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Hauta-alus, Helena H.

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1 **Urban and rural dietary patterns are associated with anthropometric and**
2 **biochemical indicators of nutritional status of adolescent Mozambican girls**

3
4 Helena H Hauta-alus¹, Liisa Korkalo², Riitta Freese², Carina Ismael³, and Marja Mutanen²

5
6 ¹Children's Hospital, University of Helsinki and Helsinki University Hospital, Helsinki, Finland,
7 Tukholmankatu 8 C, PO Box 20 Biomedicum Helsinki, 00014 University of Helsinki; ²Division of
8 Nutrition, Department of Food and Environmental Sciences, University of Helsinki, Helsinki, Finland,
9 PO Box 66, 00014 University of Helsinki; ³Food Security and Nutrition Association (ANSA), Av.
10 Agostinho Neto 1607, Maputo, Mozambique.

11

12 Corresponding author: Helena Hauta-alus; mailing address: Children's Hospital, University of
13 Helsinki and Helsinki University Hospital, Tukholmankatu 8 C, PO Box 20 Biomedicum Helsinki,
14 00014 University of Helsinki, Finland; email: helena.hauta-alus@helsinki.fi; telephone:
15 +3580947175731.

16

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18

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28

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30

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32 HHH, RF and LK performed the statistical analyses; HHH wrote the first draft of the manuscript; all
33 authors revised the manuscript and approved the final version of the manuscript.

34

35 Ethical standards disclosure: This study was conducted according to the guidelines in the Declaration
36 of Helsinki, and all procedures involving human subjects were approved by the National Ethical
37 Committee at the Ministry of Health in Mozambique. Written informed consent was obtained from all
38 participants and from their guardians if they were under 18 years of age at recruitment.

39

40

41 Abstract

42 **Objective:** The objective of this study was to explore whether dietary patterns (DPs) are associated
43 with nutritional status indicators among adolescent Mozambican girls.

44 **Design/Setting/Subjects:** In this population-based cross-sectional study we used the food frequency
45 questionnaire data of 547 girls aged 14-19 years from Central Mozambique to derive dietary patterns
46 by means of principal component analysis. We used two-level linear regression models to examine the
47 associations between the DPs and anthropometric and biochemical indicators of nutritional status.

48 **Results:** We identified three DPs: 'Urban bread and fats', 'Rural meat and vegetables', and 'Rural
49 cassava and coconut'. The Urban bread and fats DP was positively associated with body mass index-
50 for-age Z-score (BMIZ), mid-upper-arm circumference (MUAC), triceps skinfold (P for all < 0.001),
51 and blood haemoglobin (P = 0.025). A negative association was observed between Urban bread and
52 fats DP and serum folate (P < 0.001). The Rural meat and vegetables DP, and the Rural cassava and
53 coconut DP associated negatively with BMIZ, MUAC, and triceps skinfold (P for all < 0.05), but the
54 Rural meat and vegetables DP associated positively with serum ferritin (P = 0.007).

55 **Conclusions:** Urban and rural DPs were associated with nutritional status indicators. In a low-
56 resource setting, urban diet may promote body fat storage and blood haemoglobin concentrations but
57 compromise serum folate concentration. It is important to continue valuing the traditional, rural foods
58 that are high in folate.

59

60 Keywords

61 Dietary pattern, nutritional status, adolescent, undernutrition, nutrition transition, Sub-Saharan Africa,
62 Mozambique, low-income country

63

64 **Introduction**

65

66 Chronic undernutrition prevails as a public health problem in sub-Saharan Africa, and prevents
67 countries and individuals from developing to their full capacity^(1,2). During the past decade, the
68 scientific community has started paying more attention to the nutritional and health status of
69 adolescents. Patton et al. (2012) concluded that the adolescent health situation is the worst in sub-
70 Saharan Africa, with persisting high mortality due to maternal and infectious causes⁽³⁾. According to
71 several human development indices, Mozambique is at a very low stage of human development⁽⁴⁾.
72 Adolescent pregnancies are common, and 48% of girls are married before the age of 18^(5,6). These
73 issues threaten the health and development of this age group of girls, who also face the double burden
74 of malnutrition. Indeed, both high prevalence of undernutrition (stunting, anaemia as well as poor
75 zinc, vitamin A and iodine status)^(5,7) and overweight⁽⁸⁾ have been reported among Mozambican
76 adolescent girls.

77

78 The double burden of malnutrition may indicate a nutrition transition from receding famine towards a
79 phase of increased non-communicable diseases *via* changes in dietary patterns (DP)⁽⁹⁾. Nutrition
80 transition arises from economic growth and urbanisation, and is characterised by reduced physical
81 activity, a low intake of vegetables, and a supply of and preferences for ‘fast foods’ or ‘western-type’
82 foods^(10,11). An increased consumption of foods high in fat, sugar, and refined carbohydrates but low
83 in fibre and micronutrients, leads to problems of overnutrition, and may finally also cause a rise in
84 chronic diseases in sub-Saharan Africa^(10,11). Mozambique is estimated to be at the early stage of a
85 nutrition transition⁽¹²⁾. Cross-sectional surveillance data from Mozambique have shown rural-urban
86 differences in fruit and vegetable consumption⁽¹³⁾, body mass index (BMI)⁽¹⁴⁾, hypertension⁽¹⁵⁾, and
87 physical activity among adults⁽¹⁶⁾.

88

89 Valid characterisation of the Mozambican diet is needed, and a data-driven DP analysis is an effective
90 tool to achieve this. Studying the diet as DPs instead of single nutrients or foods has several
91 advantages^(17,18). Most importantly, while acknowledging that different foods are usually highly
92 correlated with each other, DP gives a more comprehensive reflection of the whole diet^(17,18).
93 Furthermore, investigating DPs on the basis of food consumption data is a useful method in diverse
94 cultural settings, where continual dynamic cultural transition may exist⁽¹⁹⁾. Further, understanding the
95 complexity of a diet in the context of a double burden of malnutrition is of interest in exploring how
96 diet associates with actual nutritional status.

97

98 Research on DPs has mainly focused on the associations with indicators of non-communicable
99 diseases, in sub-Saharan Africa and other places^(19, 20). Only a few reports exist on DPs as such or on
100 their association with nutritional status indicators in sub-Saharan Africa⁽²¹⁻²³⁾. Moreover, to our
101 knowledge, no studies have focused on DPs among adolescents in sub-Saharan countries. The
102 objective of this study was to investigate the characteristics of DPs and to explore whether certain DPs
103 are associated with the nutritional status of Mozambican adolescent girls in a cross-sectional setting.
104 The markers of nutritional status reflect body composition as well as micronutrient status in the
105 present study.

106

107 **Participants and Methods**

108

109 *Setting and participants*

110 The ZANE Study (Estudo do Estado Nutricional e da Dieta em Raparigas Adolescentes na Zambezia)
111 was a population-based cross-sectional study. A target sample size of 600 girls was determined based
112 on resources available. Detailed description of recruitment, sampling design and field work methods
113 have been previously published elsewhere⁽⁵⁾. Shortly, two separate samples of adolescent girls were
114 recruited in the Zambézia Province, Central Mozambique in 2010. The first sample was studied in
115 January–February, the ‘hunger season’ (n = 283) and the second in May–June, the harvest season
116 (n = 268). The sampling was carried out in five areas: 1) Quelimane City, 2) the district town of
117 Maganja da Costa, 3) rural villages in Maganja da Costa, 4) the district town of Morrumbala, and 5)
118 rural villages in Morrumbala. Girls were recruited from a total of 40 different localities within these
119 five areas. The localities (neighborhoods (*bairros*) or villages) were sampled using probability
120 proportional to size sampling (in the city and district towns, where population figures were available)
121 or random sampling (in the rural areas where population figures were unknown). Within each locality,
122 local recruiters were instructed to follow a recruitment plan while moving from house to house to
123 recruit girls. In the current paper, we divided the area into two categories: Quelimane City, which is
124 referred to as ‘Urban’, and district towns and rural villages, which is referred to as ‘Rural districts’.

125

126 If the participant’s date of birth was not known, it was estimated with the help of family members. A
127 total of 551 girls were studied. In this paper, we used the data on all girls who participated in a food
128 frequency questionnaire (FFQ) interview (n=547). These participants were adolescent girls aged 14–
129 19 years.

130

131 Written informed consent was obtained from all participants and from their guardians if they were
132 under 18 years of age at recruitment. This study was conducted according to the guidelines in the
133 Declaration of Helsinki, and all procedures involving human subjects were approved by the National
134 Ethical Committee at the Ministry of Health in Mozambique. The study was registered at
135 ClinicalTrials.gov (NCT01944891).

136

137 ***Background information and dietary assessment***

138 A background interview and a FFQ interview were conducted⁽⁵⁾. An asset score was calculated on the
139 basis of the household's ownership of items such as radios or bicycles, or other background variables
140 such as type of sanitation facility (for details, see⁽²⁴⁾). The interview included questions on whether the
141 girl was pregnant or breastfeeding a child at the time of the interview. Literacy was defined as the
142 ability to read a short test sentence in Portuguese. A Household Hunger Scale⁽²⁵⁾ score was calculated
143 for each participant. The scale is based on three main questions, asking whether a specific condition of
144 food insecurity ever occurred during the previous four weeks, and the frequency of occurrence. For
145 example, one question was: did you or any household member go to sleep at night hungry because
146 there was not enough food? The possible range of the score is 0-6⁽²⁵⁾. Score of 0 to 1 was categorised
147 as little or no household hunger and 2 to 6 as moderate or severe household hunger.

148

149 For this paper, we used information on the consumption frequency of all food items reported by 3% or
150 more of the participants (a total of 53 items). Of these, 37 items were included in the FFQ and 16 were
151 derived from the FFQ's empty lines reserved for additional foods mentioned by respondents during
152 the interview⁽⁵⁾. The additional 16 items were juice, soft drinks, pineapples, oranges, tangerines,
153 guavas, apples, *jambalau* fruit, potatoes, okra, green peppers, carrots, cucumbers, yams, taro, and
154 pasta. During the FFQ interview, participants were asked to estimate how many times they had
155 consumed different foods during the past seven days. They could choose from six categories: none, 1–
156 2, 3–4, 5–6, or 7 times per week, and more than 7 times per week. These were transformed into
157 continuous frequency variables using the following values: 0, 1.5, 3.5, 5.5, 7, and 10. Portion sizes
158 were not elicited.

159

160 ***Anthropometry and laboratory analyses***

161 Height was measured using a stadiometer and recorded to the nearest 0.1 cm. Weight was
162 measured using a digital scale and recorded to the nearest 100 g. Mid-upper-arm circumference
163 (MUAC) was measured twice using inelastic circumference measuring tape and recorded to the
164 nearest 0.1 cm. The mean of two measurements was used. Triceps skinfold was measured using a

165 Harpenden Skinfold Caliper (Baty International, UK). The anatomical sites were carefully located and
166 marked. Three measurements of each skinfold were taken without releasing the grasp of the skinfold.
167 If the results varied by more than 1 mm, the measurements were repeated. The final value for each
168 skinfold was the mean of the three measurements. BMI-for-age z-scores (BMIZ) were generated with
169 IBM SPSS Statistical programme (version 22) using a macro provided by the World Health
170 Organization⁽²⁶⁾. We used MUAC, triceps skinfold and BMIZ to reflect the fat mass of the body.

171

172 Pregnancy was tested from urine samples. If a pregnancy test result was not available, information
173 from the background interview was used to define pregnancy status. Information on the trimester of
174 pregnancy was not available. Venous blood samples (EDTA blood and serum) were drawn by
175 laboratory technicians. Blood haemoglobin concentration was tested using the HemoCue® 301
176 system. Serum high-sensitivity C-reactive protein (hsCRP), ferritin, and folate, as well as plasma
177 retinol concentration were analysed in the National Institute for Health and Welfare, Finland
178 (Laboratory accredited by Finas T077 (EN ISO-IEC 17025). Serum zinc concentration was analysed
179 in MTT Agrifood Research Finland. A comprehensive description of blood analysis methods has been
180 previously reported⁽⁷⁾. As infections may affect ferritin, retinol and zinc concentrations in the blood⁽²⁷⁻
181 ²⁹⁾, only results from participants with hsCRP less than 5 mg/l were included in the statistical analyses
182 of these nutrients.

183

184 *Statistical analyses*

185 Missing values for asset score items, literacy, pregnancy, and breastfeeding were imputed by hot deck
186 imputation, using area (five categories) as a deck variable. In addition, missing values for FFQ items
187 and HHS were imputed using area and season as deck variables. The number of missing values in the
188 FFQ ranged from 0 for foods such as rice and thick maize porridge to 15 (3%) for yam and taro. As
189 missing values for anthropometric and biochemical variables were not imputed, the number of girls
190 included in each analysis varied.

191

192 Principal component analysis (PCA) was applied to create DPs based on the consumption frequency
193 data of the 53 food items. We created DPs from food only and did not include dietary supplements in
194 the PCA. PCA retained 16 DPs with an Eigen value over 1. The first four DPs were initially chosen on
195 the basis of a scree plot. The analysis was then rerun with a forced four-component solution and, to
196 reduce correlation between components, Varimax (orthogonal) rotation was applied. After this, the
197 first three DPs were interpretable and were chosen for analysis. A standardized regression based DP
198 score was calculated for each girl for each of the components identified. This represents the girl's
199 adherence to each DPs.

200
201 One-way ANOVA and independent t-tests were used to test the associations between background
202 indicators and DP scores. Multivariate models were used to examine the associations between DP
203 scores with nutritional status indicators. This was done using two-level random intercept linear
204 regression models, taking into account the clustering of participants in localities. Locality (n = 40) was
205 treated as the higher-level unit and the individual girls as the lower-level unit. All models were
206 adjusted for age, season, breastfeeding status, and pregnancy status. An exception was the model for
207 BMIZ, which excluded pregnant girls and was only adjusted for season and breastfeeding status. The
208 number of girls who reported consumption of any type of dietary supplements was small (n=17) and
209 therefore we did not adjust the models for use of dietary supplements. The two-level regression
210 analyses were carried out using SAS 9.4 (proc mixed covtest) and all other analyses were conducted
211 using IBM SPSS Statistics version 22. P values of < 0.05 were considered significant.

212 **Results**

213
214 The mean age of the participants was 16 years (range: 14–19). The mean age of the non-pregnant girls
215 was 16 years and of the pregnant girls 17 years. Participants characteristics are presented in Table 1,
216 and statistics of the nutritional status indicators are presented in Table 2.

217
218 The three DPs explained altogether 24%, and the first, second and third DPs explained 11%, 7% and
219 7% of the total variance in food frequencies, respectively. The first DP was characterised by high
220 loadings of bread, tomatoes, onions, margarine & butter, rice, oil, sugar, potatoes, eggs, green peppers,
221 soft drinks, juice, fish, sweets, and buns, and was called ‘Urban bread and fats’ (Table 3). The second
222 DP was characterised by foods such as meat, poultry, pumpkins, okra, organs, bananas, other cereals
223 (sorghum, millet), cookies, maize cobs, groundnuts, papayas, boiled cassava, dark green leafy
224 vegetables, beans & peas, and yam, and was called ‘Rural meat and vegetables’. The third DP was
225 characterised by foods such as coconut, cassava porridge, mangoes, sweet potatoes, shrimps, cashew
226 nuts, and taro, and was called ‘Rural cassava and coconut’. DP scores ranged from -2.30 to 2.86 for
227 the Urban bread and fats DP, -1.59 to 5.09 for the Rural meat and vegetables DP, and -1.85 to 4.24 for
228 the Rural cassava and coconut DP.

229
230 Table 4 shows the mean DP scores according to sociodemographic characteristics. Girls who adhered
231 to the urban bread and fats DP were more likely to live in an urban area, to be literate, to have little or
232 no household hunger, and to have higher asset scores than other girls. Strong adherence to the Rural
233 meat and vegetables DP was more evident among girls who lived in rural areas, who were illiterate,

234 and who had little or no household hunger. Girls strongly adhering to the Rural cassava and coconut
235 DP were more likely to have been studied in the hunger season (January–February) and lived in a rural
236 area compared to other girls.

237

238 The Urban bread and fats DP was positively associated with BMIZ, MUAC, triceps skinfold, and
239 blood haemoglobin, and negatively associated with serum folate concentration (Tables 5 and 6). The
240 Rural meat and vegetables DP and the Rural cassava and coconut DP were both negatively associated
241 with BMIZ, MUAC and triceps skinfold. However, the rural meat and vegetables DP was positively
242 associated with serum ferritin. None of the DPs were associated with serum zinc or plasma retinol
243 concentrations.

244

245 **Discussion**

246

247 To our knowledge, the current study was the first to examine whether dietary patterns are associated
248 with anthropometric and biochemical indicators of nutritional status of adolescents in sub-Saharan
249 Africa. We studied Mozambican girls in a cross-sectional setting and identified three DPs: Urban
250 bread and fats, Rural meat and vegetables, and Rural cassava and coconut. The Urban bread and fats
251 DP was associated with a higher blood haemoglobin and anthropometric indices but was negatively
252 associated with serum folate concentration. In contrast, the two different rural DPs were negatively
253 associated with anthropometric indices. The Rural meat and vegetables DP was positively associated
254 with serum ferritin concentration, whereas the Rural cassava and coconut DP was not associated with
255 any of the micronutrient status indicators studied. Our findings show that firstly, in our study
256 population of adolescent girls living in poor socioeconomic conditions, DPs were strongly related to
257 anthropometric indices of nutritional status. Secondly, urban diet had concurrent negative and positive
258 associations with nutritional status, while rural diets had positive or no associations with micronutrient
259 status. These results underscore that moving towards a more urban diet in Mozambique may
260 compromise folate status.

261

262 Although food cultures differ in sub-Saharan Africa, and dietary assessment methods vary among
263 studies, the Mozambican DPs had similar characteristics to those of DPs identified elsewhere in sub-
264 Saharan Africa. The Urban bread and fats DP included refined energy-dense foods such as butter,
265 sugar, soft drinks, sweets and buns, but also foods that are regarded as healthy, such as vegetables and
266 fish. These findings are in line with previous reports from sub-Saharan Africa that have found DPs
267 called ‘Purchase’, ‘Urban’, ‘Fat’/‘animal’, ‘Vegetables and bread’, ‘Snacking’ or ‘Wheat-based

268 products^(20, 22, 23, 30-33). Furthermore, similarly to our results, studies in Ghana and Burkina Faso found
269 traditional DPs that included fruits, green leafy vegetables, maize, local cereals, and legumes^(20, 23). In
270 our study, the Rural meat and vegetables DP correlated with frequent consumption of different meat
271 and poultry, which are usually associated with urban dietary habits in sub-Saharan Africa^(19, 23).
272 However, the girls in our study ate only very small amounts of meat and poultry (unpublished data).

273
274 The classical nutrition transition from a ‘cereals predominant’ to ‘more fat’ diet usually starts from
275 urban surroundings and is related to increased adiposity⁽⁹⁾. Our study was cross-sectional and thus
276 does not describe a direct nutrition transition, which is a temporal process. Nevertheless, our results
277 may offer some insight into the type of consequences that are likely to follow if the Mozambican
278 population adopts more urban type diets with a high intake of energy-dense foods and a low intake of
279 nutrient-dense foods such as folate-rich green leafy vegetables and fruits. It has been suggested that
280 some valuable traditional foods are partly lost in urbanised diets⁽¹⁹⁾. Indeed, our finding that lower
281 folate status associated with an urban diet is of concern due to the importance of folate for brain health
282 during pregnancy and later life⁽³⁴⁾; and in more general, because folate is a biomarker for vegetable
283 and fruit consumption⁽³⁵⁾, which in turn is important in the prevention of non-communicable diseases.

284
285 In the context of our study population, the results showing that the urban diet had positive and the
286 rural diets negative associations with anthropometric indices of nutritional status are not as such
287 comparable to results in highly developed countries with little or no undernutrition. The majority of
288 our study participants were in the normal BMIZ range; the few overweight girls lived in an urban area.
289 We found no obesity in this study population⁽⁵⁾. Furthermore, stunting was prevalent in both the urban
290 and the rural areas⁽⁵⁾, suggesting that the population has suffered from undernutrition during
291 childhood. On one hand, the positive association between the urban diet and the anthropometric
292 indices reflecting body fat may indicate a risk of increase in overweight if this nutrition transition
293 continues in the future. On the other hand, the Rural cassava and coconut DP seemed more
294 monotonous than the other DPs, and was dominated by starchy foods. Thus, the negative associations
295 between rural DP and anthropometric indices could be viewed more as a sign of undernutrition than
296 desirable leanness.

297
298 Poor iron status, seen as low blood haemoglobin and ferritin concentrations, was prevalent in our
299 study. In this context, finding a positive relationship between the Rural meat and vegetables DP and
300 serum ferritin is important, as it highlights the valuable aspects of the rural diet. In contrast to our
301 results, Zeba et al. (2014) reported inferior nutritional status measured as blood haemoglobin, ferritin
302 and retinol among adults with a traditional diet compared to the urban diet in Burkina Faso⁽²³⁾. They

303 suggested this was due to meat consumption in the urban diet, and low bioavailability of these
304 nutrients in the traditional diet⁽²³⁾.

305

306 Our study had some limitations that should be noted. Applying DP analysis involves subjective
307 decision-making (selection of the food items included in the PCA and the choice of and naming of the
308 DPs)^(36, 37). Using data-driven PCA to retain DPs also limits the generalisation of these results⁽³⁶⁾.
309 However, a previous study in 12 different countries, including two sub-Saharan countries, discovered
310 two similar DPs across all study sites, despite the high variation in culture and economic
311 development⁽³⁸⁾. Thus, it can be suggested that DPs have significant similarities in diverse settings⁽¹⁹⁾.
312 As we used a large number of food items (53) to derive DPs, the DPs explained a moderate proportion
313 (24%) of the variance in diet. A similar proportion of variance explained was found in a previous
314 study from Sub-Saharan Africa⁽³⁰⁾. Our FFQ was not validated, and the possibility of misreporting
315 food frequencies cannot be ruled out. Finally, due to the cross-sectional study design, we were unable
316 to determine a causal relationship between DPs and nutritional status. Nonetheless, our study also has
317 some strengths. It covered two distinct seasons and different regions with diversified urbanisation
318 levels. Thus, our data provides a good representation of the adolescent girls in Central Mozambique.
319 The two-level statistical model used enabled us to reliably investigate the associations between diet
320 and nutritional status.

321

322 To conclude, our study suggests that Mozambican adolescent girls are at risk of a double burden of
323 malnutrition in urban areas. Micronutrient-rich foods from rural diets should not be discarded while
324 moving towards a more urban diet. Adolescent girls and their future children would benefit from
325 nutrition and health interventions.

326

327

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428 Table 1. Descriptive information on participants (adolescent girls in Central Mozambique,
429 year 2010, n=547)¹.

	n	Descriptive statistics
Age, mean, SD (range)	547	16, 1 (14-19)
Season when the girl was studied		
January-February	281	51%
May-June	266	49%
Place of residency		
Urban	179	33%
Rural districts	368	67%
Literacy		
Illiterate	290	54%
Literate	247	46%
Household hunger scale ²		
Little or no household hunger	440	81%
Moderate or severe household hunger	101	19%
Asset score, mean, SD (range) ³	547	20, 7 (5-44)
Household's ownership of a fridge ⁴		
Yes	470	14%
No	77	86%
Household's ownership of a bicycle ⁴		
Yes	327	60%
No	220	40%
Household's ownership of a motorbike ⁴		
Yes	60	11%
No	484	89%
Household's ownership of a car ⁴		
Yes	11	2%
No	538	98%

430 ¹ Note that n does not always add up to 547 due to missing data.

431 ² Based on questions the experience of household food deprivation during the past month
432 (for details see Ballard et al. 2011⁽²⁵⁾)

433 ³ The mean asset score was calculated using data that includes imputed values for missing
434 items. Theoretical score minimum and maximum were 0 and 45 (for details see Korkalo et al.
435 2017⁽²⁴⁾)

436 ⁴ Examples of items belonging to the asset score (without imputation of missing data).

437

438 Table 2. Nutritional status indicators of adolescent girls.

439

	Non-pregnant		Pregnant	
	N	Mean (SD)	N	Mean (SD)
BMI-for-age z-score	479	-0.30 (0.84)	60	0.10 (0.67)
Thin or severely thin (< -2 SD), %		2.3		-
Normal weight (-2 to 1 SD), %		92.5		-
Overweight (> 1 SD), %		5.2		-
Mid-upper arm circumference, cm	478	24.5 (2.1)	60	24.4 (2.0)
Triceps skinfold, mm	478	13.0 (4.3)	60	12.1 (3.7)
Haemoglobin, g/l	464	120 (16)	59	111 (17)
Low haemoglobin (< 120 g/l), %		42.7		-
Serum ferritin, µg/l ¹	407	24.9 (17.3)	39	23.9 (17.2)
Low serum ferritin (< 15 µg/l), %		37.6		-
Serum zinc, µmol/l ¹	402	9.6 (2.3)	39	9.2 (2.2)
Low serum zinc (< 9 µg/l), %		37.1		-
Plasma retinol, µmol/l ¹	405	0.90 (0.20)	39	0.78 (0.20)
Low plasma retinol (≤ 0.70 µmol/l), %		15.8		-
Serum folate, nmol/l	446	23.2 (10.4)	57	21.8 (10.3)
Low serum folate (< 10 nmol/l), %		9.4		-

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441 ¹Includes only participants with high-sensitivity C-reactive protein <5 mg/l.442 * WHO cut-offs were used for haemoglobin⁽³⁹⁾, ferritin⁽²⁷⁾, retinol⁽²⁸⁾ and folate⁽⁴⁰⁾, and443 International Zinc Nutrition Consultative Group cut-off for zinc⁽⁴¹⁾.

444 Dash (-) means not applicable.

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449 Table 3. Factor-loading matrix for dietary patterns identified by principal component analysis
450 and Varimax rotation.¹

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Food	Urban bread and fats	Rural meat and fruits	Rural cassava and coconut
Bread	0.75	0.11	0.04
Tomatoes	0.72	0.03	-0.11
Onions	0.66	-0.15	0.17
Margarine, butter	0.66	-0.03	0.04
Rice	0.63	-0.21	0.11
Oil	0.53	0.04	-0.10
Sugar, sugar cane	0.45	0.22	-0.06
Potatoes	0.45	0.02	-0.03
Eggs	0.45	0.32	0.19
Green peppers	0.41	-0.07	-0.14
Soft drinks	0.40	0.05	-0.06
Juice	0.36	0.15	0.04
Fish	0.36	-0.22	0.11
Sweets, chocolate	0.33	0.14	0.13
Buns, doughnuts	0.31	0.22	-0.01
Meat	0.25	0.61	0.03
Poultry	0.13	0.57	0.04
Pumpkins	0.10	0.55	0.07
Okra (ladies' fingers)	-0.01	0.53	-0.05
Organs	0.17	0.49	0.04
Bananas	0.10	0.49	0.05
Other cereals (sorghum, millet)	-0.17	0.47	-0.08
Cookies, biscuits	0.18	0.46	0.25
Maize cobs	-0.11	0.42	-0.06
Groundnuts	0.03	0.41	0.04
Papayas, ripe	-0.02	0.41	0.38
Cassava, boiled	-0.12	0.40	-0.20
Dark green leafy vegetables	-0.31	0.34	-0.10
Beans, peas	0.22	0.33	0.25
Papaya, green	0.15	0.32	0.18
Yams	0.02	0.32	0.06
Coconut, coconut milk	0.23	-0.24	0.59
Thick cassava porridge	-0.34	-0.13	0.56
Mangoes, ripe	-0.02	-0.07	0.53
White-fleshed sweet potatoes	0.04	0.14	0.51
Shrimps	0.25	-0.01	0.49
Orange-fleshed sweet potatoes	0.14	0.10	0.47
Cashew nuts	0.02	0.27	0.45
Mangoes, green	-0.02	-0.02	0.40
Taro	0.03	0.16	0.36
Thick maize porridge	0.04	0.22	-0.56

¹For simplicity, foods with no factor loadings above 0.3 or below -0.3 are not shown.

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453

454 Table 4. Mean dietary pattern (DP) scores according to sociodemographic characteristics
 455 (n=547)¹.

456

		Urban bread and fats DP	Rural meat and fruits DP	Rural cassava and coconut DP
	N	Mean (SD)	Mean (SD)	Mean (SD)
Season				
January–February	281	-0.01 (1.06)	-0.06 (0.99)	0.45 (1.02)
May–June	266	0.01 (0.94)	0.07 (1.01)	-0.47 (0.72)
P-value		0.895	0.124	< 0.001
Place of residency				
Urban	179	0.9 (0.84)	-0.36 (0.74)	-0.24 (0.79)
Rural districts	368	-0.44 (0.75)	0.18 (1.06)	0.12 (1.07)
P-value		< 0.001	< 0.001	< 0.001
Literacy				
Illiterate	296	-0.39 (0.86)	0.21 (1.04)	0.003 (1.05)
Literate	251	0.46 (0.95)	-0.24 (0.90)	-0.003 (0.94)
P-value		< 0.001	< 0.001	0.944
Household hunger score				
Little or no household hunger	443	0.05 (1.01)	0.06 (1.04)	-0.03 (0.98)
Moderate or severe household hunger	104	-0.23 (0.92)	-0.27 (0.77)	0.15 (1.08)
P-value		0.010	< 0.001	0.100
Household asset score				
Lowest asset score group	188	-0.60 (0.78)	-0.01 (0.94)	0.10 (1.12)
Middle asset score group	182	-0.08 (0.87)	0.04 (1.02)	-0.04 (0.97)
Highest asset score group	177	0.72 (0.86)	-0.03 (1.04)	-0.07 (0.89)
P-value		< 0.001	0.790	0.235

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458 ¹Independent-samples t-test and oneway ANOVA were used for significance testing.

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464 Table 5. Linear two-level models on association between adolescent Mozambican girls'
 465 dietary patterns and anthropometric measurements.
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	BMI-for-age z-score ¹ (n = 479)		Mid-upper arm circumference, cm (n = 544) ²		Triceps skinfold, mm (n = 544) ²	
	β (SE)	P-value	β (SE)	P-value	β (SE)	P-value
Fixed part						
constant	-0.30 (0.12)		19.8 (1.3)		5.0 (2.6)	
'Urban bread and fats' DP	0.17 (0.04)	< 0.001	0.5 (0.1)	< 0.001	0.9 (0.2)	< 0.001
'Rural meat and vegetables' DP	-0.11 (0.04)	0.006	-0.4 (0.1)	< 0.001	-0.7 (0.2)	< 0.001
'Rural cassava and coconut' DP	-0.11 (0.05)	0.019	-0.4 (0.1)	0.001	-0.7 (0.2)	0.002
Random part						
	Variance estimate (SE)		Variance estimate (SE)		Variance estimate (SE)	
Locality level	0.04 (0.02)		0.29 (0.14)		0.86 (0.55)	
Individual level	0.61 (0.04)		3.45 (0.22)		14.4 (0.92)	

467 DP, dietary pattern; SE, standard error

468 ¹ Pregnant girls excluded from analysis. Adjusted for season and breastfeeding status
 469 (yes/no).

470 ² Adjusted for age, season (January–February/May–June), pregnancy status (yes/no), and
 471 breastfeeding status (yes/no)

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Table 6. Linear two-level models on association between adolescent Mozambican girls' dietary patterns and biochemical indicators of nutritional status.

	Haemoglobin, g/l (n = 527) ¹		Ferritin, µg/l (n = 448) ²		Zinc, µmol/l (n = 443) ²		Retinol, µmol/l (n = 446) ²		Folate, nmol/l (n = 507) ¹	
	β (SE)	P-value	β (SE)	P-value	β (SE)	P-value	β (SE)	P-value	β (SE)	P-value
Fixed part										
Constant	131.3 (10.4)		52.7 (12.3)		9.62 (1.74)		0.74 (0.15)		30.4 (5.6)	
'Urban bread and fats' DP	1.9 (0.8)	0.025	-1.5 (0.9)	0.115	-0.12 (0.13)	0.374	-0.02 (0.01)	0.119	-2.2 (0.5)	< 0.001
'Rural meat and vegetables' DP	0.2 (0.8)	0.814	2.4 (0.9)	0.007	-0.04 (0.13)	0.779	0.00 (0.01)	0.955	0.7 (0.4)	0.099
'Rural cassava and coconut' DP	-0.9 (0.9)	0.297	-1.3 (1.0)	0.209	0.05 (0.14)	0.709	0.01 (0.01)	0.227	0.8 (0.5)	0.114
Random part										
	Variance estimate (SE)		Variance estimate (SE)		Variance estimate (SE)		Variance estimate (SE)		Variance estimate (SE)	
Locality level	14.0 (8.5)		19.6 (11.9)		0.46 (0.22)		0.001 (0.001)		16.9 (5.9)	
Individual level	226.4 (14.7)		250.9 (17.9)		5.02 (0.35)		0.036 (0.003)		58.0 (3.9)	

DP, dietary pattern; SE, standard error

¹ Adjusted for age, season, pregnancy status (yes/no), and breastfeeding status (yes/no).

² Includes only participants with high-sensitivity C-reactive protein < 5 mg/ l. Adjusted for age, season, pregnancy status (yes/no), breastfeeding status (yes/no).

