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Supermarket food purchases and child nutritional outcomes in Kenya

Bethelhem Legesse Debela [a, *], Kathrin M. Demmler [b], Stephan Klasen [c], Matin Qaim [a]

Abstract

In many developing countries, supermarkets are spreading rapidly at the expense of traditional food markets and shops. Changing retail environments and food choices may affect consumer diets and nutritional outcomes. Previous research suggested that supermarkets may contribute to rising rates of obesity. However, most existing research looked at adult populations. Here, we analyze effects of supermarkets on child nutrition with panel data from medium-sized towns in Kenya. Instrumental variable regressions show that supermarket food purchases significantly increase child height-for-age and weight-for age Z-scores. The effects on height are larger than the effects on weight. These are welcome findings, because child stunting continues to be a major nutrition problem in developing countries that is declining more slowly than child underweight. Supermarkets do not seem to be a driver of childhood obesity in Kenya. The positive effects of supermarkets on child nutrition are channeled through improvements in food variety and dietary quality.

JEL codes: D12; D19; I15; I39; Q02

Keywords: child nutrition; supermarkets; stunting; obesity; dietary diversity; Kenya

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1. Introduction

Malnutrition is a serious problem in most developing countries (IFPRI, 2017). While the proportion of people suffering from chronic hunger has declined considerably over time, child undernutrition is still widespread, especially when using child stunting as the undernutrition indicator (Black et al., 2013; Haddad, 2013). Child stunting is related to deficiencies in calories and nutrients, especially micronutrients. Next to undernutrition, overweight and obesity are gaining ground in many developing countries, also with severe negative health consequences (Popkin, 2014). Often, undernutrition and overweight occur in the same settings, sometimes even in the same households (Doak et al., 2005).

Food systems – including the production, processing, distribution, and retailing of food – are known to influence consumer food choices and nutrition (Timmer, 2009). Accordingly, food system transformations can affect consumer nutrition in positive or negative ways. One notable food system transformation in developing countries is the rapid rise of supermarkets at the expense of more traditional food markets and shops (Reardon et al., 2003; Neven and Reardon, 2004; Traill, 2006; Qaim, 2017). Supermarkets tend to offer foods at higher levels of processing and in larger packaging sizes than traditional retailers (Popkin, 2017). Supermarkets also differ from traditional retailers in terms of the food variety offered, the prices charged, and the shopping atmosphere (Hawkes, 2008).

Nutritional implications of the rapid rise of supermarkets are not yet sufficiently understood. A few studies have shown that supermarkets contribute to the consumption of more calories and higher levels of processed foods, even after controlling for household income, education, and other confounding factors (Asfaw, 2008; Rischke et al., 2015). In line with these findings, there are also a few studies suggesting that buying food in supermarkets is associated with higher body mass index (BMI), a higher likelihood of overweight and obesity, and a higher risk of suffering from diabetes and the metabolic syndrome (Kimenju et al., 2015; Demmler et al., 2017; Demmler et al. 2018). These effects are plausible because processed foods with high fat, sugar, and salt contents are known to contribute to overweight and obesity (Asfaw, 2011; Popkin, 2017).

However, available studies on the nutrition effects of supermarkets mostly refer to adult consumers. Much less is known about how the rise of supermarkets may affect child nutrition. It is commonly assumed that the effects may be the same as those for adults, meaning that supermarkets would also contribute to overweight and obesity in children (Hawkes, 2008; Popkin, 2017). Some have argued that the higher consumption of calorie-dense but nutrient-poor foods may be one reason why child underweight has declined much faster than child stunting during the last two decades (de Haen et al., 2011). This would imply that supermarkets may contribute to weight gains but not to height gains in children. The empirical evidence is scarce.

We are aware of only very few studies that explicitly analyzed the relationship between supermarkets and child nutritional status in developing countries. Umberger et al. (2015) used data from urban households in Indonesia to suggest that supermarket shopping raises the likelihood of child overweight in high-income households, but not in low- and middle-income households. Kimenju et al. (2015) used data from households in Kenya; they did not find a significant effect of supermarkets on indicators of child weight, but their data suggested a positive effect on indicators of child height. Kimenju and Qaim (2016) used aggregate statistics for a larger number of countries and found a negative association between the country-level share of supermarkets in food retailing and the rate of child stunting, also after controlling for average income levels and other variables. Kimenju and Qaim (2016) did not find a significant association between the share of supermarkets in food retailing and rates of child overweight and obesity. Hence, the evidence is mixed. We contribute to this scant literature to better understand how the rise of supermarkets in developing countries may affect child weight and height.

We add to the literature in two particular ways. First, we are the first to analyze the effects of supermarket shopping on child nutrition with panel data. The previous two micro-level studies used cross-section data (Kimenju et al., 2015; Umberger et al., 2015). Panel data have advantages, because they allow more robust causal inference. Second, we analyze effects of supermarkets on body height and weight for children below and above five years of age, which previous studies did not. Kimenju et al. (2015) looked at height and weight but only included children above five years of age. Children below five are especially important to consider because growth retardation during young childhood cannot be fully recovered at later ages (Black et al., 2013; IFPRI, 2017). Umberger et al. (2015) included children below and above five years of age but only analyzed effects of supermarkets on weight, not height.

Our empirical analysis focuses on Kenya, one of the countries with the fastest supermarket growth on the African continent (Planet Retail, 2018). As in other developing countries, supermarkets in Kenya were first opened in larger cities, but are now also gradually penetrating smaller towns (Neven and Reardon, 2004; Rischke et al., 2015). We build on survey data collected in selected medium-sized towns in 2012 and 2015.

2. Study context and data

2.1. Changing food environments

Food retail environments in developing countries are in rapid transition. While traditional food outlets – such as wet markets, traditional shops, kiosks, and groceries – still dominate food retailing, supermarkets are increasingly gaining market shares (Reardon et al., 2003; Neven and Reardon, 2004; Traill, 2006; Qaim, 2017). In comparison to traditional retailers, supermarkets typically offer a larger variety of processed foods in bigger packaging sizes and at lower prices (Hawkes, 2008; Rischke et al., 2015). While big supermarkets also offer a variety of fresh foods, supermarkets in smaller towns concentrate primarily on the sales of processed food items (Qaim, 2017). Another important difference between supermarkets and traditional retailers is the shopping atmosphere. Supermarkets are larger-sized self-service shops, whereas traditional retailers usually offer over-the-counter services (Demmler et al., 2018). In the context of this study, we classify a retail outlet as a supermarket if it has a size of at least 150 square meters, involves self-service shopping, and has two or more cash counters.

2.2. Data and study site

Data for this study were collected in two rounds of a survey of households in Central Kenya. The survey was conducted in 2012 and 2015 in the urban and peri-urban areas of three medium-sized towns: Ol Kalou, Mwea, and Njabini. We purposively selected these three towns based on various characteristics to obtain a quasi-experimental setting for the impact analysis. All three towns have very similar characteristics in terms of the size of the urban center, infrastructure conditions, and social institutions (Kenya National Bureau of Statistics, 2010), but they differ in terms of the availability of a supermarket. This is related to supermarket chains starting their businesses in larger cities before gradually also penetrating smaller cities and towns. Ol Kalou and Mwea both have one supermarket each, whereas in Njabini no supermarket existed until 2015, even though one was built but not opened at the time of the second survey round.

Households in the three towns were selected through systematic random sampling, about 150 households in each town. In the first round in 2012, 450 households were interviewed.[1] In the second round in 2015, 453 were interviewed. In the second round, we intended to include the same households as in the first round, but were only able to track about half of the original ones. The other households were newly selected in 2015 in the same towns using the same random sampling procedure as in 2012. Especially in urban areas of developing countries, where people relocate more often than in rural areas, significant attrition is commonplace in panel surveys. In both survey rounds, face-to-face interviews with the household head or the spouse were conducted using a structured questionnaire. Data were collected on the household composition and general socioeconomic characteristics, employment and income, food consumption details, including food sources and food prices, non-food expenditures, health conditions, and access to various types of services.

In addition to the interviews, we took anthropometric measures of adults and children living in the sampled households. Body measurements were taken following international standards (Centers for Disease Control and Prevention, 2007) with an accuracy of 0.1 kg for weight and 0.7 cm for height (de Onis, 2007). In this study, we only focus on the child observations and exclude households without children. The total child sample includes 541

[1] The 2012 cross-section data from this survey were also used by Kimenju et al. (2015).

observations. Out of these, 194 observations are from households that were included in both survey rounds. Table 1 shows the distribution of the child sample by survey round and child age. In 2012, only children above the age of five were included (5-18 years). In 2015, we also included children below the age of five (2-18 years).

Based on the child anthropometric measures, we constructed health outcomes using WHO growth references (WHO, 2006). In particular, we generated height-for-age Z-scores (HAZ), an indicator of chronic undernutrition, and weight-for-age Z-scores (WAZ), an indicator of acute or chronic undernutrition in children and adolescents. Z-scores represent the standard deviation from the median height or weight of a well-nourished reference population with the same age and gender. A child or adolescent is considered to be stunted or underweight if HAZ or WAZ take values below the cutoff point of -2 standard deviations (WHO, 2006). While HAZ is an indicator of the longer-term nutritional status of children, WAZ reflects a combination of short-term and longer-term nutrition conditions (O'Donnell, 2008; WHO, 2010).

It should be mentioned that the WHO growth references for WAZ are only available for children up to the age of 10 years (WHO, 2006). Hence, while we use all 541 child observations for the HAZ analysis, for the WAZ analysis we can only include 347 observations of children aged 2-10 years.

3. Empirical strategy

Our objective is to investigate whether purchasing food in supermarkets influences the nutritional status of children, with a focus on both height and weight. To analyze the supermarket effects, we employ a series of panel regression models of the following type:

$$Z_{it} = \beta_0 + \beta_1 S_{ht} + \beta_2' \boldsymbol{C}_{it} + \beta_3' \boldsymbol{X}_{ht} + \beta_4 T + a_i + \varepsilon_i \quad [1]$$

$$S_{ht} = \beta_0 + \beta_1 D_{ht} + \beta_2' \boldsymbol{C}_{it} + \beta_3' \boldsymbol{X}_{ht} + \beta_4 T + a_i + \varepsilon_i \quad [2]$$

where Z_{it} is the nutritional status indicator (HAZ and WAZ) of child *i* at time *t*, S_{ht} refers to supermarket food purchases of the household *h* in which child *i* lives. $\boldsymbol{C}_{it}$ is a vector of child-level characteristics, and $\boldsymbol{X}_{ht}$ is a vector of household-level variables (including maternal characteristics). T controls for the survey round, a_i captures time-invariant unobserved effects, and ε_i is an idiosyncratic error term.

We use two definitions of the supermarket purchase variable, S_{ht}, and estimate separate models for each of them. First, we use a supermarket purchase dummy variable that takes a value of one if the household has purchased any of the food items consumed during the 30 days prior to the interview in a supermarket, and zero if the household has obtained all foods from traditional sources, including traditional retailers, own production or gifts. Second, we use a continuous variable defined as the share of supermarket food purchases in the total household food expenditures during the 30 days prior to the interview. The share of supermarket purchases is expressed in percent.

3.1. Instrumental variable approach

Regardless of its definition, the supermarket purchase variable in equation [1] is expected to be endogenous. In particular, unobserved factors, such as parental dedication to healthy nutrition, may jointly influence the decision where to buy food and child nutritional status. To account for endogeneity, we use an instrumental variable (IV) approach in all estimations. Equation [2] represents the first stage of the IV model, in which the supermarket purchase variable is regressed on an instrument, D_{ht}, and the other explanatory variables from equation [1]. We use the households' distance to the nearest supermarket as instrument for supermarket purchases. The same instrument was also used in previous studies on nutrition and health effects of supermarket purchases (Asfaw, 2008; Rischke et al., 2015; Kimenju et al., 2015; Demmler et al., 2017). The validity of the instrument is discussed and tested in the following.

Distance to supermarket is significantly correlated with the supermarket purchase dummy and also with the share of supermarket purchases (Table A1). As expected, a larger distance leads to lower supermarket purchases, also after controlling for other factors. A test for instrument validity shows that the instrument is strong (F=123.7, p=0.00).

One might argue that distance to supermarket is not random, because supermarkets may be positioned in neighborhoods with certain socioeconomic characteristics. However, while such strategic placing of supermarket stores in certain neighborhoods is often observed in larger cities, the medium-sized towns surveyed here have a maximum of one supermarket, which is located in the town center, where traditional retailers are found as well. To test whether distance to the town center affects household supermarket purchases through channels other than supermarket accessibility, we correlated distance to town center with supermarket purchase only for the households living in Njabini, the town without a supermarket as of 2015. In spite of having no supermarket in town, some of the households in Njabini purchase foods in supermarkets elsewhere, for instance through occasionally traveling to other cities or towns. The correlation coefficient is statistically insignificant (r=0.05, *p*=0.46), meaning that living closer to the town center in Njabini is not associated with a higher likelihood of supermarket purchases. This supports our argument that neighborhood effects do not invalidate the instrument. Nevertheless, we control for household socioeconomic characteristics – such as living standard, education, and age – in all IV regressions.

In an additional test, we included distance to supermarket together with supermarket purchase and the other explanatory variables in the child nutritional outcome regressions (see Table A2 in the Appendix). In these regressions, distance to supermarket is not significant, suggesting that the instrument does not influence child HAZ and WAZ through channels other than supermarket purchases. Based on these tests, we conclude that distance to supermarket is a valid instrument.

3.2. Choice of estimators

To choose an appropriate estimator for the panel data models, we tried random effects (RE) and fixed effects (FE) specifications and compared the results with a Hausman test. According to the test results (shown in the result tables below), we fail to reject the null hypothesis that the coefficients are identical, hence favoring the RE estimator. The RE estimator is more efficient, because the between variation of all variables in our data is much higher than the within variation. The results are therefore based on RE-IV estimations.

Additionally, we use the pseudo FE estimator proposed by Mundlak (1978). The Mundlak approach involves the inclusion of time averages over the two survey years for all time-variant explanatory variables (Mundlak, 1978; Wooldridge, 2002). The Mundlak approach is similar to the FE estimator in that it reduces issues of time-invariant heterogeneity, but the Mundlak approach is more efficient when the within variation is small (Wooldridge, 2002). We combine the Mundlak models with the IV approach as follows:

$$Z_{it} = \beta_0 + \beta_1 S_{ht} + \beta_2' \boldsymbol{C}_{it} + \beta_3' \boldsymbol{X}_{ht} + \beta_4' \widetilde{\boldsymbol{X}}_h + \beta_5 T + a_i + \varepsilon_i \qquad [3]$$

$$S_{ht} = \beta_0 + \beta_1 D_{ht} + \beta_2' \boldsymbol{C}_{it} + \beta_3' \boldsymbol{X}_{ht} + \beta_4' \widetilde{\boldsymbol{X}}_h + \beta_5 T + a_i + \varepsilon_i \qquad [4]$$

This two-stage model is similar to the one in equations [1] and [2], with the only difference that $\widetilde{\boldsymbol{X}}_h$, the time averages of the household characteristics, are additionally included as explanatory variables. In all estimations, we cluster the standard errors at the town level to control for possible heteroscedasticity of the error term.

In a robustness check, we run the RE and Mundlak models also without the IV. In a second robustness check, we use a control function approach instead of the standard IV estimator. The standard IV estimator builds on the assumption that the endogenous variable is continuous. This assumption is violated in our case for the supermarket purchase dummy variable. Even the supermarket purchase share is not entirely continuous, because it is censored at zero. The control function approach is better suited to deal with binary and censored endogenous variables (Wooldridge, 2015). It involves a first-stage regression where the endogenous variable is regressed on the instrument and the other explanatory variables. For this first-stage, we use a double-hurdle specification (Burke, 2009). The second-stage regression of the control function approach involves estimating the nutritional outcome equations and including the first-stage residuals as an additional explanatory variable. For this second stage, we use the standard RE and Mundlak estimators.

3.3. Analysis of possible dietary mechanisms

Purchasing food in supermarkets may influence child nutritional status, but the effects are expected to be indirect, namely channeled through changes in household diets. To better understand the underlying mechanisms, we analyze whether dietary differences exist between supermarket shoppers and non-shoppers. This analysis is carried out at the household level, because we do not have individual-level dietary data. In particular, we use the 30-day food consumption data to calculate a food variety score (FVS) and a dietary diversity score (DDS) at the household level. FVS is a simple count of the different food items consumed by the household. DDS is a count of the different food groups consumed, whereby the food items are categorized into groups according to their nutritional value. We use the 12 food groups recommended for calculation of the household dietary diversity score (Kennedy et al., 2013).

FVS and DDS are suitable proxies of dietary quality, as diversified diets were shown to be positively associated with micronutrient intakes and nutritional outcomes in children (Ruel, 2003; Arimond and Ruel, 2004; Rah et al., 2010). In addition to the simple comparison of dietary indicators, we run panel regressions to investigate whether supermarket purchase affects dietary quality also after controlling for relevant confounding factors.

4. Results

4.1. Descriptive statistics

Table 2 summarizes descriptive statistics of major variables used in our analysis for the total child sample and separately for children in households with and without supermarket food purchases. It shows that households who shop in supermarkets have higher socioeconomic status, are heavier (average BMI of 27), but not taller. This indicates that we need to control for socioeconomic status and worry about unobserved heterogeneity using our IV-strategy. Table 3 shows the nutritional status of children. The average HAZ for all children in the sample is -0.80. About 15% of the children are stunted, and 7% are underweight.[2] Children in households with supermarket purchases have a significantly higher mean HAZ and also a higher mean WAZ than children in households without supermarket purchases. Especially the difference in HAZ is relatively large, as is also reflected in the stunting rates. Children in households with supermarket purchases are only half as likely to be stunted as children in households without supermarket purchases. The middle and lower part of Table 3 differentiates between children above and below five years of age. For both groups, the patterns are similar with significant differences in mean HAZ between children in households with and without supermarket food purchases. Of course these differences are unconditional and we need to see whether they survive once we control for differences in socioeconomic status.

Figures 1 and 2 go beyond mean value comparisons and show distribution functions for HAZ and WAZ for children in households with and without supermarket purchases. All distribution functions show consistently higher HAZ and WAZ for children in households with supermarket purchases. These descriptive statistics provide a first indication that supermarkets may contribute to both height and weight gains in children above and below five years of age. The econometric analysis below examines whether these relationships can be interpreted as causal effects.

[2] Child overweight and obesity rates in the sample are relatively low. About 6% of the children have WAZ>1, and only 2% have WAZ>2. This is different among adults in the same households; Kimenju et al. (2015) showed that around 40% of all adults are either overweight or obese.

4.2. Effects of supermarkets on child height

Table 4 shows results from the IV regressions with child HAZ as the nutritional outcome variable and the supermarket purchase dummy variable as the treatment variable.[3] Columns (1) to (3) present the RE-IV estimates with different types of explanatory variables included. Column (4) shows the Mundlak-IV estimates. The estimated supermarket effects do not vary much between the different model specifications.

The estimates in Table 4 suggest that purchasing food in supermarkets has a positive and significant effect on child height. On average, children living in households with supermarket purchases have 0.34 higher HAZ than children living in households that obtain all their foods from traditional sources. This effect remains consistent even after controlling for total household expenditure (columns 2 and 3) and for health and sanitation related factors (column 3).

Most of the control variables in Table 4 have the expected effects. Total household expenditures, child age, mother's height, and drinking water treatment affect child HAZ in a positive way. Female children have a higher HAZ than male children when holding other factors constant. Children living in female-headed households have a lower HAZ than children living in male-headed households, even after controlling for total household expenditures.

Table 5 shows results from the HAZ models with the share of supermarket purchases as the treatment variable. Children in households with a higher supermarket share have a higher HAZ than children in households with a lower supermarket share. A 1% increase in the share of supermarket purchases leads to a 0.02 higher HAZ. These estimates further

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[3] First-stage results of the IV models are shown in Table A1.

support the hypothesis that supermarkets have a positive effect on child height. Results for the control variables in Table 5 are very similar to those in Table 4.

The effect of supermarket shopping on child height might differ depending on the particular age cohort. As mentioned, the impact of supermarkets on the height of children below the age of five has not been evaluated before, even though child developments below five are particularly crucial for lifelong physical and cognitive ability (Black et al., 2013). To analyze possible differences, we run the HAZ regression models separately for children that are five years and older, and children below the age of five. Results are shown in Tables 6 and 7. Children above the age of five were included in both survey rounds, so that RE-IV and Mundlak-IV panel models were used for the estimates in Table 6. Children below five were only surveyed in 2015; hence the estimates in Table 7 are based on IV and OLS models with cross-section data.[4] The results in Tables 6 and 7 suggest that buying food in supermarkets positively affects HAZ of children above and below five years of age. In a different specification, we used the total sample but included an interaction term between the treatment variable and an age cohort dummy variable (Table A4). The insignificance of the interaction term suggests that supermarket purchases have similar effects on HAZ of children in both age cohorts.

4.3. Effects of supermarkets on child weight

To analyze the effect of supermarket food purchases on child weight, we use the same regressions as in the previous subsection but now with child WAZ as dependent variable. Results are shown in Table 8. After controlling for other factors, children in households with supermarket purchases (columns 1 and 3) have a 0.09 higher WAZ than children in

[4] Due to the small sample size of children below the age of five (n=109), we included fewer control variables in Table 7 to save degrees of freedom and increase estimation efficiency.

households that obtain all of their food from traditional sources. This effect is statistically significant, but it is much smaller than the supermarket effect on HAZ. Hence, supermarkets seem to have a bigger effect on child height than on child weight in the study region. The models in columns (2) and (4) of Table 8 produce insignificant estimation coefficients, suggesting that child weight does not significantly increase with a rising share of supermarket purchases.

Previous research in Indonesia suggested that supermarkets may contribute to childhood obesity in richer population segments (Umberger et al., 2015). As mentioned, childhood obesity is not yet a major problem in Kenya. In our sample, only 2% of the children were classified as obese with WAZ>2. We re-estimated the models in Table 8 and excluded the seven obese children, in order to test whether the results change in any direction (Table A5). The estimated treatments effects are even slightly larger than those in Table 8, suggesting that the gains in WAZ are not primarily driven by the subsample of obese children. We cautiously conclude that supermarkets are not a driver of childhood obesity in the Kenyan context.

4.4. Robustness checks

In a first robustness check we run the HAZ and WAZ models without the IV approach, that is we use standard RE and Mundlak panel models. These alternative results are shown in Table A6 and A7. The results are similar to the IV results discussed above. For the HAZ models, the estimates without IV are slightly smaller than with IV. For the WAZ models, the estimates without IV are slightly larger. But the main findings – namely that supermarket food purchases contribute to height and weight growth in children with the effects on height being more pronounced – remain robust and are therefore not driven by the choice of the instrument.

In a second robustness check, we use a control function approach instead of the standard RE-IV and Mundlak-IV estimators. The first-stage double-hurdle model for the residual calculations is presented in Table A8. The second-stage models with the treatment effects on HAZ and WAZ are shown in Tables A9 and A10. The results are similar to those estimated with the standard IV estimators, thus further underlining the robustness of our findings.

4.5. Dietary effects

We hypothesize that the main effects of supermarkets on child nutrition are channeled through changing diets. That is, households that purchase at least some of their food in supermarkets are expected to have different diets than households that obtain all of their food from traditional sources. A simple comparison using different indicators of dietary quality is provided in Table 9. Households with supermarket purchases have significantly higher food variety scores (FVS) and dietary diversity scores (DDS) than households without supermarket purchases. It might be argued that these differences are primarily driven by unhealthy food items purchased in supermarkets. However, significant differences remain also when less healthy foods (fats, oils, sugars and spices) are excluded from the FVS and DDS calculations.

The lower part of Table 9 provides further details by comparing the likelihood of specific food groups being consumed in households with and without supermarket purchases. Positive differences are observed particularly for meat (including sausages), fish, and eggs, and to a lesser extent fruits. This suggests that households with supermarket food purchases have higher dietary quality. Animal products are rich in protein and micronutrients, which could explain the positive effects on child height. Research shows that higher consumption of animal-sourced foods is negatively associated with child stunting in Africa (Headey et al., 2017).

However, the comparisons in Table 9 do not control for other factors that may be jointly correlated with supermarket purchases and dietary quality, such as household expenditures and education levels. To control for such other factors, we ran IV regression models using FVS and DDS as dependent variables. The RE-IV models for FVS are shown in Table 10, those for DDS in Table A11. The supermarket purchase dummy variable and the share of supermarket purchases have positive and significant effect on FVS, also after controlling for confounding factors and excluding less-healthy food items from the FVS calculations. In the DDS models, the supermarket purchase variables also have positive coefficients, even though these are statistically insignificant (Table A11).

5. Conclusion

In many developing countries, supermarkets are spreading rapidly at the expense of more traditional food markets and shops. Changing retail environments and sales portfolios may affect consumer food choices and nutritional outcomes. Previous research suggested that the rise of supermarkets in developing countries may contribute to the obesity pandemic through higher consumption of processed and calorie-dense foods (Asfaw, 2008; Hawkes, 2008; Kimenju, 2015; Popkin, 2017; Demmler et al., 2018). However, most of this research looked at adult populations. The nutritional implications for children are not yet sufficiently understood.

In this paper, we have analyzed the effects of supermarkets on child height and weight with panel data from medium-sized towns in Kenya. The focus on medium-sized towns allowed us to take advantage of a quasi-experimental sampling design: at the time of the survey, some of the medium-sized towns already had a supermarket, while others were waiting for one to be opened in the near future. Our results with panel instrumental variable estimators show that supermarket food purchases significantly increase child height-for-age Z-scores. This positive effect on height is observed for children below and above five years of age. Supermarket purchases also increase child weight-for-age Z-scores, but the effects on height are larger than the effects on weight. Supermarkets do not seem to be a driver of child obesity in the study region. The positive effects on child height are particularly welcome, as child stunting is still widespread and a major health problem in developing countries. Our results are in line with Kimenju et al. (2015) and Kimenju and Qaim (2016), who also suggested that the rise of supermarkets may contribute to a reduction in child stunting.

One channel of the nutrition effects of supermarkets are changes in consumer diets. Our data show that dietary quality is higher in households with supermarket purchases than in households that obtain all their foods from traditional sources. We found significant differences in terms of food variety and the likelihood of consumption of certain healthy food groups, such as fruits, meat, fish, and eggs. Positive effects of supermarkets on food variety scores are also observed after controlling for household living standards, levels of education, and other possible confounding factors.

That supermarkets contribute to rising obesity in adults but not in children is interesting and plausible. Adults cannot grow in height anymore, so additional calories and nutrients from supermarket purchases will primarily lead to gains in body weight. In situations where mean BMI levels among adults are already quite high, as is the case in many urban areas of developing countries, additional weight gains will inevitably contribute to rising rates of overweight and obesity. For children this is different. First, as children are still growing, additional calories and nutrients can contribute to gains in height, as observed in our sample. Second, in most situations overweight and obesity rates are still much lower in children than in adults, meaning that moderate weight gains in children do not necessarily drive up child obesity rates substantially. Third, the effect of sedentary lifestyles on a changed diet-the other big driver of obesity- is prominent among better-off adults in developing countries much more than children.

However, the nutritional effects of supermarkets will obviously depend on the initial dietary and nutrition situation and the types of dietary shifts that occur. In the medium-sized towns in Kenya, many of the households are still moderately poor, and traditional diets are not highly diversified. In this context, the greater variety of foods offered by supermarkets at affordable prices can improve diets and nutrient intakes, even when most of the products purchased in supermarkets are in processed or semi-processed form. The nutritional effects could be different in settings where households are already richer, diets are more diversified, and supermarkets primarily add to the consumption of highly-processed snacks and convenience foods. This would be in line with the finding by Umberger et al. (2015), namely that supermarkets contribute to child overweight in the richer population segments of urban Indonesia.

Our results help to better understand the nutritional implications of supermarkets in developing countries and to guide policies aimed at improving diets and nutrition. A few limitations should be mentioned. First, our sample size is relatively small, especially for children below the age of five, which were only included in one of the survey rounds. Second, the panel with two survey rounds is short, so that the analysis of longer-term dynamics was not possible. Third, in our survey, diets were only captured through a 30-day recall at the household level, so that dietary details at the individual child level could not be examined. Further research with longer panels, more detailed dietary data, and carried out in different contexts will be useful to add to our understanding of the links between changing food environments and child nutrition.

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Table 1. Number of children included in the sample by age group and survey year

	2012	2015	Total
Total children included	200	341	541
Above five years of age	200	232	432
Below five years of age	0	109	109
Total households included	200	288	488
Overlap in both survey rounds	97	97	194

Table 2. Descriptive statistics

Variables	All	Supermarket purchase=1	Supermarket purchase=0
Child characteristics			
Age of child in years	8.27 (4.11)	7.68 (3.87)	8.95 (4.29)
Female child (1,0)	0.52 (0.50)	0.52 (0.50)	0.52 (0.50)
Malaria or respiratory infection in past month	0.09 (0.28)	0.10 (0.30)	0.07 (0.26)
Maternal characteristics			
Height of mother/caregiver in cm	159.10 (5.79)	159.1 (5.35)	159.00 (6.27)
Weight of mother/caregiver in kg	66.40 (13.90)	68.4 (14.30)	64.00 (13.00)
Education of mother/caregiver in years	10.00 (4.58)	11.6 (4.50)	8.27 (4.01)
Age of mother/caregiver in years	35.30 (9.70)	33.8 (7.80)	36.90 (11.30)
Household characteristics			
Female headed household (1,0)	0.26 (0.44)	0.24 (0.43)	0.28 (0.45)
Household always treats drinking water (1,0)	0.57 (0.50)	0.59 (0.49)	0.54 (0.50)
Distance to health center in km	2.30 (2.29)	2.71 (2.53)	1.82 (1.86)
Distance to supermarket in km	15.20 (20.50)	3.10 (9.73)	29.20 (20.80)
Household expenditure (1000 KES /adult equivalence)	9.90 (6.09)	11.80 (6.79)	7.73 (4.23)
Share of supermarket purchase (percent)	7.65 (10.50)	14.20 (10.60)	0.00
Supermarket purchase dummy (1,0)	0.54 (0.50)		
Number of observations	541	291	250

Note: Mean values are shown with standard deviations in parentheses.

Table 3. Child nutritional status with and without supermarket purchases

	All	Supermarket purchase=1	Supermarket purchase=0	Difference	Obser-vations
All children					
HAZ	-0.80 (1.24)	-0.56 (1.18)	-1.08 (1.26)	0.52***	541
WAZ	-0.59 (1.06)	-0.49 (1.09)	-0.74 (1.01)	0.26**	347
% Stunted	15.16	10.31	20.80	10.49***	541
% Underweight	7.20	6.28	8.57	2.29	347
Children above five years					
HAZ	-0.85 (1.20)	-0.60 (1.07)	-1.11 (1.28)	0.50***	432
WAZ	-0.63 (1.07)	-0.54 (1.08)	-0.75 (1.03)	0.22	238
% Stunted	15.74	9.82	22.12	12.30***	432
% Underweight	7.56	6.43	9.18	2.75	238
Children below five years					
HAZ	-0.62 (1.38)	-0.42 (1.48)	-0.94 (1.17)	0.52*	109
WAZ	-0.51 (1.06)	-0.38 (1.09)	-0.72 (0.97)	0.34*	109
% Stunted	12.84	11.94	14.29	2.35	109
% Underweight	6.42	5.97	7.14	1.17	109

Notes: Mean values are shown with standard deviations in parentheses. HAZ, height-for-age Z-score; WAZ, weight-for-age Z-score.

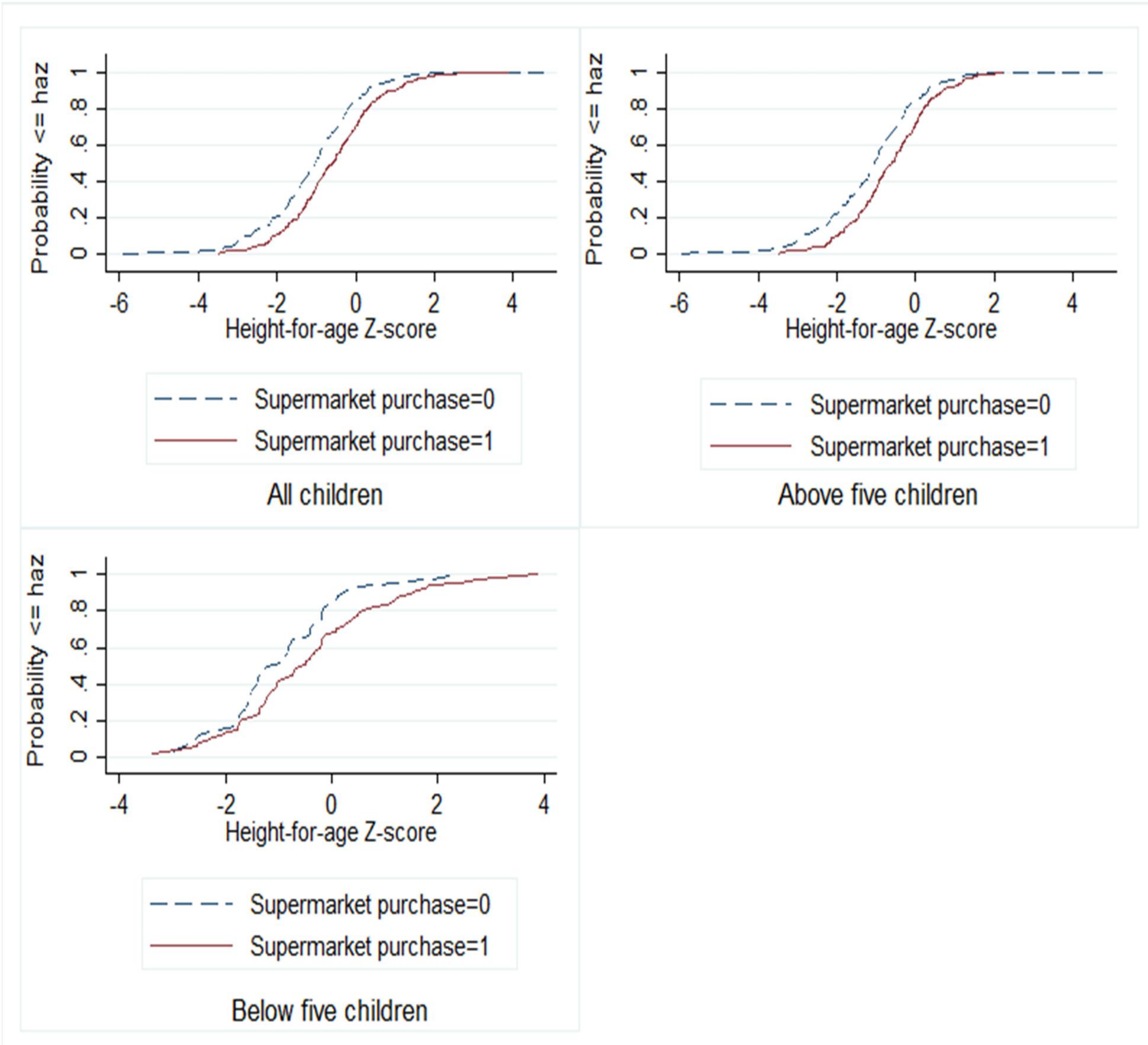

Figure 1. HAZ distribution functions for children with and without supermarket purchases

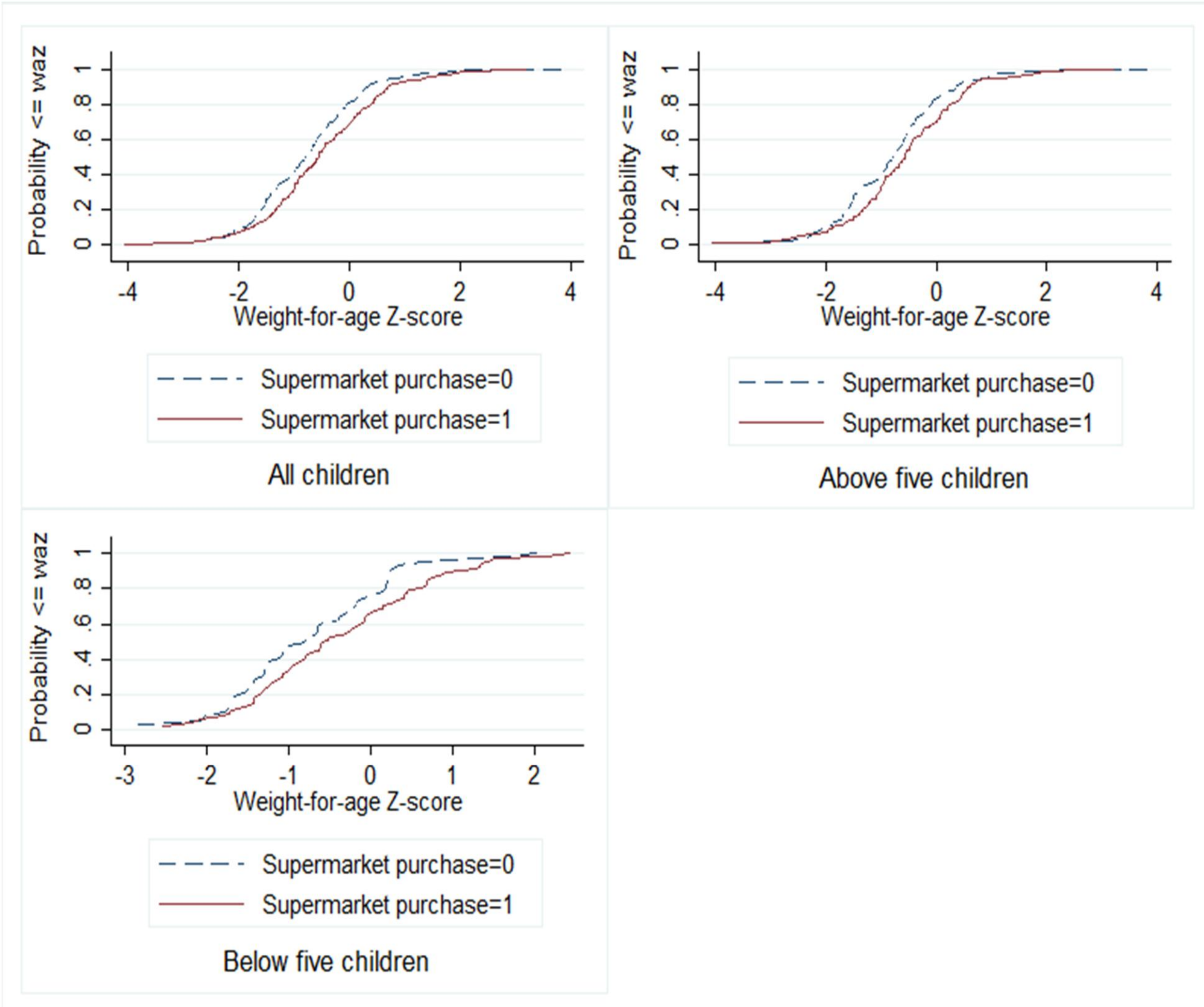

Figure 2. WAZ distribution functions for children with and without supermarket purchases

Table 4. Effects of supermarket purchase on child HAZ

	Random effects (RE)			Mundlak
	(1)	(2)	(3)	(4)
Supermarket purchase (1,0)	0.34***	0.28***	0.34***	0.33***
	(0.07)	(0.08)	(0.04)	(0.04)
Age of child in years	0.10***	0.11***	0.13***	0.12***
	(0.02)	(0.02)	(0.01)	(0.01)
Age of child squared	-0.01***	-0.01***	-0.01***	-0.01***
	(0.00)	(0.00)	(0.00)	(0.00)
Female child (1,0)	0.20***	0.18**	0.25**	0.25**
	(0.07)	(0.08)	(0.10)	(0.12)
Height of mother in cm	0.04**	0.04**	0.04**	0.16**
	(0.02)	(0.02)	(0.02)	(0.07)
Education of mother in years	0.03***	0.01	0.01	0.04
	(0.01)	(0.01)	(0.01)	(0.07)
Age of mother in years	0.02***	0.02***	0.01***	0.02
	(0.00)	(0.00)	(0.01)	(0.02)
Female-headed household (1,0)	-0.13*	-0.16***	-0.15*	-0.61
	(0.08)	(0.06)	(0.08)	(1.07)
Year dummy (1=2015)	0.31***	0.31***	0.26***	0.20***
	(0.06)	(0.06)	(0.04)	(0.04)
Household expenditure (1000 KES per adult equivalent)		0.03***	0.03***	0.01
		(0.00)	0.00)	(0.01)
Malaria/respiratory infection (1,0)			-0.33	-0.33
			(0.23)	(0.25)
Treated drinking water (1,0)			0.16***	0.07*
			(0.05)	(0.04)
Distance to health center in km (log)			-0.03	-0.24
			(0.02)	(0.16)
Time averages included [a]	No	No	No	Yes
Constant	-9.25***	-8.82***	-8.98***	-8.77***
	(2.86)	(2.75)	(2.71)	(2.50)
Number of observations	541	541	541	541
Number of groups	391	391	391	391
R-squared (overall)	0.17	0.19	0.20	0.21
Chi2	74.54	365.06	6.48	9.29
p-value(chi2)	0.00	0.00	0.04	0.01

Notes: All models estimated with panel IV estimators. Coefficient estimates are shown with cluster-corrected standard errors in parentheses. The RE specification has been tested against the FE specification with a Hausman test (chi2=6.55; p=0.92). [a] Estimates for the time average values in the Mundlak specification are shown in Table A3. * $p<0.1$; ** $p<0.05$; *** $p<0.01$

Table 5. Effects of the share of supermarket purchases on child HAZ

	Random effects (RE)			Mundlak
	(1)	(2)	(3)	(4)
Share of supermarket purchases (%)	0.02***	0.02***	0.02***	0.02***
	(0.00)	(0.00)	(0.00)	(0.00)
Age of child in years	0.10***	0.11***	0.12***	0.12***
	(0.02)	(0.02)	(0.01)	(0.01)
Age of child squared	-0.01***	-0.01***	-0.01***	-0.01***
	(0.00)	(0.00)	(0.00)	(0.00)
Female child (1,0)	0.21***	0.19***	0.24***	0.25**
	(0.06)	(0.07)	(0.08)	(0.10)
Height of mother in cm	0.04**	0.04**	0.04**	0.15**
	(0.02)	(0.02)	(0.02)	(0.08)
Education of mother in years	0.02***	0.01	0.01	0.04
	(0.00)	(0.01)	(0.01)	(0.07)
Age of mother in years	0.02***	0.02***	0.02**	0.02
	(0.01)	(0.01)	(0.01)	(0.02)
Female-headed household (1,0)	-0.17**	-0.20***	-0.19**	-0.65
	(0.08)	(0.06)	(0.08)	(1.09)
Year dummy (1=2015)	0.35***	0.35***	0.30***	0.24***
	(0.07)	(0.08)	(0.06)	(0.07)
Household expenditure (1000 KES per adult equivalent)		0.03***	0.03***	0.01
		(0.00)	(0.01)	(0.01)
Malaria/ respiratory infection (1,0)			-0.27	-0.28
			(0.21)	(0.23)
Treated drinking water (1,0)			0.20***	0.08
			(0.03)	(0.06)
Distance to health center in km (log)			0.02	-0.29*
			(0.01)	(0.16)
Time averages included [a]	No	No	No	Yes
Constant	-9.28***	-8.87***	-9.08***	-8.84***
	(2.82)	(2.69)	(2.49)	(2.22)
Number of observations	541	541	541	541
Number of groups	391	391	391	391
R-squared (overall)	0.17	0.19	0.21	0.21
Chi2	24.89	55.68	9.42	11.84
p-value(chi2)	0.00	0.00	0.01	0.00

Notes: All models estimated with panel IV estimators. Coefficient estimates are shown with cluster-corrected standard errors in parentheses. The RE specification has been tested against the FE specification with a Hausman test (chi2=9.78; p=0.71). [a] Estimates for the time average values in the Mundlak specification are shown in Table A3. * $p<0.1$; ** $p<0.05$; *** $p<0.01$

Table 6. Effects of supermarket purchase on HAZ of children five years and older

	Random effects (RE)		Mundlak	
	(1)	(2)	(3)	(4)
Supermarket purchase (1,0)	0.25***		0.23***	
	(0.09)		(0.09)	
Share of supermarket purchases (%)		0.01**		0.01***
		(0.01)		(0.01)
Age of child in years	-0.08**	-0.08**	-0.08**	-0.08**
	(0.04)	(0.04)	(0.04)	(0.04)
Female child (1,0)	0.15	0.16	0.16	0.18
	(0.10)	(0.11)	(0.13)	(0.13)
Height of mother in cm	0.05**	0.05**	0.17***	0.17***
	(0.02)	(0.02)	(0.05)	(0.06)
Education of mother in years	0.02***	0.02***	0.06	0.06
	(0.00)	(0.00)	(0.08)	(0.08)
Age of mother in years	0.01*	0.01**	0.02	0.02
	(0.01)	(0.01)	(0.02)	(0.02)
Household expenditure (1000 KES per adult equivalent)	0.03***	0.03***	0.00	-0.00
	(0.00)	(0.00)	(0.02)	(0.02)
Female-headed household (1,0)	-0.11	-0.14**	-0.07	-0.11
	(0.07)	(0.07)	(0.55)	(0.55)
Malaria/respiratory infection (1,0)	-0.28	-0.26	-0.31	-0.29
	(0.27)	(0.25)	(0.30)	(0.29)
Treated drinking water (1,0)	0.19***	0.20***	0.08	0.08
	(0.07)	(0.07)	(0.06)	(0.08)
Distance to health center in km (log)	-0.03	0.01	0.00	-0.04
	(0.03)	(0.02)	(0.06)	(0.04)
Year dummy (1=2015)	0.40***	0.40***	0.28***	0.29***
	(0.06)	(0.06)	(0.01)	(0.01)
Time averages included	No	No	Yes	Yes
Constant	-9.19***	-9.24***	-8.40***	-8.50***
	(3.35)	(3.10)	(2.94)	(2.70)
Number of observations	432	432	432	432
Number of groups	343	343	343	343
R-squared (overall)	0.22	0.23	0.23	0.24
Chi2	8.08	2.44	1.62	1.50

Notes: All models estimated with panel IV estimators. Coefficient estimates are shown with cluster-corrected standard errors in parentheses. * p<0.1; ** p<0.05; *** p<0.01

Table 7. Effects of supermarket purchase on HAZ of children below five years of age

	IV		OLS	
	(1)	(2)	(3)	(4)
Supermarket purchase (0,1)	0.77*		0.53*	
	(0.40)		(0.28)	
Share of supermarket purchases (%)		0.05*		0.02
		(0.03)		(0.01)
Age of child in years	0.16	0.16	0.17	0.17
	(0.14)	(0.14)	(0.15)	(0.15)
Female child (1,0)	0.62**	0.67***	0.60**	0.60**
	(0.25)	(0.26)	(0.26)	(0.26)
Height of mother in cm	0.03	0.03	0.03	0.03
	(0.02)	(0.02)	(0.02)	(0.02)
Education of mother in years	-0.05	-0.05	-0.04	-0.03
	(0.04)	(0.04)	(0.04)	(0.04)
Age of female mother in years	0.05***	0.05***	0.04***	0.04**
	(0.02)	(0.02)	(0.02)	(0.02)
Household expenditure (1000 KES per	0.03	0.02	0.03	0.03
adult equivalent)	(0.02)	(0.02)	(0.02)	(0.02)
Female-headed household (1,0)	-0.33	-0.30	-0.28	-0.21
	(0.33)	(0.34)	(0.34)	(0.34)
Distance to health center in km (log)	-0.13	-0.00	-0.13	-0.08
	(0.11)	(0.13)	(0.12)	(0.13)
Constant	-7.65**	-7.55**	-7.40*	-7.11*
	(3.59)	(3.69)	(3.74)	(3.77)
Number of observations	109	109	109	109
Chi2	31.90	30.07		
R-squared			22.90	21.32

Notes: Models based on cross-section data collected in 2015 (children below five were not included in the 2012 survey round). Coefficient estimates are shown with cluster-corrected standard errors in parentheses. * *p*<0.1; ** *p*<0.05; *** *p*<0.01

Table 8. Effects of supermarket purchase on child WAZ

	Random effects (RE)		Mundlak	
	(1)	(2)	(3)	(4)
Supermarket purchase dummy (1,0)	0.09**		0.09**	
	(0.04)		(0.04)	
Share of supermarket purchases (%)		0.003		0.003
		(0.004)		(0.003)
Age of child in years	-0.04	-0.03	-0.04**	-0.04*
	(0.02)	(0.02)	(0.02)	(0.02)
Female child (1,0)	0.09	0.20	0.12	0.19
	(0.10)	(0.13)	(0.13)	(0.14)
Height of mother in cm	0.03*	0.03*	0.16***	0.15***
	(0.02)	(0.02)	(0.05)	(0.05)
Weight of mother in kg	0.02***	0.02***	0.01	0.01
	(0.00)	(0.00)	(0.02)	(0.02)
Education of mother in years	-0.00	-0.00	0.00	-0.00
	(0.03)	(0.03)	(0.06)	(0.06)
Age of female mother in years	0.02***	0.01***	0.03***	0.03**
	(0.00)	(0.00)	(0.00)	(0.01)
Household expenditure (1000 KES per adult equivalent)	0.02*	0.02***	-0.01	0.00
	(0.01)	(0.01)	(0.03)	(0.02)
Female-headed household (1,0)	-0.01	0.05	-1.26	-1.59
	(0.12)	(0.15)	(1.22)	(1.43)
Malaria/respiratory infection (1,0)	-0.40***	-0.48***	-0.42***	-0.48***
	(0.11)	(0.16)	(0.14)	(0.18)
Treated drinking water (1,0)	0.13	0.16	-0.13	-0.08
	(0.12)	(0.12)	(0.16)	(0.15)
Distance to health center in km (log)	-0.03	-0.01	-0.06	-0.19
	(0.02)	(0.01)	(0.16)	(0.22)
Year dummy (1=2015)	-0.21*	-0.26*	-0.33	-0.35*
	(0.12)	(0.14)	(0.20)	(0.21)
Time averages included [a]	No	No	Yes	Yes
Constant	-7.36**	-7.48***	-7.17**	-7.39***
	(3.01)	(2.87)	(2.92)	(2.84)
Number of observations	347	347	347	347
Number of groups	277	277	277	277
R-squared (overall)	0.19	0.20	0.21	0.21
Chi2	12.85	9.16	1.24	7.74
p-value(chi2)	0.00	0.01	0.54	0.02

Notes: All models estimated with panel IV estimators. Coefficient estimates are shown with cluster-corrected standard errors in parentheses. [a] Estimates for the time average values in the Mundlak specifications are shown in Table A3. * p<0.1; ** p<0.05; *** p<0.01

Table 9. Dietary quality in households with and without supermarket purchases

	All	Supermarket purchase=1	Supermarket purchase=0	Difference
FVS 1 (including all food items)	42.875	46.822	38.223	8.599***
	(0.586)	(0.773)	(0.790)	
FVS 2 (excluding less healthy foods) [a]	37.336	40.902	33.134	7.768***
	(0.517)	(0.676)	(0.702)	
DDS 1 (including all food groups)	11.073	11.295	10.813	0.483***
	(0.039)	(0.043)	(0.064)	
DDS 2 (excluding less healthy foods) [a]	8.080	8.303	7.817	0.486***
	(0.038)	(0.042)	(0.064)	
Consumption of food groups (1,0)				
Roots and tubers	0.986	0.977	0.996	-0.018*
	(0.005)	(0.009)	(0.004)	
Legumes, nuts, seeds	0.990	0.989	0.991	-0.002
	(0.005)	(0.007)	(0.006)	
Fruits	0.990	1.000	0.978	0.022**
	(0.005)	(0.000)	(0.010)	
Meat	0.951	0.985	0.911	0.074***
	(0.010)	(0.008)	(0.019)	
Fish	0.391	0.485	0.281	0.204***
	(0.022)	(0.031)	(0.030)	
Eggs	0.781	0.875	0.670	0.205***
	(0.019)	(0.020)	(0.031)	
Milk and milk products	0.992	0.992	0.991	0.001
	(0.004)	(0.005)	(0.006)	
Sweets	0.998	0.996	1.000	-0.004
	(0.002)	(0.004)	(0.000)	
Spices	0.996	0.996	0.996	0.001
	(0.003)	(0.004)	(0.004)	
Number of observations	488	264	224	

Notes: Mean values are shown with standard errors in parentheses. [a] Less healthy foods include oils and fats, sweets, and spices. FVS, food variety score; DDS, dietary diversity score.

Table 10. Effect of supermarket purchase on food variety score (FVS)

	FVS 1		FVS 2	
	(1)	(2)	(3)	(4)
Supermarket purchase (1,0)	3.09**		2.40**	
	(1.51)		(1.17)	
Share of supermarket purchases (%)		0.18**		0.14*
		(0.09)		(0.08)
Education of mother in years	0.14***	0.13***	0.16***	0.14***
	(0.02)	(0.02)	(0.02)	(0.03)
Age of mother in years	-0.18***	-0.18***	-0.12***	-0.12***
	(0.02)	(0.03)	(0.02)	(0.02)
Female-headed household (1,0)	-0.86	-1.09***	-0.73*	-0.99***
	(0.58)	(0.41)	(0.38)	(0.22)
Year dummy (1=2015)	2.89**	3.21***	4.12**	4.36***
	(1.40)	(1.12)	(1.66)	(1.41)
Household expenditure (1000 KES per adult equivalent)	0.97***	0.96***	0.84***	0.82***
	(0.20)	(0.21)	(0.14)	(0.16)
Distance to health center in km (log)	0.52	0.94	0.52	0.82
	(0.39)	(0.62)	(0.33)	(0.54)
Constant	34.97***	35.30***	28.15***	28.31***
	(2.38)	(2.42)	(2.41)	(2.51)
Number of observations	488	488	488	488
Number of groups	391	391	391	391
R-squared (overall)	0.36	0.36	0.36	0.36
Chi2	24.96	17.20	81.06	55.75
p-value(chi2)	0.00	0.00	0.00	0.00

Notes: Random effects models at household level. All models estimated with panel IV estimators (RE-IV). Coefficient estimates are shown with clustered standard errors in parentheses. FVS 1 includes all foot items. FVS 2 excludes less healthy food items, such as oils and fats, sweets, and spices. * p<0.1; ** p<0.05; *** p<0.01

Appendix

Table A1. First stage regressions of instrumental variable regressions

	Supermarket dummy		Share of superm. purchase	
	RE	Mundlak	RE	Mundlak
Distance to supermarket in km (log)	-0.15***	-0.14***	-2.40***	-2.51***
	(0.01)	(0.01)	(0.25)	(0.18)
Age of child in years	0.01*	0.00	-0.01	-0.14
	(0.00)	(0.00)	(0.16)	(0.15)
Age of child squared	-0.00***	-0.00**	-0.00	0.00
	(0.00)	(0.00)	(0.01)	(0.01)
Female child (1,0)	-0.02	-0.01	-0.99*	-0.84**
	(0.03)	(0.03)	(0.51)	(0.35)
Height of mother in cm	-0.00	-0.01	-0.06	0.04
	(0.00)	(0.03)	(0.09)	(0.24)
Education of mother in years	0.01***	0.00	0.36***	0.31***
	(0.00)	(0.01)	(0.09)	(0.05)
Age of mother in years	-0.00	0.01	-0.03	-0.05
	(0.00)	(0.01)	(0.07)	(0.10)
Female-headed household (1,0)	-0.03	0.02	1.06*	2.64
	(0.02)	(0.13)	(0.64)	(2.62)
Year dummy (1=2015)	0.01	-0.00	-0.76	-0.85
	(0.02)	(0.05)	(0.72)	(1.04)
Household expenditure (1000 KES per adult equivalent)	0.01***	-0.00	0.25***	-0.04
	(0.00)	(0.01)	(0.08)	(0.06)
Malaria/respiratory infection (1,0)	-0.02	-0.02	-1.76**	-2.02**
	(0.03)	(0.03)	(0.80)	(0.88)
Treated drinking water (1,0)	0.03	-0.01	-0.39	-0.81
	(0.06)	(0.08)	(0.45)	(0.60)
Distance to health center in km (log)	0.01	-0.00	-2.09***	2.87***
	(0.02)	(0.01)	(0.54)	(0.42)
Mean height of mother		0.01		-0.11
		(0.03)		(0.16)
Mean education of mother		0.01		-0.04
		(0.01)		(0.05)
Mean age of mother		-0.01**		0.02
		(0.00)		(0.09)
Mean female-headed household		-0.05		-2.14
		(0.15)		(3.31)
Mean household expenditure		0.01		0.39***
		(0.01)		(0.06)
Mean treated drinking water		0.06		0.86
		(0.06)		(0.52)
Mean distance to health center		0.01		-5.34***
		(0.01)		(0.25)
Constant	0.75	0.79	16.75	19.13
	(0.60)	(0.50)	(14.69)	(13.94)
Number of obs. (groups)	541 (391)	541 (391)	541 (391)	541 (391)
R-squared (overall)	0.52	0.52	0.42	0.43

* $p<0.1$; ** $p<0.05$; *** $p<0.01$

Table A2. Test of instrument validity (random effects models)

	HAZ	WAZ
Supermarket purchase (1,0)	0.20*	0.15**
	(0.11)	(0.06)
Distance to supermarket in km (log)	-0.02	0.01
	(0.02)	(0.01)
Age of child in years	0.10***	-0.04
	(0.02)	(0.02)
Age of child squared	-0.01***	
	(0.00)	
Female child (1,0)	0.16**	0.08
	(0.06)	(0.09)
Height of mother in cm	0.04**	0.03*
	(0.02)	(0.02)
Weight of mother in kg		0.02***
		(0.00)
Education of mother in years	0.01	-0.00
	(0.01)	(0.03)
Age of mother in years	0.02***	0.02***
	(0.00)	(0.00)
Female-headed household (1,0)	-0.18***	-0.01
	(0.03)	(0.12)
Year dummy (1=2015)	0.30***	-0.20*
	(0.06)	(0.12)
Household expenditure (1000 KES per adult equivalent)	0.03***	0.02
	(0.00)	(0.01)
Malaria/respiratory infection (1,0)	-0.21	-0.39***
	(0.23)	(0.11)
Treated drinking water (1,0)	0.18***	0.12
	(0.01)	(0.12)
Distance to health center in km (log)	-0.04	-0.03
	(0.03)	(0.02)
Constant	-8.84***	-7.38**
	(2.96)	(3.02)
Number of observations	541	347
Number of groups	391	277
R-squared (overall)	0.20	0.19

* *p*<0.1; ** *p*<0.05; *** *p*<0.01

Table A3. Full result of IV Mundlak models (with time average coefficients)

	HAZ		WAZ	
	(1)	(2)	(3)	(4)
Supermarket purchase (1,0)	0.33***		0.09**	
	(0.04)		(0.04)	
Share of supermarket purchases (%)		0.02***		0.003
		(0.00)		(0.003)
Age of child in years	0.12***	0.12***	-0.04*	-0.04*
	(0.01)	(0.01)	(0.02)	(0.02)
Age of child squared	-0.01***	-0.01***		
	(0.00)	(0.00)		
Female child (1,0)	0.25**	0.25**	0.12	0.19
	(0.12)	(0.10)	(0.13)	(0.14)
Height of mother in cm	0.16**	0.15**	0.16***	0.15***
	(0.07)	(0.08)	(0.05)	(0.05)
Weight of mother in kg			0.01	0.01
			(0.02)	(0.02)
Education of mother in years	0.04	0.04	0.00	-0.00
	(0.07)	(0.07)	(0.06)	(0.06)
Age of mother in years	0.02	0.02	0.03***	0.03**
	(0.02)	(0.02)	(0.00)	(0.01)
Female-headed household (1,0)	-0.61	-0.65	-1.26	-1.59
	(1.07)	(1.09)	(1.22)	(1.43)
Year dummy (1=2015)	0.20***	0.24***	-0.33	-0.35*
	(0.04)	(0.07)	(0.20)	(0.21)
Household expenditure	0.01	0.01	-0.01	-0.00
	(0.01)	(0.01)	(0.03)	(0.02)
Malaria/respiratory infection (1,0)	-0.33	-0.28	-0.42***	-0.48***
	(0.25)	(0.23)	(0.14)	(0.18)
Treated drinking water (1,0)	0.07*	0.08	-0.13	-0.08
	(0.04)	(0.06)	(0.16)	(0.15)
Distance to health center in km (log)	-0.24	-0.29*	-0.06	-0.19
	(0.16)	(0.16)	(0.16)	(0.22)
Mean height of mother	-0.12**	-0.11*	-0.13***	-0.12**
	(0.06)	(0.07)	(0.05)	(0.05)
Mean weight of mother			0.01	0.01
			(0.02)	(0.02)
Mean education of mother	-0.04	-0.03	-0.01	0.00
	(0.08)	(0.08)	(0.06)	(0.05)
Mean age of mother	-0.00	-0.00	-0.01	-0.02
	(0.02)	(0.02)	(0.01)	(0.02)
Mean female-headed household	0.46	0.47	1.28	1.67
	(1.17)	(1.20)	(1.36)	(1.59)
Mean household expenditure	0.03*	0.02	0.03	0.02
	(0.01)	(0.02)	(0.02)	(0.02)
Mean treated drinking water	0.10*	0.13***	0.34***	0.28**
	(0.05)	(0.04)	(0.11)	(0.12)
Mean distance to health center	0.22	0.32**	0.04	0.19
	(0.15)	(0.16)	(0.18)	(0.23)
Constant	-8.77***	-8.84***	-7.17**	-7.39***
	(2.50)	(2.22)	(2.92)	(2.84)
Number of obs. (groups)	541 (391)	541 (391)	347 (277)	347 (277)
R-squared (overall)	0.21	0.21	0.21	0.21
Chi2	9.29	11.84	1.24	7.74

* *p*<0.1; ** *p*<0.05; *** *p*<0.01

Table A4. Supermarket effects on HAZ for children above and below five years of age

	(1)	(2)
Supermarket purchase dummy (1,0)	0.39**	
	(0.18)	
Share of supermarket purchases (%)		0.02**
		(0.01)
Supermarket purchase x Below five	-0.22	-0.01
	(0.27)	(0.02)
Age of child in years	0.07	0.08
	(0.06)	(0.06)
Age of child squared	-0.01**	-0.01**
	(0.00)	(0.00)
Female child (1,0)	0.16	0.18*
	(0.10)	(0.11)
Height of mother in cm	0.04***	0.04***
	(0.01)	(0.01)
Education of mother in years	0.01	0.00
	(0.01)	(0.01)
Age of mother in years	0.02**	0.02***
	(0.01)	(0.01)
Household expenditure (1000 KES per adult equivalent)	0.03***	0.03***
	(0.01)	(0.01)
Female-headed household (1,0)	-0.17	-0.20
	(0.14)	(0.13)
Malaria/respiratory infection (1,0)	-0.22	-0.19
	(0.15)	(0.17)
Treated drinking water (1,0)	0.18*	0.20**
	(0.10)	(0.10)
Distance to health center in km (log)	-0.05	0.00
	(0.05)	(0.05)
Year dummy (1=2015)	0.32***	0.34***
	(0.09)	(0.09)
Constant	-8.84***	-8.96***
	(1.73)	(2.04)
Number of obs. (groups)	541 (391)	541 (391)
R-squared (overall)	0.20	0.20
Chi2	110.12	124.19

Notes: Models estimated with panel FE-IV estimator. * p<0.1; ** p<0.05; *** p<0.01

Table A5. Effects of supermarket purchase on child WAZ excluding obese children

	RE		Mundlak	
Supermarket purchase (1,0)	0.10***		0.09***	
	(0.01)		(0.01)	
Share of supermarket purchases (%)		0.004**		0.004**
		(0.002)		(0.001)
Age of child in years	-0.03	-0.02	-0.03	-0.02
	(0.03)	(0.03)	(0.03)	(0.03)
Female child (1,0)	0.08	0.15	0.10	0.15
	(0.10)	(0.11)	(0.12)	(0.12)
Height of mother in cm	0.02	0.02*	0.11**	0.11**
	(0.01)	(0.01)	(0.05)	(0.05)
Weight of mother in kg	0.02***	0.02***	0.02	0.02
	(0.00)	(0.00)	(0.02)	(0.02)
Education of mother in years	-0.00	-0.01	0.02	0.01
	(0.02)	(0.01)	(0.08)	(0.08)
Age of mother in years	0.01**	0.01	0.02***	0.02**
	(0.01)	(0.01)	(0.00)	(0.01)
Household expenditure (1000 KES per adult equivalent)	0.02***	0.02***	0.01	0.02***
	(0.01)	(0.01)	(0.01)	(0.01)
Female-headed household (1,0)	-0.01	0.01	-1.32	-1.56
	(0.12)	(0.15)	(1.24)	(1.37)
Malaria/respiratory infection (1,0)	-0.32***	-0.38***	-0.34***	-0.37***
	(0.06)	(0.08)	(0.09)	(0.10)
Treated drinking water (1,0)	0.20***	0.22***	-0.08	-0.05
	(0.06)	(0.06)	(0.15)	(0.15)
Distance to health center in km (log)	-0.09***	-0.07***	-0.12	-0.22
	(0.01)	(0.01)	(0.21)	(0.25)
Year dummy (1=2015)	-0.17**	-0.19*	-0.24	-0.24
	(0.07)	(0.10)	(0.15)	(0.16)
Mean height of mother			-0.09	-0.08
			(0.05)	(0.06)
Mean weight of mother			0.00	-0.00
			(0.02)	(0.02)
Mean education of mother			-0.02	-0.02
			(0.08)	(0.07)
Mean age of mother			-0.01	-0.01
			(0.01)	(0.01)
Mean female-headed household			1.34	1.60
			(1.37)	(1.53)
Mean household expenditure			0.01	0.00
			(0.01)	(0.00)
Mean treated drinking water			0.35*	0.32*
			(0.19)	(0.19)
Mean distance to health center in km (log)			0.04	0.16
			(0.22)	(0.26)
Constant	-5.77***	-5.98***	-5.73***	-5.93***
	(2.18)	(2.13)	(2.20)	(2.14)
Number of obs. (groups)	340 (271)	340 (271)	340 (271)	340 (271)
R-squared-overall	0.20	0.20	0.21	0.21
Chi2 P-value(chi2)	28.14 (0.00)	22.75 (0.00)	7.03 (0.03)	7.16 (0.03)

* *p*<0.1; ** *p*<0.05; *** *p*<0.01

Table A6. Panel models for HAZ without IV

	RE		Mundlak	
Supermarket purchase (1,0)	0.25***		0.25***	
	(0.06)		(0.05)	
Share of supermarket purchases (%)		0.01**		0.01***
		(0.01)		(0.01)
Age of child in years	0.10***	0.11***	0.10***	0.10***
	(0.02)	(0.02)	(0.02)	(0.02)
Age of child squared	-0.01***	-0.01***	-0.01***	-0.01***
	(0.00)	(0.00)	(0.00)	(0.00)
Female child (1,0)	0.16**	0.17**	0.17*	0.18*
	(0.06)	(0.07)	(0.09)	(0.09)
Height of mother in cm	0.04**	0.04**	0.15**	0.15*
	(0.02)	(0.02)	(0.07)	(0.08)
Education of mother in years	0.01	0.01	0.04	0.04
	(0.01)	(0.01)	(0.07)	(0.07)
Age of mother in years	0.02***	0.02***	0.01	0.02
	(0.00)	(0.00)	(0.02)	(0.02)
Female-headed household (1,0)	-0.17***	-0.19***	-0.60	-0.63
	(0.04)	(0.05)	(1.07)	(1.08)
Year dummy (1=2015)	0.30***	0.32***	0.25***	0.26***
	(0.06)	(0.07)	(0.06)	(0.08)
Household expenditure	0.03***	0.03***	0.01	0.01
	(0.00)	(0.00)	(0.01)	(0.01)
Malaria/respiratory infection (1,0)	-0.21	-0.19	-0.23	-0.21
	(0.23)	(0.22)	(0.24)	(0.24)
Treated drinking water (1,0)	0.18***	0.19***	0.06	0.07
	(0.01)	(0.01)	(0.05)	(0.06)
Distance to health center (log)	-0.04	-0.00	-0.24	-0.29*
	(0.03)	(0.04)	(0.15)	(0.15)
Mean height of mother			-0.11*	-0.11
			(0.07)	(0.07)
Mean education of mother			-0.03	-0.03
			(0.08)	(0.09)
Mean age of mother			0.00	-0.00
			(0.02)	(0.02)
Mean female-headed household			0.43	0.45
			(1.17)	(1.19)
Mean household expenditure			0.02**	0.02**
			(0.01)	(0.01)
Mean treated drinking water			0.15***	0.16***
			(0.02)	(0.04)
Mean distance to health center			0.22	0.29**
			(0.15)	(0.15)
Constant	-8.88***	-8.93***	-8.51***	-8.59***
	(2.93)	(2.85)	(2.44)	(2.33)
Number of obs. (groups)	541 (391)	541 (391)	541 (391)	541 (391)
R-squared (overall)	0.20	0.20	0.20	0.21

* *p*<0.1; ** *p*<0.05; *** *p*<0.01

Table A7. Panel models for WAZ without IV

	RE		Mundlak	
Supermarket purchase (0,1)	0.12***		0.11*	
	(0.04)		(0.06)	
Share of supermarket purchases (%)		0.01***		0.01***
		(0.00)		(0.00)
Age of child in years	-0.04	-0.04	-0.05**	-0.05**
	(0.02)	(0.03)	(0.02)	(0.02)
Female child (1,0)	0.08	0.09	0.09	0.09
	(0.09)	(0.10)	(0.11)	(0.11)
Height of mother in cm	0.03*	0.03*	0.16***	0.16***
	(0.02)	(0.02)	(0.05)	(0.06)
Weight of mother in kg	0.02***	0.02***	0.01	0.01
	(0.00)	(0.00)	(0.02)	(0.02)
Education of mother in years	-0.00	-0.01	0.00	0.00
	(0.03)	(0.02)	(0.06)	(0.05)
Age of mother in years	0.02***	0.02***	0.03***	0.03***
	(0.00)	(0.00)	(0.00)	(0.00)
Household expenditure (1000 KES)	0.02	0.01	-0.01	-0.01
	(0.01)	(0.01)	(0.03)	(0.03)
Female-headed household (1,0)	-0.01	-0.02	-1.12	-1.10
	(0.12)	(0.13)	(1.09)	(1.07)
Malaria/respiratory infection (1,0)	-0.39***	-0.36***	-0.40***	-0.37***
	(0.11)	(0.09)	(0.13)	(0.11)
Treated drinking water (1,0)	0.12	0.13	-0.14	-0.14
	(0.12)	(0.12)	(0.16)	(0.14)
Distance to health center in km (log)	-0.03*	-0.00	-0.01	-0.02
	(0.02)	(0.01)	(0.14)	(0.12)
Year dummy (1=2015)	-0.20*	-0.19	-0.31	-0.31
	(0.11)	(0.12)	(0.20)	(0.21)
Mean height of mother			-0.13***	-0.13***
			(0.05)	(0.05)
Mean weight of mother			0.01	0.01
			(0.02)	(0.02)
Mean education of mother			-0.01	-0.01
			(0.06)	(0.06)
Mean age of mother			-0.01	-0.01*
			(0.01)	(0.01)
Mean female-headed household			1.14	1.10
			(1.22)	(1.21)
Mean household expenditure			0.03	0.03
			(0.02)	(0.02)
Mean treated drinking water			0.35***	0.36***
			(0.11)	(0.09)
Mean distance to health center			-0.01	0.02
			(0.16)	(0.13)
Constant	-7.36**	-7.44**	-7.06**	-7.13**
	(3.01)	(2.92)	(2.91)	(2.82)
Number of obs. (groups)	347 (277)	347 (277)	347 (277)	347 (277)
R-squared (overall)	0.19	0.20	0.20	0.21

* *p*<0.1; ** *p*<0.05; *** *p*<0.01

Table A8. Double-hurdle model for supermarket purchase and share of supermarket purchases

	Supermarket dummy	Share of purchase
Distance to supermarket in km (log)	-0.53***	-3.10**
	(0.05)	(1.28)
Age of child in years	0.02	0.70
	(0.06)	(0.96)
Age of child squared	-0.00	-0.04
	(0.00)	(0.06)
Female child (1,0)	-0.11	-4.21**
	(0.15)	(2.01)
Height of mother in cm	-0.05	1.75
	(0.11)	(1.25)
Education of mother in years	0.03	-0.08
	(0.05)	(1.15)
Age of mother in years	0.04	-0.64
	(0.03)	(0.46)
Female headed-household (1,0)	0.27	-1.15
	(1.00)	(8.64)
Year dummy (1=2015)	-0.01	-4.92**
	(0.19)	(2.47)
Household expenditure (1000 KES)	0.00	-0.17
	(0.04)	(0.59)
Malaria/respiratory infection (1,0)	0.11	-5.95
	(0.26)	(4.09)
Treated drinking water (1,0)	0.05	-0.66
	(0.24)	(5.00)
Distance to health center in km (log)	-0.19	8.25**
	(0.44)	(3.53)
Mean height of mother	0.04	-1.95
	(0.11)	(1.27)
Mean education of mother	-0.00	0.63
	(0.05)	(1.20)
Mean age of mother	-0.06*	0.39
	(0.03)	(0.50)
Mean female-headed household	-0.47	4.88
	(1.02)	(8.97)
Mean household expenditure	0.09**	0.50
	(0.04)	(0.61)
Mean treated drinking water	0.14	-3.14
	(0.30)	(5.49)
Mean distance to health center	0.13	-13.22***
	(0.45)	(3.76)
Constant	2.58	45.31
	(2.42)	(35.77)
Sigma	12.19***	12.19***
	(1.13)	(1.13)
Number of observations	541	541
Chi2 (*p*-value)	138.40 (0.00)	138.40 (0.00)

Note: This is the double-hurdle model used for the HAZ control function approach. The WAZ double-hurdle model is very similar but excludes squared age and includes maternal weight. * $p<0.1$; ** $p<0.05$; *** $p<0.01$

Table A9. Control function approach for HAZ (second stage)

	RE		Mundlak	
	(1)	(2)	(3)	(4)
Supermarket purchase (1,0)	0.35**		0.34**	
	(0.16)		(0.15)	
Share of supermarket purchases (%)		0.02***		0.02***
		(0.00)		(0.00)
Age of child in years	0.10***	0.10***	0.09***	0.09***
	(0.02)	(0.02)	(0.02)	(0.02)
Age of child squared	-0.01***	-0.01***	-0.01***	-0.01***
	(0.00)	(0.00)	(0.00)	(0.00)
Female child (1,0)	0.17**	0.20***	0.17*	0.20***
	(0.07)	(0.06)	(0.09)	(0.07)
Height of mother in cm	0.04**	0.04**	0.15*	0.14
	(0.02)	(0.02)	(0.08)	(0.09)
Education of mother in years	0.01	0.00	0.03	0.04
	(0.01)	(0.01)	(0.08)	(0.07)
Age of mother in years	0.02***	0.02***	0.01	0.02
	(0.00)	(0.01)	(0.02)	(0.01)
Female-headed household (1,0)	-0.17***	-0.22***	-0.58	-0.62
	(0.04)	(0.04)	(1.08)	(1.08)
Household expenditure (1000 KES per adult equivalent)	0.03***	0.03***	0.01	0.01
	(0.01)	(0.00)	(0.01)	(0.01)
Malaria/respiratory infection (1,0)	-0.21	-0.16	-0.23	-0.18
	(0.23)	(0.24)	(0.25)	(0.24)
Treated drinking water (1,0)	0.18***	0.21***	0.06	0.07
	(0.00)	(0.01)	(0.05)	(0.06)
Distance to health center in km (log)	-0.04*	0.02	-0.23	-0.31**
	(0.02)	(0.03)	(0.14)	(0.16)
Year dummy (1=2015)	0.30***	0.34***	0.24***	0.28***
	(0.06)	(0.06)	(0.07)	(0.09)
Time averages included	No	No	Yes	Yes
Residuals from first stage	-0.09	-0.01**	-0.09	-0.01
	(0.11)	(0.00)	(0.09)	(0.01)
Constant	-8.97***	-9.13***	-8.64***	-8.79***
	(2.98)	(2.78)	(2.52)	(2.12)
Number of obs. (groups)	541 (391)	541 (391)	541 (391)	541 (391)
R-squared (overall)	0.20	0.20	0.20	0.21

* p<0.1; ** p<0.05; *** p<0.01

Table A10. Control function approach for WAZ (second stage)

	RE		Mundlak	
	(1)	(2)	(3)	(4)
Supermarket purchase (1,0)	0.15		0.14	
	(0.12)		(0.11)	
Share of supermarket purchases (%)		0.01***		0.01***
		(0.00)		(0.00)
Age of child in years	-0.04	-0.04	-0.05**	-0.05**
	(0.02)	(0.03)	(0.02)	(0.02)
Female child (1,0)	0.08	0.08	0.09	0.08
	(0.10)	(0.09)	(0.11)	(0.11)
Height of mother in cm	0.03	0.03*	0.16***	0.17***
	(0.02)	(0.02)	(0.06)	(0.06)
Weight of mother in kg	0.02***	0.02***	0.01	0.01
	(0.00)	(0.00)	(0.02)	(0.02)
Education of mother in years	-0.00	-0.00	0.00	0.00
	(0.02)	(0.03)	(0.06)	(0.05)
Age of mother in years	0.02***	0.02***	0.02***	0.02***
	(0.00)	(0.00)	(0.00)	(0.00)
Female-headed household (1,0)	-0.01	-0.01	-1.13	-1.11
	(0.12)	(0.13)	(1.10)	(1.08)
Household expenditure (1000 KES per adult equivalent)	0.02 (0.01)	0.01 (0.01)	-0.01 (0.03)	-0.01 (0.03)
Malaria/respiratory infection (1,0)	-0.39***	-0.38***	-0.40***	-0.40***
	(0.11)	(0.11)	(0.13)	(0.13)
Treated drinking water (1,0)	0.12	0.13	-0.14	-0.13
	(0.12)	(0.13)	(0.16)	(0.14)
Distance to health center in km (log)	-0.03*	-0.01	-0.00	-0.00
	(0.02)	(0.01)	(0.15)	(0.14)
Year dummy (1=2015)	-0.20*	-0.20*	-0.32	-0.33*
	(0.11)	(0.12)	(0.20)	(0.20)
Time averages included	No	No	Yes	Yes
Residuals from first stage	-0.02	0.00	-0.02	0.01
	(0.14)	(0.00)	(0.16)	(0.00)
Constant	-7.39**	-7.33***	-7.09**	-6.90***
	(3.17)	(2.82)	(3.07)	(2.67)
Number of obs. (groups)	347 (277)	347 (277)	347 (277)	347 (277)
R-squared (overall)	0.19	0.20	0.20	0.21

* p<0.1; ** p<0.05; *** p<0.01

Table A11. Effect of supermarket purchase on dietary diversity score (DDS)

	DDS 1		DDS 2	
	(1)	(2)	(3)	(4)
Supermarket purchase (1,0)	0.09		0.09	
	(0.10)		(0.09)	
Share of supermarket purchases (%)		0.01		0.01
		(0.01)		(0.01)
Education of mother/caregiver	0.02***	0.02***	0.02***	0.02***
	(0.00)	(0.01)	(0.00)	(0.00)
Age of female mother/caregiver	-0.01**	-0.01*	-0.01*	-0.01*
	(0.00)	(0.01)	(0.00)	(0.01)
Female headed household	-0.07	-0.08	-0.06	-0.07
	(0.09)	(0.09)	(0.07)	(0.08)
Year dummy, 1=2015	0.29**	0.30***	0.29***	0.30***
	(0.11)	(0.10)	(0.11)	(0.10)
Household expenditure (1000 KES	0.04***	0.04***	0.04***	0.04***
/adult equivalence)	(0.01)	(0.01)	(0.01)	(0.01)
Distance to health center in km (log)	0.04***	0.06***	0.04***	0.05***
	(0.02)	(0.02)	(0.01)	(0.02)
Constant	10.60***	10.61***	7.57***	7.58***
	(0.11)	(0.11)	(0.13)	(0.13)
Number of observations	488	488	488	488
Number of groups	391	391	391	391
R-squared-overall	0.23	0.22	0.23	0.22
Chi2	71.88	131.48	109.90	239.07
P-value(chi2)	0.00	0.00	0.00	0.00

Notes: Random effects models at household level. All models estimated with panel IV estimators (RE-IV). Coefficient estimates are shown with clustered standard errors in parentheses. DDS 1 includes all foot groups. DDS 2 excludes less healthy foods, such as oils and fats, sweets, and spices. * p<0.1; ** p<0.05; *** p<0.01