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Market Food Environments and Child Nutrition

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Abstract: Child malnutrition and low-quality diets remain widespread public health problems in sub-Saharan Africa. Providing access to nutritious and healthy foods for all is key, but it is not at all clear how this can be achieved in various local contexts. Here, we analyze the role of markets and food environments for child diets and nutrition in Malawi along an urban-rural continuum. We develop a new methodology to characterize food environments in terms of the variety of fresh and processed foods available in local market settings. Geocoded data of market food variety are combined with individual-level child diet and anthropometric data collected through a household survey. We find large differences in food environments and diet and nutrition outcomes between urban, rural, and remote locations. The spatially-explicit analysis shows that market food variety is positively associated with child dietary diversity and negatively associated with child stunting, even after controlling for household wealth, own farm production, and other confounding factors. Our findings stress the importance of improving the functioning of markets for nutritious foods, especially in rural areas. Conceptually, we add novelty to the literature on measuring food environments.

Keywords: Food diversity, Remoteness, Malnutrition, Processed foods, Malawi

JEL codes: F63; I15; Q18

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1 Introduction

Child undernutrition and low-quality diets remain serious public health concerns, particularly in sub-Saharan Africa (FAO et al., 2023). Childhood undernutrition leads to various adverse health and development outcomes, including child mortality and susceptibility to infectious diseases, as well as hampered physical and cognitive growth (Alderman et al., 2006; Pelletier et al., 1995). Access to healthy and nutritious foods in local contexts is an important pre-condition for improved child nutrition. Depending on the situation, food can come from various sources, including own farm production and market purchases. While many households in Africa are involved in farming and produce some of their food at home, markets are now more important for many, especially when it comes to accessing nutritious food groups such as fruits, vegetables, and animal-sourced foods (Dzanku et al., 2024; Headey et al., 2019; Sibhatu & Qaim, 2017). Here, we analyze the role of markets, and especially the variety of foods available in local markets, for child diets and nutrition outcomes.

Different strands of literature have looked at the role of markets for nutrition in low- and middle-income countries. One strand focuses especially on rural areas and analyzes how households' market access is associated with income, food security, and dietary diversity (Abay & Hirvonen, 2017; Dercon et al., 2009; Jacoby & Minten, 2009; Usman & Haile, 2022). These studies clearly suggest that better market access leads to better food security outcomes. However, in most of this research market access is measured either in terms of a simple binary variable (e.g., a market exists in the local context) or in terms of distance (how far away is the closest market). This has limitations because the nature of the market remains unclear. In some markets, a large variety of nutritious foods may be available, while in others only processed und ultra-processed food items are sold. A few studies try to be more specific by developing metrics of market food diversity and linking these to people's dietary patterns (Ambikapathi et al., 2019; Headey et al., 2019; Pingali & Ricketts, 2014). However, the few existing studies in this direction are either confined to very specific locations (Headey et al., 2019), or they use proxies of market diversity without actually collecting detailed data on foods available in local markets (Ambikapathi et al., 2019; Zanello et al., 2019). Important to note is also that households typically do not rely on only one market, but have access to different types of food retailers that they may use more or less frequently, depending on the conditions.

Another strand of literature focuses more on urban areas of low- and middle-income countries, where a modernization of the food retail sector has been ongoing for a while, sometimes referred to as a 'supermarket revolution' (Reardon et al., 2021). Studies have analyzed links between access to supermarkets, processed and ultra-processed food consumption, dietary quality, and the likelihood of overweight and obesity (Asfaw, 2008; Demmler et al., 2018; Kimenju et al., 2015; Otterbach et al., 2021; Rischke et al., 2015; Umberger et al., 2015). But again, most of these studies use binary variables for the existence of supermarkets or simple distance measures for capturing access, without considering in more detail what types of foods are actually sold in supermarkets. Depending on local conditions, both modern supermarkets and traditional retailers may sell healthy and unhealthy foods (Debela et al., 2020; Khonje et al., 2020; Kimenju et al., 2015; Rupa et al., 2019), so that using simple dummy or distance variables is insufficient to evaluate food environment characteristics (Toure et al., 2021).

We add to these strands of literature by developing a more detailed approach of characterizing market food environments, with a particular focus on the variety of foods offered by local food retailers in a given setting, capturing both fresh and processed foods. These metrics of market food variety are then analyzed in terms of their associations with indicators of child dietary diversity and nutrition in a spatially-explicit way. We use primary market and household survey data collected along an urban-rural continuum in Malawi, one of the countries with the highest rates of child undernutrition worldwide (NSO and ICF, 2017). We address three research objectives. First, we examine how food environments, and market food variety in particular, change with urban proximity. Second, we analyze how child diets and nutrition outcomes change with urban proximity. Third, we estimate how access to market food variety for each household is associated with child diets and nutrition, controlling for household living standard, own farm production, and other confounding factors, in order to better understand the relationships between food environments and child nutrition.

The remainder of this paper is structured as follows. Section 2 provides a short description of the regional context of this work. Section 3 explains the data and statistical methods used for the analysis. Section 4 presents the empirical results, while section 5 concludes and discusses some research and policy implications.

2 Background

2.1 Diets in Malawi

Malawi is among the poorest countries globally with 80% of the population dependent on agriculture as the main source of income (Benson, 2021). Diets in Malawi are not much diversified on average, with starchy staples, especially maize, making up the bulk of people's food expenditures (IPC, 2022). The overall quality of diets is low, which holds for all population groups, including children (Fitzsimons et al., 2016). Less than 8% of the children in Malawi receive a minimum acceptable diet (Worku et al., 2022), and only one out of ten children consume nutrient-rich animal-sourced foods, such as meat, eggs, or dairy (fish in small quantities is consumed more widely). These dietary patterns have hardly changed over the last decade (IPC 2022). Hence, it is unsurprising that Malawi has one of the highest child undernutrition rates globally, with child stunting and underweight rates at 37% and 23% respectively (NSO and ICF, 2017). Children in urban areas of Malawi are somewhat better nourished than children in rural areas: child stunting in urban Malawi is around 24%, whereas in rural areas it is 39% (NSO and ICF, 2017).

2.2 Food environments in Malawi

Malawi's market food environments are mostly characterized by traditional retailers. Food value chains mostly range from traditional (subsistence, short local supply chains, limited food processing, informal logistics) to transitional (wet markets, street food vendors, small mills, longer rural-urban supply chains) (Barrett et al., 2022), which holds true for most parts of the rural-urban continuum. Especially in rural areas, farmers and traders mostly transport the food to markets either by foot or by bicycle, underlining the small quantities typically involved. Only a few larger traders use trucks for longer-distance transport (Gelli et al., 2020). Even though most rural households are involved in own farming, the majority of them are actually net-buyers of food, meaning that they buy more food than they sell (NSO and ICF, 2017).

Food retailers in Malawi take a variety of shapes, but most of them are traditional, including trading markets (large open-air markets, including wet markets), tabletop and roadside vendors, convenience stores, and neighborhood kiosks. A few modern retailers, such as supermarkets and mini-markets, exist in urban and peri-urban environments.

3 Materials and methods

The study was reviewed and approved by the Ethics Board of the University of Goettingen. Data collection in Malawi took place in November and December 2022, which is the onset of the lean season. During this time, most rural households still have some smaller stocks remaining from the last harvest, but the use of markets gains in importance, especially for fresh nutritious foods. The 'hunger' season, when most own stocks are exhausted and market supplies in rural areas are also at their minimum, usually starts in January and extends to April.

We purposively selected six districts in Central Malawi, each having its own urban center, namely Dedza, Dowa, Lilongwe, Lilongwe City, Mchinji, and Salima (Fig. 1). This Central Region offers significant heterogeneity in terms of food environments but relatively similar climatic and cultural conditions (Hirvonen et al., 2017), which is an advantage for our analysis. In the six districts, we first sampled Extension Planning Areas (EPAs), considering distances to urban centers. In the EPAs, we sampled sections and villages randomly.

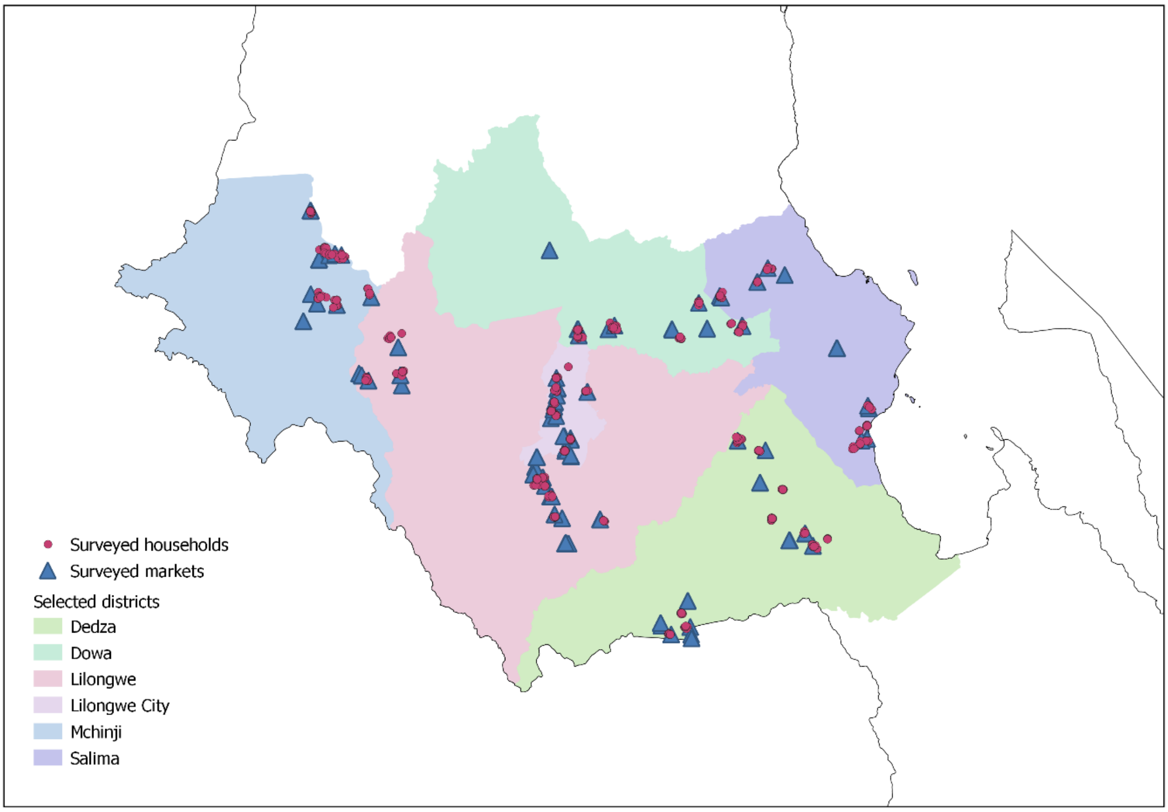

Figure 1: Map of Central Region in Malawi with surveyed districts, households, and markets

3.1 Household survey

In each of the randomly selected villages, we relied on local extension officers to provide complete household lists. From these lists, households were sampled randomly. Only in Lilongwe City, we used a somewhat different approach. We obtained an updated City planning map from the Ministry of Local Government, which we used to randomly sample ten City neighborhoods. In each of these neighborhoods, we used a random walk method and selected households with a sampling interval of eight.

In each sampled household in rural and urban areas, whenever available, we included one male and one female adult (>18 years) as well as three children (1-17 years) for interviews and anthropometric measurements. Children below one year of age were not included because they typically consume few solid food items. For children below the age of 14, a caregiver responded to the interview questions. We interviewed a total of 701 households. Out of these, 563 households had at least one child. Our total sample include 1162 children.

The interviews were carried out face-to-face in local languages. We collected household-level information on a wide range of socioeconomic and contextual factors, geo-coordinates, details of agricultural production, a 7-day food consumption recall, and detailed information on shopping behavior to be able to establish links between the diets of households and individuals and the food retailers they frequented. At the individual level, we conducted 24-hour dietary recalls, accompanied by anthropometric measurements and health-related inquiries, including questions on disease history and physical activity.

3.2 *Market survey*

In conjunction with the household survey, we conducted a market survey, collecting the geo-coordinates of all relevant food retailers (N=330) in and around the sampled villages. In each village and its environment, we collected more detailed information from each type of retailer locally available, namely supermarkets, mini-markets, convenience stores, traditional markets, mobile markets, tabletop vendors, and neighborhood kiosks. In particular, we captured physical, operational, and infrastructural aspects of these retailers, as well as information on the food items available in each outlet (using a list of 190 food items), their processing levels, and prices. These details were collected from a total of 81 retailers. Together with the geo-coordinates from all relevant retailers, local food environments can be described and analyzed as explained in more detail below.

3.3 Measuring market food variety

One of the main novelties of our study is to develop meaningful metrics of market food environments that can be linked to individual diets and nutrition. We are particularly interested in the variety of foods offered by food retailers, as we hypothesize that market food variety is positively associated with the variety of foods consumed and therefore with dietary quality and nutrition.

In developing our 'market food variety' metrics, we are not only interested in the variety of foods sold by individual retailers, but in the variety of foods offered by all retailers in the market food environment relevant to each individual household. In other words, we compute a spatial exposure measure that comprehensively considers food variety within a given travel time around the household. In particular, based on the data collected, we determine how many and which food items are available from each retailer. Then, we compute the travel time from each household to each retailer in the sample, using a friction map at the 1km grid cell and finding the least-cost-path through each cell, taking into account the quality of the road, altitude, rivers, and maximum travel speed on various road types (Weiss et al., 2020). Finally, for each household we compute a market food variety variable, expressed as the number of food items available from retailers within 20 minutes reach, counting each food item only once, even if sold by different retailers. Based on the information from the household interviews, the 20-minute cutoff appears reasonable in the local context, even though we also perform robustness checks with 10-minute, 30-minute, and 40-minute travel-time cutoffs.

In one version of the market food variety metric, we count all food items regardless of their processing stage. In alternative versions, we further differentiate between fresh foods and lightly processed foods. Food processing can increase the shelf-life of products, helping to provide a more stable access to macro- and micronutrients especially in situations where markets fail to consistently provide access to fresh foods. Examples in the local context of rural Malawi are dried beans, powdered milk, or dried fish (Table 1, for a full list of food items relevant in Malawi, also see Table A1 in the Appendix). Lightly-processed foods often contain similar nutrient contents as fresh foods but are easier to transport and store (Msuku & Kapute, 2018). We do not consider moderately- and highly-processed foods in the calculation of our market food variety metrics.

Table 1: Food processing category, definition and examples

Category	Definition	Examples
Unprocessed/ fresh	Single food ingredient with no or little modification	Fresh milk; fresh vegetables, fruits, legumes, and nuts; fresh eggs, fish, and meat; fresh whole-grain cereal, brown rice, honey
Basic/ lightly processed	Single food modified for preservation or precooking	Dried, canned (unsweetened), and frozen vegetables, fruits, legumes and nuts, and cereals; unsweetened fruit juice; canned meat; refined-grain pasta and flour; white rice; plain yoghurt; dried fish and meat; frozen meat and fish; powered milk; whole-grain bread; pasta
Moderately processed	Single food with the addition of flavor additives	Sweetened/flavored fruit or vegetable juice; sweetened canned, dried, frozen fruits, vegetables, legumes; cheese, sweetened yoghurt, condensed milk, cream
Highly processed	Multi-ingredient industrially formulated mixtures	Tomato sauce, salsa, jelly; syrup; chocolate; soda, alcohol, energy drinks; French fries; sausage, cake, pie, pastries, candy

Source: Adapted from Poti et al., (2015) and Fanzo & Davis (2021).

To address concerns that a food variety measure may not fully reflect the availability of nutritious foods, we also calculate a 'market food diversity' metric, counting the number of healthy food groups available in local retailers, instead of all food items separately. However, the mere presence of a food group may be insufficient to cater for individual food preferences;

larger variety of food items also within the same food groups offers more choices. These choices also provide more flexibility in terms of affordability and relative prices, which is particularly important in situations with widespread poverty (Headey & Alderman, 2019). Hence, we use the market food variety as our main food environment metric and look at market food diversity in a robustness check.

3.4 Measuring urban proximity

Our main variation in the market food variety metric comes from the fact that urban and peri-urban food environments are often different from rural ones. For the analysis, we compute urban proximity as travel time (measured in minutes) to the closest urban area, as defined by the official Malawian 'urban' classification. This classification includes major cities as well as district capitals (*'bomas'*) and major agricultural trading hubs (UNDESA, 2014). Hence, urban proximity for the households in our sample is always with respect to the closest urban area. We use the same friction map to compute travel time from each household to the closest urban center, which takes into account the quality of the road, altitude, rivers, and maximum travel speed (Weiss et al., 2020). For descriptive comparisons of some key variables, we also differentiate between three types of regions according to urban proximity, namely urban and periphery (0-10 minutes), rural (10-50 minutes), and remote (>50 minutes).

3.5 Child diets and nutrition

We measure child diets with the child dietary diversity score (CDDS), a widely-used proxy for dietary quality that correlates with more complex measures of food consumption (Hirvonen et al., 2017). CDDS is calculated from the individual-level 24-hour dietary recall, considering the following seven nutritious food groups: grains, roots and tubers; vitamin A rich fruits and vegetables; other vegetables and fruits; flesh foods; dairy products; legumes and nuts; and eggs.

The diet is considered minimally acceptable when the child consumed four out of these seven food groups in the previous 24 hours (WHO, 2007).

For measuring child nutritional outcomes, we use height-for-age z-scores (HAZ), the most commonly-used indicator of chronic child undernutrition. Insufficient intake of calories, protein, and micronutrients contributes to ‘stunted’ linear growth. HAZ compares the height of the child to an established growth chart for well-nourished and healthy children at different ages (WHO, 2006). The z-scores are measured in terms of standard deviations (SD) from the mean of the reference population. Related to HAZ, we also use stunting as an additional outcome, measured in terms of a dummy variable that takes a value of one if the individual child HAZ<-2 SD.

Stunting is typically measured for children below the age of 5 years, as the first years of life are the most critical for body and brain development (UN IGME, 2022). However, growth retardation can also occur through nutritional deficiencies during older childhood and adolescence (Leroy & Frongillo, 2019). As explained, our sample includes children aged 1-17 years. However, in order to test whether the results change significantly, we only look at children aged 12-59 months is a robustness check.

3.6 *Statistical analysis*

We start the analysis by descriptively analyzing market food diversity and child diet and nutrition patterns along the urban-rural continuum. We also analyze relationships between these variables using local polynomial regressions. Equation (1) estimates how child dietary diversity changes with increasing urban proximity,

$$CDDS_i = \beta_1 URB_i + \varepsilon \quad (1)$$

where *CDDS* is the dietary diversity score of child i, and URB measures urban proximity for the same child in terms of travel time to the closest urban center.

Equation (2) looks at the association between market food variety (*MFV*) for individual child *i* within 20 minutes travel time and urban proximity,

$$MFV_i \ = \ \beta_1 URB_i + \varepsilon \qquad (2)$$

Equation (3) estimates the relationship between dietary diversity and market food variety,

$$CDDS_i \ = \ \beta_1 MFV_i + \varepsilon \qquad (3)$$

These local polynomial regressions are run without controlling for confounding factors. However, in additional regression models we explain child diets and nutrition outcomes with *MFV* while controlling for relevant covariates,

$$Y_i \ = \gamma_0 + \gamma_1 MFV_i + \gamma_2 X_{ih} + \ \gamma_3 \ Agr_h + \epsilon_s \qquad (4)$$

where Y_i denotes our child diet and nutrition outcomes (CDDS, HAZ, stunting), X is a vector of individual child (*i*) and household-level (*h*) controls, including child age, sex, and schooling status, sex and education of the household head, household size, consumption expenditures, and religion, among others. Agr is a vector of agricultural control variables, namely a dummy whether the household farms and/or owns livestock and the number of food crops grown. A detailed description of all covariates is provided in Table A2 in the Appendix.

Our hypothesis that market food variety is positively associated with child diets and nutrition, also after controlling for confounding factors, is tested through the sign and significance level of the coefficient γ_1 in equation (4). We deliberately interpret γ_1 in terms of associations, not causal effects, as *MFV* may potentially be endogenous.

We run different versions of the model in equation (4). First, we run separate regressions with our alternative *MFV* metrics, including the variety of all foods, only fresh foods, and only lightly processed foods. Second, we run separate regressions for our three outcome variables. CDDS is a count variable, so we use a Poisson estimator and report marginal effects evaluated at the mean. For HAZ and stunting we use ordinary least squares (OLS) estimators. A logit estimator for stunting leads to almost identical marginal effects. To address potential spatial correlation of the error terms, we cluster standard errors at the section level, which is one administrative level higher than the village. We chose the section level, as some villages share larger markets at the section level, possibly leading to spatial correlation.

4 Results

4.1 *Sample characteristics*

Table 2 shows dietary patterns and nutrition outcomes for the children in our sample and related household and market food environment characteristics. We see notable differences by geographic location. In line with official statistics (NSO and ICF, 2017), children in urban areas are better off in terms of diet and nutrition indicators than children in rural and remote areas. However, even in urban areas, CDDS remains well below the minimum acceptable level of four food groups per day. As expected, market food variety is significantly larger in urban areas and declines with distance to urban centers.

Table 2: Individual, household, and food environment characteristics

	Total		Urban and periphery		Rural		Remote	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Outcome variables								
Child dietary diversity	2.60	0.79	2.91	0.91	2.55	0.78	2.49	0.67
HAZ	-1.54	1.34	-1.13	1.36	-1.62	1.34	-1.65	1.30
Stunting	0.36	0.48	0.24	0.43	0.38	0.49	0.40	0.49
Food environment variables								
Market variety	44.34	25.66	84.07	0.59	40.79	19.65	26.34	14.15
Market variety - fresh foods	25.70	15.79	50.20	0.40	23.08	12.46	15.28	8.43
Market variety - processed foods	18.64	10.06	33.87	0.54	17.71	7.51	11.05	5.99
Individual demographics								
Age (years)	8.45	4.77	8.05	4.86	8.58	4.70	8.48	4.82
Female (dummy)	0.51	0.50	0.47	0.50	0.53	0.50	0.51	0.50
Attending school (dummy)	0.88	0.32	0.94	0.25	0.89	0.31	0.84	0.37
Observations	1162		217		581		364	
Household characteristics								
Household size (members)	4.96	1.78	4.93	2.06	4.87	1.67	5.10	1.75
Female head (dummy)	0.30	0.46	0.30	0.46	0.30	0.46	0.29	0.46
Age head (years)	43.83	20.07	43.04	14.72	43.25	16.23	45.13	26.82
Education head (years)	5.43	3.89	7.97	4.05	4.79	3.68	4.81	3.47
Per capita expend. (1000 MWK)	21,16	28,11	38,98	53,29	16,34	10,02	17,44	18,21
Owns bicycle (dummy)	0.28	0.45	0.24	0.43	0.28	0.45	0.30	0.46
Religion: Traditional	0.01	0.09	0.00	0.00	0.01	0.09	0.02	0.13
Religion: Christian	0.82	0.39	0.93	0.26	0.79	0.41	0.79	0.41
Religion: Muslim	0.15	0.36	0.06	0.24	0.18	0.38	0.16	0.37
Improved water source	0.87	0.33	0.96	0.18	0.88	0.33	0.81	0.39
Agricultural variables								
Farming household (dummy)	0.87	0.34	0.46	0.50	0.97	0.17	0.97	0.16
Count of crops grown	2.54	1.68	1.20	1.59	2.80	1.63	2.99	1.37
Owns livestock	0.56	0.50	0.39	0.49	0.60	0.49	0.60	0.49
Observations	578		114		275		189	

Markets are the most important sources of food for households in Malawi. Some food groups, such as oils, fats, and dairy, are obtained from markets to over 90%. But even staple foods, vegetables, and fruits, which are produced by many households, are obtained from the market in proportions of over 40% (Fig. A1 in the Appendix). Of course, seasonal differences, which we do not capture with our data, may play a role. Unsurprisingly, market reliance increases with urban proximity (Fig. 2). However, even in remote regions several nutritious food groups are primarily obtained from markets (e.g., legumes, flesh foods, dairy).

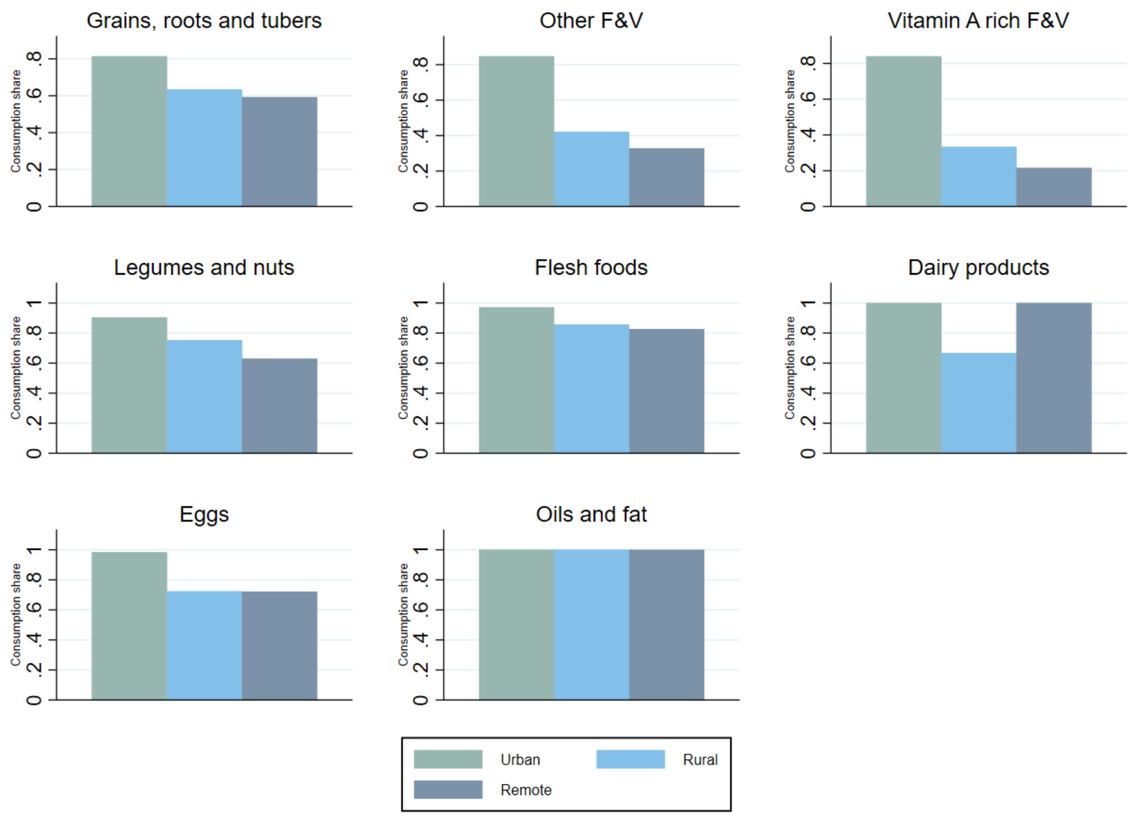

Figure 2: Share of different food groups obtained from markets by urban proximity

Notes: The consumption shares shown are relative to total consumption of each food group from all sources (including market purchases, own production, gifts/transfers, and collection) calculated on a calorie basis. Households that have not consumed a particular food group are excluded (*N*=701). Other F&V refer to other fruits and vegetables. Vitamin A rich F&V refer to vitamin A rich fruits and vegetables.

Fig. 3 shows the average composition of child diets in our sample in terms of the food groups used for CDDS. As can be seen, the consumption of various nutritious food groups, such as flesh foods, dairy, eggs, and vitamin A rich fruits and vegetables, all critical sources of nutrients, is strikingly low. These dietary patterns highlight substantial areas for nutritional improvements.

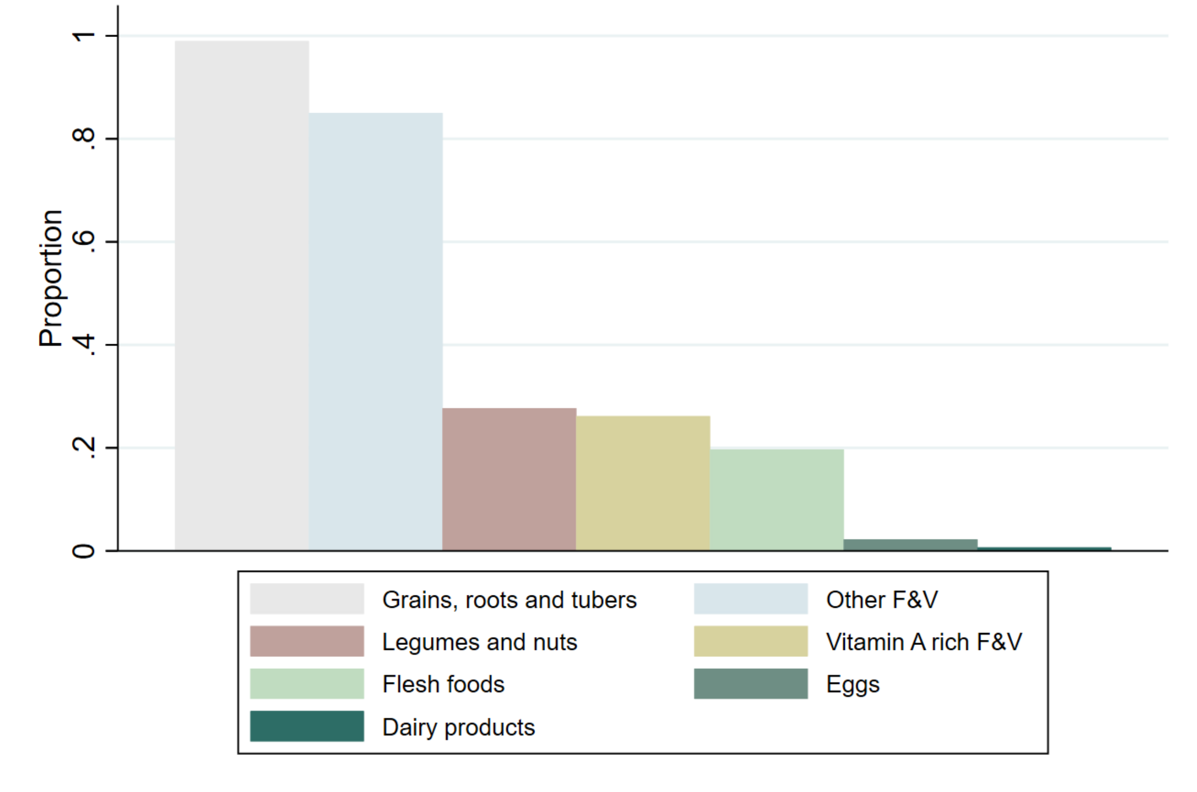

Figure 3: Proportion of children consuming different food groups

Notes: Consumption refers to food group intake of children (1-17 years) during a 24-hour recall period (*N*=1,162). Other F&V refer to other fruits and vegetables. Vitamin A rich F&V refer to vitamin A rich fruits and vegetables.

Differences in dietary patterns between locations are shown in Fig. 4. Here, we exclude grains because these are consumed on a daily basis by almost all children throughout the urban-rural continuum. Children in rural and remote locations are less likely to consume several nutritious food groups than children in urban areas. This is likely related to differences in market food environments, as is analyzed in greater detail below.

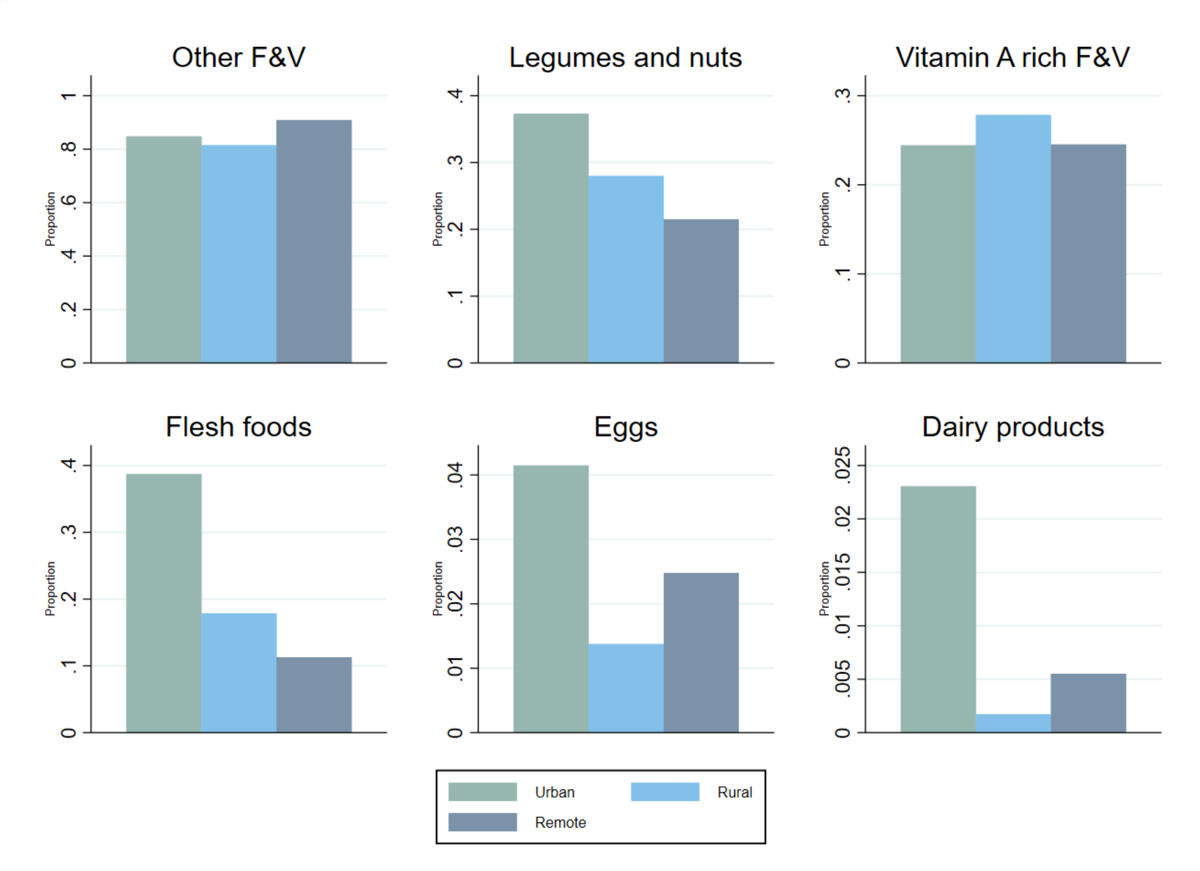

Figure 4: Proportion of children consuming different food groups by urban proximity

Notes: Consumption refers to food group intake of children (1-17 years) during a 24-hour recall period (*N*=1,162). Other F&V refer to other fruits and vegetables. Vitamin A rich F&V refer to vitamin A rich fruits and vegetables.

4.2 *Market food variety and child diets along the urban-rural continuum*

Results from the weighted local polynomial regressions linking child diets, market food variety, and urban proximity are shown in Fig. 5. Panel (A) shows a clear negative relationship between child dietary diversity and travel time to urban centers. In the most remote locations, CDDS is one-third lower (one full food group) than in urban centers. Panel (B) shows a strong negative relationship between market food variety and travel time to urban centers, which holds true for the aggregate market variety metric as well as for the two separate metrics for fresh and lightly processed food variety. In the most remote locations, market food variety is 80%

lower than in urban centers. Panels C and D show that both fresh and lightly processed food variety are positively associated with child dietary diversity.

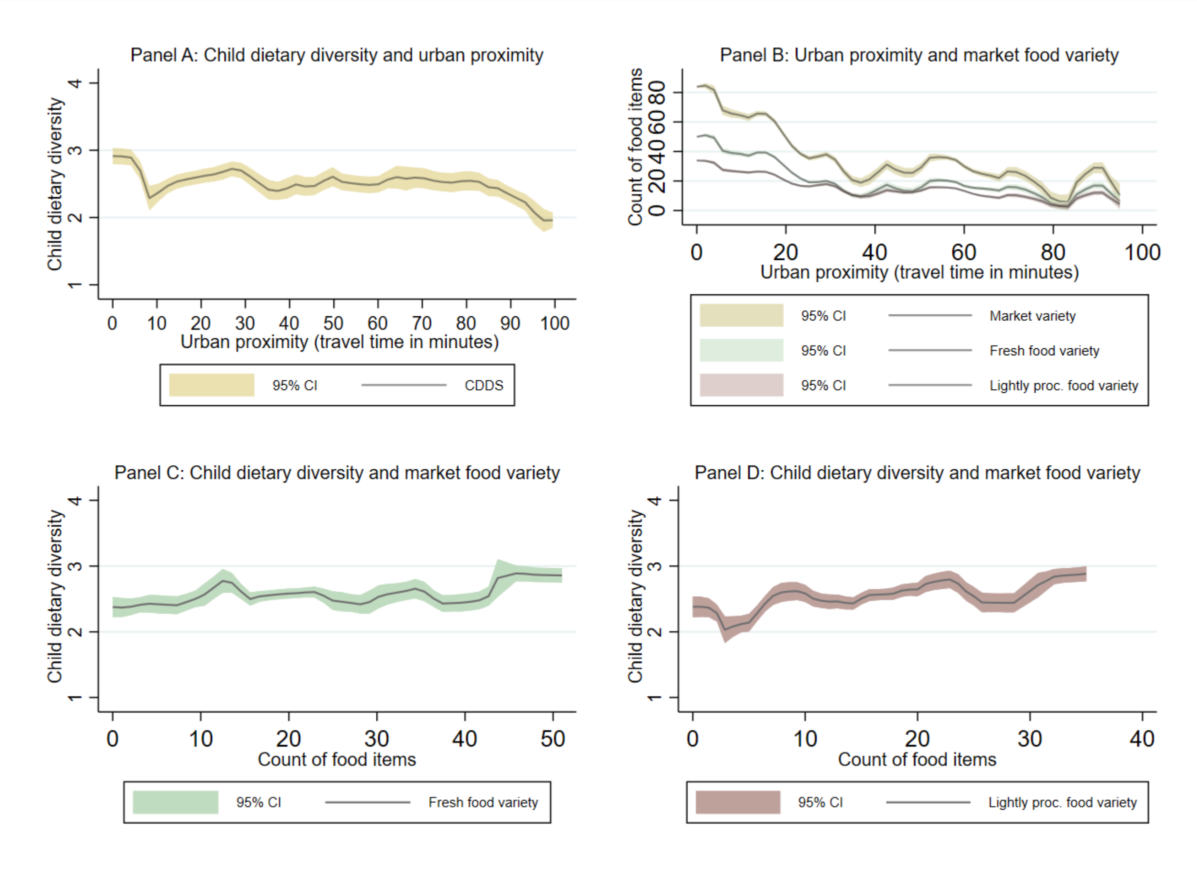

Figure 5: Relationships between child diets, market food variety, and urban proximity

Notes: Results from local polynomial regressions are shown with 95% confidence intervals (*N*=1,162).

4.3 Results after controlling for confounding factors

We now run the regression models explained in equation (4), testing the associations between child diets and nutrition and market food variety while controlling for confounding factors. Table 3 summarizes the results with CDDS as the outcome variable. Column (1) shows the relationship between CDDS and the aggregate market variety metric without any controls included. The same model including controls is shown in column (2). The association is positive and statistically significant, supporting our hypothesis that the market food environment plays an important role for child diets. Ten additional food items available in food retailers within 20 minutes travel time are associated with a 0.04 higher CDDS. Disaggregating the market variety metric into fresh (column 4) and lightly processed foods (column 6) shows that both are positively and significantly associated with CDDS. Interestingly, the association for lightly processed foods is even somewhat larger in magnitude. This underlines that lightly processed foods can be important nutritious components of child diets, especially in remote rural locations where markets for fresh nutritious foods are often not functional.

Table 3: Associations between market food variety and child dietary diversity

	Child dietary diversity scores (CDDS)					
	(1)	(2)	(3)	(4)	(5)	(6)
Market variety	0.005***	0.004***				
	(0.002)	(0.001)				
Market variety – fresh foods			0.008**	0.005**		
			(0.003)	(0.002)		
Market variety – lightly proc. foods					0.016***	0.011***
					(0.005)	(0.003)
Controls	No	Yes	No	Yes	No	Yes
Observations	1162	1162	1162	1162	1162	1162

Note: Marginal effects from Poisson regressions are shown with robust standard errors clustered at section level in parentheses. Full results including all covariates are shown in Table A3 in the Appendix. *** p<0.01, ** p<0.05, * p<0.1.

Associations between market food variety and child nutritional status are summarized in Table 4. All three market variety metrics are positively and significantly associated with child HAZ and negatively and significantly associated with the likelihood of child stunting. Again, the magnitude of the associations in absolute terms is somewhat larger for lightly processed foods than for fresh foods. For instance, increasing market variety by 10 additional lightly processed foods is associated with a 0.09 higher HAZ and a 4 percentage point lower likelihood of child stunting.

Table 4: Associations between market food variety and child nutrition

	HAZ		Stunting	
	(1)	(2)	(3)	(4)
Panel A				
Market variety	0.007***	0.004**	-0.002***	-0.001**
	(0.002)	(0.002)	(0.001)	(0.001)
Controls	No	Yes	No	Yes
Observations	1154	1154	1154	1154
Panel B				
Market variety – fresh foods	0.011***	0.006**	-0.004***	-0.002**
	(0.003)	(0.003)	(0.001)	(0.001)
Controls	No	Yes	No	Yes
Observations	1154	1154	1154	1154
Panel C				
Market variety – lightly processed foods	0.017***	0.009*	-0.006***	-0.004**
	(0.004)	(0.005)	(0.002)	(0.002)
Controls	No	Yes	No	Yes
Observations	1154	1154	1154	1154

Note: Results from OLS regressions are shown with robust standard errors clustered at section level in parentheses. Full results including all covariates are shown in Table A3 in the Appendix. *** p<0.01, ** p<0.05, * p<0.1.

4.4 Robustness checks

In a first robustness check, we analyze the same associations between market food variety and child diets and nutrition for the subsample of children aged 12-59 months. The results in Table A4 in the Appendix show that the associations are consistently significant and even larger in absolute magnitude than those shown in Tables 3 and 4 for the whole sample also including older children.

In a second robustness check, we test the spatial sensitivity of our results. Fig. 6 shows coefficient plots for each of our three outcome variables (CDDS, HAZ, stunting), where each coefficient refers to model estimates with different cutoff values for the travel time to food retailers. Some interesting patterns can be observed. In panel (A), the associations between CDDS and market variety are insignificant for very localized food environments with a 10-minute cutoff. However, the associations are consistently positive and significant at 20-minute and higher cutoff times. For the anthropometric outcomes (HAZ in panel B and stunting in panel C), the patterns are different. Here we see significant results for the localized food environments (10- and 20-minute cutoffs) but insignificant results for larger cutoff times.

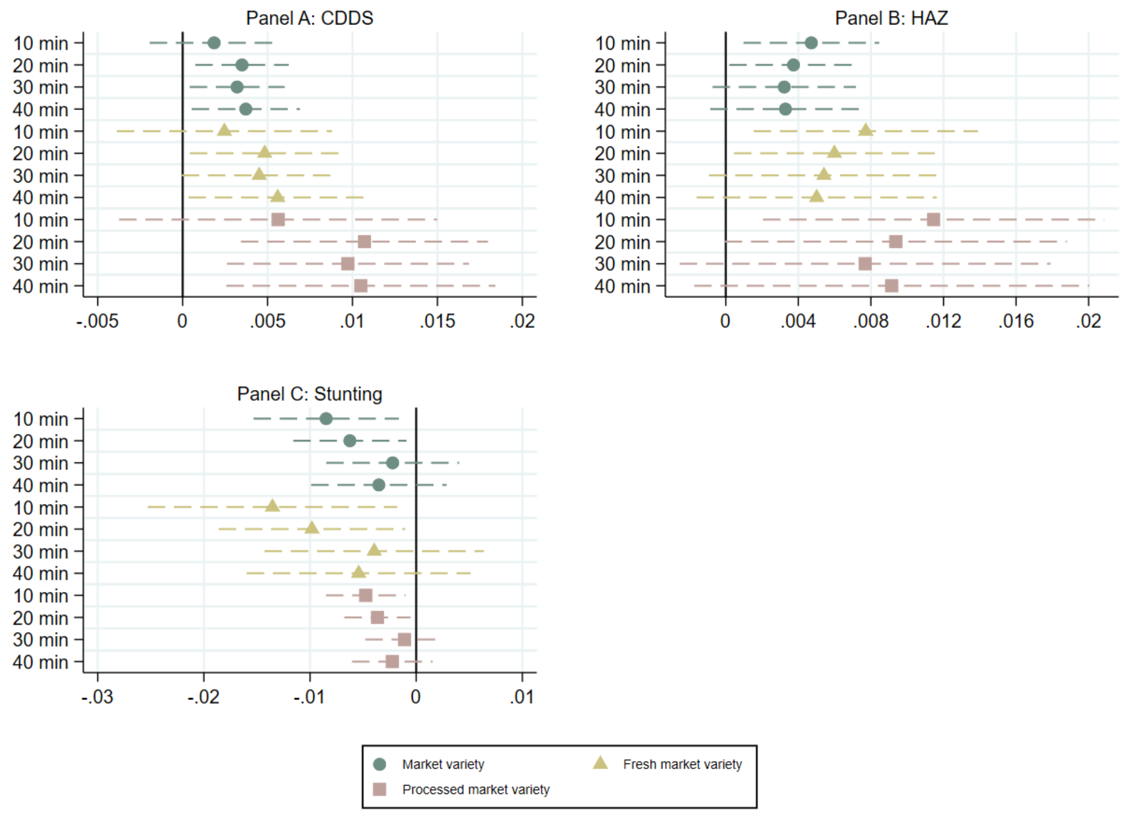

Figure 6: Spatial sensitivity analysis of the association between market food variety and child nutrition with four different travel time cutoffs

Note: Coefficients are shown with 95% confidence intervals. Each model represents a separate regression. Socioeconomic controls are included in all models but not shown here for brevity.

In a third robustness check, instead of using travel time to define individual food environments, we use physical distance and delineate spatial radii of 5km around each household to test the associations between market food variety and child diet and nutrition outcomes. The results are shown in Table A5 in the Appendix. They are similar to those with using a 20-minute travel cutoff in terms of both magnitude and significance levels.

In a final robustness check, instead of market food variety, which counts the number of food items, we define an alternative metric of market food diversity, counting the number of food groups and using the same groups as for constructing the CDDS. The results are shown in Table A6 in the Appendix. This market food diversity metric is also positively associated with CDDS and HAZ and negatively associated with child stunting. The associations are larger in magnitude, which is unsurprising because each food group contains multiple food items. Interestingly, as before for the food variety metrics, the associations referring to the diversity of lightly processed foods are somewhat larger than those referring to the diversity of fresh foods. These results again underline the important positive role of light processing for enhancing child nutrition outcomes.

5 Conclusion and policy implications

Child malnutrition and low-quality diets are persistent concerns across much of sub-Saharan Africa. In addition to own food production, which is widely observed especially in rural areas, markets play an increasing importance for accessing nutritious foods for urban and rural households alike (Ivanic and Martin, 2014; Sibhatu and Qaim, 2017). Hence, understanding what types of markets and market characteristics can contribute to enhanced child diets and nutrition is important from research and policy perspectives. Previous research has shown that improved market access has positive nutrition effects, but the characteristics of markets themselves and how differences in market food environments are linked to individual diets and nutrition has received insufficient research attention up till now (Gelli et al., 2020; Headey et al., 2019).

We have added to this literature by collecting and spatially linking household and market survey data along an urban-rural continuum in order to analyze relationships between food environments and child diets and nutrition outcomes. In particular, using the example of Malawi, we have developed new metrics of market food variety, counting the number of food items available within 20-minute travel time around each household.

A first important result is that food environments differ considerably with urban proximity. Market food variety is much larger in urban and peri-urban areas than in rural and more remote areas of Malawi. A second important result is that our metrics of market food variety seem to influence child diets and nutrition significantly. Market food variety is positively associated with child dietary diversity scores and height-for-age z-scores, and negatively associated with rates of child stunting, even after controlling for household living standard, own farm production, and various other confounding factors. A third important result is that the variety of lightly processed foods available in nearby markets is at least as important for child diet and nutrition outcomes as the variety of fresh foods. In many cases, the magnitude of the associations is even larger for the variety of lightly processed foods. This is likely due to the fact that markets for fresh and perishable foods often do not work well in rural areas, so that processed products are the only option for some households to access certain nutritious food groups at all. We have carried out various robustness checks without any changes to these major findings.

Our study has some limitations. One limitation relates to the potential role of seasonality. We have collected data in Malawi during the onset of the lean season, where food from own household production and food obtained from the market are both relevant for the majority of households. We expect that the influence of market food variety for child diets and nutrition may still be larger during the 'hunger' season, when own food stocks are exhausted in most households, and possibly somewhat smaller during the harvest and immediate post-harvest season. Capturing seasonal variation of food environments and linking this to seasonal variation of diets and nutrition could be an interesting topic for follow-up work. A second limitation relates to causal identification of the effects. While we have controlled for an array of socioeconomic characteristics in our regressions, potential issues of endogeneity remain. Our study therefore remains associational.

In spite of these limitations, a few policy implications can be derived. Our results clearly imply that markets and food environments show a lot of heterogeneity and are significantly associated with child diets and nutrition. Market food environments can be influenced through policies in multiple ways (Frelat et al., 2016). One way is improving road and market infrastructure and facilitating regulatory frameworks in order to reduce transport and transaction costs and thus make various types of foods more accessible across locations. Improved infrastructure and storage technologies can also help reduce food losses, which is true especially for fresh and perishable food items. Another important area for action is to invest in food processing technologies and infrastructure. Food processing increases the shelf-life of products and is particularly relevant for nutrient access in sparsely populated remote locations, where a large variety of fresh nutritious foods is difficult to provide outside of local harvest seasons. Reliance on ultra-processed foods can also have negative health and nutrition effects, which is why nuance is required (Reardon et al., 2021). Certain forms of light food processing are desirable to improve diets and nutrition, while ultra-processing is not.

A focus on market food environments is not the only area that matters for improving child nutrition in sub-Saharan Africa. Improvements in farm production, household incomes, education, and nutritional awareness are certainly also very important, as are direct nutrition interventions targeting particularly vulnerable population groups. However, our findings clearly show that market food environments are relevant and that there is a need to better measure and understand their role in different regional contexts.

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Appendix

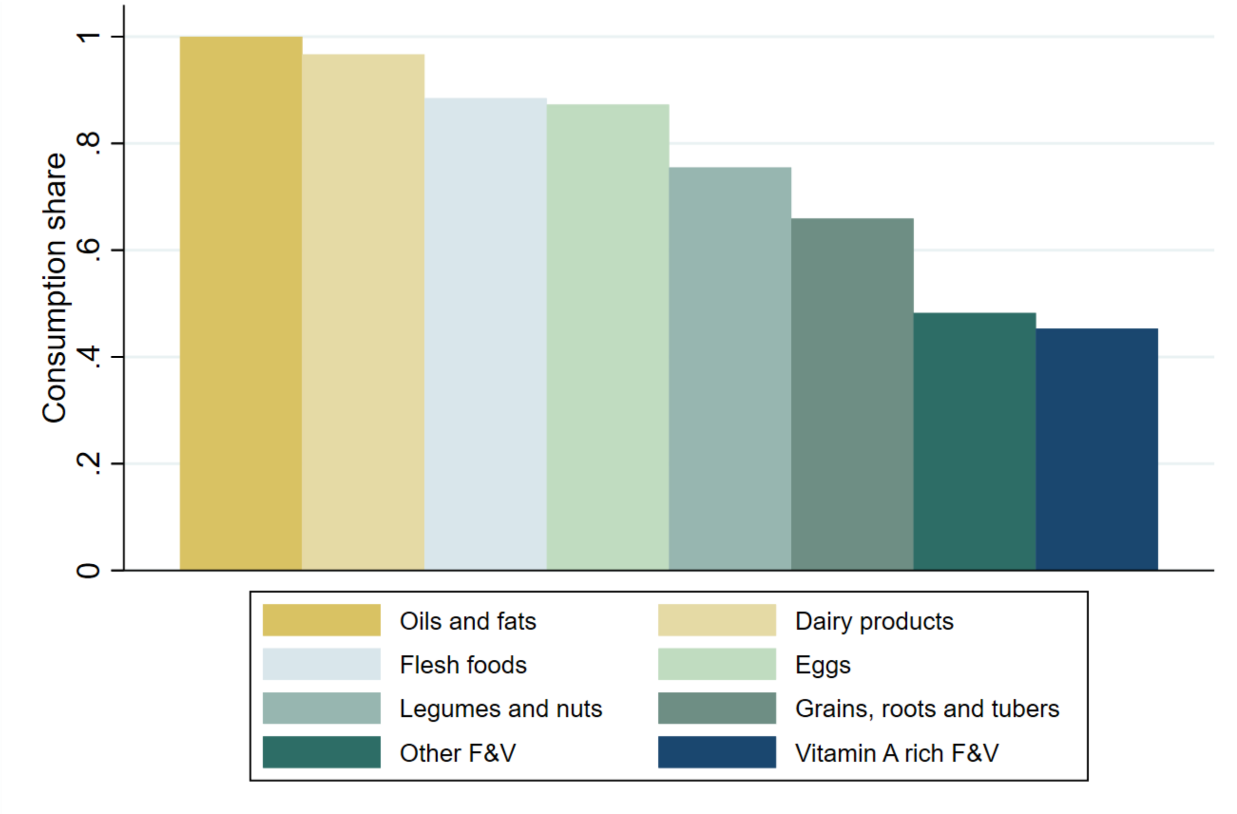

Figure A1: Share of different food groups consumed purchased from markets

Notes. The consumption shares shown are relative to total consumption of each food group from all sources (including market purchases, own production, gifts/transfers, and collection) calculated on a calorie basis. Households that have not consumed a particular food group are excluded (N=701). Other F&V refer to other fruits and vegetables. Vitamin A rich F&V refer to vitamin A rich fruits and vegetables.

Table A1: List of food items

Category	Complete list of food items
Unprocessed/ fresh	Fruits: mango, pineapple, papaya, avocado, baobab, plantains, watermelon, guava, pears, strawberries, grapes, apples Vegetables: Chinese cabbage, pumpkin leaves, bean leaves, cassava leaves, amaranths leaves, cowpea leaves, sweet potato leaves, mustard leaves, rape leaves, blackjack, spinach, carrots, sweet potatoes, tomatoes green, bean, eggplant, onions, okra, mushrooms, lettuce, cucumber, bell pepper, cabbage, fresh maize, potato, cassava, plantain Fresh legumes: peas Animal-sourced foods: fresh milk, eggs, meat (beef, goat, chicken, wild birds, duck, pork, pigeon), fish (tilapia, usipa, utaka, matemba)
Basic/ lightly processed	Fruits: baobab Vegetables: leaves (dried, unspecified) Grains: maize flour, pasta, bread (brown), cassava flour, rice (brown), rice (white), bread (white), sorghum, millet Dried legumes: cowpea, ground bean, soybean, pigeon pea, kidney bean, soya pieces, soybean flour, groundnut, groundnut flour, common bean Animal-sourced foods: yoghurt, milk (processed), milk (powdered), milk (flavored), chambiko canned meat, frozen chicken, frozen beef, dried fish small (usipa, matemba), dried fish medium (usipa), dried fish large (chambo, tilapia), smoked fish

Note: The food items depicted in this list are all items that were locally available for at least one household. Dried leaves were recorded as unspecified. No dried or canned fruits were present in any the local food environments.

Table A2: Variable measurement and description

Variable	Type	Min	Max	Description
Market variety	Count	0	85	Indicates the variety of foods available at a spatial dimension around the household.
Market variety -fresh foods	Count	0	51	Indicates the variety of fresh foods available at a spatial dimension around the household
Market variety – lightly processed foods	Count	0	35	Indicates the variety of lightly processed foods available at a spatial dimension around the household
Market diversity	Count	0	7	Indicates the number of food groups available at a spatial dimension around the household. Ranges from 0-7.
Market diversity – fresh foods	Count	0	7	Indicates the number of fresh food groups available at a spatial dimension around the household. Ranges from 0-7.
Market diversity – lightly processed foods	Count	0	6	Indicates the number of lightly processed food groups available at a spatial dimension around the household. Ranges from 0-6 (as eggs were not available in lightly processed form).
Age	Years	1	17	Indicates the age of the child
Female	Dummy	0	1	Indicates the sex of the child (1= female)
In school	Dummy	0	1	Indicates whether the child is currently attending school (1=yes)
Household size	Count	2	16	Indicates the number of household members
Religion	Dummies	0	1	We use three dummy variables to indicate Traditional, Christian, and Muslim households (other is used as the references))
Female head	Dummy	0	1	Sex of household head (1= female)
Age head	Years	19	98	Age of household head
Schooling head	Dummy	0	1	Indicates whether the household head finished secondary school
Total per capita expenditure (log)	MWK	6.73	12.93	Log of total per capita monthly expenditure on food and non-food items
Farm	Dummy	0	1	Indicates whether the household farms (1=yes)
Food crop	Count	0	9	Indicates how many food crops the household grows
Livestock	Dummy	0	1	Indicates whether the households owns any livestock (1=yes)
Improved water source	Dummy	0	1	Whether the household has access to an improved water source or treats unsafe water sources (boiling, chlorine) (1= improved)

Table A3: Associations between market food variety and child nutrition – full sample (age group 1-17 years) with covariates

	CDDS			HAZ			Stunting		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Market variety	0.004***			0.004**			-0.001**		
	(0.001)			(0.002)			(0.001)		
Market variety - fresh foods		0.005**			0.006**			-0.002**	
		(0.002)			(0.003)			(0.001)	
Market variety- lightly processed foods			0.011***			0.009*			-0.004**
			(0.003)			(0.005)			(0.002)
Age	-0.001	-0.001	-0.001	-0.023**	-0.023**	-0.023**	0.005	0.005	0.005
	(0.002)	(0.002)	(0.002)	(0.010)	(0.010)	(0.010)	(0.003)	(0.003)	(0.004)
Female	0.019	0.019	0.019	0.183**	0.182**	0.183**	-0.092***	-0.092***	-0.093***
	(0.016)	(0.016)	(0.016)	(0.082)	(0.082)	(0.082)	(0.027)	(0.027)	(0.027)
In school (1=yes)	0.006	0.007	0.005	-0.260**	-0.259**	-0.259**	0.100*	0.100*	0.100*
	(0.031)	(0.031)	(0.031)	(0.109)	(0.109)	(0.109)	(0.051)	(0.051)	(0.051)
HH size	0.010	0.010	0.010	-0.015	-0.015	-0.015	0.015	0.015	0.015
	(0.007)	(0.007)	(0.007)	(0.027)	(0.027)	(0.027)	(0.010)	(0.010)	(0.010)
Female head	0.031	0.032	0.031	0.005	0.005	0.005	-0.015	-0.015	-0.015
	(0.027)	(0.027)	(0.027)	(0.095)	(0.095)	(0.095)	(0.034)	(0.034)	(0.034)
Age head	-0.000	-0.000	-0.000	0.005	0.005	0.005	-0.001	-0.001	-0.001
	(0.001)	(0.001)	(0.001)	(0.003)	(0.003)	(0.003)	(0.001)	(0.001)	(0.001)
Education head	0.006	0.007*	0.006	0.024*	0.024*	0.024*	-0.008	-0.008	-0.008
	(0.004)	(0.004)	(0.004)	(0.012)	(0.012)	(0.012)	(0.005)	(0.005)	(0.005)
Total per capita expenditure (log)	0.138***	0.140***	0.136***	0.031	0.032	0.030	0.003	0.002	0.004
	(0.028)	(0.028)	(0.027)	(0.091)	(0.091)	(0.092)	(0.026)	(0.026)	(0.026)
Assets: bicycle	0.044	0.045	0.043	0.163	0.165	0.161	-0.077**	-0.078**	-0.076**
	(0.031)	(0.031)	(0.031)	(0.109)	(0.108)	(0.109)	(0.037)	(0.037)	(0.037)
Religion: Traditional	0.114*	0.110*	0.120**	-0.099	-0.104	-0.093	-0.275	-0.273	-0.278
	(0.061)	(0.062)	(0.061)	(0.483)	(0.483)	(0.483)	(0.207)	(0.207)	(0.207)
Religion: Christian	0.035	0.034	0.037	-0.094	-0.097	-0.090	-0.219*	-0.218*	-0.220*
	(0.038)	(0.038)	(0.038)	(0.418)	(0.419)	(0.417)	(0.121)	(0.121)	(0.121)
Religion: Muslim	0.089	0.087	0.090*	-0.233	-0.233	-0.236	-0.153	-0.153	-0.153
	(0.055)	(0.055)	(0.053)	(0.432)	(0.434)	(0.430)	(0.123)	(0.124)	(0.122)
HH farms (1=yes)	-0.000	-0.006	0.007	-0.231	-0.232	-0.236	0.106*	0.108*	0.107*
	(0.050)	(0.049)	(0.051)	(0.171)	(0.169)	(0.173)	(0.063)	(0.063)	(0.063)
Food crops grown	0.018*	0.018*	0.019*	-0.034	-0.034	-0.033	0.003	0.003	0.003
	(0.010)	(0.010)	(0.010)	(0.032)	(0.033)	(0.032)	(0.012)	(0.012)	(0.012)
HH owns livestock (1=yes)	0.019	0.018	0.020	0.107	0.107	0.106	-0.042	-0.042	-0.042
	(0.030)	(0.031)	(0.030)	(0.086)	(0.086)	(0.086)	(0.033)	(0.033)	(0.032)
Improved water source (1= yes)				0.029	0.032	0.028	-0.008	-0.010	-0.007
				(0.111)	(0.110)	(0.113)	(0.042)	(0.041)	(0.042)
Constant	-0.645**	-0.646**	-0.646**	-1.664	-1.666	-1.665	0.477	0.479	0.477
	(0.276)	(0.277)	(0.274)	(1.125)	(1.125)	(1.125)	(0.326)	(0.326)	(0.325)
N	1162	1162	1162	1153	1153	1153	1153	1153	1153
R^2				0.04	0.04	0.04	0.05	0.05	0.05
adj. R^2				0.03	0.03	0.03	0.04	0.04	0.04

Notes. Robust standard errors, clustered at the section level, in parentheses. Columns 1-3 report marginal effects for Poisson models. Columns 4-9 show OLS model results * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A4: Associations between market food variety and child nutrition – subsample (age group 12-59 months) with covariates

	CDDS			HAZ			Stunting		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Market variety	0.005**			0.007*			-0.002**		
	(0.002)			(0.004)			(0.001)		
Market variety - fresh foods		0.007**			0.011*			-0.004**	
		(0.003)			(0.006)			(0.002)	
Market variety- lightly processed foods			0.015***			0.017			-0.006**
			(0.005)			(0.010)			(0.003)
Age	0.025*	0.025*	0.024*	0.077	0.077	0.077	-0.054*	-0.054*	-0.054*
	(0.013)	(0.013)	(0.013)	(0.083)	(0.082)	(0.083)	(0.027)	(0.027)	(0.028)
Female	0.055	0.057	0.051	0.134	0.137	0.129	-0.043	-0.044	-0.042
	(0.035)	(0.035)	(0.035)	(0.157)	(0.157)	(0.157)	(0.046)	(0.046)	(0.046)
HH size	0.012	0.013	0.012	-0.054	-0.054	-0.053	0.029*	0.029*	0.028*
	(0.012)	(0.012)	(0.012)	(0.058)	(0.058)	(0.058)	(0.015)	(0.015)	(0.015)
Female head	0.053	0.054	0.053	-0.125	-0.129	-0.120	0.061	0.062	0.058
	(0.038)	(0.038)	(0.038)	(0.229)	(0.229)	(0.229)	(0.061)	(0.061)	(0.061)
Age head	-0.001	-0.000	-0.001	0.022***	0.022***	0.022***	-0.007***	-0.007***	-0.007***
	(0.002)	(0.002)	(0.002)	(0.008)	(0.008)	(0.007)	(0.002)	(0.002)	(0.002)
Education head	0.015***	0.015***	0.014***	0.044*	0.045*	0.044*	-0.009	-0.009	-0.009
	(0.005)	(0.005)	(0.005)	(0.025)	(0.025)	(0.025)	(0.009)	(0.009)	(0.009)
Total per capita expenditure (log)	0.130***	0.133***	0.126***	-0.368**	-0.366**	-0.370**	0.079**	0.078**	0.078**
	(0.036)	(0.036)	(0.035)	(0.173)	(0.172)	(0.175)	(0.035)	(0.035)	(0.035)
Owns bicycle	0.032	0.033	0.031	0.461**	0.460**	0.463**	-0.127*	-0.127*	-0.128*
(1=yes)	(0.038)	(0.039)	(0.038)	(0.216)	(0.216)	(0.216)	(0.064)	(0.064)	(0.064)
Religion: Traditional	-0.024	-0.028	-0.014	-1.868*	-1.888*	-1.836*	0.077	0.085	0.067
	(0.095)	(0.098)	(0.091)	(0.930)	(0.939)	(0.919)	(0.336)	(0.337)	(0.337)
Religion: Christian	0.137**	0.136**	0.142**	-1.527*	-1.543*	-1.503*	0.165	0.171	0.157
	(0.067)	(0.066)	(0.067)	(0.762)	(0.769)	(0.752)	(0.181)	(0.183)	(0.179)
Religion: Muslim	0.217**	0.213**	0.224**	-1.442*	-1.455*	-1.427*	0.081	0.085	0.078
	(0.089)	(0.090)	(0.087)	(0.845)	(0.850)	(0.839)	(0.184)	(0.185)	(0.184)
HH farms (1=yes)	0.064	0.056	0.073	-0.475	-0.475	-0.485	0.173	0.170	0.180
	(0.081)	(0.081)	(0.081)	(0.334)	(0.331)	(0.335)	(0.108)	(0.106)	(0.109)
Food crops grown	0.014	0.014	0.014	-0.012	-0.012	-0.013	-0.004	-0.004	-0.003
	(0.013)	(0.013)	(0.012)	(0.055)	(0.056)	(0.055)	(0.023)	(0.023)	(0.023)
HH owns livestock (1=yes)	0.022	0.021	0.022	-0.089	-0.088	-0.092	-0.011	-0.011	-0.009
	(0.038)	(0.038)	(0.037)	(0.190)	(0.190)	(0.190)	(0.064)	(0.064)	(0.064)
Improved water source				0.110	0.115	0.108	0.043	0.043	0.041
(1= yes)				(0.284)	(0.281)	(0.288)	(0.068)	(0.067)	(0.069)
Constant	-0.878***	-0.885***	-0.872***	2.384	2.386	2.365	-0.224	-0.229	-0.211
	(0.334)	(0.337)	(0.329)	(2.151)	(2.148)	(2.153)	(0.391)	(0.394)	(0.389)
N	298	298	298	298	298	298	298	298	298
R^2				0.09	0.09	0.09	0.09	0.09	0.09
adj. R^2				0.04	0.04	0.04	0.04	0.04	0.04

Notes. Robust standard errors, clustered at the section level, in parentheses. Columns 1-3 report marginal effects for Poisson models. Columns 4-9 show OLS model results * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A5: Associations between market food variety and child nutrition using spatial radii (5 km)– full sample (age 1-17 years)

	CDDS						HAZ						Stunting					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Market variety	0.008***	0.005**					0.009***	0.005*					-0.003***	-0.002**				
	(0.003)	(0.002)					(0.002)	(0.003)					(0.001)	(0.001)				
Market variety - fresh foods			0.011***	0.007**					0.013***	0.007*					-0.005***	-0.003**		
			(0.004)	(0.003)					(0.003)	(0.004)					(0.001)	(0.001)		
Market variety- lightly processed foods					0.026***	0.017**					0.028***	0.017*					-0.010***	-0.007**
					(0.009)	(0.007)					(0.007)	(0.009)					(0.002)	(0.003)
Age		-0.001		-0.001		-0.001		-0.023**		-0.023**		-0.023**		0.006		0.006		0.006
		(0.002)		(0.002)		(0.002)		(0.010)		(0.010)		(0.010)		(0.004)		(0.004)		(0.004)
Female		0.020		0.020		0.019		0.184**		0.184**		0.183**		-0.093***		-0.093***		-0.093***
		(0.016)		(0.016)		(0.017)		(0.082)		(0.082)		(0.082)		(0.026)		(0.026)		(0.027)
In school (1=yes)		0.007		0.007		0.008		-0.256**		-0.256**		-0.254**		0.099*		0.099*		0.099*
		(0.030)		(0.030)		(0.030)		(0.112)		(0.112)		(0.111)		(0.051)		(0.051)		(0.051)
HH size		0.011		0.011		0.010		-0.013		-0.013		-0.015		0.014		0.014		0.015
		(0.007)		(0.007)		(0.007)		(0.027)		(0.027)		(0.027)		(0.010)		(0.010)		(0.010)
Sex head (1=female)		0.034		0.033		0.034		0.011		0.011		0.013		-0.018		-0.018		-0.018
		(0.026)		(0.026)		(0.026)		(0.094)		(0.094)		(0.094)		(0.034)		(0.034)		(0.034)
Age head		-0.000		-0.000		-0.000		0.005		0.005		0.005		-0.001		-0.001		-0.001
		(0.001)		(0.001)		(0.001)		(0.003)		(0.003)		(0.003)		(0.001)		(0.001)		(0.001)
Education head		0.006		0.006		0.006		0.024**		0.024**		0.024*		-0.008		-0.008		-0.008
		(0.004)		(0.004)		(0.004)		(0.012)		(0.012)		(0.012)		(0.005)		(0.005)		(0.005)
Total per capita expenditure (log)		0.134***		0.136***		0.131***		0.023		0.028		0.015		0.007		0.004		0.012
		(0.027)		(0.027)		(0.027)		(0.092)		(0.092)		(0.093)		(0.026)		(0.026)		(0.025)
Owns bicycle		0.047		0.046		0.049		0.170		0.168		0.175		-0.080**		-0.079**		-0.082**
		(0.031)		(0.031)		(0.031)		(0.108)		(0.108)		(0.107)		(0.037)		(0.037)		(0.037)
Traditional		0.099*		0.095		0.109*		-0.136		-0.145		-0.114		-0.261		-0.258		-0.271
		(0.060)		(0.060)		(0.060)		(0.479)		(0.479)		(0.478)		(0.206)		(0.206)		(0.206)
Christian		0.029		0.030		0.029		-0.107		-0.106		-0.107		-0.214*		-0.214*		-0.213*
		(0.038)		(0.038)		(0.037)		(0.413)		(0.413)		(0.414)		(0.119)		(0.119)		(0.119)
Muslim		0.076		0.077		0.072		-0.267		-0.265		-0.272		-0.141		-0.141		-0.139
		(0.052)		(0.053)		(0.051)		(0.424)		(0.424)		(0.424)		(0.119)		(0.119)		(0.118)
HH farms (1=yes)		0.010		0.006		0.013		-0.217		-0.226		-0.212		0.097		0.104		0.090
		(0.054)		(0.053)		(0.055)		(0.178)		(0.176)		(0.182)		(0.067)		(0.066)		(0.069)
Food crops grown		0.018*		0.018*		0.019*		-0.033		-0.035		-0.031		0.003		0.003		0.001
		(0.010)		(0.010)		(0.010)		(0.033)		(0.033)		(0.033)		(0.013)		(0.013)		(0.013)
Owns livestock (1=yes)		0.018		0.018		0.017		0.102		0.103		0.099		-0.041		-0.041		-0.040
		(0.030)		(0.030)		(0.030)		(0.086)		(0.087)		(0.086)		(0.032)		(0.032)		(0.032)
Improved water source (1= yes)								0.024		0.033		0.012		-0.005		-0.010		0.004
								(0.106)		(0.105)		(0.106)		(0.039)		(0.039)		(0.038)
Constant	0.841***	-0.623**	0.847***	-0.634**	0.839***	-0.600**	-1.862***	-1.613	-1.849***	-1.650	-1.863***	-1.541	0.477***	0.454	0.471***	0.472	0.481***	0.416
	(0.046)	(0.273)	(0.046)	(0.275)	(0.046)	(0.270)	(0.094)	(1.129)	(0.095)	(1.126)	(0.091)	(1.131)	(0.032)	(0.323)	(0.033)	(0.324)	(0.029)	(0.320)
N	1162	1162	1162	1162	1162	1162	1153	1153	1153	1153	1153	1153	1153	1153	1153	1153	1153	1153
R^2							0.02	0.04	0.02	0.04	0.02	0.04	0.02	0.05	0.02	0.05	0.02	0.05
adj. R^2							0.02	0.03	0.02	0.03	0.02	0.03	0.02	0.04	0.02	0.04	0.02	0.04

Notes. Robust standard errors, clustered at the section level, in parentheses. Columns 1-6 report marginal effects for Poisson models. Columns 7-18 show OLS model results * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A6: Associations between market food diversity and child nutrition - full sample (age group 1-17 years) with covariates

	CDDS			HAZ			Stunting		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Market diversity	0.020			0.026			-0.015**		
	(0.019)			(0.021)			(0.006)		
Market diversity - fresh foods		0.034*			0.040*			-0.018***	
		(0.020)			(0.020)			(0.006)	
Market diversity - lightly processed foods			0.063**			0.055**			-0.028***
			(0.032)			(0.027)			(0.008)
Age	-0.001	-0.001	-0.001	-0.022**	-0.023**	-0.023**	0.005	0.005	0.006
	(0.002)	(0.002)	(0.002)	(0.010)	(0.010)	(0.010)	(0.004)	(0.004)	(0.004)
Female	0.018	0.018	0.017	0.179**	0.181**	0.179**	-0.091***	-0.092***	-0.091***
	(0.017)	(0.016)	(0.016)	(0.082)	(0.082)	(0.082)	(0.027)	(0.027)	(0.027)
In school (1=yes)	0.012	0.009	0.009	-0.247**	-0.255**	-0.250**	0.096*	0.099*	0.098*
	(0.030)	(0.030)	(0.030)	(0.110)	(0.111)	(0.110)	(0.052)	(0.052)	(0.052)
HH size	0.011*	0.011	0.011*	-0.012	-0.013	-0.012	0.013	0.014	0.014
	(0.007)	(0.007)	(0.007)	(0.027)	(0.027)	(0.027)	(0.010)	(0.010)	(0.010)
Female head	0.037	0.033	0.037	0.021	0.010	0.020	-0.023	-0.017	-0.022
	(0.027)	(0.027)	(0.027)	(0.093)	(0.096)	(0.094)	(0.034)	(0.034)	(0.034)
Age head	-0.000	-0.000	-0.000	0.005*	0.005	0.005	-0.001	-0.001	-0.001
	(0.001)	(0.001)	(0.001)	(0.003)	(0.003)	(0.003)	(0.001)	(0.001)	(0.001)
Education head	0.007*	0.007	0.007	0.026**	0.025*	0.026**	-0.009*	-0.008	-0.008
	(0.004)	(0.004)	(0.004)	(0.013)	(0.012)	(0.012)	(0.005)	(0.005)	(0.005)
Total per capita	0.147***	0.144***	0.144***	0.051	0.043	0.044	-0.004	-0.001	-0.001
expenditure (log)	(0.027)	(0.027)	(0.026)	(0.089)	(0.090)	(0.090)	(0.026)	(0.026)	(0.026)
Owns bicycle	0.044	0.042	0.039	0.157	0.155	0.153	-0.073*	-0.073*	-0.071*
(1=yes)	(0.032)	(0.032)	(0.032)	(0.110)	(0.110)	(0.108)	(0.038)	(0.038)	(0.038)
Religion:	0.100	0.102*	0.116**	-0.124	-0.127	-0.094	-0.266	-0.265	-0.281
Traditional	(0.061)	(0.061)	(0.059)	(0.475)	(0.484)	(0.474)	(0.204)	(0.210)	(0.204)
Religion: Christian	0.038	0.037	0.043	-0.084	-0.085	-0.075	-0.225*	-0.223*	-0.229*
	(0.039)	(0.039)	(0.039)	(0.415)	(0.418)	(0.415)	(0.120)	(0.121)	(0.120)
Religion: Muslim	0.084	0.083	0.095*	-0.242	-0.242	-0.223	-0.157	-0.153	-0.164
	(0.055)	(0.055)	(0.055)	(0.423)	(0.426)	(0.423)	(0.118)	(0.121)	(0.119)
HH farms (1=yes)	-0.036	-0.024	-0.027	-0.325*	-0.292*	-0.311*	0.140**	0.126*	0.133**
	(0.046)	(0.049)	(0.047)	(0.171)	(0.171)	(0.170)	(0.066)	(0.065)	(0.065)
Food crops grown	0.017	0.018*	0.018*	-0.037	-0.034	-0.035	0.004	0.003	0.003
	(0.010)	(0.010)	(0.010)	(0.034)	(0.033)	(0.034)	(0.013)	(0.012)	(0.012)
HH owns livestock	0.013	0.015	0.013	0.093	0.097	0.093	-0.037	-0.039	-0.037
(1=yes)	(0.030)	(0.030)	(0.030)	(0.087)	(0.087)	(0.087)	(0.032)	(0.032)	(0.032)
Improved water source				0.057	0.029	0.039	-0.013	-0.004	-0.006
(1= yes)				(0.106)	(0.110)	(0.110)	(0.042)	(0.044)	(0.043)
Constant	-0.705**	-0.702**	-0.735**	-1.858	-1.803	-1.846	0.572*	0.535	0.559*
	(0.305)	(0.289)	(0.297)	(1.124)	(1.122)	(1.127)	(0.321)	(0.325)	(0.324)
N	1162	1162	1162	1153	1153	1153	1153	1153	1153
R^2				0.04	0.04	0.04	0.05	0.05	0.05
adj. R^2				0.03	0.03	0.03	0.04	0.04	0.04

Notes. Robust standard errors, clustered at the section level, in parentheses. Columns 1-3 report marginal effects for Poisson models. Columns 4-9 show OLS model results * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.