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Dietary patterns in Tanzania's transitioning rural and urban areas

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Abstract

Background Like other Sub-Saharan Africa (SSA) countries, Tanzania is undergoing socio-economic changes that impact lifestyles and dietary choices. Traditionally, differences in dietary habits between rural and urban areas in Tanzania and other SSA countries were prominent. However, recent research indicates converging lifestyles and dietary choices associated with increased risk of cardiometabolic diseases. The objective of the current study was hence to investigate differences and similarities in dietary patterns, energy, and food groups intake in urban and rural Tanzania.

Methods Dietary habits were assessed by use of a Food Frequency Questionnaire (FFQ) for 442 respondents aged 44–65 years in urban (Ubungo -Dar es Salaam) and rural (Kilindi- Tanga) districts of Tanzania. Dietary patterns were determined using Principal Components Analysis (PCA). Bivariate analyses identified determinants of dietary patterns in urban and rural Tanzania.

Results Two dietary patterns, a "mixed pattern" characterized by whole grains, potatoes, fruits, vegetables, meat, fried potatoes and tubers, alcohol, sugar-sweetened beverages (SSB), sugar and sweets, and added oils and a "plant-rich pattern" characterized by whole grains, fruits, pulses and peas, seasoning vegetables and salads, SSB, sugar and sweets, and added oils were identified. Urban residents contributed more to the mixed pattern, while rural residents had a higher contribution to the plant-rich pattern. Overall, dietary diversity was greater in urban than rural Tanzania. The estimated median daily energy intake was 2,902 kcal (IQR: 1449.2) with a lower energy intake in rural (2,817 kcal, IQR: 1,274) as compared to urban residents (3,052 kcal, IQR: 1558) ($p = 0.021$). The percent contribution to the median average daily energy intake for grains, fruits, and milk was higher in rural than urban participants. No differences were observed for meat, poultry and eggs.

Conclusion We identified two distinct dietary patterns: a "mixed pattern" prominent in urban and a "plant-rich pattern" more common in rural. Urban diets were more diverse with slightly higher energy intake. These findings underscore the effects of urbanization on diets and the need for targeted nutritional intervention for both rural and urban populations.

Keywords Diet, Dietary pattern, Energy intake, Macronutrients, Urban, Rural, Sub-Saharan Africa, Tanzania

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Background

Diet is a well-known predictor for health outcomes at individual and population levels [1–4]. Traditional diets have been associated with preventive effects against the occurrence of non-communicable diseases (NCDs) [5]. For example, the Mediterranean diet rich in whole grains, vegetables, fruits, low fat dairy products, fish and nuts is widely recognized for its potential in preventing cardiovascular diseases [2]. Globally, diets are shifting from traditional to diets high in refined foods including in SSA in a process referred to as "nutrition transition" [6]. For East African countries, changes in dietary patterns are hypothesized to have evolved over centuries driven by colonization and global trade [7], with a recent acceleration linked to pronounced ongoing lifestyle changes influenced by demographic, economic, and technological changes [5, 8, 9]. Notably, significant shifts in dietary patterns and energy intake towards refined foods with high energy content, fats and sugar, and low fiber, linked to inflammation, metabolite derangements, and non-communicable diseases [10, 11] have been observed in urbanized communities. Similar trends are increasingly documented in rural areas [12–14].

Presently, Tanzania's population spans over five overlapping sustenance points across the rural-urban gradient with different dietary patterns. These include hunter-gatherers, pastoralists, agro-pastoralists, farmers, and urban communities. Notably, a limited number of communities, such as the Hadzabe and Akie/Ndorobo tribes in the Northern part of the country, primarily rely on hunting and gathering [15–18]. The Barbaig, Maasai, and Sukuma predominantly lead semi-nomadic pastoralist lifestyles, with some engaging in agro-pastoralism [19, 20]. Various factors, including changes in land policies, diminishing pasture lands, and rapid population growth, are driving a shift from traditional practices within many of these communities [18, 19, 21, 22]. The remaining communities have diversified into a combination of small-scale agriculture and cattle-keeping or have migrated to urban areas. This diversity in livelihoods has been recognized as a crucial determinant of dietary patterns especially in rural areas [23–25]. Notably, pastoralists and agro-pastoralists are believed to have diets rich in dairy products and meat, whereas farmers rely more on cereals and tubers. However, the dietary patterns of pastoralists are undergoing a transition, with maize and beans gaining prominence alongside milk [26–28]. Hunter-gatherers' communities on the other hand, primarily depend on wild meat, tubers, and fruits. Generally, dietary patterns of rural communities are dynamic in nature due to seasonal variation [29], unlike urban areas where dietary changes are relatively minimal [30, 31].

Contemporary dietary patterns in Tanzania are driven by traditional patterns and informal interactions with other ethnic groups, particularly Indian and Arabs [32, 33]. As previous studies undertaken in Tanzania have mostly assessed dietary patterns either in rural or urban areas [12, 34, 35], in this study, we assessed the dietary patterns of the residents of two districts in urban (Ubungo) Dar es Salaam and rural (Kilindi) Tanga. The Dar es Salaam food supply largely depends on imported foods from other regions apart from saltwater fish that are available from the Indian Ocean. Based on this, residents have access to diversified food options including access to highly processed foods. Conversely, rural residents depend on seasonal home-grown foods and farm produce supplemented with occasional purchases from markets. Hence, we hypothesize their diets to be relatively less diversified, compared to urban residents.

Materials and methods

Study setting

Data were collected in Ubungo and Kilindi districts, in 2 of the 31 administrative regions of Tanzania namely Dar es Salaam and Tanga. Ubungo, one of 5 districts of the Dar es Salaam region is found on the South-Eastern part of the city at 6°47′20″S 39°12′20″E and borders Kinondoni district on the South-East and the Pwani region on the West and North. With a population of 1 million people, it is densely populated and unplanned in some areas and mostly covered with tarmac road networks, access to electricity, clean water, and better health care. Most residents in Ubungo district, and elsewhere in urban Dar es Salaam are migrants from other regions of Tanzania, who have mostly lost their traditional lifestyles. Ubungo was purposively selected for being the host district for the Cardiovascular Centre of Excellence in an effort to engage the surrounding communities.

On the contrary, Kilindi, a rural district in the Tanga region is sparsely populated with no tarmac roads, limited access to electricity, and health care services without a reliable source of clean water. It has a total population of 398,391 according to the 2022 census spread over 21 wards. It borders Handeni district to the East, and the Kilimanjaro and Morogoro regions to the North and South respectively [36]. The district is predominated by two native tribes of Nguu and Zigua who are mainly small-scale farmers. Kilindi was selected as a rural comparator to Ubungo district based on the geographical distance and socio-economic differences.

Study design, sample size, and sampling strategy

We conducted a cross-sectional study involving 492 men and women aged 44–65 years from January to February 2022. The sample size of 492 allowed us to detect a difference of 1.23 g of the average daily food intake between the two districts. It was calculated using the precision formula below;

$$n = \sigma_1^2 + \sigma_0^2/e^2$$

Where; σ_1 - Standard deviation of the average daily food intake in district 1

σ_0 - Standard deviation of the average daily food intake in district 0

$\sigma_1^2 + \sigma_0^2$– Sum of the variances of the two districts

e - Standard error [37].

A two-stage sampling approach was used whereby first random sampling was done to select clusters (2 wards in Kilindi and 2 wards in Ubungo districts) and subsequently to sample one person at the household level. A ward refers to an administrative division within a district, typically encompassing a collection of several streets in urban areas or 3–4 villages in rural areas. Data were collected at the household level through face-to-face interviews with the respondents. Most households had one or two people aged 44–65 years. Where two eligible participants were found, priority was given to males and where more than two participants of the same sex were present a research assistant was instructed to use a random number generator to select one person. After the recruitment of the study participants demographic, medical history, lifestyle, 24-hour dietary recall, and food frequency questionnaire (FFQ) data were collected. In this analysis, a total of 442 participants were included as shown in Supplemental Fig. 1.

Data collection

Data were collected at the household level through face-to-face interviews with the respondents by seven trained research assistants and one field supervisor. A REDCap (Research Electronic Data Capture) survey software hosted at the Muhimbili University of Health and Allied Sciences (MUHAS) was used for the collection and management of data [38, 39]. A validated FFQ for use in the Tanzanian population was used to assess dietary intake [40]. In addition, information on socioeconomic status, anthropometric measurements, and lifestyle variables such as smoking habits, alcohol intake, and information on physical activity was collected.

Dietary assessment

Dietary data were collected by use of a 30-day Food Frequency Questionnaire (FFQ) with 179 food items. The FFQ was initially developed and validated to estimate nutrient intake in the adult population in urban Dar es Salaam [40]. For this study, we refined and adapted the FFQ based on data from two non-consecutive 24-hour dietary recalls conducted with 50 participants in a pilot study.

Trained research assistants inquired about the consumption of each food item, one at a time, during the past week and 30 days before the study. The respondents were asked about the frequency of consumption per week and the usual amount consumed per meal.

To estimate portion size, participants were presented with a physical utensil model and asked to choose the one that corresponded to the utensil they typically use. The utensils models were selected during the pilot study done in the two districts and were used to estimate average quantities of commonly eaten foods including stiff porridge, all types of porridge, vegetables, rice, beans, tea, and milk. In cases where respondents expressed uncertainty about their utensil selection, they were asked to provide the actual utensil they use at home allowing the interviewer to make a more accurate estimation. To determine the average daily intake for countable food items like fruits, tubers, and boiled eggs, portion sizes were obtained from the Tanzanian Food Composition Table (TFCT) [41] or by weighing a sample of foods in the study area [41–43]. The portion sizes were multiplied by the reported frequencies and then divided by seven to obtain the average daily intake.

Average daily energy intake was estimated using reported frequencies, portion sizes, and the corresponding energy values from the Tanzanian [41], respectively Kenyan [43], and Indian [42] Food Consumption Tables. The distribution of energy intake across the study population was reported using the mean values across the dietary quartiles. As FFQs are prone to both under and overestimation of the dietary intake and subsequent energy intake, we report the proportion of the macronutrient contribution to the total daily energy intake to minimize the effects of misreporting of the absolute food intake values estimates by the FFQ [44]. In line with the previous FFQ validation study, we excluded all respondents with an average daily energy intake < 500 kcal or > 5000 kcal [40].

Dietary patterns

Reported food items were collapsed into 26 groups based on their nutritional similarities as shown in Table 1.

The reported frequency for each item was aggregated to obtain a single value for each group. The matrix of the group frequencies was used to derive dietary patterns using Principal Component Analysis (PCA). The PCA analysis was performed using the "Factorextra" and "FactorMiner" R packages. Scaling was applied to ensure each variables contributes equally to the PCA. Upon visual assessment of the scree plot we retained dimensions 1 and 2 (Supplemental Fig. 2).

These two dimensions explained 28% of the total variability observed in the data, with the first component explaining 21.1% of the observed variability. Subsequently, dietary patterns were obtained by considering food groups with factor loadings ≥ 2 (absolute value). The differences in dietary patterns between the districts were

Table 1 Food items from the FFQ collapsed into 26 food groups based on nutritional similarities

Food group	Food items
Whole grains	Maize cooked with beans (kande), maize on cob, maize porridge, mixed grains porridge, wheat porridge, millet porridge, popcorn, sorghum porridge, maize stiff porridge, industrial mixed grains porridge, millet stiff porridge
Refined grains	Rice with beans, pilau rice, plain boiled rice, rice flakes
Pasta and bread	Pasta and bread, rice bread
Pastries	Chappati, buns, pancakes, biscuits, cake
Tubers	Cassava, cooked green banana, taro, mixed taro, mixed cassava, roasted cassava
Potatoes	Potato boiled or baked, sweet potato alone, sweet potato in a mixed dish, irish potato, yam, mixed yam, ground yam
Fried potatoes and tubers	Fried plantains, potato chips, fried banana, fried yam, potato crisps
Pulses and peas	Beans/legumes alone, Beans in mixed dish, bhajia, green peas, green peas in a mixed dish, bean soup, bean cakes, bambara nuts, green beans
Nuts	Groundnuts alone, groundnuts mixed in food, cashew, ground groundnuts
Coconut products	Immature coconut water, Coconut milk (squeezed out of coconut)
Unprocessed red meat	Beef not minced, goat, pork, minced meat, meat samosa
Processed red meat	Sausage, bacon, bologna, Vienna sausage, ham, canned meat,
Organ meat	Offals, liver
Poultry	Chicken, eggs
Fish	Grilled fish, Dried fish, anchovies (dagaa), canned tuna in salt water, canned tuna in oil, canned fish in salt water, canned fish in tomato broth, fish curry, fresh fish, salt fish,
Dairy	Cow milk, yogurt, milk tea, powdered whole fat cow's milk, powdered fat free cow's milk, cow's milk full fat, cow's milk low fat, cow's milk fat-free, non-dairy creamer, plain yogurt, sweetened yogurt, ice cream, skimmed milk, cremora
Fruits	Ripe banana, papaya, jackfruit, baobab fruit, pineapple, avocado, orange, tamarind, mango, peaches, guava, avocado, lemon, apple, apricot, grapes, passion, sweet melon, berry, blood fruit, fruit canned in syrup, raisins, and other dried fruit, plum, tangerine, peas
Green leafy vegetables	Spinach, lettuce, amaranth leaves, pumpkin leaves, cow pea leaves, cassava leaves, other green leafy vegetables, okra alone, okra in mixed dish, green peas alone, green peas in mixed dish, zucchini, green beans, beet, broccoli, cauliflower,
Cruciferous vegetables	Cabbage, Chinese cabbage, other cabbage, broccoli, cauliflower
Seasoning vegetables and Salads	Green pepper fresh as in salad, tomato fresh in salad, mushrooms, carrot fresh in salad, tomato cooked, onions, okra, okra in mixed dish, green pepper fresh not in salad, mushrooms, carrot fresh not in salad, tomato fresh not in salad, green pepper fresh not in salad, vegetable samosa,
Cucurbits and Solanum	Cucumber, pumpkin, eggplant in mixed dish, African eggplant, eggplant alone, zucchini, watermelon
Alcohol	Fermented mealie pap drink, beer commercially prepared, beer locally brewer or homemade, wine commercially prepared, wine homemade or locally brewed, distilled alcoholic beverages commercially prepared, distilled alcoholic beverages
Other drinks	Coconut water, soy drink
Tea and coffee	Tea without milk, coffee
Juices	Other juices, sugarcane juice, orange juice
Sugar-sweetened beverages, Sugar, and sweets	Sugar, sweets, Soda, jam, honey, soda diet, squash or syrup, chocolate
Fats and oils	Cheese soft but not in liquid, cheese in liquid, other types of cheese, ghee, butter, mayonnaise, animal fats

assessed visually using a score plot of each observation onto the principal components (PC1 and PC2). Subsequently, a multivariate analysis of variance (MANOVA) was done to test the independence of the two PCs across districts. Additionally, a post-hoc Tukey test was conducted to evaluate the individual contribution of each PC within each district. Ordinal logistic regression was performed using variable selection based on Akaike's Information Criterion (AIC) to assess the relationship between exposure variables and dietary pattern quartiles.

Dietary diversity

Dietary diversity differences between the districts were measured using Bray-Curtis dissimilarity and the significance level tested using PERMANOVA. Additionally, dietary diversity for both overall and individual food groups was evaluated using the Shannon Diversity Index [45]. The differences in Shannon Diversity Index between districts were tested using the Kruskal-Wallis test.

Primary outcome variable

Dietary pattern quartiles were derived using PCA.

Physical measurements - weight, height, and waist and hip circumference

Anthropometric measurements including weight, height, waist, and hip circumference were obtained according to the WHO STEPS survey procedures and as previously used in the Tanzanian STEPS survey [46, 47]. Body mass index (BMI) was calculated based on weight and height (weight in kilograms/height^2 in meters) and categorized as per WHO classification into; less than 18.5– underweight, 18.5–24.9 normal, 25–29.9 overweight, and more than 30– obese.

Demographic and lifestyle variables

Demographic and lifestyle variables, i.e. age, sex, marital status, education level, level of income, source of water, alcohol consumption, cigarette smoking, and domestic animals kept were obtained. Age was categorized into four groups: 44–49, 50–54, 55–59, and 60–65 years. Marital status was reported as never married, currently married, separated, divorced, widowed, or cohabiting and was merged into the two categories into "in a union' and 'not in a union'.

Occupation and income levels per year

Respondent's occupation was detailed as government employee, non-government (NGO) employee, self-employed, student, homemaker, retired, unemployed (able to work), and unemployed (unable to work). These categories were re-classified into; 1– government employee or NGO employee, 2- self-employed, 3- student or non-paid work 4- homemaker or retired or unemployed during analysis. The level of income was assessed as the reported estimates of total income per year, month, or week (in Tanzanian Shillings) as used in Tanzania's STEPS survey with 5 levels; 1– less than 250,000 (~100 USD) per year, 2 - >250,000–499,999, 3- 500,000-749,000, 4–750,000-999,999, 5 – ≥1,000,000 per year, 6- Don't know or refused to answer. These levels were recategorized as 1–2– low, 3–4– middle, and 5- high-income levels.

Smoking and alcohol use

Smoking was assessed by asking the respondent about the current use of any tobacco products (cigarettes, cigars, or pipe), or smokeless tobacco. Alcohol use was assessed by current use of alcoholic beverages in the past 30 days.

Data analysis

Data was analyzed using the R software statistical package [48, 49]. Continuous variables were assessed using mean and standard deviations and in the case of not normally distributed data median, and interquartile range (IQR) while Pearson's Chi-squared or Fisher's exact tests were used to compare the frequencies between categorical variables and gender and geographical locations. Chi-square and regression analysis was used to investigate the determinants of dietary patterns.

Missing data

Missing data were addressed using multiple imputation techniques assuming data to be missing at random (MAR). We used the MICE package in R to create 10 different datasets each with imputed means [50]. The means were then averaged to give a single estimate and adjusted standard errors according to Rubin's rule. A sensitivity analysis was performed to compare the outcomes between the imputed and complete datasets. The results revealed no substantial differences in the derived dietary patterns quartiles or their association with various variables. However, a notable effect was observed in the education level variable, where the significance level increased from 0.2 to 0.09 after imputation. Overall, the impact on other variables in relation to both patterns was minimal, and sensitivity analysis suggests minimal effects of the imputed missing data on the overall findings.

Results

Of the 492 study participants reached, 489 individuals with complete data records were included in the analysis, 247 urban and 242 rural residents. Out of the 489 individuals, 13 individuals were not found at home during subsequent visits for anthropometric measurements. Therefore, missing values for these individuals for height, weight, hip, and waist circumference were considered to be "at random" and were estimated using multiple imputations as described in the methods section. In line with the previous validation study [40], 47 individuals whose average reported daily energy intake exceeded 5000 kcal were excluded, resulting in a final sample size of 442 respondents.

In both rural and urban areas, more females than males participated. Age categories were evenly distributed across locations and genders. Males more often were in a union than females. Most respondents had primary-level or less education ($n = 402$). Few participants ($n = 40$), mostly from urban district reported having attained secondary/college education or above ($p < 0.001$). Income was assessed based on reported monetary earnings; overall more urban respondents were ranked in the high-income category compared to rural (70 versus 55 in rural, $p < 0.001$).

Prevalence of smoking was found to be higher in rural compared to urban participants (15 rural vs. 8.6% urban, $p = 0.038$) and significantly higher among males compared to females (34 vs. 1.3%, $p < 0.001$). Alcohol intake was more prevalent in urban compared to rural (56 vs. 24%; $p < 0.001$) participants while a smaller percentage of females reported alcohol intake compared to males (35 vs. 48%; $p = 0.01$). Median BMI (kg/m^2) was higher in those residing in urban compared to rural (26.3, IQR: 9.1 vs. 23.4, IQR:6.5; $p < 0.001$) and in females compared to males (25.5, IQR: 8.2 vs. 22.5, IQR:6.0; $p < 0.001$), whereas no significant differences were observed in the waist/hip ratio between locations or gender. Table 2 presents details on the participants' socio-demographic profile and lifestyle characteristics.

Food consumption and dietary diversity

The most frequently reported food items (Supplemental Fig. 3) included maize (stiff porridge), mangoes, black tea, sugar, beans, pumpkin, amaranth, rice, and sardines. Tubers were among the less frequently reported food items, with cooked bananas, sweet potatoes, and fried plantains being the most common, especially in urban areas. Mangoes, ripe bananas, and watermelons were the fruits most frequently reported. Sardines and fresh fish were the most reported fish. Among vegetables, amaranth, cooked tomatoes, jute leaves, pumpkin leaves, cassava leaves, and African eggplant were the most frequently reported. Unprocessed meat such as beef, goat, offals, and chicken were also reported frequently. Information on the most frequently reported 25 food items is provided in Supplemental Fig. 3.

The consumption of staple foods including maize, rice, and beans was observed to be high in both rural and urban participants. However, significant differences in the amounts consumed for certain varieties were observed as shown in Fig. 1. For example, the median intake of stiff porridge was higher in rural (385.7 g, IQR:300.0) compared to urban areas (222.9 g, IQR: 150) grams whereas the median intake of rice was higher in urban (180.0 g, IQR:166.7) compared to rural areas (60 g, IQR: 95). Generally, the intake of tubers and fried tubers, including plantains, bananas, potato chips, and sweet potatoes, was significantly higher in urban participants while there were no significant differences in the amount

Table 2 Baseline characteristics of the study participants

Variable– *n* (%)	*N*	Urban, *N* = 209	95 CI[2]	Rural, *N* = 233	95 CI[2]	*p*-value[3]
Age[1]	442	53.0 (12.0)		52.0 (11.0)		0.3
Age groups	442					0.8
44–49		68 (33)	26, 39	79 (34)	28, 40	
50–54		48 (23)	18, 29	61 (26)	21, 32	
55–59		40 (19)	14, 25	39 (17)	12, 22	
60–65		53 (25)	20, 32	54 (23)	18, 29	
Sex	442					0.050
Female		151 (72)	66, 78	148 (64)	57, 70	
Male		58 (28)	22, 34	85 (36)	30, 43	
Marital status	442					0.034
In union		131 (63)	56, 69	168 (72)	66, 78	
Non-union		78 (37)	31, 44	65 (28)	22, 34	
Education level	442					< 0.001
College/Secondary/High school completed		32 (15)	11, 21	8 (3.4)	1.6, 6.9	
Primary education or less		177 (85)	79, 89	225 (97)	93, 98	
Level of income	442					< 0.001
High		166 (79)	73, 85	129 (55)	49, 62	
Middle		10 (4.8)	2.4, 8.9	44 (19)	14, 25	
Low		18 (8.6)	5.3, 13	57 (24)	19, 31	
Don't know		15 (7.2)	4.2, 12	3 (1.3)	0.33, 4.0	
Ever Smoked	442					0.038
Yes		18 (8.6)	5.3, 13	35 (15)	11, 20	
No		191 (91)	87, 95	198 (85)	80, 89	
Ever Used Alcohol	442					< 0.001
Yes		116 (56)	48, 62	56 (24)	19, 30	
No		93 (44)	38, 52	177 (76)	70, 81	
Body Mass Index (kg/m2)	442					< 0.001
Underweight		12 (5.7)	3.1, 10	27 (12)	7.9, 17	
Normal		78 (37)	31, 44	122 (52)	46, 59	
Overweight		50 (24)	18, 30	57 (24)	19, 31	
Obese		69 (33)	27, 40	27 (12)	7.9, 17	
Median BMI[1]	442	26.3 (9.1)		23.4 (6.5)		< 0.001

[1]Median (IQR); n ()

[2]CI = Confidence Interval

[3]Wilcoxon rank sum test; Pearson's Chi-squared test

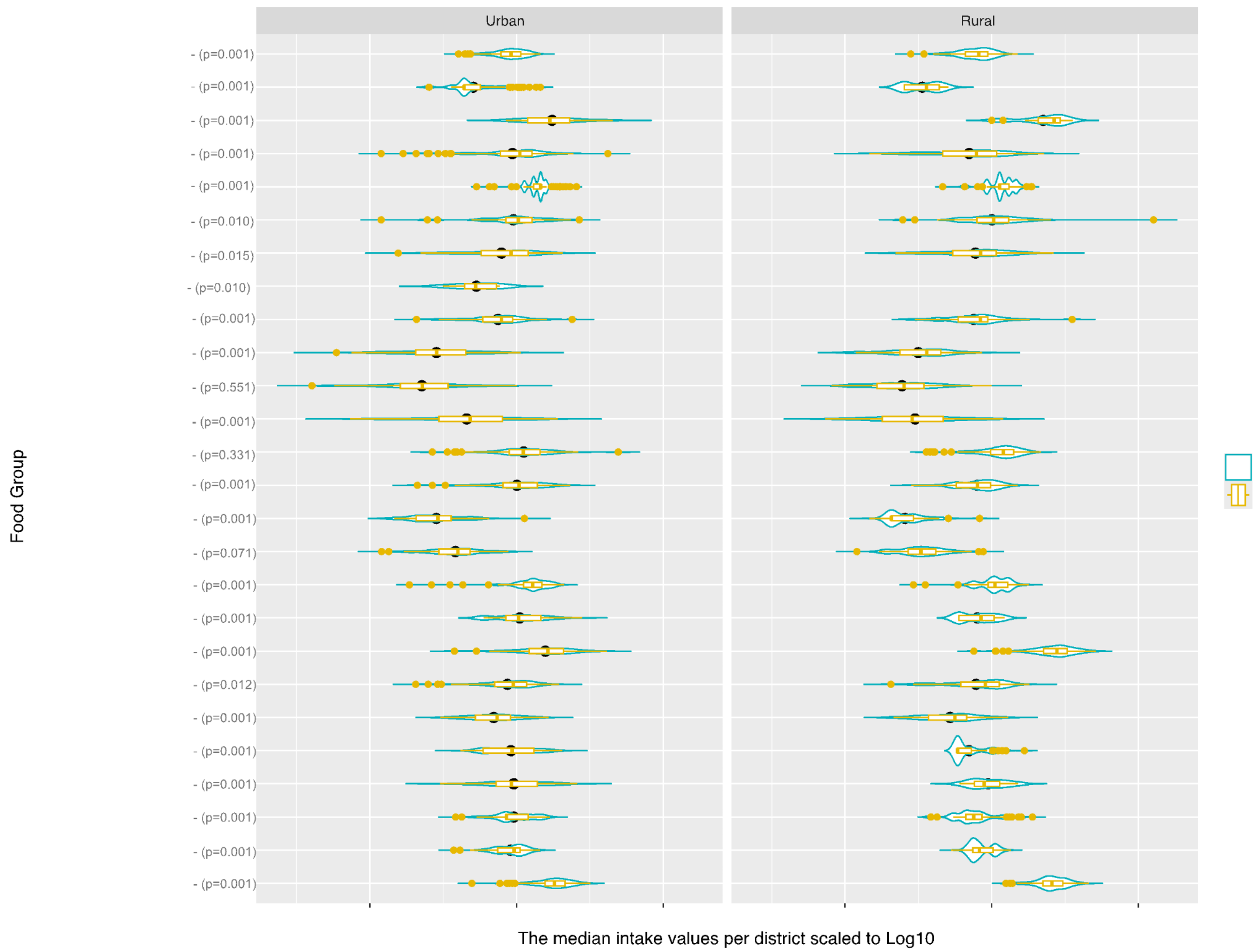

Fig. 1 A violin graph scaled to log10 showing the median, Interquartile range, and density distribution of the dietary intake per district. The blue line is the density plot, the yellow box represents the median and IQR and the yellow dots are the outliers. Wider parts show high data density i.e. more data around the specified value

of boiled cassava consumed in the two districts. Bread, spaghetti, and African doughnuts were consumed in greater amounts by urban than rural residents, whereas no differences in the amount of chapati, pancakes, biscuits, pastries, and bread were found in the two sites (Fig. 1).

Overall, the dietary diversity differed significantly by district (Pseudo $F = 68.74$, $p < 0.001$, $R^2 = 0.135$ based on Bray-Curtis dissimilarity and PERMANOVA). The urban district had a higher dietary diversity compared to the rural district (Shannon diversity index; 2.76, 95%CI [2.73, 2.78] in urban vs. 2.56, 95%CI [2.53,2.59], $t = 10.762$, $df = 435.09$, p-value < 0.001). Similarly, the dietary diversity was significanlty higher in urban Tanzania for most food groups (14/26) with no differences in SSB, sugar and sweets, tubers, tea and coffee, dairy, unprocessed meat, pastries and green leafy vegetables between urban and rural Tanzania (Fig. 2). Only three food groups showed a significantly greater diversity in rural Tanzania; whole grains, nuts and added oils.

Energy and food groups intake

The estimated median average daily energy intake was (2,903 kcal, IQR: 1449.2) with lower reported intake in rural (2,817 kcal, IQR: 1,274 versus 3,052 kcal, IQR: 1558 for urban residents; $p = 0.021$). Women reported a lower median average daily energy intake of (2,719 kcal, IQR:1,376 vs. 3,105 kcal, IQR: 1,368 for men; $p < 0.001$). The median reported daily energy intake decreased from high to low income levels, although the difference was not statistically significant ($p = 0.031$, Kruskal-Walli's rank sum test).

Bread, grains and cereals had a significantly higher contribution to the *median* average total daily energy intake in rural residents (0.37, IQR: 0.11 compared to 0.32, IQR: 10 in urban; $p < 0.001$). A similar trend was seen for fruits (0.18, IQR: 0.13 in rural vs. 0.06, IQR: 0.05 in urban;

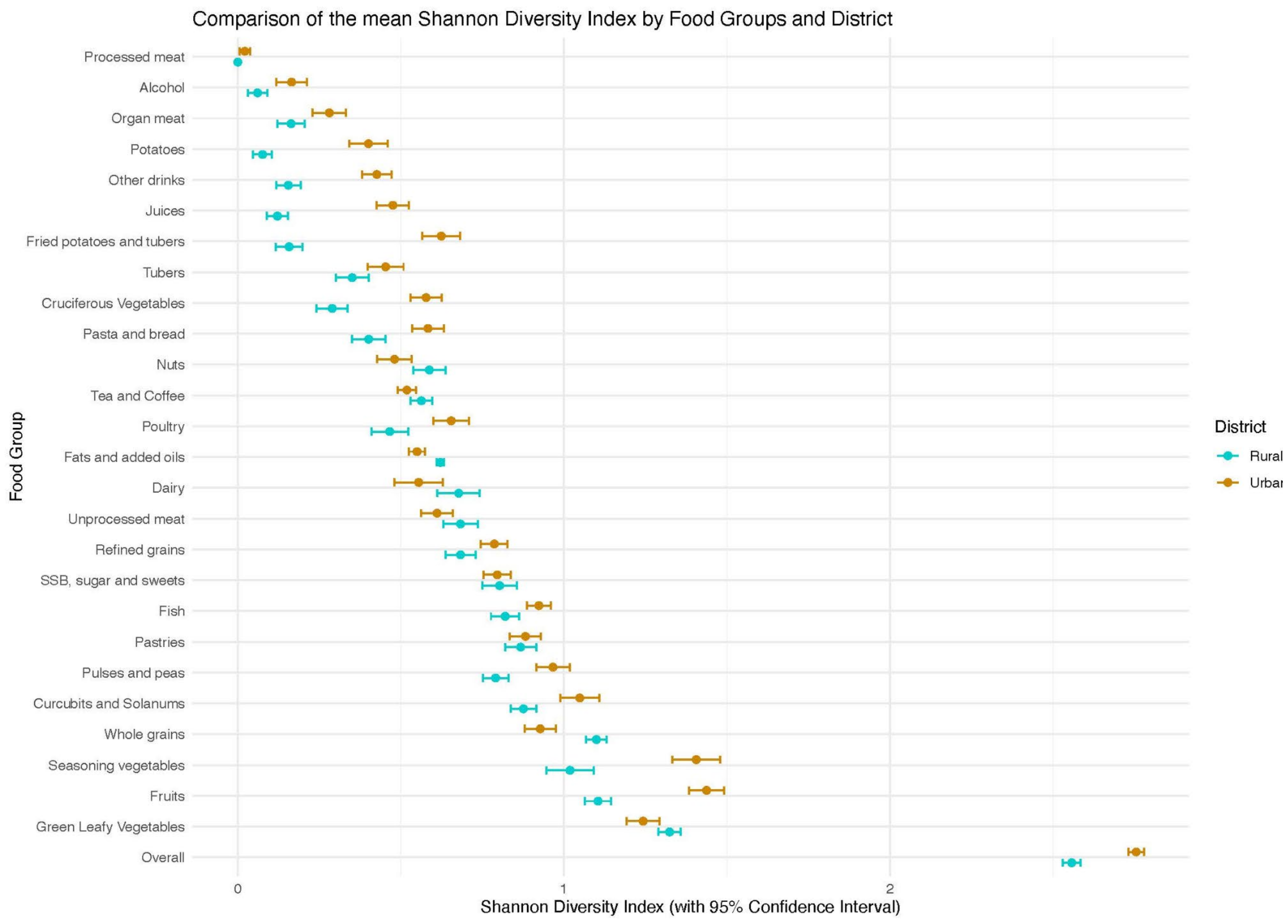

Fig. 2 Comparison of the Shannon diversity by Food Groups and Location

$p < 0.001$) and milk and other milk products (0.015, IQR: 0.029 in rural compared to 0.007, IQR: 0.02 in urban; $p < 0.001$). Urban residents had a higher intake of their energy from tubers, fried-tubers, and potatoes, nuts and pulses, tea, coffee, SSB and alcohol, fats and vegetables compared to rural. No differences was seen for the meat, poultry, fish, and egg. Further details are shown in Fig. 3.

Dietary patterns

Two dietary patterns were identified as illustrated in Fig. 4. The first pattern was classified as a "mixed pattern" characterized by the consumption of whole grains, tubers, potatoes, fried potatoes and tubers, fruits, juices, green leafy vegetables, seasoning vegetables and salads, organ meat, processed meat, and alcohol. The second pattern, named "plant-rich pattern", included whole grains, fruits, pulses and peas, seasoning vegetables and salads, sugar-sweetened beverages (SSB), sugar, and sweets, and added oils indicating a diet rich in plant-based foods. Both urban and rural diets included similar plant-based foods such as whole grains, potatoes, fruits, green leafy vegetables, and seasoning vegetables.

Rural- urban differences in dietary patterns are visually shown using a score plot of each observation onto the principal components (PC1 and PC2) (Fig. 5).

A multivariate analysis of variance (MANOVA) of the two PCs was done to investigate rural-urban differences in dietary patterns. The result showed a significant effect of the district on dietary patterns, $F(2,439) = 357.11$, Pillai's trace = 0.61933, $p < 0.001$. Post-hoc comparisons using Tukey's HSD test indicated significant rural-urban differences in mean PC1 scores (mean difference = – 2.82, 95%CI [-3.17,-2.47], $p < 0.001$). Similarly, significant differences were seen in the mean rural-urban PC2 scores (mean difference = 1.36, 95% CI [1.15,1.58], $p < 0.001$). These findings suggest that the dietary patterns vary significantly with the urban residents contributing more to the PC1– mixed pattern and rural to PC2– plant-rich pattern.

Analysis showed a similar number of food items and type loading to the "mixed" dietary pattern in both rural and urban sites, whereas for the plant-rich pattern, fewer items with higher loading was observed in the rural site. Further information is provided in Supplemental Table 1.

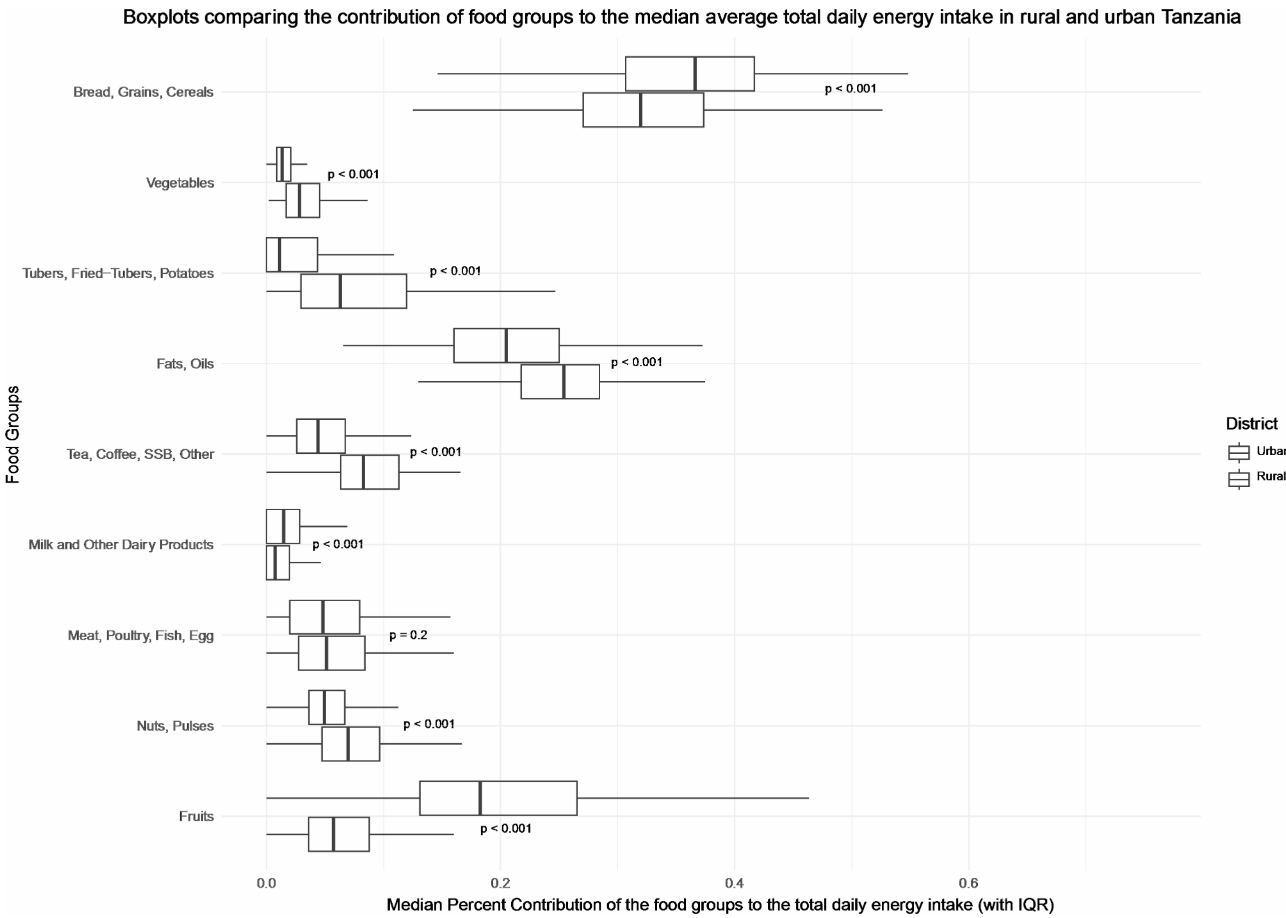

Fig. 3 Boxplots showing the median (IQR) percentage contribution of the food groups to the median average total daily energy intake in rural and urban Tanzania

Factors associated with adherence to the mixed and plant-rich dietary patterns

The adherence of participants to the mixed and plant-rich dietary patterns was assessed by subdividing the PC values into four quartiles. For the mixed pattern, the median (IQR) for bread, grains, and cereals and fruits intake increased over the dietary quartiles ($p < 0.001$), indicating a high contribution to the mixed pattern for these food groups. Conversely, tea, coffee, SSB and other and tubers, fried-tubers and potatoes decreased across the quartiles ($P = 0.001$) while the vegetable group median intake had a bimodal change over the dietary quartiles ($p = 0.035$) as shown in Fig. 6.

For the plant-rich dietary pattern, a significant difference was noted for milk and other dairy products, tubers, fried-tubers and potatoes and vegetables (Supplemental Fig. 4). Individuals in the 4th quartile had a higher intake of vegetables contrary to the trend seen in the mixed pattern. Respondents in the 1st and 2nd quartiles consumed more milk and other dairy products. The consumption of tubers did not differ between the two patterns.

Urban residents showed a decreasing adherence to the mixed dietary pattern over the quartiles opposite to the rural residents ($p < 0.001$). A similar trend was also observed for alcohol, reported monetary income, and education level. Age, sex, history of smoking, BMI, or marital status did not show any significant relationship with the dietary quartiles of the mixed patterns. Marital status is the only variable showing a significant inverse relationship with the quartiles of the plant-rich dietary pattern. Respondents who were in a union had lower adherence to the plant-rich pattern compare to those who were not partnered. Further information is shown in Supplementary Table 3.

Futher analysis showed that income levels, rural residence, and the absence of a history of alcohol consumption significantly increased the log-odds of adhering to the higher (4th) quartile compared to the 1st quartile of the mixed dietary pattern, as shown in Table 3.

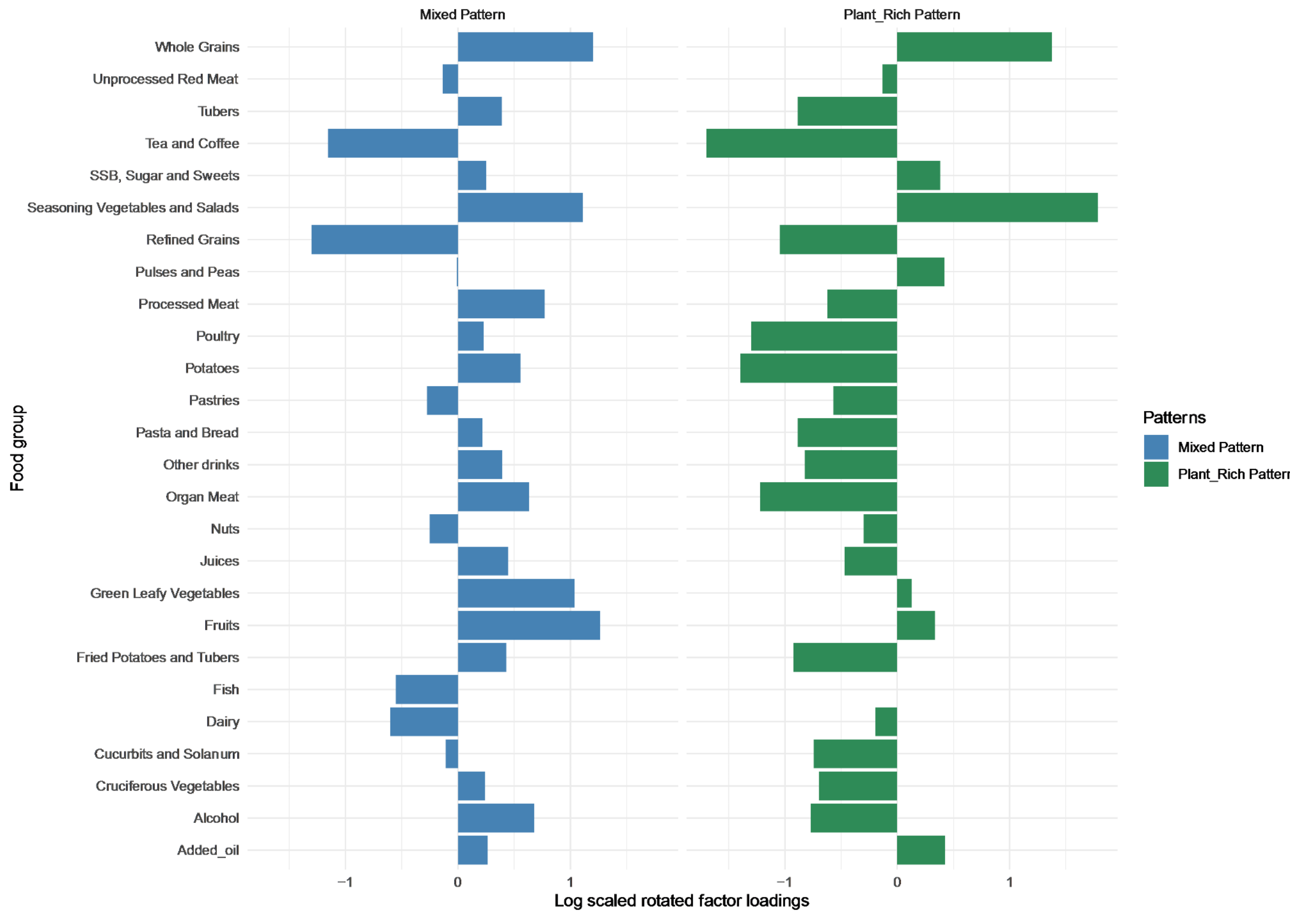

Fig. 4 A bar graph comparing the distribution differences of factor loadings for dietary patterns (scaled to $\log_{10}$). Positive bars represent dietary patterns associated with foods that have loadings greater than 2, corresponding to a log-scaled value greater than 0.5

Discussion

We have identified two distinct dietary patterns, referred to as the "mixed pattern" and the "plant-rich pattern" with rural and urban participants contributing differently to the patterns. Dietary diversity was significantly greater in urban compared to the rural district. The estimated median daily energy intake was slightly higher in urban Tanzania in line with the thoeries of nutrition transition and urbanization, with men consuming significantly more energy than women as expected. The proportion of the contribution of different food groups to the median average daily energy intake differed between the districts. These findings suggest differences in dietary habits and access to food between urban and rural populations, as well as differences based on gender.

Several other studies have compared dietary patterns in rural or urban settings in Sub-Saharan African countries including Tanzania with a few comparing rural and urban locations [12, 34, 51]. Evidence from Ethiopia showed distinct patterns with urban residents consuming a 'westernized pattern', rural residents predominantly followed a 'traditional pattern' and some overlap with respect to a 'healthy pattern' [52]. Further evidence from Ghana identified a 'mixed pattern' identical in both rural and urban areas with three distinct patterns in each location [53]. Consistent with the results of this study, there is evidence indicating rural-urban disparity in dietary patterns as the two locations contributed differently to the dietary patterns. The observed differences in dietary pattern could be attributed to economic disparities and variations in food availability. Rural residents reported lower monetary incomes compared to their urban counterparts, which may have limited their ability to purchase additional food sources. Furthermore, Kilindi residents primarily depend on subsistence farming, occasionally supplemented by weekly farmers' markets, whereas Ubungo residents benefit from access to a diverse range of foods sourced from other regions.

In line with results from other African urban areas, higher consumption of processed foods was reported by urban residents. However, we observed high loadings for SSB, sweets and sugar in the mixed dietary pattern in rural residents as well in line with the noted presence of manufactured foods in the rural villages in Tanzania by

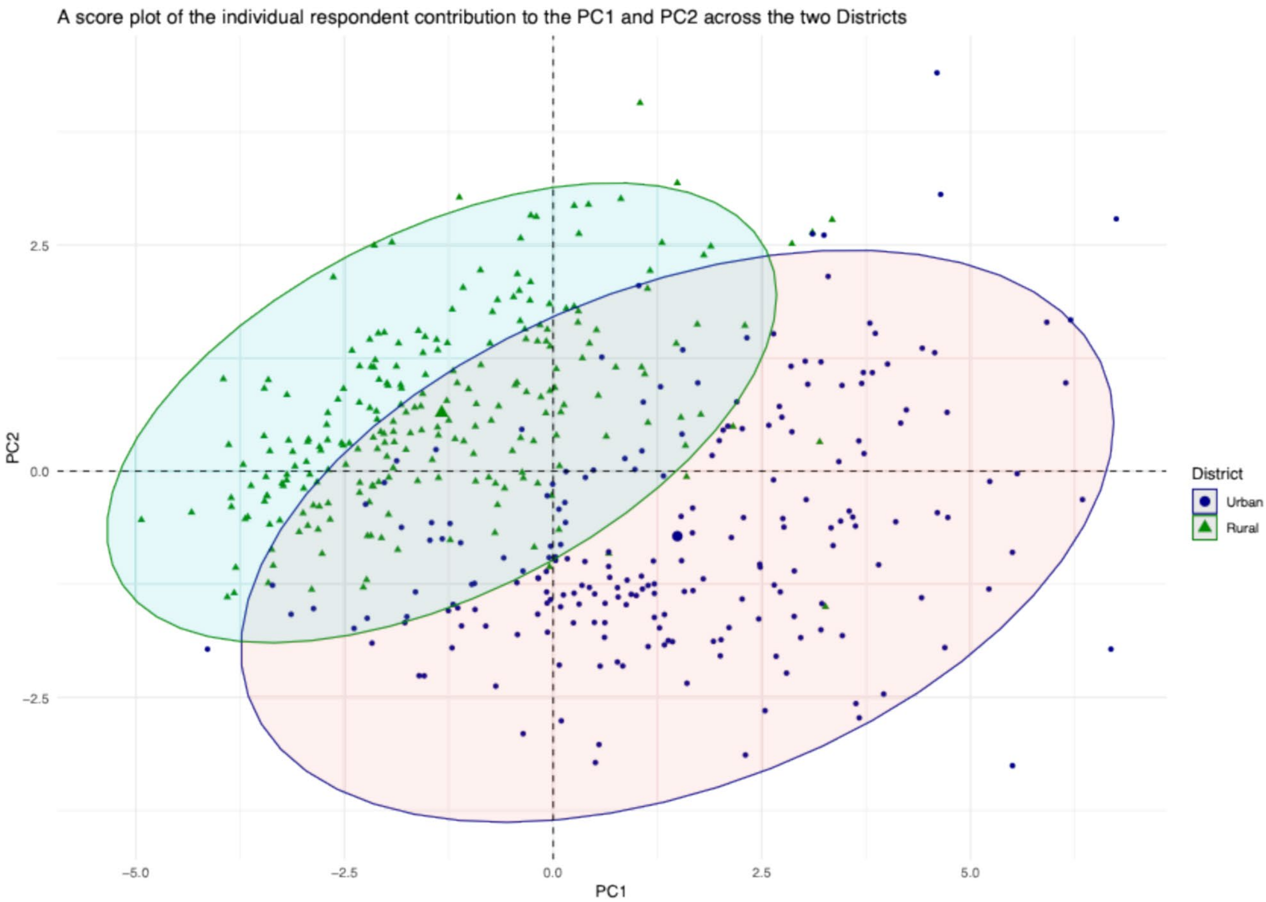

Fig. 5 A score plot of the individual respondent contributions to PC1 and PC2– the larger oval blue shape represents urban residents while the green circle represents rural residents

Sauer et al. [54]. Our findings contradict those reported in other developing countries over a decade ago where SSB, sugar, and sweets consumption was higher in urban than rural [55]. This signifies possible consumption patterns shifts due to increasing production of SSB and penetration to rural markets. In Tanzania for example, annual production of SSB increased by ~6 folds between 1997 and 2017 [56]. Further, SSB, sugar, and sweets have been documented to penetrated rural areas in developing countries decades earlier than essential health commodities [57]. Previous evidence reported high consumption among the younger generation, however, the findings of this study show possible high consumption among the older generation in both settings [55]. Further, we observed food items like fats and added oil, and alcohol to be equally present in the rural study location.

The dietary diversity used in this analysis uses Shannon diversity measures with the aim of understanding the broader differences between the two districts [45]. Hence, no prior scores were assigned to food groups and do not reflect the healthiness of food between the districts. Urban residents demonstrated significantly higher dietary diversity overall and in more than 50% of the food groups, with the exceptions of whole grains, added oils, and nuts. These findings aligns with the higher contribution to the mixed pattern observed in urban and indicate better access to a range of food items compared to the rural district. It is also worth noting that traditional protein-rich staples, such as sorghum and millet, ranked low in both urban and rural settings.

In this study, urban residents consumed a wider variety of fruits, while rural residents consumed larger quantities of one type of fruit (Mango). As noted earlier, rural residents primarily rely on locally grown foods, which limits their fruit options to those available during the season. In low and middle-income settings, fruit intake is generally considered low, and previous studies done in rural Tanzania have highlighted the presence of a seasonal effect on fruit consumption [58–60]. Since the data collection for this study coincided with the mango season in Kilindi district, future studies may show a different pattern. In contrast, urban residents have unrestricted access to a variety of imported fruits from other regions or countries, depending on their purchasing power. However,

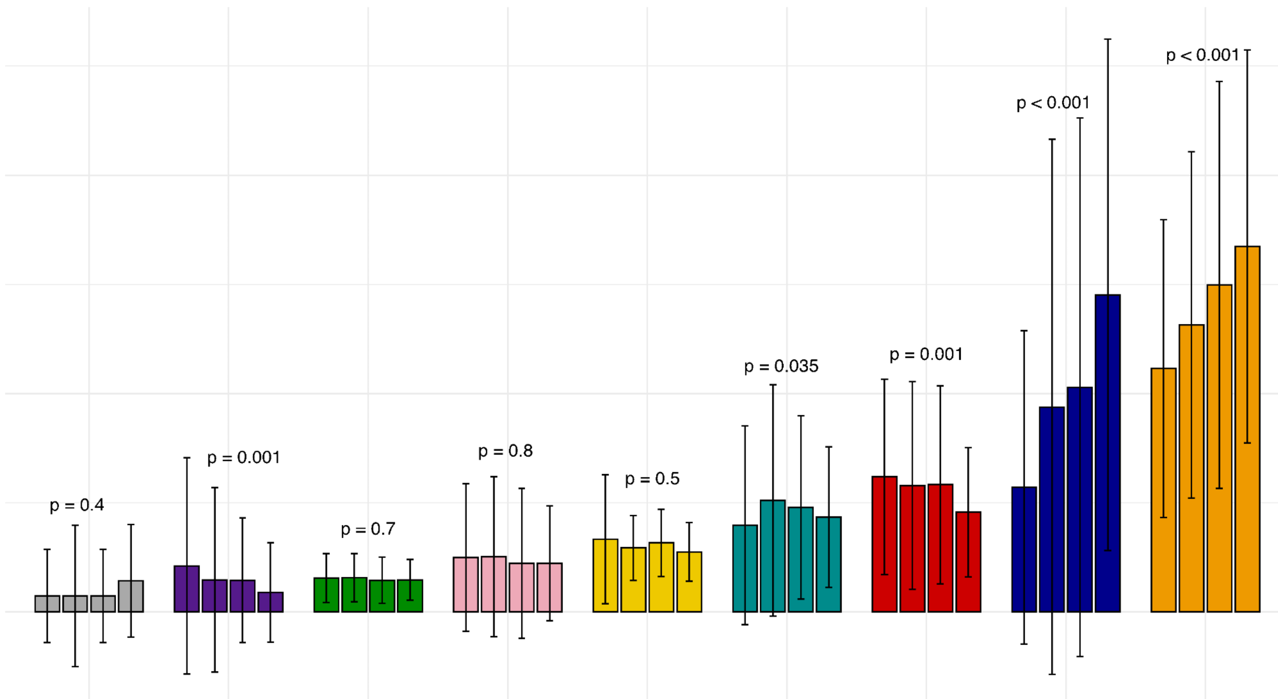

Fig. 6 The relationship between food group consumption and dietary pattern quartiles for the mixed dietary pattern. Each quartile represents a grouping of individuals based on their adherence to the mixed dietary pattern, where the four boxes corresponds to 1st,2nd, 3rd and 4th quartiles respectively for each food group

Table 3 Ordinal logistic regression results table showing the relationship between the demographic variables and the quartiles of the mixed dietary pattern

Variable		Odds_Ratio	95% CI
Sex	Female	REF	REF
	Male	0.72	0.5 - 1.05
Income	Low Income	1	1
	Middle Income	1.9	1.01–3.56
	High Income	1.16	0.72–1.86
	Don't know	0.32	0.11–0.89
Ever used alcohol	No	1	1
	Yes	0.56	0.39 - 0.82
District	Urban	1	1
	Rural	3.35	2.27 - 4.93
Intercepts			
Q1|Q2		0.43	0.25–0.74
Q2|Q3		1.52	0.9–2.59
Q3|Q4		5.44	3.12–9.49

despite reporting a wider variety of fruit consumption, their median daily fruit intake was lower compared to rural residents.

In contrast to the findings of this study, a study by Cockx et al. which used Tanzania's National panel survey data, reported higher quantities of cassava, sweet potatoes, and banana consumption in rural areas [61]. These differences could be attributed to a higher sample size in the study by Cockx et al., potential disparities between individual regions, or replacement by other foods [32]. Further, our study findings could signify dietary shift to tubers in urban areas as foods such as fried plantains/cassava are increasingly popular in Dar es Salaam. In this research, there were no differences in the daily amount of animal-source foods consumed in the two locations although goat meat and cow milk intakes were higher in rural while eggs, sardines, chicken (boiled or roasted) and liver were higher in the urban district. Kilindi district has a few Maasai communities who are cattle keepers, providing both milk and meat at affordable prices to nearby farming families compared to Ubungo. In contrast, the high consumption of sardines and poultry in Dar es Salaam region is driven by a steady commercial supply of sardines from the Indian ocean, Zanzibar, Mwanza and Kigoma regions, along with region's dominant production of exotic chicken, which surpases other regions of Tanzania [62]. Evidence from Lesotho showed a higher consumption of both poultry and milk in urban than rural residents [63]. Our findings are also in line with trends reported in India where eggs and chicken consumption was higher in urban compared to rural areas [64]. However, contrary to the findings of this study where only income determined food consumption, in the current study both income and residence were significantly related to food consumption.

The median average daily energy intake was lower in rural than urban residents. Rural residents primarily obtained their energy from healthier, homemade diets, while urban residents consume higher amounts of energy-dense foods that are easily accessible such as fried tubers and potatoes, SSB, and alcohol. For fats, the overal proportion contribution to the daily energy intake is notably less (23%) in our urban study population compared to the reported percentage of approximately 32 in the adult population of the United States [65, 66]. These findings are in line with nutrition transition theory associating higher energy intake in urbanized as compared to rural residents.

The median intake of food groups showed a varied trend, with certain food items significantly higher, lower, or similar in one location compared to the other. Similar results were also observed in Morocco [67]. For example, the consumption of foods rich in carbohydrates was high in both sites, but the types varied. Notably, rural residents had higher levels of maize compared to their urban counterparts. Maize is the most affordable staple that is also subsidized by the government and the most common food in rural areas. Conversely, urban residents had a higher intake of rice in line with a previous rural-urban migration study in Tanzania [61]. Migration to urban has been associated with increased monetary income and ability to afford non-staple diets and those high in energy.

Considerations related to the methodology, strengths, and limitations of the study

We used a validated FFQ [40] that we adapted for use in both our rural and urban populations for the assessment of dietary habits. Although effective in describing dietary patterns, the recall time of 30 days used in this study does not capture the effects of seasonal changes or episodic intakes on dietary patterns. The FFQ has previously observed to overestimate/underestimate the average daily dietary intake [68, 69], which was mitigated by excluding all participants with an average daily energy intake < 500 or > 5000 kcal from the analysis. The dietary diversity assessment performed in this study uses indices which reflect community differences but may not be generalizable to individual respondents or households.

Our cross-sectional design did not allow us to capture individual dietary changes over time or as they transition from rural to urban lifestyles. Future research should consider studying the changes in dietary patterns longitudinally while tracking the influence of urban-rural migration and other important parameters.

Conclusion

The findings of this study contribute to a broader understanding of dietary patterns and diversity for informed public health strategies aimed at addressing the evolving nutritional landscape in Tanzania. Rural-urban differences in dietary patterns, identified as "mixed" and "plant-rich" as well as dietary diversity in the current study were observed. While dietary diversity varied across district, the dietary patterns of both rural and urban residents were characterized by the consumption of alcohol, fats, oils, and sugar-sweetened beverages. This finding emphasizes the need for targeted interventions to address emerging dietary trends in both rural and urban areas, promoting healthier food choices.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s41043-025-00774-w.

Supplementary Material 1

Supplementary Material 2

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Author contributions

LSP, KKG, VL, FAW, AK, GK, and PC conceptualized the research question and reviewed the proposal and data collection tools. LSP supervised data collection, cleaned data, analyzed, and drafted the manuscript. All other authors (LSP, KKG, VL, MW, GP, DM, FAW, AK, GK, VH, and PC) reviewed and commented on the manuscript.

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Data availability

The data that supports the findings of this study can be obtained by contacting the corresponding author.

Declarations

Ethics approval and consent to participate

Ethical clearance for the study was obtained from MUHAS-Institutional Research Review Board (IRB)– MUHAS-REC-03-2021-530 and the National Institute for Medical Research (NIMR)- NIMR/HQ/R.3a/Vol.IX/4015. Additionally, we sought permission from the regional, district, and local government levels to conduct the study. All respondents were asked to give written consent to take part in the study after going through the informed consent process. All interviews and sample collection were done in a manner that ensures privacy, confidentiality, and comfort to study participants.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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