	0.05	1.95	2.58	0.47	14.23	0.83

Table 4 (continued)

Q1 (Ref)	Transitioning DP									
	Q2			Q3			Q4			*p* trend
	RRR	95% CI		RRR	95% CI		RRR	95%CI		
Thinness										
Overall Sample										
model 1	0.37	0.13	1.08	0.70	0.27	1.78	1.05	0.44	2.53	0.60
model 2	0.37	0.13	1.10	0.71	0.28	1.82	1.13	0.44	2.95	0.57
Girls										
Model 1	0.94	0.17	5.10	1.16	0.17	7.91	3.77	0.74	19.05	0.13
Model 2	1.17	0.21	6.57	1.40	0.20	9.83	3.99	0.72	22.23	0.16
Boys										
Model 1	0.17	0.03	0.88	0.40	0.12	1.30	0.79	0.24	2.60	0.81
Model 2	0.19	0.03	1.02	0.42	0.13	1.39	1.09	0.28	4.28	0.89
Stunting										
Overall sample										
model 1	0.73	0.35	1.52	1.03	0.53	2.03	1.04	0.52	2.06	0.83
model 2	0.73	0.35	1.52	1.00	0.51	1.97	0.90	0.43	1.87	0.77
Girls										
Model 1	0.51	0.18	1.45	0.87	0.32	2.37	0.88	0.32	2.38	0.79
Model 2	0.54	0.19	1.54	0.85	0.31	2.34	0.80	0.28	2.30	0.95
Boys										
Model 1	1.21	0.41	3.59	1.29	0.49	3.36	1.47	0.53	4.03	0.68
Model 2	1.11	0.36	3.35	1.22	0.46	3.23	1.22	0.40	3.76	1.00

Model 1—Adjusting for age, education, meal skipping, ethnicity, slum of residence, duration of residency

Model 2—Adjusting for variables in model 1 + energy intake and physical activity

*$p < 0.05$

considered popular/unpopular for their communities. Ethnic influences on DPs have been demonstrated in other contexts in Kenya [58]. Data from Uganda, showed that urban dwellers kept some of their cultural dietary habits and norms as a way of allegiance to their cultural heritage [59]. In The Gambia, social cultural practices played an important role in shaping adolescents' diets [60], while in the USA cultural (ethnic) variations in the home food environment was identified as a key influencer of adolescents dietary behaviour [61].

Within the physical environment, neighbourhood/slum of residence and duration of stay in the neighbourhood influenced the adherence to DPs by adolescents. In line with this finding, neighbourhood characteristics such as availability of food outlets, types of foods available, deprivation level and neighbourhood safety have been shown to influence individual food choices and dietary behaviour [62]. In Bangladesh, for instance, popularity of street foods in the adolescents' neighbourhoods was a major factor influencing their dietary behaviour [63]. In this study, adolescents who had lived for shorter period in the study area had a higher adherence to the transitioning DP compared to those who had stayed for a longer duration. In a study among women in Nairobi slums, who have migrated from rural areas, they reported influence from their children to consume new energy dense foods and snacks from street food vendors [64] and adopted obesogenic urban diets due to lack of steady income and time to prepare foods [64]. Qualitative studies can assist in understanding the underlying reasons and the pathways through which cultural background and neighbourhood influence the DPs of adolescents in the context of nutrition transition. Development and implementation of context specific interventions to promote healthy dietary behaviours among adolescents should also consider aspects of social (cultural background), and physical environment (neighbourhood and duration of residence) that may influence adolescents dietary patterns.

There was no clear association between the DPs and nutritional status in the overall study. The transitioning DP however was associated with overweight/obesity in girls. Though non-linear, this finding suggests a potential association between overweight/obesity and transitioning diets characterised by consumption of obesogenic foods such as refined, ultra-processed or deep fried snacks foods and snacks. These results are in line with

a review of adolescent nutrition in South Africa, which concluded that girls are at higher risk of obesity fuelled by consumption of diets that are energy dense, processed, high in fat and sugar and low in essential nutrients [2]. As such, interventions to limit the consumption of unhealthy and obesogenic foods identified in the transitioning DP should be implemented as strategies of addressing the increasing trend in overweight and obesity, especially in adolescent girls in urban settings.

Strengths and limitations

The dietary data were based on two 24 h recalls, which may not fully capture adolescents' food consumption over a longer period. However, the multiple 24 h recalls, reflected diet on a weekday and a weekend, hence capturing foods consumed both at school and at home. In addition, days of unusual food consumption, such as fasting, celebrations and illnesses were not included in the data collection period allowing for assessment of normal 24 h food consumption of the adolescents during the study period. The 24 h recall questionnaire was pretested in the study area, amended to include foods available and commonly consumed by adolescents, as well as local food names used in the study area to ensure that the food intake data were comprehensive. The study was cross-sectional and hence difficult to establish causality between DPs and DBM. Longitudinal studies that capture adolescents' food consumption and patterns for longer durations may derive patterns that have clearer associations with nutrition indicators and should therefore be considered in future studies.

Conclusions

The study findings found DBM among adolescents in urban slums and highlights DPs that are indicative of the different levels of nutritional transition in these settings. These DPs may contribute to both undernutrition and overweight/obesity in the long-term, such as poor consumption of vegetables and animal source foods (traditional DP), and high consumption of refined cereals and ultra-processed or deep-fried foods that are energy dense and nutrient poor (transitioning DP). Based on the study findings, interventions to reinforce a traditional DP, while also enhancing the consumption of vegetables, optimal intake of animal source proteins and limiting the consumption of refined, ultra-processed or deep-fried foods and snacks are recommended. Examples of such interventions may include school meals that promote locally available, diverse and minimally processed foods that align with the energy and nutrient requirements of adolescents. In addition, healthy eating messages and interventions targeting adolescents should focus on reinforcing the positive aspects, while curbing the negative aspects, identified in either of the observed DP that adolescents adhere to, as a strategy to address the DBM, in the context of urbanisation and nutrition transition. Development and implementation of such interventions should consider factors in the individual, social and physical environment that may influence adolescents' dietary behaviour such as adolescents' cultural background, the neighbourhoods where they live and duration of living in slum areas as highlighted in this study.

Abbreviations

BMIAZ	BMI for age Zscore
CI	Confidence intervals
DBM	Double burden of malnutrition
DPs	Dietary patterns
HAZ	Height for age Zscores
Kcal	KiloCalories
NUHDSS	Nairobi Urban Health Demographic Surveillance System
OR	Odds ratio
PCA	Principal componet analysis
RRR	Relative risk ratio
SD	Standard deviation

Supplementary Information

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Additional file 1.

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Author contributions

MW: led study conceptualisation and design, data collection, data analysis, drafting, review and finalisation of manuscript; EKM, GA, KKG: guided the study conceptualisation, methodology, data analysis, reviewed all versions of the manuscript: MH, RP, NL, CW, DA: guided data analysis, re-viewed all versions of the manuscript. All authors read and agreed on the final version of the manuscript for submission.

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Availability of data and materials

The dataset(s) supporting the conclusions of this article are included within the article and additional information included in the additional file 1. Additional data may be availed by the corresponding author on reasonable request.

Declarations

Ethical approval and consent to participate

The study was conducted according to the guidelines of the Helsinki Declaration. Ethical approval was obtained from AMREF ethics and scientific review committee (protocol number P919/2020) while a research permit was obtained from the National Commission for Science and Technology (NACOSTI/P/21/9739). Written assent and parental consent were obtained from all the adolescents < 18 years and their parents or primary caregivers

while informed consent was obtained from all adolescents ≥ 18 years, prior to data collection.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Author details
[1]Nutrition and Food Systems Unit, African Population and Health Research Center, Nairobi 10987-00100, Kenya. [2]Chronic Disease Management Unit, African Population and Health Research Center, Nairobi 10987-00100, Kenya. [3]UMR MoISA (Montpellier Interdisciplinary Centre on Sustainable Agri-Food Systems), (Univ Montpellier, CIRAD, CIHEAM-IAMM, INRAE, Institut Agro, IRD), 34394 Montpellier, France. [4]Julius Global Health, Department of Global Public Health and Bioethics, Julius Center for Health Sciences and Primary Care, University Medical Center, Utrecht University, Universiteitsweg 100, 3584 CX Utrecht, The Netherlands. [5]Division of Epidemiology and Biostatistics, School of Public Health, Faculty of Health Sciences, University of the Witwatersrand, 27 St Andrews Road, Parktown 2193, Johannesburg, South Africa.

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