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# Rural food markets and child nutrition

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Derek Headey
International Food Policy Research Institute

Kalle Hirvonen
International Food Policy Research Institute

John Hoddinott
Cornell University

David Stifel
Lafayette College

Address for correspondence: John Hoddinott, Savage Hall, Room 305, Division of Nutritional Sciences, Cornell University, Ithaca, NY, USA, 14853.

**Abstract**

Child dietary diversity is poor in much of rural Africa and developing Asia, prompting significant efforts to leverage agriculture to improve diets. However, growing recognition that even very poor rural households rely on markets to satisfy their demand for nutrient-rich non-staple foods warrants a much better understanding of how rural markets vary in their diversity, competitiveness, frequency and food affordability, and how such characteristics are associated with diets. This paper addresses these questions using data from rural Ethiopia. Deploying a novel market survey in conjunction with an information-rich household survey, we find that children in proximity to markets that sell more non-staple food groups have more diverse diets. However, the association is small in absolute terms; moving from three non-staple food groups in the market to six is associated with an increase the number of non-staple food groups consumed by ~0.24 and the likelihood of consumption of any non-staple food group by 12 percentage points. These associations are similar in magnitude to those describing the relationship between dietary diversity and household production diversity; moreover, for some products, notably dairy, we find that household and community production diversity is especially important. These modest associations may reflect several specific features of our sample which is situated in very poor, food-insecure localities where even the relatively better off are poor in absolute terms and where, by international standards, prices for non-staple foods are very high.

**Keywords: food markets, child nutrition, diet diversity, Ethiopia**

**JEL codes:** Q18, O15, I15

Improving the diets of pre-school children's children has intrinsic and instrumental value: intrinsic because improving the wellbeing of children is of value in its own right (Hirvonen and Hoddinott 2018); instrumental because healthy diets are important for the development of well-nourished and healthy children, which renders them more likely to accumulate other forms of human capital such as cognitive skills and subsequently higher incomes in adulthood (Hoddinott et al, 2013). Arimond and Ruel (2004), Mallard et al. (2014), Headey, Hirvonen and Hoddinott (2018) and others find that diverse diets rich in animal-sourced proteins and micro-nutrients are associated with reductions in chronic undernutrition, particularly in the 6-23 months age range in which stunting rates increase sharply. It is not surprising, therefore, that improving the diets of children has attracted attention from policymakers and researchers, including a growing body of literature in agricultural economics (Headey and Masters, 2018, Ruel, et al., 2018).

A major focus of both the burgeoning scientific literature and the programmatic focus on improving diets in poor countries has emphasized diversifying household food production, particularly via the cultivation of homestead garden plots and small-scale dairy and poultry operations (Ruel, et al., 2018). The logic of these approaches is twofold. First, child undernutrition still remains a predominantly rural problem in low-income countries, especially Africa (Headey and Masters, 2018). In Ethiopia, for example, we estimate that around 91% of the country's 7.15 million stunted pre-schoolers are rural.[1] Second, since most rural households

[1] Source: The 2016 Ethiopian Demographic Health Survey, which reports a 39.9% stunting rate in rural areas and 25.4% rate in urban areas, and an overall rate of 38.4%. The United Nations estimate that there are 18.26 million pre-school children in Ethiopia (aged 0-5 years), implying that there are 7.15 million stunted children, 6.66 million of whom are rural.

in low income countries still predominantly depend on farming, agricultural diversification could improve diets either through increasing cash income from the sale of high value foods, or through improving access to non-staple foods that are expensive or unavailable in markets (Haselow, et al., 2016). There are countless programs aimed at diversifying household food production and more than 40 studies that document associations between household production diversity and diversity of household diets. Systematic reviews of this literature find “small but consistent associations” (Jones 2017), but “little evidence to support the assumption that increasing farm production diversity is a highly effective strategy to improve smallholder diets” (Sibhatu and Qaim 2018).

For economists, the relatively weak association between farm production diversity and consumption diversity is unsurprising given the economic returns to specialization and the relatively basic preconditions for efficient markets. At the same time, development economists have long stressed that markets in low-income countries, particularly in rural areas, can be characterized by systematic and widespread failures (de Janvry, et al., 1991), which may be particularly important in the context of highly perishable nutrient-dense foods. In the presence of market failures, household decisions on food production and consumption may be non-separable (Singh, et al., 1986). Hoddinott, Headey and Dereje (2015), for example, argue that dairy markets in rural Ethiopia are highly underdeveloped, with virtually no market for processing and storing highly perishable cow’s milk in isolated rural areas. Households therefore have an incentive to own cattle in order to access milk that cannot otherwise be accessed in markets. Consistent with this hypothesis they find that in households owning dairy cattle children 6-23 months of age are more likely to drink milk, but that this association does not hold when households live close to a food market. Other studies in Ethiopia also confirm the importance of market access in shaping diets and conditioning the relationship between production patterns and dietary patterns. Hirvonen and Hoddinott (2017) find that increases in household level production diversity leads to increased dietary diversity in children 6-23m, but not when households live in close proximity to a food market. Hirvonen, Hoddinott, Minten and Stifel (2017) find that better nutrition knowledge leads to considerable improvements in children's dietary diversity but only in areas with relatively good market access. Finally, Sibhatu and Qaim (2017) use nationally representative expenditure survey data for Ethiopia to study the extent of consumers' dependence on own production and markets. They find that while rural Ethiopians are indeed highly dependent on consuming their own production of staple foods, their diversification away from staples is mainly based on market purchases.[2]

Despite this more nuanced analysis of the interactions between household food production and access to markets, economists have arguably done a poor job of conceptualizing and measuring market access (Chamberlin and Jayne, 2013). In Ethiopia alone, Chamberlin note that market access has been measured as "the distance or walking time to the nearest district administrative seat (woreda town), market town (which may be different than the woreda town), all-weather road, seasonal road, bus service, development agent, input supply shop, or grain mill; whether access to a road had improved in the recent past; whether an all-weather road passes

[2] Relatedly, Mulmi, Block, Shively and Masters (2016) assess whether Nepalese households have access to food from elsewhere than their own farm production, by using their district share of total food consumption that is purchased or received in-kind. Studies elsewhere in the literature also explore the importance of markets for buffering the adverse nutritional impacts of climatic shocks (Darrouzet-Nardi and Masters 2017; Mulmi, Block, Shively and Masters 2016).

through the woreda; and road density in the woreda". These types of proxies for market access may be very poor indicators of the latent quality of a market, particularly the nutritional dimensions of market quality. Despite sizeable literatures on market integration and specific value chains (Fafchamps and Gavian, 1996, Minten, et al., 2014) and the emergence of supermarkets in low-income countries (Reardon, et al., 2003), which predominantly serve urban populations at much less risk of undernutrition, in many settings we know little about such basic constructs as the availability of different types of foods.

In this paper, we redress these knowledge gaps through a more granular analysis of rural food markets and the associations between food market characteristics and the quality of children diets. Specifically, we address three novel and policy-relevant research questions. First, how do rural food markets vary in terms of a range of potentially important characteristics such as the frequency of their opening, the availability of different foods, food prices, and location and infrastructure characteristics? Second, are market characteristics – particularly the diversity and affordability of foods – associated with the quality (diversity) of children's diets, even after we control for the diversity of foods produced by the household? And third, what sorts of factors condition the relationship between market quality and dietary quality?

## Data and Methods

In this section, we describe our sample, data and our econometric methods.

### *Data*

We use a combined child, household and market survey conducted to understand the determinants of nutrition in food-insecure areas of rural Ethiopia (Berhane, et al. 2017). Our sample consists of children aged 6-30 months living in households residing in the highland regions of Ethiopia: Amhara; Oromia; Southern Nations, Nationalities and Peoples' (SNNP) and Tigray. These households live in woredas (districts) selected for inclusion in ongoing (2016-2020) impact evaluations of the fourth phase of Ethiopia's Productive Safety Net Programme (PSNP). Beginning in 2018, this fourth phase of the PSNP includes a suite of nutrition-sensitive activities, centered around the provision of information on improved maternal and child nutrition practices (GFDRE 2014). Consequently, the evaluation work has two components: (1) an assessment of the impact of the PSNP on food security, assets and livelihoods; and (2) an assessment of its impact on maternal and child nutrition. Baseline data for the second component, collected in March and August 2017, form the basis of this study, augmented by an unusually extensive survey of the nearest food market for each community.

Within each region, probability proportional to size sampling was used to select 22 woredas from a list of woredas where the PSNP was operational as of January 2016, the proportions being derived from population size and program coverage. Within each woreda, three kebeles (sub-districts) were selected at random (corresponding to the enumeration areas), yielding a sample of 88 woredas and 264 kebeles (Appendix Figure A1 shows the locations of these kebeles). For the first component of the impact evaluation, lists of PSNP and non-PSNP participant households within each kebele were obtained and random samples of 28 households were drawn from each group (16 PSNP; 12 relatively poor non-PSNP). As this sample did not contain enough children needed for the second component of the impact evaluation (on maternal and child nutrition), using the same selection process, additional households with children aged 0-23 months were sampled (Berhane et al, 2018). Surveys were fielded in March (when children were 0-23 months) and August (when they were 6-30 months). Given the objectives of this paper, we use data collected on children six months or older. After dropping households with missing data and the 57 households living more than 50 km from a food market, we have 4,286 such children in the sample evenly distributed across all four regions: 1,888 (44%) observed in March; and 2,398 (56%) observed in August. [3] The sample is 50.1% female with 93% being sons or daughters of the household head. A wide variety of household data were included in the survey (described in more detail below), including information on child diets, farm production, household wealth/assets, maternal nutritional knowledge and household demographics.

***Outcome variables***

Our main outcome of interest is child dietary quality as measures by dietary diversity metrics. Mothers were asked a series of yes/no questions about foods consumed by children in our sample. Following recommendations found in WHO (2008), these were grouped into the following categories: Grains, roots and tubers (e.g., barley, enset, maize, teff, and wheat); legumes and nuts; dairy products (milk, yogurt, cheese); flesh foods (meat, poultry and fish products); eggs; vitamin A rich fruits and vegetables; and other fruits and vegetables.[4] Summing answers to these questions gives the child's Dietary

[3] The sample size increases over time because children aged 0-5 months in March age into the August survey round. Household and child attrition between March and August 2017 was less than 3 percent and was driven largely by insecurity in Oromia which rendered some kebeles inaccessible (Berhane et al, 2018).

[4] These groups and their aggregation reflect the need for young children to consume a variety of food groups if they are to meet both energy and micronutrient needs (FANTA 2006; WHO 2008; Allen 2013). They are highly correlated with more detailed and complex measures of food and micronutrient intake (Daniels et al. 2009; Moursi

Diversity Score (DDS) which ranges in value from 0 to 7, with a cut-off of four groups used to define minimum dietary diversity.[5]

***Measuring market quality characteristics***

In addition to the household survey, we fielded a survey of the market closest to households in each kebele. Apart from collecting price data on 71 different foods, enumerators were instructed to assess whether each of these foods was available anywhere in the market. Data on market characteristics – number of food sellers, days of operation, and descriptions of infrastructure including road quality, availability of cell phone service, electricity and buses – were also collected. These data were collected at two points in time in 2017 (March and August) allowing seasonal comparison of food availability.

In addition to these non-price characteristics of the market, we use our price data in two ways. First, we calculate the cost of acquiring calories from the cheapest staple in each market to capture how expensive it is to satisfy basic calorie requirements. Lower staple prices have beneficial real income effects for net food consumers. Across our full sample, the mean cost of acquiring 500 calories from the cheapest staple cereal was 0.88 birr in March and 1.05 birr in August (the lean season). Second, we calculate the cost of diversifying away from staple foods.

et al. 2008; FANTA 2006; Ruel 2003) and with measures of children's nutritional status such as height in a number of developing countries including Ethiopia (Jones et al. 2014; Ali et al. 2012). See Hirvonen and Hoddinott (2017) for additional discussion and references.

[5] A limitation of this 24 hour recall is that there may be children who consume non-staple foods but do not do so with regularity. This will lead to some attenuation bias, see Thorne-Lyman, Spiegelman, and Fawzi (2014).

Following (Headey, et al., 2017), we measure the ratio of non-staple calories relative to staple food calories (cereals/roots/tuber), the calorie price ratio (CPR). These CPRs are calculated for each food group using the cheapest source of calories within that group and the cheapest source of cereals/roots/tubers in that market.[6] CPRs have a straightforward interpretation. For example, if, in a market, the dairy food group has a CPR of 10.3, it means that in that market it costs 10.3 times more to obtain a calorie from a dairy product than it does a calorie from a staple.

### *Econometric approach*

Our outcomes are measures of diet (*DIET*) of child *i*, in households *h* that reside in woreda *w* and kebele *k* observed at time *t*. In addition to market (MARKET) characteristics which are the focus of this paper, we control for vectors of child (CHILD), maternal (MATERNAL), household (HH), and kebele (KEBELE) characteristics. In all models, we also control for woreda (W) and survey round (T) fixed effects. Vectors of estimated coefficients are denoted by β while ε is the disturbance term. We estimate models of the following form.

[6] We applied the following strategy to address missing prices for items that were not sold in the market. First, we took the zonal level price for the item in March and August 2017 from the monthly retail price survey administrated by the Central Statistical Agency (CSA) of Ethiopia. Second, to proxy for transaction costs associated with travelling to another market, we computed the distance to the nearest town of 10,000 people and multiplied this distance with the price of a 1 km bus ticket reported in the CSA's retail price survey. In the final step, we added this transaction cost to the zonal level CSA price and replaced the missing price in our market data with this imputed price value.

$$DIET_{ihwkt} = \beta_{CHILD} \cdot CHILD_{ihwkt} + \beta_{MATERNAL} \cdot MATERNAL_{hwkt} + \beta_{HH} \cdot HH_{hwkt} + \beta_{KEBELE} \cdot KEBELE_{hwt} + \beta_{MARKET} \cdot MARKET_{kwt} + W_w + T_t + \varepsilon_{ihkwt} \quad (1)$$

Where DIET is measured as a dichotomous outcome, we estimate the model using linear regression and probit estimators. Where DIET is measured as a continuous variable, we estimate linear regression models, but because these continuous measures are non-negative counts, we also estimate poisson regressions. Acknowledging the sampling design (Abadie et al. 2017), we cluster the standard errors at the woreda level. In the case of probit and poisson estimators, we convert the coefficients into marginal effects.[7]

The coefficients on market diversity, $\beta_{MARKET\ DIVERSITY}$, are the principal outcome of interest in this study, but we also control for a number of other market characteristics: a dummy variable equaling one if the market has more than 20 vendors selling food; number of days per week the market operates; whether the market has a bus service; and the cost, per calorie, of purchasing the cheapest cereal available in the market. We do not include other infrastructure measures such as electricity or cell phone service because, while they differ across woredas, they rarely differ within woredas and so are differenced out when we estimate our woreda fixed effects models.

A number of previous studies explore household level determinants of child dietary diversity, including production diversity, maternal nutritional knowledge and education, and household wealth. CHILD includes child age, sex and whether the child is the son or daughter of

[7] For probit, the woreda fixed effects are implemented using the so called brute force approach in which dummies for each woreda are added into the model and then this model is estimated using a probit estimator.

the household head. MATERNAL includes grades of education, log age and mothers' score on a 12 question test of her knowledge of complementary foods and feeding.[8] Household (HH) characteristics include head's grades of education, log age, sex and religion (denoted by two dummy variables for Muslim and for Protestant with Orthodox Christian being the reference category). We control for household size, the food gap,[9] and three measures of household wealth – livestock holdings as measured by tropical livestock units (TLU), land operated (hectares), and an asset index based on ownership of consumer durables constructed using principal components (Filmer and Pritchett, 2001). At the kebele level, we control for the mean level of the food gap, mean maternal knowledge of complementary feeding and the mean of the asset index. These can be thought of as locality level demand side factors that might shift household demands for certain foods through norms shifting or through dispersion of information about what constitutes a good child diet. These controls also soak up some otherwise unobservable locality characteristics that might be correlated with the diversity of foods sold in the market. For example, traders might be more likely to sell high value products in markets where, on average households are wealthier or where mothers are more knowledgeable about the importance of different complementary foods.

In an observational study such as this, there is concern that there will exist correlation between our estimated coefficients and the disturbance term. Here of particular concern is the

[8] Items on this test included questions such as "What are some foods that are rich in iron?" and "What can happen to children if they do not eat enough vitamin A-rich foods?"

[9] The food gap is a food security measure used extensively in Ethiopia. A household is considered as food insecure in a given month if it self-reports that it was unable to satisfy its food needs for at least five days in that month.

possibility that $E(\beta_{MARKET\ DIVERSITY}\ \varepsilon_{ihkwt}) \neq 0$. While we cannot rule this out, we note that our model addresses many sources of such a correlation. In addition to controlling for fixed woreda effects and survey round, we control for other market characteristics that might be associated with market diversity (size, cereal price levels, accessibility) and locality demand side characteristics (mean kebele wealth, food security, knowledge of complementary foods). At the household level, we include characteristics that shift demand for child diet quality through taste (maternal age, education and knowledge of complementary foods) or income (education, food security, wealth).[10]

**Descriptive results**

In this section we focus on describe the basic nutritional characteristics of the sample of children in the household survey, and some of the main findings of the market characteristics survey. Figure 1 shows the results of estimating a weighted local polynomial regression of the child dietary diversity score against child age, with a 95% confidence interval (shown as the shaded area around the regression line). Two features are readily apparent from Figure 1: (1) Dietary diversity rises slowly with age; and (2) in line with previous work in rural Ethiopia (Hirvonen, 2016; Hirvonen, Headey, Golan, & Hoddinott, 2019), DDS is abysmally low for children at all ages. Table 1 provides more detail. The average child consumes 1.6 food groups and only 5 percent consume the WHO (2008) recommended daily consumption of four groups or more.

[10] We do not include PSNP status in our model but note that many of these characteristics, such as food security and livestock holdings, are correlated with whether the household receives PSNP payments. Including it does not change our findings.

Basic staples are the most commonly consumed food group (80 percent) followed by other fruit and vegetables (29 percent) and legumes and nuts (26 percent). Less than 15 percent of children consumed vitamin A rich fruits and vegetables or dairy and few consume flesh foods or eggs. On average, children consume 0.8 non-staple food groups. Dietary diversity is higher in August, reflecting, in part, the ageing of the sample.

[FIGURE 1 & TABLE 1 HERE]

Approximately 15% of children in our sample, mostly aged 6-8 months, consumed no foods the previous day.[11] When we exclude these children, as shown in the bottom panel of Table 1, we see that virtually all the remaining children consume grains, tubers or roots. Given this fact, what is of interest to us is the consumption of non-staple food groups.[12] Table 2 gives the distribution of non-staple consumption patterns by survey round. Just under half the children in our sample consumed no non-staple foods, 32 percent consumed one non-food group, 17 percent consumed two non-food groups and 5 percent consumed three or more. Non-staple food consumption is more prevalent in the August round of data.

[TABLE 2 HERE]

Mean maternal age is 29 years. Mothers are poorly educated. Maternal mean grades of schooling is only 0.8 and 84% report never attending school. In March and August, we administered short quizzes consisting of 12 questions on complementary feeding (CF). Mean

[11] 95 % of the children who did not consume foods in the previous day were not yet introduced to complementary foods at the time of the interview; they were either exclusively or intensively (breastmilk and liquids such as water, juices) breastfed.

[12] The consumption of foods apart from grains, roots or tubers is, for brevity, referred to as "non-staples".

scores were 5.8 in March and 6.0 in August. Schooling levels of the household head are also low with 80% never having attended school. Mean age of the head is 38 years. Only 10.6% of heads are female. Moreover, 50% are Ethiopian Orthodox Christians, 30.4% are Muslim, and 16.8% are Protestant. The mean household size in this sample is 5.8 members.

The poor dietary diversity of children in this sample is consistent with the high levels of food insecurity and low levels of wealth of the households in which they reside. The average months of self-reported food shortages (food gap) is 2.7 months with 27.2% having a food gap of four months or more. Median land holdings are 0.64 ha; on average, households own 3.1 TLU.

Averaging over both survey rounds, 41 percent of households produce no non-staple foods, just 36 percent produce one non-staple food group, 17 percent produce two and 6 percent produce three or more non-staple food groups.[13] This very limited variety of foods produced suggests that markets are indeed likely to be an important source of dietary diversification in rural Ethiopia (Sibhatu and Qaim, 2017).

Table 3 provides descriptive data on these markets in terms of market frequency and infrastructure characteristics (Table 3a), diversity of foods sold in markets (Table 3b) and calorie-relative prices of foods sold (Table 3c). Table 3a shows that approximately half (53 percent) of markets operate on a weekly basis with another 30 percent operating twice a week. The number of vendors selling food in these markets is relatively high with 76 percent having more than 50 traders selling food and another 14 percent having 21 to 50, while 77 percent have bus service and 76 have electricity. Cell phone coverage is nearly universal.

[13] For on-farm crop production we consider the growing season before the survey (meher for March and belg for August and for livestock production, we consider the 3 months prior to the survey.

Table 3b demonstrates that rural markets in Ethiopia are “incomplete” in terms of the number of markets that do not sell at least one product within a given food group. All markets sell at least one grain, root or tuber, and virtually all markets (>95%) sell other (non-vitamin A-rich) vegetables, eggs and legumes, while 89% sell other fruits (Table 3b). However, only 83% sell vitamin A-rich fruits or vegetables, 74% of markets sell nuts, while just 45% sell dairy products. Figure 2 shows that the average market sells 7.6 different staples, 4.2-4.8 beans, peas nuts and seeds but fewer than one dairy product and between 0.5 and 1.2 flesh foods. There is also limited choice in terms of Vitamin A rich fruits and vegetables. The absence of dairy in many markets partly accounts for the fact that only 35.2% of markets in the March round and just 16.7% of markets in the August round sold all 6 non-staple food groups, although many markets fall short of providing even four non-staple food groups. In addition to a number of markets failing to provide a wide range of non-staple foods, in the lean-season (August) market diversity falls.

[TABLE 3 HERE]

[FIGURE 2 HERE]

Table 3c reports calorie price ratios by food groups as well as the market geometric mean by round, including imputed missing price, as described in footnote 6. Nutrient-dense non-staple foods tend to be very expensive in rural Ethiopia. In the March survey, for example, the cheapest dairy-based calorie source was 14.5, while flesh foods and eggs are 25-30 times more expensive than staple grains, while Vitamin A-rich fruits and vegetables are 10-20 times more expensive, and other fruits 7-12 times more expensive. Legumes and nuts, being much less perishable and relatively calorie-dense, are substantially more affordable, just 3-4 times more expensive than staple-based calories.[14]

## Regression analysis

In this section we explore the associations between child dietary diversity, market characteristics and household characteristics, controlling for the various other factors described in the Methods section above. We also explore various extensions, such as alternative controls, food-specific associations, and considered the prices of non-staple foods.

### *Main regression results*

Table 4 gives the results of estimating equation (1). Coefficient estimates for the number of non-staple food groups sold in the market are given in the first row. We also report coefficients for the number of non-staple food groups produced by the household, the number of food vendors in the market and mean kebele scores of maternal knowledge of complementary foods. Drawing on the linear regression woreda fixed effects specification, Appendix Table 1 gives results for all covariates. These show that child consumption of non-staple food groups rises with age. There are no well measured associations with maternal characteristics (including her knowledge of complementary foods) or characteristics of the household head. Increases in household food

[14] We explored associations between CPRs and market characteristics. Controlling for region and round fixed effects, CPRs are lower in markets with more traders and higher in markets that are farther away from urban centers (towns or cities with populations exceeding 10,000 people). Markets that operate more frequently have lower CPRs as do markets that offer more products. CPRs appear to not be associated with market infrastructure as measured by access to electricity, road quality or bus service.

insecurity (food gap) is associated with lower non-staple food consumption; increases in wealth are associated with higher consumption. Market characteristics such as bus service and number of days a market is open have no association with non-staple food consumption.

[TABLE 4 HERE]

Column (1) in Table 4 shows that there is a statistically significant association between the number of non-staple food groups available in the market and children's consumption of non-staple food groups. This association exists after controlling for woreda fixed effects and a wide range of market, kebele, household, maternal and child characteristics. Looking across other econometric specifications, this association remains when we use a poisson specification (columns 2), account for household fixed effects (columns 3 and 4) or when we treat our outcome variable as binary (columns 5 and 6).

While statistically significant, the magnitudes of these associations are relatively low in absolute terms, although this is likely to be the result of the exceptionally poor sample of households and communities surveyed. Using results from our poisson woreda fixed effects regression (column 2), moving from three non-staple food groups in the market to six would increase the number of non-staple food groups consumed by 0.24. Considering that the average child in our sample consumed 0.8 non-staple food groups (Table 1), this corresponds to a relatively large 30-percent increase in the non-staple dietary diversity score. The marginal effects reported in column (6) tell us that such an increase in the availability of non-staple foods would increase the likelihood of consumption of any non-staple food group by 10 percentage points. Since 54 percent of the children in our sample consumed non-staple foods in the previous day, this translates into an 18 percent increase in the likelihood of a child consuming a non-staple food group.

There is also an association between the number of traders selling food and non-staple food consumption but the precision of this association varies by model specification. The strongest evidence comes from columns (5) and (6) which show that in markets with more than 20 food sellers the likelihood that a child consumes a non-food group rises by about 11 percentage points.

Table 4 also tells us that there are statistically significant associations between the number of non-staple food groups produced by the household and consumption of non-staple food groups. This holds across all model specifications, except in the poisson model based on household fixed effects. Consistent with the literature cited at the beginning of this paper, the magnitudes of these associations are small and are comparable to the magnitudes we observe on market (non-staple) diversity. Increases in maternal knowledge of complementary foods, as measured by the kebele mean, are also associated with increases in children's consumption of non-staple food groups. But this association is not precisely measured and it too is small in magnitude.

Changing the control variables we include in these regressions, or changing how they are specified (for example, including dummy variables for child age rather than a linear term; expressing maternal education as a dummy variable and so on) does not affect our findings. Our findings are also not sensitive to how we measure market diversity. For example, if we express it as the number of non-staple foods sold in the market, we again see a statistically significant association but one that is small in magnitude. Our sample is restricted to children in households that are 50 km or closer to the nearest food market. Changing this restriction, for example limiting the sample to households that are at most 25 km from a food market, does not change our findings. We see no meaningful difference in the magnitude of these associations when we disaggregate by age.[15] When we disaggregate by child sex, we find that the associations for boys tends to be slightly larger and slightly more precisely estimated but there is no meaningful difference between the estimates for boys and girls.

***Accounting for Locality Production of Non-staple Foods***

Markets are not the only non-household source of food; foods can be purchased, borrowed or received from other households in the same locality. Does accounting for this affect our results? We assess this possibility in two ways.

Using our poisson woreda fixed effects specification, we add as additional controls the percentage of households in each kebele producing different non-staple food groups. For less seasonal foods (dairy, poultry, fish and meat, and eggs) this indicator is based on recalled production in the last three months. For the remaining food groups (nuts and legumes; vitamin A rich fruit and vegetables; other fruit and vegetables), it is based on recalled production in the last 12 months. Table 5 shows that when we do so, our coefficients on market diversity, household production diversity, number of traders and kebele knowledge of CF remain largely unchanged.

[TABLE 5 HERE]

[15] We wondered if the availability of non-staple foods would make it more likely that mothers would begin feeding children solid foods in the first six months of life, a time when children should be exclusively breastfed. We estimated equation (1) but used as our sample children aged six months or less at the time of the survey. A woreda fixed effects probit model showed no association between the consumption of solids (either any non-staples or any solids, including grains) and market diversity.

In Table 6, we report food-specific results from linear probability models with woreda fixed effects. These regressions model whether the child consumed a specific food group the previous day as a function of whether that food group is available in the market,[16] produced by the household or produced by large numbers of households in the kebele (measured in proportional terms). Strikingly, all three aggregations are associated with consumption of dairy products, suggesting that own consumption, barter/gifts/informal trade and market interactions may all be important for dairy, a highly perishable product in milk form. Consider two children. Child A lives in a community where dairy is sold in the market and in a household that produces dairy, as do 30% of households in her kebele. Child B lives in a community where dairy is not sold in the market, in a household that does not produce dairy and where only 10% of households in her kebele do so. Child A is 20 percentage points more likely to consume dairy than Child B. These results, along with the fact that dairy products are frequently missing from food markets (Table 1), suggest that dairy products are a special case. Household dairy production is likely to be an important source of child consumption when there are no opportunity for processing, storage or sale, precisely because fresh milk is so perishable. Moreover, even when markets are available, they will usually only take milk extracted in the morning; yet lactating cows typically also produce "evening milk" that cannot be sold and must be consumed or processed into butter/ghee or yoghurt.

Market availability of flesh foods (poultry, fish, meat) is also associated with a greater likelihood of consuming those foods but the magnitude – a one percentage point increase – is

[16] We exclude the market covariate in the legumes and nuts, eggs, and other fruit and vegetable specifications as the percentage of markets where these are available exceeds 95%.

tiny. Household egg production increases the likelihood that the child consumed an egg, as does the percentage of households in the kebele who produce eggs, but again the magnitude of these associations is low. Household production of fruit and vegetables increases the likelihood that the child consumes both vitamin-A rich fruits and vegetables and other fruits and vegetables. [17]

[TABLE 6 HERE]

***Child dietary diversity and the price of non-staple foods***

One reason for these small magnitudes might be that this sample is simply very very poor. A second reason is that, relative to CPRs observed in other settings, CPRs in these Ethiopian markets are exceptionally high. Headey, Hirvonen and Hoddinott (2018) report that CPRs for animal source foods (cow's milk, eggs, fish, meat) in high income countries range from 2.0-4.3 and in African countries – where CPRs are highest – from 5.6 to 16.5. By contrast, Table 3c shows that in this sample, they range from 10.5 to 29.2 with the average calorie from a non-staple food is approximately 12 times more expensive than a calorie from a staple. With this in mind, we explored the relationship between CPRs and children's consumption of non-staple foods by replacing the number of non-staple food groups with log geometric mean of CPRs. Results are reported in Table 7. The association is negative indicating that higher market prices are associated with lower dietary diversity. Moreover, the estimated coefficients are highly statistically significant ($p<0.05$), but the magnitudes small; doubling the mean price ratio is

[17] Averaging across rounds, only about 5% of the households produced vitamin A-rich fruits and vegetables and about 7% produced other types of fruits and vegetables.

associated with a 0.15 food group decrease in dietary diversity (column 2). The magnitudes in the probability models are somewhat larger; doubling the mean price ratio is associated with a 7.6 percentage point (or 14 percent) increase in the likelihood that the child consumes from a non-grain food group.[18]

[TABLE 7 HERE]

**Conclusions**

Child stunting remains a predominantly rural problem in much of the developing world, particularly sub-Saharan Africa (Headey and Masters, 2018), with a considerable amount of growth faltering emerging in the 6-23 month age window when infants and young children's growing nutrient requirements must be met by high quality nutrient-dense foods. However, dietary diversity is extremely poor in most of rural Africa and developing Asia, prompting significant efforts to leverage agriculture to improve diets. However, growing cognizance that even very poor and very remote rural household rely extensively on markets to satisfy their demand for nutrient-rich non-staple foods warrants a much better understanding of how rural markets vary in their diversity, competitiveness, frequency and food affordability, and how these market characteristics are associated with diets as well as household and community production patterns.

This paper is a first foray into addressing these questions. We deployed a novel but highly replicable market survey, in conjunction with an information-rich household survey, to

[18] The variations in the price ratios are quite large across market; the sample mean is 12.3 birr with a standard deviation of 6.9 birr and interquartile range of 7.4 birr. Thus, doubling the mean price corresponds to ~2 standard deviation increase in prices.

explore the characteristics of food markets and their associations with child diets. We find that children in proximity to markets that sell a larger number of non-staple food groups do indeed have more diverse diets, though the effect small in absolute terms: moving from three non-staple food groups in the market to six would increase the number of non-staple food groups consumed by ~0.24 and the likelihood of consumption of any non-staple food group by 12 percentage points. These associations are similar in magnitude to those describing the relationship between dietary diversity and household production diversity; moreover, for some products we find that household and community production diversity is especially important, particularly dairy, but also fruits and vegetables.

At first glance, the relatively modest association between market characteristics and dietary diversity is surprising but may well be explained by several empirical limitations of our data and survey design. First, we focus on 24 hour diet recall data that, while standard in nutrition sciences, may lead to under-recording of children who consume non-staple foods on a more irregular basis. Second, while rural Ethiopia is agriculturally diverse, our study sites are all situated in very poor, food-insecure localities where even the relatively better off are poor in absolute terms; indeed, remarkably few children in our sample achieve even the minimum dietary diversity level recommended by the WHO (2008). Third, while there is some variation in non-staple food prices, prices for non-staple foods in almost all localities are very high: on average, the cost of a calorie from a non-staple food is 12 times higher than a calorie from the cheapest staple. These three factors may attenuate responsiveness to price variation and market diversity, leaving poor households trapped into heavy dependence on staple foods (grains, roots, tubers) that are cheap sources of calories but sparse in high-quality proteins and micronutrients. Indeed, Africa-wide studies suggest that household demand for most non-staple foods –

particularly animal-sourced foods – is income-elastic (Colen, et al., 2018) and price-elastic (Headey, et al., 2018). The implication of this is that poverty and high calorie-price ratios are major constraints on the ability of markets to improve rural diets.

Despite the relatively weak association between market characteristics and child dietary diversity, our results also do not provide strong support for farm-level diversification programs, unless they are implemented at a scale capable of reducing the CPRs of non-staple foods (Hirvonen and Headey, 2018). Small-scale diversification projects are unlikely to substantially improve when high prices for those products prevail in markets because the opportunity cost of feeding high value products to infants is extremely high for cash-constrained rural households. This is the likely reason we observe that household egg production increases children's consumption of eggs by just 3 percentage points: on average, egg calories are almost 30 times more expensive than calories from the cheapest staple food in the market. We do, however, find some indirect evidence that dairy and fruit and vegetable promotion might improve children's consumption of these products, and that some relatively nutritious foods are highly affordable (legumes, nuts and some fruits and vegetables, albeit seasonally), and perhaps underappreciated by parents with limited nutritional knowledge.

Ultimately though, sizeable improvements in rural diets must be built upon improved access to high quality markets that deliver a wide array of healthy foods at affordable prices. The agricultural foundations of better rural markets likely stem from increased specialization (rather than production of a wider array of foods), and even greater dependence on markets for both agricultural sales and food purchases. How best to accelerate the development of higher quality rural food markets is not a well-understood question and thus represents a promisingly line for future research.

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**Table 1. Descriptive Statistics for Child Dietary Diversity by Survey Round**

| Survey round | Sample size | Dietary Diversity Score | 4 or more food groups | Grains, roots and tubers | Legumes and nuts | Dairy | Meat, fish, poultry (Flesh foods) | Eggs | Vitamin A rich fruits and vegetables | Other fruits and vegetables | Non grain food groups |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Child consumed | | | | | |
| | | Mean | | | | Percent | | | | | Mean |
| | | | | | | *All children* | | | | | |
| March | 1888 | 1.4 | 3 | 77 | 22 | 7 | 1 | 5 | 5 | 19 | 0.6 |
| August | 2398 | 1.8 | 6 | 83 | 29 | 17 | 2 | 5 | 10 | 36 | 1.0 |
| All | 4286 | 1.6 | 5 | 80 | 26 | 13 | 1 | 5 | 8 | 29 | 0.8 |
| | | | | | | *Children who consumed at least one food group* | | | | | |
| March | 1521 | 1.7 | 4 | 96 | 27 | 9 | 1 | 6 | 7 | 24 | 0.7 |
| August | 2085 | 2.1 | 7 | 96 | 34 | 20 | 2 | 6 | 12 | 42 | 1.1 |
| All | 3606 | 1.9 | 6 | 96 | 31 | 15 | 1 | 6 | 10 | 34 | 1.0 |

**Table 2. Distribution of Number of Non-staple Food Groups Consumed by Round**

| Non staple food groups consumed | March | August | Total |
|---|---|---|---|
| | Percent | | |
| 0 | 58.6 | 35.5 | 45.7 |
| 1 | 27.4 | 36.3 | 32.4 |
| 2 | 11.1 | 21.7 | 17.0 |
| 3 | 2.6 | 5.9 | 4.5 |
| 4 | 0.3 | 0.4 | 0.3 |
| 5 | 0.0 | 0.1 | 0.1 |
| 6 | 0.0 | 0.1 | 0.1 |

## Table 3. Market Characteristics

### *Table 3a. Basic Characteristics*

| Characteristic | | Percent |
|---|---|---|
| Number of days per week market is open | 1 | 53 |
| | 2 | 30 |
| | 3 | 5 |
| | 4 | 2 |
| | 5 | 1 |
| | 6 | 4 |
| | 7 | 5 |
| Number of vendors selling food | Less than 5 | 3 |
| | 6 to 10 | 2 |
| | 11 to 20 | 5 |
| | 21 to 50 | 14 |
| | More than 50 | 76 |
| Do buses service this market | Yes | 77 |
| | No | 23 |
| Does the market have electricity | Yes | 76 |
| | No | 24 |
| Does the market have cell coverage | Yes | 96 |
| | No | 4 |

*Table 3b. Market Diversity by round*

| | Percent markets selling: | | | | | | | | | Mean | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Grains, roots and tubers** | **Legumes** | **Nuts** | **Dairy** | **Meat, fish, poultry (Flesh foods)** | **Eggs** | **Vitamin A rich fruits and vegetables** | **Other vegetables** | **Other fruits** | **Market diversity** | **Non-staple market diversity** |
| March | 100 | 95 | 71 | 47 | 57 | 98 | 80 | 100 | 89 | 5.8 | 4.8 |
| August | 100 | 92 | 77 | 44 | 31 | 95 | 86 | 99 | 89 | 5.5 | 4.5 |
| All | 100 | 94 | 74 | 45 | 44 | 97 | 83 | 99 | 89 | 5.6 | 4.6 |

| | Percent of markets selling different non-staple food groups | | | | | | |
|---|---|---|---|---|---|---|---|
| | **0** | **1** | **2** | **3** | **4** | **5** | **6** |
| March | 0.0 | 0.4 | 1.1 | 13.3 | 25.8 | 24.2 | 35.2 |
| August | 0.0 | 0.0 | 1.1 | 11.0 | 39.4 | 31.8 | 16.7 |
| All | 0.0 | 0.2 | 1.1 | 12.1 | 32.6 | 28.0 | 26.0 |

***Table 3c. Calorie Price Ratios by Round***

| | Legumes | Nuts | Dairy | Meat, fish, poultry (Flesh foods) | Eggs | Vitamin A rich fruits and vegetables (leafy greens) | Vitamin A rich fruits and vegetables (other) | Other vegetables | Other fruits | Market (geometric) mean |
|---|---|---|---|---|---|---|---|---|---|---|
| March | 3.1 | 3.7 | 14.5 | 25.7 | 28.8 | 18.6 | 17.6 | 11.5 | 12.1 | 12.9 |
| August | 2.9 | 3.6 | 10.3 | 29.2 | 29.1 | 10.8 | 15.0 | 10.7 | 7.0 | 11.7 |

**Table 4. Basic Results**

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Number, non-staple food groups consumed | | | | Any non-staple food group consumed | |
| estimator: | OLS | poisson | OLS | poisson | LPM | probit |
| Number, non-staple food groups sold in market | 0.071*** | 0.081*** | 0.093*** | 0.100*** | 0.033*** | 0.033** |
| | (0.019) | (0.030) | (0.023) | (0.036) | (0.011) | (0.014) |
| Number, non-staple food groups produced by household | 0.088*** | 0.102*** | 0.058** | 0.049 | 0.046*** | 0.046*** |
| | (0.015) | (0.020) | (0.023) | (0.032) | (0.008) | (0.009) |
| Market has more than 20 traders | 0.149 | 0.234 | | | 0.111** | 0.114** |
| | (0.100) | (0.145) | | | (0.055) | (0.055) |
| Maternal knowledge of complementary feeding (kebele mean) | 0.060* | 0.080* | | | 0.031* | 0.031 |
| | (0.032) | (0.043) | | | (0.018) | (0.021) |
| Child level controls? | Yes | Yes | Yes | Yes | Yes | Yes |
| Household level controls? | Yes | Yes | Yes | Yes | Yes | Yes |
| Kebele and market level controls? | Yes | Yes | Yes | Yes | Yes | Yes |
| Woreda fixed effects? | Yes | Yes | No | No | Yes | Yes |
| Household fixed effects? | No | No | Yes | Yes | No | No |

Notes: Sample consists of 4,286 child observations living in 1,498 households and 87 woredas. Estimates control for child (age, sex, relationship to head), maternal (education, log age and score on test of CF knowledge), household head (education, log age, sex and religion (Muslim, Protestant), household (size, food gap, livestock, land operated, assets, distance to market), kebele (mean food gap, mean asset index) and market (number of food traders, number of days per week market operates; bus service, cost of purchasing cheapest cereal). The reported estimates for poisson and probit are marginal effects. Standard errors in parentheses and clustered at the woreda level in columns (1), (2), (5) and (6) and at the household level in columns (3) and (4). * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

**Table 5. Accounting for locality production of non-staple foods**

| | (1) | (2) |
|---|---|---|
| | Number, non-staple food groups consumed | |
| | poisson Woreda FE | |
| Number, non-staple food groups sold in market | 0.081*** | 0.079*** |
| | 0.030 | 0.030 |
| Number, non-staple food groups produced by household | 0.102*** | 0.091*** |
| | 0.020 | 0.020 |
| Market has more than 20 traders | 0.234 | 0.194 |
| | 0.145 | 0.149 |
| Kebele mean maternal knowledge of CF | 0.080* | 0.108** |
| | 0.043 | 0.044 |
| Percent of households in kebele producing: | | |
| Nuts, legumes (in last year) | - | 0.322 |
| | | 0.208 |
| Dairy (last 3 months) | - | -0.526 |
| | | 0.475 |
| Poultry, fish meat (last 3 months) | - | 0.223 |
| | | 0.181 |
| Eggs (last 3 months) | - | -0.102 |
| | | 0.210 |
| Vitamin A rich fruit and vegetables (in last year) | - | 0.938*** |
| | | 0.293 |
| Other fruit and vegetables (in last year) | - | -0.180 |
| | | 0.287 |

Notes: See Table 4.

**Table 6. Commodity specific results, estimated using linear probability model and controlling for woreda FE**

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Child consumed | | | | | |
| | Legumes and nuts | Dairy products | Poultry, fish meat | Eggs | Vitamin A rich fruits and vegetables | Other fruits and vegetables |
| Food Group: | | | | | | |
| Available in market | - | 0.042** | 0.015*** | - | -0.001 | - |
| | | 0.017 | 0.005 | | 0.014 | |
| Produced by household | -0.022 | 0.110*** | 0.009 | 0.034*** | 0.080*** | 0.092*** |
| | 0.019 | 0.014 | 0.006 | 0.008 | 0.020 | 0.029 |
| % hh in kebeles producing | 0.078 | 0.260*** | -0.031 | 0.060* | 0.036 | 0.066 |
| | 0.071 | 0.056 | 0.041 | 0.032 | 0.068 | 0.106 |
| Mean of dependent variable | 0.26 | 0.13 | 0.01 | 0.05 | 0.08 | 0.29 |

Notes: See Table 4 .We exclude the regressor “available in market” for legumes and nuts, eggs and dairy products as more than 95% of markets report having these available.

**Table 7. Associations between price ratios and diet diversity**

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Number, non-grain food groups consumed | | | | Any non-grain food group consumed | |
| estimator: | OLS | poisson | OLS | poisson | LPM | probit |
| (ln) Geometric mean of price ratios | -0.129*** | -0.147** | -0.165*** | -0.154** | -0.076*** | -0.076** |
| | (0.044) | (0.066) | (0.052) | (0.076) | (0.024) | (0.030) |
| Number, non-grain food groups produced by household | 0.088*** | 0.102*** | 0.058*** | 0.048 | 0.046*** | 0.046*** |
| | (0.015) | (0.020) | (0.023) | (0.032) | (0.008) | (0.009) |
| Market has more than 20 traders | 0.190* | 0.285** | | | 0.132** | 0.135** |
| | (0.100) | (0.144) | | | (0.055) | (0.057) |
| Maternal knowledge of complementary feeding (kebele mean) | 0.052 | 0.070 | | | 0.027 | 0.028 |
| | (0.032) | (0.043) | | | (0.018) | (0.021) |
| Child level controls? | Yes | Yes | Yes | Yes | Yes | Yes |
| Household level controls? | Yes | Yes | Yes | Yes | Yes | Yes |
| Kebele and market level controls? | Yes | Yes | Yes | Yes | Yes | Yes |
| Woreda fixed effects? | Yes | Yes | No | No | Yes | Yes |
| Household fixed effects? | No | No | Yes | Yes | No | No |

Notes: See Table 4.

**Figure 1. Local polynomial regression of children's dietary diversity and age**

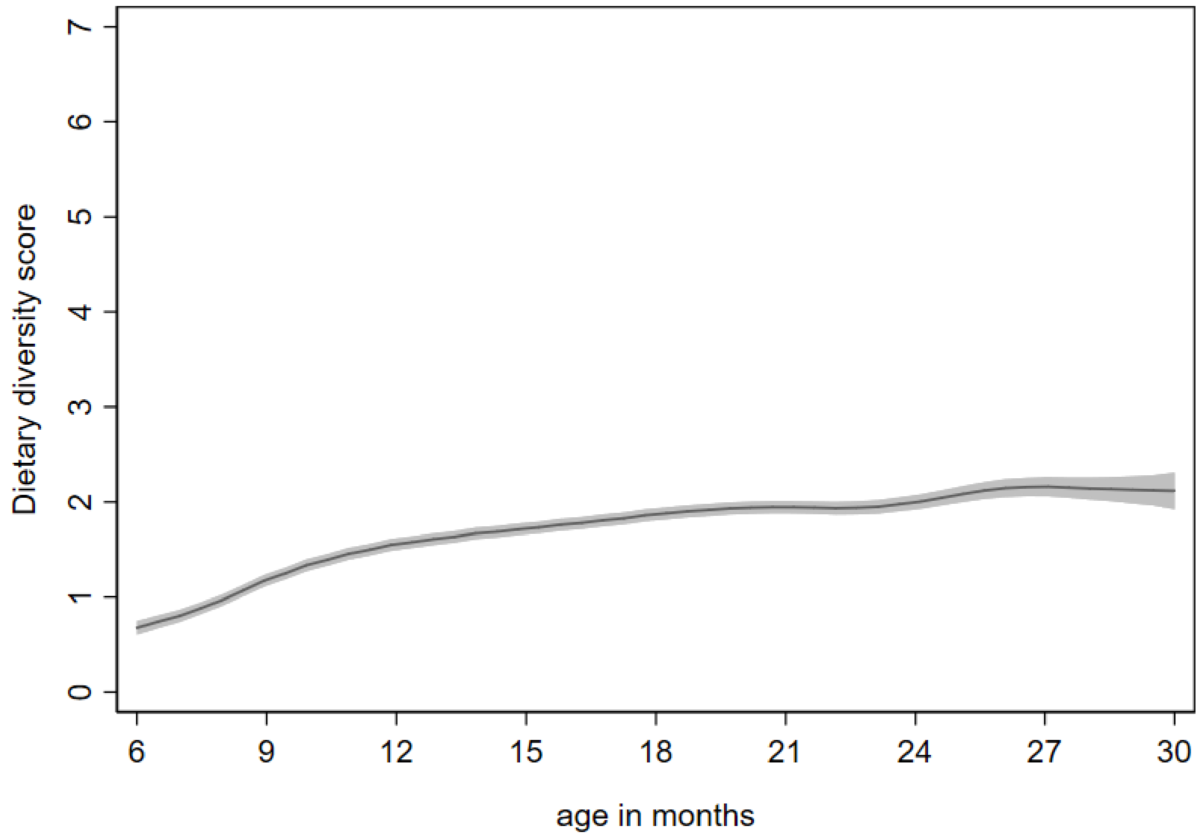
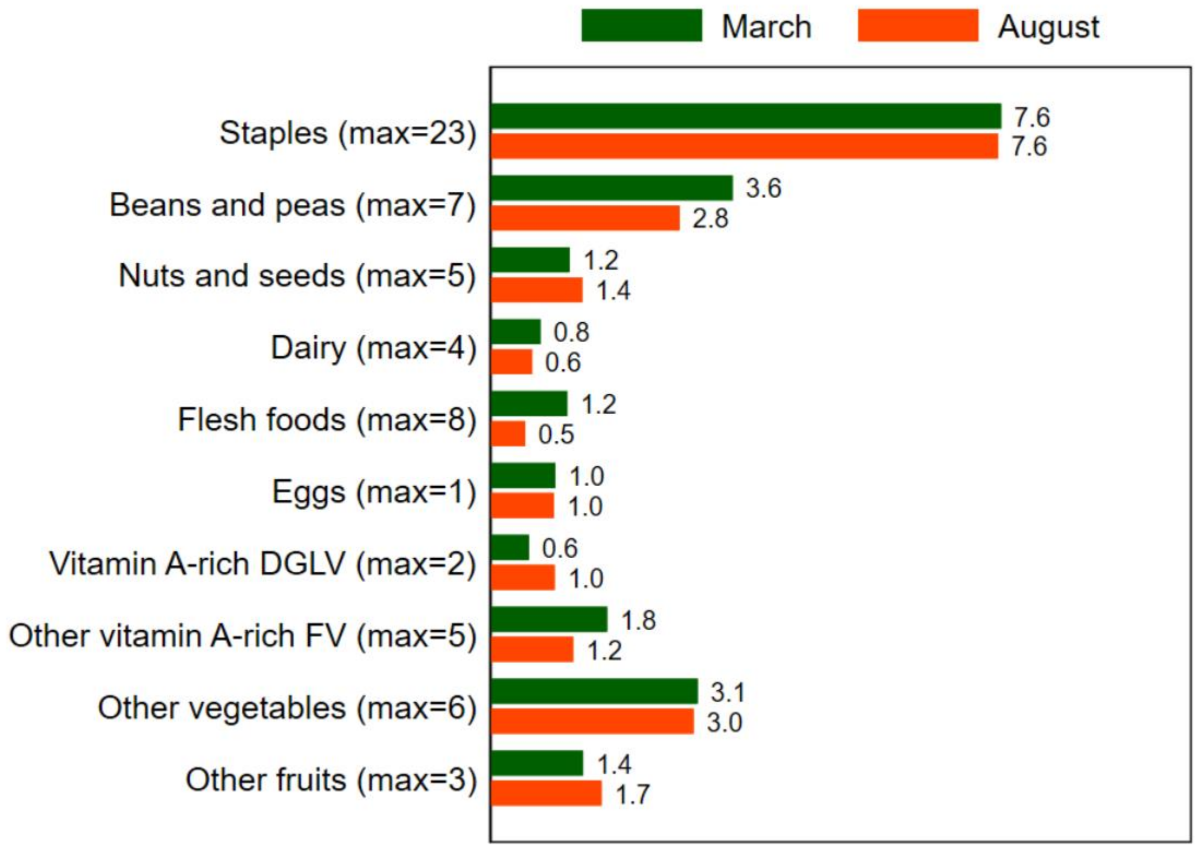


**Figure 2. Number of foods available by food group and survey round**




Note: DGLV=Dark-green leafy vegetables; FV=Fruits and vegetables

**Supplementary Materials**

**Appendix Table 1. Full Results for Linear Regression Woreda FE Model**

| | (1)<br>Number, non-staple food groups consumed |
|---|---|
| *Child characteristics* | |
| Age (months) | 0.036*** |
| | (0.002) |
| Male | -0.023 |
| | (0.025) |
| Not son/daughter of head | 0.030 |
| | (0.086) |
| *Maternal characteristics* | |
| Education (grades of schooling) | 0.004 |
| | (0.008) |
| Log age | -0.003 |
| | (0.103) |
| CF knowledge score | 0.002 |
| | (0.005) |
| *Head characteristics* | |
| Education (grades of schooling) | 0.009 |
| | (0.006) |
| Log age | -0.141 |
| | (0.087) |
| Male | 0.014 |
| | (0.051) |
| Muslim | -0.099* |
| | (0.057) |
| Protestant | -0.058 |
| | (0.065) |
| *Household characteristics* | |
| Size | 0.016* |
| | (0.009) |
| Food gap (months) | -0.023*** |
| | (0.006) |
| Livestock (TLU) | 0.004 |
| | (0.004) |
| Land operated (hectares) | -0.009 |
| | (0.006) |
| Durable asset index, (PCA) | 0.035*** |
| | (0.009) |
| (Geodetic) distance to nearest food market (km) | -0.001 |
| | (0.002) |
| Number, non-staple food groups produced | 0.088*** |
| | (0.015) |
| *Kebele characteristics: Mean* | |

| | |
|---|---|
| Food gap | -0.025 |
| | (0.018) |
| Maternal CF knowledge score | 0.060* |
| | (0.032) |
| Durable asset index | 0.055** |
| | (0.024) |
| *Market characteristics* | |
| Has more than 20 traders | 0.149 |
| | (0.099) |
| Number of days (per week) market is open | -0.050 |
| | (0.047) |
| Buses come to the market | -0.049 |
| | (0.051) |
| Birr per calorie: cheapest cereal | -34.060 |
| | (22.736) |
| Number, non-staple food groups sold in market | 0.071*** |
| | (0.019) |
| *Survey round* | |
| August survey round | 0.341*** |
| | (0.027) |
| | |
| Observations | 4,286 |
| Number of woredas | 87 |

Notes: Sample consists of 4,286 child observations living in 1,498 households and 87 woredas. Standard errors in parentheses. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

**Appendix Figure A1. Map of surveyed kebeles**