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Zhen Liu, Lukas Kornher, and Matin Qaim

# Impacts of supermarkets on child nutrition in China

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Zentrum für Entwicklungsforschung (ZEF)
Center for Development Research
Genscherallee 3
D – 53113 Bonn
Germany
Phone: +49-228-73-1861
Fax: +49-228-73-1869
E-Mail: zef@uni-bonn.de
www.zef.de

**The author[s]:**
**Zhen Liu**, Center for Development Research (ZEF), University of Bonn. Contact: zliu@uni-bonn.de
**Lukas Kornher**, Center for Development Research (ZEF), University of Bonn. Contact: lkornher@uni-bonn.de
**Matin Qaim**, Center for Development Research (ZEF) and Institute for Food and Resource Economics, University of Bonn. Contact: mqaim@uni-bonn.de

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## Abstract

In many developing countries, food environments are changing rapidly. One emblematic trend is the proliferation of supermarkets and other modern retailers. While changing food environments likely influence the types of foods supplied and consumed, research on the implications for people's diets and nutrition is still scant. Here, we analyze the effects of supermarkets on child diets and nutrition in China. We use nationally representative panel data that include information on households' access to supermarkets and individual-level anthropometric and dietary indicators. Results show that improved access to supermarkets leads to higher child dietary diversity and nutrient intakes, especially among children in rural areas and from low-income households. Supermarkets are also found to increase child height, but not weight. Estimates with different model specifications and placebo tests confirm the results' robustness. The effects are mediated through supermarkets contributing to more variety in local food supplies and lower average food prices. Our findings suggest that the spread of supermarkets improves child dietary quality and nutrition in China.

Keywords: Food environments, Supermarkets, Child malnutrition, Dietary quality, Panel data, China

JEL Codes: Q18, I18, O10

# 1. Introduction

Food environments – defined as the places where people interact with the food system to acquire and consume food – are playing an important role for dietary choices and nutrition outcomes (FAO, 2016). In many developing countries, food environments are currently changing rapidly. One notable trend is the proliferation of supermarkets and other modern retailers, especially in urban areas but increasingly also in rural areas (Barrett et al., 2022). In many parts of Latin America and Asia, and in some parts of Africa, supermarkets have already gained sizeable market shares in food retailing (Reardon et al., 2003; Gorton et al., 2011; Khonje et al., 2020). Supermarkets do not only affect the place of purchase, but often also the types of foods supplied as well as food prices and accessibility (Qaim, 2017; Wanyama et al., 2019; Barrett et al., 2022).

In comparison to traditional wet markets and street vendors, supermarkets often provide a wider variety of processed and unprocessed foods with more standardized quality and safety, which may be associated with nutritional improvements. However, there are also claims that supermarkets in many places have a strong focus on selling ultra-processed foods and convenience products, which could contribute to unhealthy diets and negative nutritional outcomes. Better understanding the effects of supermarkets on people's diets and nutrition in different contexts is useful for developing policies that can promote fair and healthy food environments. Here, we analyze the effects of supermarkets on diets and nutrition among children in China with nationally representative panel data. Healthy nutrition during childhood is pivotal for physical growth, cognitive development, and human capital accumulation during the life course. Unfortunately, many children in developing countries, including China, suffer from poor diets and nutritional deficiencies with long-term negative effects for human and economic development (Alderman and Fernald, 2017; UN, 2022). Improving child diets and nutrition is therefore an important development priority.

Several studies analyzed nutritional effects of supermarkets in different countries, but most of this existing work focuses on nutritional outcomes in adults. A common finding is that the spread of supermarkets is associated with a higher body mass index (BMI) and a higher likelihood of overweight and obesity among adults (Rummo et al., 2017; Demmler et al., 2017; Demmler et al., 2018; Otterbach et al., 2021). Much less is known about the effects on child nutrition. A few studies looked at children and found no significant association between supermarkets and child overweight and obesity (Kimenju and Qaim, 2016; Debela et al., 2020; Zhou et al., 2021), while one study reported a positive association for children from high-income households in Indonesia (Umberger et al., 2015). Important to stress is that data on overweight and obesity alone can only provide a partial picture of nutrition, as nutritional quality is not only a function of food energy but also of dietary diversity and micronutrient intakes. In fact, micronutrient deficiencies are widespread, including in countries with rapidly rising rates of overweight and obesity (UNICEF et al., 2021).

A few studies analyzed effects of supermarkets on dietary choices, mostly using household-level food consumption data. Better access to supermarkets is often associated with higher consumption of processed and lower consumption of unprocessed foods (Asfaw, 2008; Rischke et al., 2015; Demmler et al., 2018). In some situations, supermarkets also seem to be associated with higher consumption of animal-sourced foods such as meat and dairy (Seto and Ramankutty, 2016; Debela et al. 2020). A small number of studies also showed positive associations between supermarket use and dietary quality indicators, such as dietary diversity scores or the healthy eating index (Nandi et al., 2021; Ren et al., 2022).

We are aware of only one study that used individual-level dietary intake data from children to analyze supermarket effects, namely Khonje et al. (2020) with a sample from Lusaka, the Capital City of Zambia. Khonje et al. (2020) showed that children living in households that use supermarkets regularly have higher protein and micronutrient intakes, higher child height-for-age Z-scores, and lower rates of stunting. But this study in Zambia only looked at one large city, so the external validity is limited. Moreover, it used cross-sectional data, which has drawbacks in terms of addressing possible endogeneity issues.

We contribute to the literature in four particular ways. First, we evaluate the effects of supermarkets on child diets and nutrition in China, which has not been done before, neither with dietary data nor with anthropometric measures. We use different dietary quality indicators, including child dietary diversity scores and intakes of food energy, protein, and various micronutrients. We also use child anthropometric measures, including height-for age and BMI-for-age Z-scores. Second, we use nationally representative data from the China Health and Nutrition Survey (CHNS), covering urban and rural areas and a wide range of socioeconomic conditions. This allows us to also compare effects across geographical and sociodemographic contexts. Third, we use panel data, allowing us to control for unobserved heterogeneity. By adding several robustness checks and placebo tests, we also address other concerns around endogeneity and can cautiously interpret our estimates as causal. Fourth, we analyze possible impact pathways looking at the role of supermarkets for food variety and local food prices.

The remainder of this article is structured as follows. Section 2 provides some context on the spread of supermarkets in China and a conceptual framework for explaining likely effects. Section 3 discusses the data, the key variables, and the econometric approaches used. Section 4 presents and discusses the results, while section 5 concludes.

## 2. Research context and conceptual framework

The rapid diffusion of supermarkets in many developing countries has been promoted by general economic development, urbanization, international trade and investment, innovations in food processing and logistics, and market-oriented reforms, among other factors (Reardon et al., 2012; Qaim, 2017; Barrett et al., 2022). In China, the government views supermarkets as tools for modernizing agricultural supply chains and food retailing.[i] Over the last two decades, a series of policies, such as the "*Nonggaichao*" program (converting traditional free markets into supermarkets) induced in 2003, have been implemented to encourage supermarket development (Hu et al., 2004). Consequently, the number of supermarkets in China more than tripled between 2002 and 2010, and has stayed at a high level since then (Fig. 1).

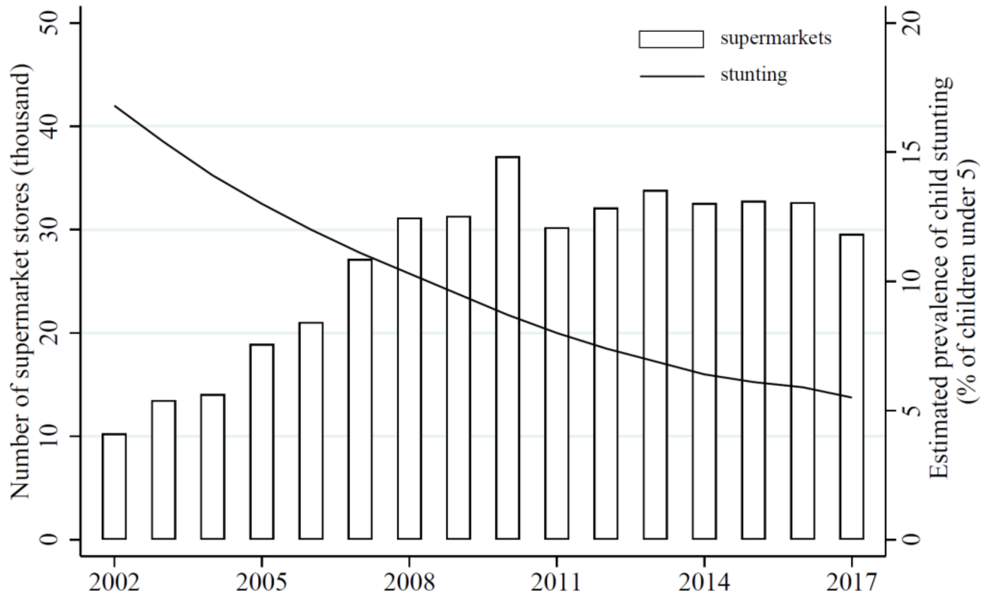


**Fig.1. Supermarket expansion and child stunting in China 2002-2017. Sources: Supermarket data from CEIC (https://www.ceicdata.com/en/china/supermarket), child stunting data from the World Bank (https://data.worldbank.org/country/china).**

Fig. 1 also shows that – in parallel to the expansion of supermarkets – China was successful in reducing rates of child stunting considerably. The two trends are not necessarily causally related, even though supermarkets could – in principle – improve diets and nutrition in several ways. First, supermarkets often offer a larger variety of foods than traditional food stores (Reardon et al., 2003; Qaim, 2017). While many of the foods offered in supermarkets are processed, larger food variety can still contribute to higher dietary diversity. Processed foods with longer shelf-lives can also stabilize food supply and reduce seasonal fluctuations. Important to note is that supermarkets try to adjust to local dietary cultures. In China, fresh foods are popular and many consumers are used to shop frequently rather than storing processed foods for a longer period of time (Maruyama et al., 2016). Hence, many supermarkets in China offer a variety of fresh foods; some also mimic modern versions of wet markets within their stores, so that consumers can satisfy all their shopping preferences under one roof.

Beyond food variety, positive nutritional effects can also be mediated through lower food prices. A conventional view is that supermarkets offer foods at higher prices than traditional markets because of higher costs associated with physical assets (e.g., buildings and equipment) and services (e.g., sorting, packing, and refrigerating) (Goldman et al., 2002). However, evidence from various developing countries shows that supermarkets tend to be more expensive than traditional markets in the beginning, but then become more price-competitive over time, especially for processed foods, due to economies of scale (Hawkes, 2008; Rischke et al., 2015). Recent studies also suggest that supermarkets may contribute to lowering the prices of certain fresh foods at local and regional levels by increasing market efficiency (Minten et al., 2010; Atkin et al., 2018; Bergquist and Dinerstein, 2020; Yuan et al., 2021). The entry of supermarkets adds to market competition. Moreover, supermarkets often foster vertical integration of food supply chains, leading to fewer intermediaries and reduced transaction costs (Gale and Hu, 2012; Nuthalapati et al., 2020).

However, supermarkets can also contribute to negative nutritional outcomes. While supermarkets sell all types of foods, healthy and unhealthy ones, advertisement and promotional activities may lure consumers to choose more ultra-processed foods that are often rich in terms of energy and salt but poor in terms of protein and micronutrient contents. Overconsumption of ultra-processed foods contributes to overweight and obesity. Moreover, especially in children, high consumption of energy-dense processed foods may lead to a crowding out of more nutrient-dense foods, thus potentially resulting in lower-quality diets. Childhood obesity is rising in middle-income countries including China (UN, 2022), and so far it is not clear whether the spread of supermarkets is contributing to this trend.

# 3. Materials and methods

## 3.1 Econometric approach

We evaluate the effects of supermarkets on child diets and nutrition with panel data econometric models of the following type:

$$Y_{it} = \alpha + \beta SM_{it} + \gamma \boldsymbol{X}_{it} + \theta_i + \delta Z_t + u_{it} \quad (1)$$

where $Y_{it}$ refers to dietary and nutritional indicators of individual child $i$ in year $t$, such as dietary diversity scores, nutrient intakes, or anthropometric measures. $SM_{it}$ is our main explanatory variable indicating access to supermarkets. Details of the dependent and independent variables are described further below. The main coefficient of interest is $\beta$. To control for potential confounding factors, we also include $\boldsymbol{X}_{it}$ , which is a vector of socioeconomic characteristics. We include individual characteristics, such as child age, education, and physical activity, and household characteristics, such as per capita income, parental education and dietary knowledge, household size, agricultural production diversity, and asset ownership. Furthermore, we control for community characteristics, such as transport infrastructure and access to traditional markets and restaurants.

To control for time-invariant unobserved heterogeneity, we use a two-way fixed effects (TWFE) estimator. $\theta_i$ is the individual fixed effect to control for time-invariant characteristics, such as location effects and food and shopping preferences. We also use a vector of controls ($Z_t$) to include time fixed effects in different ways: year fixed effects to control for time trends as well as annual shocks common to each child, such as national economic policy; year-by-region fixed effects to control for unobserved time-variant heterogeneity at region level;[ii] and year-by-month fixed effects to control for seasonal differences.[iii] These specifications largely rule out the possibility of estimation bias due to observable and unobservable heterogeneity. Food preferences and dietary patterns may be more similar within communities than across communities (Cooke and Wardle, 2005). Moreover, there may be systematic differences between boys and girls. Hence, we cluster standard errors at the community-sex level to resolve potential correlation in the error term $u_{it}$. Alternative clustering methods are also used to check the robustness of the results.

In addition to the average effects of supermarket access on child diets and nutrition, we are also interested in heterogeneous effects for different subsamples. Previous studies show that food insecurity and nutrient deficiencies are particularly severe among rural populations and low-income households (Gao et al., 2022). Differences between male and female individuals are also of interest. Accordingly, we estimate heterogenous effects for children in rural versus urban areas, from low- versus higher-income households, and for boys versus girls.

### 3.2 Placebo tests

To test for possible reverse causality and time-variant unobserved heterogeneity, we perform two placebo tests. The first test looks at whether differences in dietary and nutrition outcomes between communities with and without supermarkets are already observed prior to the supermarket establishment. For this, we re-estimate the models in equation (1) but additionally include $SM_{it-1}$, as follows:

$$Y_{it} = \alpha + \lambda SM_{it-1} + \varphi SM_{it} + \gamma \boldsymbol{X}_{it} + \theta_i + \delta Z_t + u_{it} \tag{2}$$

where $SM_{it-1}$ is a dummy variable indicating the survey wave prior to the supermarket opening. $SM_{it-1}$ captures location-specific characteristics and trends of communities that have a supermarket in later survey waves. A significant coefficient $\lambda$ would be an indication that there is either reverse causality or that equation (1) was not successful in controlling for unobserved time-variant heterogeneity. However, an insignificant $\lambda$ would be reassuring for a causally identified $\beta$ in equation (1).

In the second test, we separately analyze effects of supermarkets on energy and nutrient intakes at home and away from home.[iv] This test assumes that supermarkets influence child diets primarily through foods eaten at home. In contrast, if the supermarket effects were spurious and only due to correlation with unobserved time-variant factors in the supermarket locations, we would expect to see significant effects on both intakes at home and away from home. In other words, if in this second placebo test supermarkets were significantly associated with intakes away from home, equation (1) would fail to rule out unobserved time-variant factors and the estimated effects of supermarkets would be biased.

### 3.3 Survey data

The data used here come from the China Health and Nutrition Survey (CHNS), which is nationally representative. CHNS is a collaborative project by the Chinese Center for Disease Control and Prevention and the University of North Carolina in the USA and is still ongoing. This longitudinal survey has been conducted in twelve provinces and three municipalities in China since 1985, including well-developed and less-developed regions. In each province, two prefecture-level cities and four counties were randomly selected. Then, communities, households, and individuals were randomly selected in these cities and counties. The total sample includes over 4,000 households and 11,000 individuals.

We use variables from three CHNS datasets. The individual dataset contains detailed dietary intakes for three consecutive days, as well as anthropometric data, including body weight and height measurements. Dietary intake is collected by asking individuals or their caregivers to report all foods consumed at home and away from home during the last 24 hours. The household dataset includes household food consumption for the same three days and a large set of socioeconomic characteristics. Household food consumption is obtained by computing inventory changes from the beginning to the end of each day, combining weighing all purchased and home-prepared foods. In our analysis, we rely on the individual intake data for children but supplement these data with the consumption of spices, condiments, and edible oils from the household dataset. We also use the household consumption data to check for and resolve possible severe discrepancies. The third dataset is the community dataset that contains information on the availability of local services, including supermarkets.

An advantageous feature of the CHNS is that the dietary data are collected under the supervision of nutritionists and the anthropometric data are measured by medical staff. This helps reduce measurement error. We use data from four survey waves (2004, 2006, 2009, and 2011). Waves before 2004 cannot be used because data on supermarket access were not collected. Waves after 2011 cannot be used because individual-level dietary data were not released. However, as much of the supermarket growth in China occurred during the 2000s (Fig. 1), the time period from 2004 to 2011 perfectly captures the variation of interest in this study.

The children included in our sample are aged 2 to 17.9 with diverse socioeconomic backgrounds from urban and rural households. We use unbalanced panel data with 6,596 child observations and full information for all variables of interest. Specifically, we use 1,860, 1,572, 1,431, and 1,733 observations from 211, 211, 193, and 253 communities in 2004, 2006, 2009, and 2011, respectively.

### 3.4 Measuring supermarket access

Supermarket access is the key explanatory variable in this study. It can be measured in different ways. One approach is to evaluate the actual use of supermarkets by households or individuals. For instance, several studies use a dummy variable that takes a value of one if a household used a supermarket for any of its food purchases (Demmler et al., 2018; Debela et al. 2020). Other studies look at the amount or the share of money spent on supermarket food purchases (Asfaw, 2008; Kimenju et al., 2015; Umberger et al., 2015). Another approach is to evaluate the availability of supermarkets in a certain setting. For instance, several studies created a dummy based on the presence of a supermarket within a certain radius around the household (Allcott et al., 2019; Zeng et al., 2019), or looked at the distance between the household and the closest supermarket (Drewnowski et al., 2012; Otterbach et al., 2021; Ren et al., 2022). Here, we use the second approach and focus on the local availability of supermarkets, as this is the type of information included in CHNS.

CHNS defines supermarkets as larger-sized self-service stores that sell a larger variety of foods and non-food products than traditional grocery stores. The community survey includes data on the number of supermarkets within a 5 km radius of each community. In our study, we measure supermarket access through a dummy variable that takes a value of one if at least one supermarket exists within 5 km of a child's residence community, which means that a supermarket is located either within the community or relatively nearby. Communities in China are generally compact (Xi et al., 2011), so the community represents the household locations sufficiently well. According to this supermarket access variable, 48.2% of the communities and households had supermarket access in 2004, a proportion that had increased to 65.0% by 2011.

As an alternative variable, we use proximity to supermarkets based on the distance between a community and the closest supermarket.[v] However, we only use this alternative for robustness checks, not as our main supermarket variable, because proximity in our context has two potential drawbacks. First, CHNS does not set a threshold for collecting the distance, therefore some communities have a distance measure also when the closest supermarket is more than 5 km away, while others do not. Hence, measurement error may be an issue. Second, proximity based on distance at a small local scale may possibly be associated with selection bias, as households may choose their place of residence based on unobserved preferences. Supermarkets are often located near busy streets with excessive noise and air pollution, so that households that can afford may deliberately keep some distance from these places (Peris and Fenech, 2020).

## 3.5 Measuring diet and nutrition outcomes

*Dietary diversity scores*

The child dietary diversity score (CDDS) is considered a good and easy-to-measure proxy of child dietary quality (Fongar et al., 2019). CDDS is calculated as the number of food groups consumed by the child during the last 24 hours. In our case, we calculate the average number of food groups consumed by each child during the three survey days.

We use two versions of CDDS with different food group classifications (Table 1). The first version is the Chinese CDDS with a total of nine food groups, building on the guidelines of the Chinese Children's Food Guide Pagoda (CCFGP) 2022. CCFGP 2022 was created by the Chinese Nutrition Society, aiming to recommend daily food consumption quantities that satisfy the requirements of children's healthy growth. The second version is the WHO CDDS based on seven food groups (WHO, 2008).[vi] While both versions aim to proxy child dietary quality, the focus is slightly different. The Chinese CDDS emphasizes the variety of foods consumed, the WHO CDDS cares more about the minimum dietary quality. For instance, the Chinese CDDS considers meat, poultry, and fish as separate food groups, whereas all three are in one group in the WHO CDDS; the WHO CDDS differentiates between vitamin A rich and other fruits and vegetables, whereas the Chinese CDDS does not.

**Table 1: Two versions of child dietary diversity scores (CDDS)**

| Number | Chinese CDDS | WHO CDDS |
|---|---|---|
| 1 | Staples (grains and potatoes) | Grains, roots, and tubers |
| 2 | Vegetables | Flesh foods (meat, fish, poultry, and liver/organ meats) |
| 3 | Fruits | Eggs |
| 4 | Meat and poultry | Dairy products (milk, yoghurt, and cheese) |
| 5 | Eggs | Legumes and nuts |
| 6 | Aquatic products (fish and shrimp) | Vitamin A rich fruits and vegetables |
| 7 | Milk and its products | Other fruits and vegetables |
| 8 | Legumes and nuts | |
| 9 | Edible oil | |

*Nutrition index*

A balanced, healthy diet must satisfy child needs for energy and all essential nutrients. Drawing on Busgang et al. (2022), we construct a nutrition index (NI) considering the intakes of calories, protein, and various micronutrients, namely vitamins A, C, and E, calcium, iron, and zinc.[vii] At first, we calculate the three-day average intakes of these nutrients by matching individual consumption quantities of all food items with the China Food Composition Tables. Then, we compare the real intake with the recommended intake to assess the sufficiency level for each nutrient $j$. Finally, the NI is calculated as the sum of the eight sufficiency levels:

$$Sufficiency\ level_j = \begin{cases} \dfrac{real\ intake_j}{recommended\ intake_j} & if \quad real\ intake_j < recommended\ intake_j \\ 1 & if \quad real\ intake_j \geq recommended\ intake_j \end{cases}, j = 1, 2 \cdots, 8 \quad (3)$$

$$Nutrition\ index\ (NI) = \sum_{j=1}^{8} Sufficiency\ level_j \quad (4)$$

Thus, the NI can take any value between 0 and 8. In separate versions of the NI, we use two different child age- and sex-based recommended intake levels, namely those from the Chinese Nutrition Society (CNS, 2000) and from the joint FAO/WHO expert consultation (FAO/WHO, 2004). The CNS-recommended levels refer to the intake level of nutrients that can meet the requirements of the vast majority (nearly 98%) of individuals in the specific age and sex groups. The FAO/WHO-recommended levels are lower, as they refer to the mean nutrient requirements of healthy and well-nourished individuals in the specific age and sex groups.

*Nutritional status*

Nutritional status is commonly evaluated with anthropometric indicators, such as body height, weight, or BMI. For children, age also needs to be considered. We use the height-for-age Z-score (HAZ), which is the most comprehensive indicator of longer-term healthy nutrition, as it reflects the body's biological response to continued nutrient intake. Furthermore, we calculate BMI-for-age Z-scores (BAZ). In these calculations, we use the WHO Child Growth Standards (WHO, 2006). In addition, we generate three dummy variables: (i) underweight, defined as a weight-for-age Z-score (WAZ) below -2 standard deviations (SD) of the median of the WHO growth reference; (ii) overweight, defined as BAZ > 1 SD; and (iii) obesity, defined as BAZ > 2 SD.

## 3.6 Control variables

Diet and nutrition outcomes may be influenced by various socioeconomic variables, which we control for in the econometric analysis. Individual-level controls include child age, sex, education, and physical activity. Physical activity is measured in terms of how long the child participates in sports or physical exercises outside of the normal school hours per week. In terms of household-level variables, we control for per capita income, parental education, dietary knowledge, household size, ownership of a refrigerator, car, or motorcycle, and diversity of household agricultural production. Dietary knowledge is measured as a score, using answers of the child's mother to ten nutrition-related questions (Table A.1 in the Appendix). Agricultural production diversity, which can affect the diets of rural households in particular, is measured by counting the number of household cropping, livestock, fishing, and home gardening activities.

At the community level, we control for the availability of traditional wet markets, which are still important sources of food purchases for many households. In addition, we control for the availability of restaurants, including traditional ones and fast-food restaurants. Finally, we use a dummy variable indicating whether a bus stop is available in the community because residents may rely on public transport to reach supermarkets and other shops located outside of the community. Table 2 lists all explanatory variables used in the econometric models.

**Table 2: Definition of explanatory variables and descriptive statistics**

| Variable | Definition | Mean | SD |
|---|---|---|---|
| **Individual child** | | | |
| Age | Years of age | 10.15 | 4.37 |
| Edu | Years of education completed | 4.37 | 3.61 |
| Physical activity | Time (minutes) on physical activities each week | 198.18 | 305.21 |
| **Household** | | | |
| Ln(income) | Per capita household income inflated to 2011 prices | 8.57 | 1.11 |
| Edu_mother | Mother's years of education completed | 7.57 | 4.18 |
| Edu_father | Father's years of education completed | 7.66 | 4.56 |
| Dietary knowledge | Score for mother's dietary knowledge | 35.67 | 3.67 |
| Household size | Number of household members | 4.46 | 1.43 |
| Refrigerator | Does household own a refrigerator (dummy)? | 0.56 | 0.50 |
| Car | Does household own a car? (dummy) | 0.09 | 0.29 |
| Motorcycle | Does household own a motorcycle? (dummy) | 0.41 | 0.49 |
| Production diversity | Household number of farming activities (crop, fishing, gardening, livestock) | 1.28 | 1.27 |
| **Community** | | | |
| Supermarket access | Community has access to a supermarket within 5 km (dummy) | 0.54 | 0.50 |
| Traditional market | Community has traditional market within 5 km (dummy) | 0.92 | 0.26 |
| Chinese restaurant | Community has traditional restaurant within 5 km (dummy) | 0.42 | 0.49 |
| Fast-food restaurant | Community has fast-food restaurant within 5 km (dummy) | 0.21 | 0.41 |
| Bus stop | Community has a bus stop (dummy) | 0.63 | 0.48 |

Note: Number of observations = 6596.

### 3.7 Sample attrition

One possible drawback of unbalanced panel data is attrition. Attrition may be caused by migration, community demolition and reconstruction, administrative division adjustment, etc. If the attrition is not random, the estimates could be biased towards a specific population group. Therefore, we need to assess if sample attrition may be a problem. We generate a dummy variable to indicate whether a particular child drops out at the next survey wave. Then, we regress this attrition dummy on the different dietary and nutrition outcomes and supermarket access, using fixed effects and including all control variables. Results are shown in Table A.2 in the Appendix. Neither the diet and nutrition outcomes nor supermarket access are statistically significant in any of these attrition models. Likewise, education, income, and most of the other control variables are statistically insignificant, suggesting that sample attrition does not cause any systematic bias in our analysis.

# 4. Results

## 4.1 Descriptive results

Table 3 shows mean child dietary outcomes by survey wave. Dietary diversity increased constantly between 2004 and 2011, as indicated by both the Chines CDDS and the WHO CDDS. However, the nutrition index remains low with values significantly smaller than 8, suggesting that nutrient deficiencies are still a widespread problem among Chinese children. The lower part of Table 3 shows calorie and nutrient intakes. Vitamin A and calcium intakes increased significantly between 2004 and 2011, whereas calorie intakes dropped. This may be due to dietary shifts over time with carbohydrates losing in relative importance (Table A.3 in the Appendix). Intakes of other nutrients remained constant or even declined slightly in some cases. However, Table 3 also shows that the mean age of children in the sample decreased between 2004 and 2011, so that a slight decline in nutrient intakes cannot necessarily be interpreted as a nutritional deterioration. We control for child age in the econometric analysis.

**Table 3: Dietary diversity and nutrient intakes of Chinese children (2004-2011)**

| | | 2004 | 2006 | 2009 | 2011 |
|---|---|---|---|---|---|
| | | (*n* = 1860) | (*n* = 1572) | (*n* = 1431) | (*n* = 1733) |
| Mean age | years | 10.85 | 10.31 | 9.83 | 9.51 |
| | | (4.36) | (4.38) | (4.23) | (4.36) |
| Child DDS | | | | | |
| Chinese CDDS | Score, range (0-9) | 5.45 | 5.65 | 5.89 | 6.31 |
| | | (1.12) | (1.15) | (1.13) | (1.25) |
| WHO CDDS | Score, range (0-7) | 3.73 | 3.92 | 4.11 | 4.43 |
| | | (0.97) | (0.98) | (0.92) | (1.03) |
| Nutrition index | | | | | |
| Chinese NI | Score, range (0-8) | 4.67 | 4.54 | 4.61 | 4.58 |
| | | (1.28) | (1.26) | (1.28) | (1.38) |
| FAO/WHO NI | Score, range (0-8) | 5.90 | 5.88 | 5.96 | 5.92 |
| | | (0.97) | (0.97) | (0.99) | (1.11) |
| Calorie | kcal/day | 1721.25 | 1635.39 | 1579.30 | 1461.74 |
| | | (666.59) | (636.30) | (611.66) | (565.29) |
| Protein | g/day | 53.25 | 50.19 | 49.80 | 50.40 |
| | | (25.14) | (21.98) | (21.21) | (21.67) |

| | | | | | |
|---|---|---|---|---|---|
| Vitamin A | µg RE/day | 340.98 | 323.95 | 345.84 | 439.60 |
| | | (507.38) | (472.49) | (369.68) | (698.56) |
| Vitamin C | mg/day | 68.42 | 58.32 | 56.75 | 54.23 |
| | | (111.60) | (44.68) | (48.22) | (58.67) |
| Vitamin E | mg/day | 3.70 | 3.41 | 3.37 | 3.60 |
| | | (3.18) | (3.20) | (2.90) | (3.03) |
| Calcium | mg/day | 307.90 | 293.57 | 307.60 | 339.36 |
| | | (244.15) | (221.17) | (232.59) | (268.70) |
| Iron | mg/day | 16.05 | 15.00 | 14.76 | 14.13 |
| | | (8.94) | (8.64) | (8.62) | (9.98) |
| Zinc | mg/day | 8.82 | 8.11 | 7.97 | 7.55 |
| | | (4.16) | (3.69) | (3.56) | (3.70) |

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

Table 4 shows mean DDS and NI for children in communities with and without supermarket access. In all survey waves, children in communities with supermarket access have higher dietary diversity and higher levels of nutrient adequacy than children in communities without supermarket access.

**Table 4: DDS and NI of children with and without supermarkets access**

| | 2004 | | | 2011 | | |
|---|---|---|---|---|---|---|
| | Supermarkets within 5 km | | | Supermarkets within 5 km | | |
| | Access | No access | Diff. | Access | No access | Diff. |
| Chinese DDS | 5.93 | 4.99 | 0.94*** | 6.59 | 5.80 | 0.79*** |
| | (1.14) | (0.89) | | (1.22) | (1.14) | |
| WHO DDS | 4.18 | 3.32 | 0.87*** | 4.67 | 3.98 | 0.69*** |
| | (0.91) | (0.82) | | (1.00) | (0.92) | |
| Chinese NI | 4.92 | 4.44 | 0.47*** | 4.75 | 4.28 | 0.46*** |
| | (1.28) | (1.24) | | (1.36) | (1.37) | |
| FAO/WHO NI | 6.10 | 5.72 | 0.38*** | 6.03 | 5.71 | 0.32*** |
| | (0.95) | (0.96) | | (1.09) | (1.11) | |
| N | 1,860 | | | 1,733 | | |

Notes: Mean values are shown with standard deviations in parentheses. Differences between the two groups in 2006 and 2009 are similar as in 2004 and 2011. *** indicates significance at the 1% level.

Table 5 compares CDDS and NI by region, child sex, and income groups. Urban children and children from high-income households show better dietary outcomes than rural children and children from low-income households. Girls have a somewhat lower NI than boys, pointing at dietary inequality. Whether supermarkets have different effects on these subsamples will be analyzed below.

**Table 5: DDS and NI in various groups (pooled sample)**

| | Urban | Rural | Diff. | Boys | Girls | Diff. | High income | Low income | Diff. |
|---|---|---|---|---|---|---|---|---|---|
| Chinese DDS | 6.36 | 5.59 | 0.77*** | 5.82 | 5.82 | 0.01 | 5.94 | 5.76 | 0.18*** |
| | (1.30) | (1.10) | | (1.19) | (1.24) | | (1.22) | (1.20) | |
| WHO DDS | 4.51 | 3.84 | 0.67*** | 4.04 | 4.04 | -0.00 | 4.15 | 3.99 | 0.16*** |
| | (1.03) | (0.94) | | (1.00) | (1.03) | | (1.02) | (1.01) | |
| Chinese NI | 4.88 | 4.49 | 0.39*** | 4.72 | 4.48 | 0.24*** | 4.73 | 4.54 | 0.19*** |
| | (1.23) | (1.25) | | (1.29) | (1.30) | | (1.31) | (1.29) | |
| FAO/WHO NI | 6.12 | 5.83 | 0.29*** | 5.95 | 5.87 | 0.08*** | 6.00 | 5.87 | 0.13*** |
| | (1.96) | (0.98) | | (0.99) | (1.04) | | (0.99) | (1.02) | |
| N | 1965 | 4631 | | 3525 | 3071 | | 2100 | 4496 | |

Notes: Mean values are shown with standard deviations in parentheses. We use *t*-tests to statistically compare mean differences. High-income and low-income households are classified by the mean per capita income of all households in each community. *** indicates significance at the 1% level.

## 4.2 Mean effects of supermarkets on child diets

*Effects on dietary diversity and nutrition index*

Table 6 reports the results of the panel data models explained in equation (1) above. The upper part of Table 6 uses the Chinese CDDS and the WHO CDDS as dependent variables (models 1-8). In all models, we use individual fixed effects, but the models differ in terms of the inclusion of year fixed effects, year-by-region fixed effects, and year-by-month fixed effects, as indicated in the respective columns. Controlling for possible confounding factors, supermarket access increases the Chinese CDDS by more than 0.15 food groups and the WHO CDDS by about 0.20 food groups. This is equivalent to about 30% of the observed rise in child dietary diversity between 2004 to 2011, clearly suggesting that supermarkets contributed to child dietary improvements in China.

The lower part of Table 6 uses the Chinese NI and FAO/WHO NI as dependent variables (models 9-16). After controlling for confounding factors, supermarket access increases the Chinese NI by around 0.25 and the FAO/WHO NI by about 0.16. Given that the mean values of both types of NI barely changed between 2004 and 2011, these nutritional improvements through supermarket access are considerable. All results are quite consistent across the different model specifications.

**Table 6: Mean effects of supermarkets on child dietary diversity scores (CDDS) and nutrition index (NI)**

| | Chinese CDDS | | | | WHO CDDS | | | |
|---|---|---|---|---|---|---|---|---|
| Models | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Supermarket | 0.138** | 0.151** | 0.198*** | 0.162** | 0.200*** | 0.208*** | 0.243*** | 0.197*** |
| | (0.068) | (0.066) | (0.066) | (0.065) | (0.062) | (0.061) | (0.056) | (0.057) |
| Controls | No | Yes | Yes | Yes | No | Yes | Yes | Yes |
| Individual FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | No | No | Yes | Yes | No | No |
| Year-by-region FE | No | No | Yes | No | No | No | Yes | No |
| Year-by-month FE | No | No | No | Yes | No | No | No | Yes |
| | Chinese NI | | | | FAO/WHO NI | | | |
| Models | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) |
| Supermarket | 0.251*** | 0.231*** | 0.287*** | 0.241*** | 0.167** | 0.142** | 0.194*** | 0.157** |
| | (0.086) | (0.086) | (0.087) | (0.084) | (0.069) | (0.069) | (0.068) | (0.068) |
| Controls | No | Yes | Yes | Yes | No | Yes | Yes | Yes |
| Individual FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | No | No | Yes | Yes | No | No |
| Year-by-region FE | No | No | Yes | No | No | No | Yes | No |
| Year-by-month FE | No | No | No | Yes | No | No | No | Yes |
| N | 6,596 | 6,596 | 6,596 | 6,595 | 6,596 | 6,596 | 6,596 | 6,595 |

Notes: ** and *** indicate significance at the 5% and 1% level, respectively. Robust standard errors clustered at the community-sex level are shown in parentheses. Full results with all covariates included are shown in Tables A.4 and A.5 in the Appendix.

As a robustness check, we use the proximity to supermarkets instead of the supermarket access dummy as explanatory variable in the regression models. Results are shown in Table A.6 in the Appendix. They confirm the significantly positive effects of supermarkets on CDDS and NI. In different robustness checks, we use alternative clustering approaches for the standard errors. In the main models in Table 6, we cluster standard errors at the community-sex level. In alternative specifications in Tables A.7 and A.8 in the Appendix, we cluster standard errors at the household level and the community level, respectively. The estimates and significance levels remain almost unchanged.

*Effects on nutrient intakes*

We now supplement and reinforce the validity of the above findings by investigating the effects of supermarkets on the intake of each nutrient separately. Results with calorie and nutrient intakes as dependent variables are shown in Table 7. As can be seen, supermarket access increases the intake of calories and all nutrients, except for vitamin C.

**Table 7: Effects of supermarkets on calorie and nutrient intakes**

| Models | Calories | Protein | Vitamin A | Vitamin C | Vitamin E | Calcium | Iron | Zinc |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Supermarket | 69.144* | 4.220*** | 54.156** | -4.688 | 0.414** | 38.638*** | 1.351*** | 0.757*** |
| | (37.753) | (1.297) | (24.554) | (6.596) | (0.177) | (10.164) | (0.500) | (0.239) |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Individual FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Year-by-region FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| N | 6,596 | 6,596 | 6,596 | 6,596 | 6,596 | 6,596 | 6,596 | 6,596 |

Notes: *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. Robust standard errors clustered at the community-sex level are shown in parentheses.

*Placebo test results*

Results of the two placebo tests explained above are presented in Tables A.9 and A.10 in the Appendix. The estimated coefficient for $SM_{it-1}$ is very small and not statistically significant in any of the models in Table A9, whereas supermarket access itself remains significant. Table A10 reveals that supermarkets have a significantly positive impact on calorie and nutrient intakes at home, but not on intakes away from home. These results further reinforce our confidence in the validity of the main findings and their interpretation in a causal sense, as reverse causality and unobserved (time-variant and time-invariant) heterogeneity do not seem to be relevant issues.

## 4.3 Heterogeneous results

This section analyzes possible heterogeneous effects of supermarkets on different segments of the population. We start by comparing effects in rural and urban settings. Fig. 2 (panel a) shows that the positive effects on CDDS and NI are all statistically significant in rural areas, but not in urban areas. This is a welcome finding because children in rural areas suffer more from poor dietary quality and nutritional deficiencies than children in urban areas. There are two possible reasons for the different effects. First, rural households tend to rely more on own and/or local food production, which may be limited in terms of variety and subject to seasonal fluctuation. In such situations, supermarkets can add to the variety and stability of local food supplies. Second, and related to the first point, urban areas tend to have a larger choice of different retailers anyway, including traditional grocery stores, wet markets, and other types of outlets. In such situations, the additional effects of supermarkets may be less relevant.

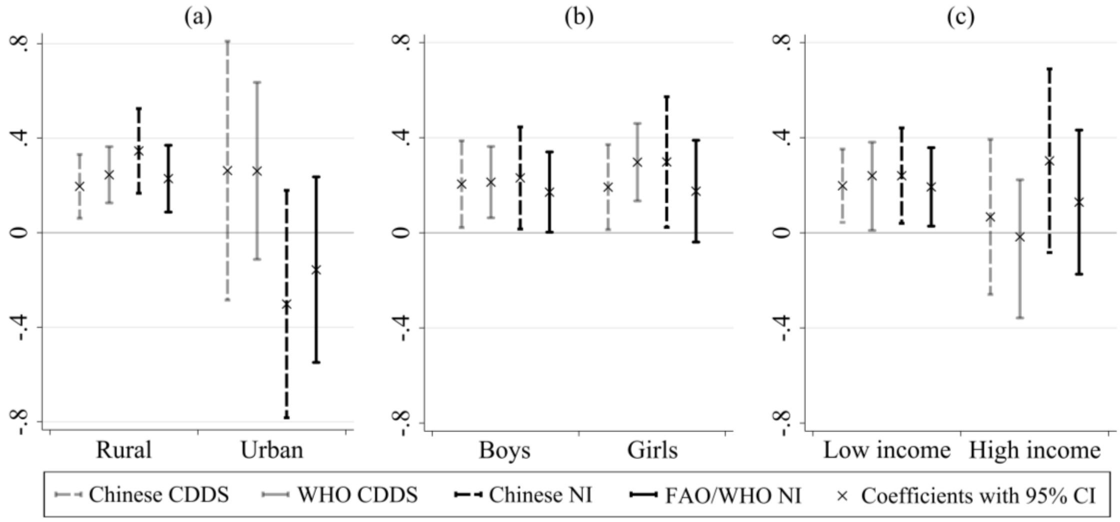


**Fig. 2. Heterogeneous effects of supermarkets on DDS and NI. Notes: Control variables and year-by-region fixed effects are used in all regressions. The numbers of observations in the subsamples are: rural (4631), urban (1965), boys (3525), girls (3071), children from low-income (4496) and high-income (2100) households.**

Panel (b) of Fig. 2 compares the effects of supermarkets for boys and girls. We see mostly positive and significant effects on CDDS and NI for both sexes with very similar coefficients and confidence intervals. We have seen above that some nutritional discrimination of girls exists in the sample, but this is not visible in the supermarket effects and also seems to have declined more generally. First, most households got richer and the food expenditure share declined over time (Yu, 2018), meaning that providing equal food for boys and girls became more affordable. Second, the one-child policy implemented in China between 1982 and 2016 means that most households only have one child. Research showed that this policy is associated with reduced gender gaps in health and human capital investments (Zhang, 2017).

Panel (c) of Fig. 2 compares the effects of supermarkets for children from low- and high-income households. This classification is based on income differences within each community. We find that supermarkets have statistically significant positive effects on children from low-income households, whereas the effects for children from high-income households are insignificant. These pro-poor effects are a welcome finding and can likely be explained by the fact that children from high-income households are nutritionally better off anyway.

### 4.4 Effects of supermarkets on child nutritional status

We now assess the effects of supermarkets on child nutritional status, using the anthropometric indicators explained above and the same panel data TWFE models. Results are shown in Table 9. Access to a supermarket increases child HAZ by 0.09. This is consistent with the dietary findings above. Improved protein and micronutrient intakes contribute to linear growth and reduced rates of stunting. In contrast, access to a supermarket does not seem to increase child overweight or obesity. Additional regressions differentiating by household income show that insignificant effects on BAZ, overweight, and obesity are true for both children from low- and high-income households. Overall, these findings suggest that supermarkets have favorable effects on child nutritional status in China, increasing child height without contributing to overweight and obesity.

**Table 9: Impacts of supermarkets on nutritional status**

| | HAZ | BAZ | Underweight | Overweight | Obese |
|---|---|---|---|---|---|
| Models | (1) | (2) | (3) | (4) | (5) |
| Supermarket | 0.094$^{*}$ | -0.001 | -0.027 | -0.023 | 0.013 |
| | (0.054) | (0.065) | (0.018) | (0.020) | (0.014) |
| Controls | Yes | Yes | Yes | Yes | Yes |
| Individual FE | Yes | Yes | Yes | Yes | Yes |
| Year-by-region FE | Yes | Yes | Yes | Yes | Yes |
| N | 6,066 | 6,009 | 6,009 | 6,009 | 6,009 |

Notes: $^{*}$, $^{**}$, and $^{***}$ indicate significance at the 10%, 5%, and 1% level, respectively. Robust standard errors clustered at the community-sex level are shown in parentheses.

## 4.5 Impact pathways

In this subsection, we analyze two possible pathways of how supermarkets may affect child diets and nutrition, namely through a larger supply of food variety and through lowering food prices. We start by looking at food variety. Fig. 3. shows the average number of different types of foods sold by the supermarkets in the CHNS sample communities and how this number evolved over time. As can be seen, supermarkets tend to sell a large variety of unhealthy snacks and candies, and this variety increased over time. Yet, supermarkets also sell a variety of fresh vegetables and fruits, and this variety increased at even larger rates over time. Between 2004 and 2011, the variety of fresh vegetables and fruits sold in supermarkets almost doubled. This variety of healthy foods can explain the positive effects on child dietary diversity and nutrient intakes.

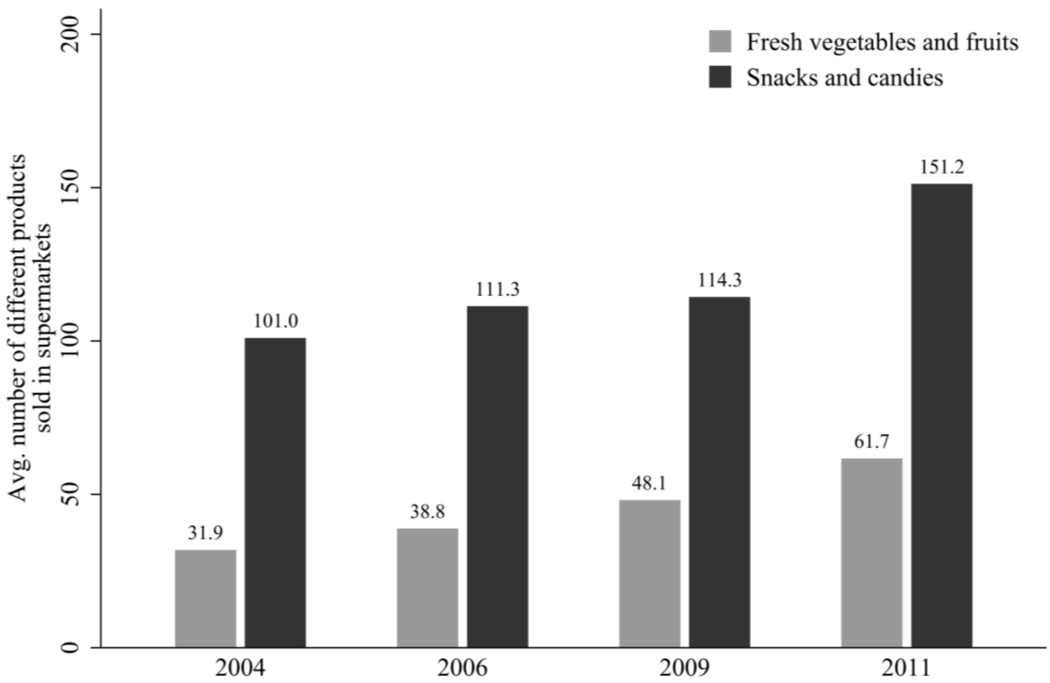


**Fig. 3. Variety of different types of foods sold in supermarkets in China (2004-2011). Source: Derived from CHNS community survey.**

Next, we look at the effects of supermarkets on food prices. The CHNS community survey data include prices of various foods from a traditional wet market and a larger retail store in or near each community. When a community has a supermarket nearby, the larger store price is typically the supermarket price, but in communities without a supermarket this can also be a different type of shop, which is not specified in the dataset. Based on these two prices, we determine the average community-level price for each food product $k$ in year $t$ by calculating the arithmetic mean. Then, we create a dummy variable, $P_{kt}$, which takes a value of one if this average price is lower than the traditional wet market price, and zero otherwise. This dummy variable is used for community-level fixed effects panel regressions of the following type:

$$P_{kt} = \alpha + \psi F_{kt} + Community + Y_t + \varepsilon_{kt} \quad (5)$$

where $F_{kt}$ is a dummy that takes a value of one if the community has access to a supermarket that sells the specific food product $k$, and zero otherwise. This information to specify $F_{kt}$ is obtained from related questions in the CHNS community surveys. Thus, the coefficient $\psi$ indicates the price effect of supermarkets. A positive and significant $\psi$ would indicate that supermarkets tend to lower average community-level food prices. $Community$ and $Y_t$ are community fixed effects and year-by-region fixed effects, respectively. $\varepsilon_{kt}$ is a random error term.

Table 10 shows the estimation results for various food products that are popular across all regions of China, namely rice, wheat flour, eggs, pork, chicken, and specific vegetables. For several of these food products we do not observe significant price effects. However, for pork and chicken the coefficients are positive and significant, meaning that supermarkets tend to lower community-level food prices. The estimates in columns (4) and (5) of Table 10 suggest that the availability of a supermarket increases the likelihood of reduced prices by 17.1 and 9.3 percentage points for pork and chicken, respectively. Pork and chicken are widely consumed in China and are important sources of protein and micronutrients. Reduced prices of these products can explain increased nutrient intakes, especially for children in low-income households.

**Table 10: Associations between supermarkets and food prices (community-level regressions)**

| | Rice | Wheat flour | Eggs | Pork | Chicken | Vegetables |
|---|---|---|---|---|---|---|
| Models | (1) | (2) | (3) | (4) | (5) | (6) |
| Supermarket ($F_{kt}$) | -0.041 | -0.038 | -0.033 | $0.171^{***}$ | $0.093^{***}$ | 0.023 |
| | (0.035) | (0.031) | (0.053) | (0.041) | (0.035) | (0.038) |
| Community FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Year-by-region FE | Yes | Yes | Yes | Yes | Yes | Yes |
| N | 886 | 886 | 886 | 886 | 886 | 886 |

Notes: $^{***}$ indicates significance at the 1% level. Robust standard errors are shown in parentheses. Positive coefficient estimates indicate that supermarkets lower the average food price at the community level.

## 5. Conclusion and policy implications

The rapid expansion of supermarkets in many developing countries is reshaping food environments, which may influence people's food choices, diets, and nutritional outcomes. The nutritional effects of supermarkets in different contexts are not yet well understood. This is particularly true for children, where issues of dietary quality have long-term implications for economic and human development. In this article, we have addressed this knowledge gap by providing the first study analyzing supermarket effects on child nutrition in China, and the first study in any country using panel data with individual-level indicators of child diets. Using fixed effects panel data regression models and various robustness checks we were able to reduce potentially relevant sources of endogeneity and cautiously interpret the estimates as causal effects.

The results suggest that improved access to supermarkets has significantly increased child dietary diversity, nutrient intakes, and height-for-age Z-scores. Analysis of heterogeneous effects further shows that both boys and girls benefit from supermarket-related nutritional improvements and that children in rural areas and from low-income households benefit more than children from urban areas and higher-income households. We did not find any significant effects of supermarkets on child overweight or obesity, concluding that the expansion of supermarkets has clear positive child nutritional effects in China.

We have also explored possible pathways of the observed effects of supermarkets on child nutrition. First, we could show that supermarkets in China sell both fresh and processed products and thus add to the variety of foods available in local communities. The variety of fresh vegetables and fruits sold in supermarkets increased substantially over time. Second, using community-level data we could show that supermarkets lower the prices of certain foods, such as pork and chicken – both important sources of protein and micronutrients. We interpret these price effects as a consequence of supermarkets contributing to increased market competition and economies of scale. Greater variety and seasonal stability in local food supplies and lower food prices can explain the observed child nutritional improvements, and also the more pronounced effects in rural areas and low-income population segments.

Several previous studies in other countries showed that the rapid spread of supermarkets leads to more consumption of processed foods and contributes to overweight and obesity among adults (Asfaw, 2008; Kimenju et al., 2015; Demmler et al., 2018; Otterbach et al., 2021). Nevertheless, some studies also show improvements in dietary diversity and nutrient intakes (Rischke et al., 2015; Khonje et al. 2020). For children, the evidence is more patchy even though some studies with data from Africa suggest that supermarkets help reduce child nutritional deficiencies and stunting (Debela et al., 2020; Khonje et al., 2020). This is in line with our findings for China, even though the earlier research in Africa focused only on urban areas, whereas here we looked at both urban and rural areas. In any case, the notion that supermarkets and other modern retailers would always contribute to lower-quality diets is incorrect. Our results from China demonstrate that supermarkets can help improve people’s access to healthy foods and thus contribute to improved diets and nutrition.

Obviously, the nutritional effects will vary depending on what types of foods supermarkets sell. In China, supermarkets do not only sell ultra-processed foods but also a variety of fresh and nutritious foods. This is partly related to local consumer preferences but likely also to well-developed road infrastructure in rural and urban areas, facilitating the logistics for fresh food supplies. This may be much more difficult in rural regions of Africa, where the road infrastructure is typically less developed. A general policy implication is that private market developments and food environment trends can contribute to favorable health and nutrition outcomes provided that proper public infrastructure is in place. Public infrastructure investments to improve the functioning of markets coupled with specific policies to incentivize higher supply of and demand for healthy foods may help to promote desirable diet and nutrition outcomes at scale, in China and beyond.

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# Appendix

## A.1 Measurement of maternal dietary knowledge

The CHNS designed ten questions to analyze individual's dietary knowledge, as shown in Table A1. If the answer is "9 unknown", we categorize it as "3 neutral." The final score for dietary knowledge is calculated as:

$$Dietary\ knowledge\ score = a1 + (6 - a2) + a3 + (6 - a4) + a5 + (6 - a6) + a7 + a8 + a9 + (6 - a10)$$

**Table A1: Dietary knowledge questionnaire**

| Questions<br>Do you strongly agree, somewhat agree, somewhat disagree or strongly disagree with this statement? | Score<br>1 strongly disagree<br>2 disagree<br>3 neutral<br>4 agree<br>5 strongly agree<br>9 unknown |
|---|---|
| Choosing a diet with a lot of fresh fruits and vegetables is good for one's health. | a1 |
| Eating a lot of sugar is good for one's health. | a2 |
| Eating a variety of foods is good for one's health. | a3 |
| Choosing a diet high in fat is good for one's health. | a4 |
| Choosing a diet with a lot of staple foods (rice and rice products and wheat and wheat products) is not good for one's health. | a5 |
| Consuming a lot of animal products daily (fish, poultry, eggs, and lean meat) is good for one's health. | a6 |
| Reducing the amount of fatty meat and animal fat in the diet is good for one's health. | a7 |
| Consuming milk and dairy products is good for one's health. | a8 |
| Consuming beans and bean products is good for one's health. | a9 |
| The heavier one's body is, the healthier he or she is. | a10 |

### A.2 Attrition test

To assess whether attrition may cause bias, we use the following two-way fixed effects model:

$$Attrition_{it} = \beta_0 + \varphi Y_{it} + \beta supermarket_{it} + \gamma \mathbb{X}_{it} + \theta_i + \delta \mathbb{Z}_t + u_{it}$$

where $Attrition_{it}$ is a dummy variable indicating whether the child drops out at the next survey wave; $Y_{it}$ refers to diet and nutrition indicators (i.e., DDS and NI); and all other variables and fixed effects keep the same. We present the results in Table A2, which shows that attrition is not correlated with child diets and nutrition and the presence of supermarkets, nor is it significantly related to the 14 out of 16 covariates. Hence, there is not severe sample attrition that may bias our estimates.

**Table A2: Results of attrition analysis**

| | Dep. Var.: $Attrition_{it}$ | | | |
|---|---|---|---|---|
| Models | (1) | (2) | (3) | (4) |
| Chinese CDDS | -0.009 | | | |
| | (0.008) | | | |
| WHO CDDS | | -0.004 | | |
| | | (0.010) | | |
| Chinese NI | | | -0.010 | |
| | | | (0.006) | |
| FAO/WHO NI | | | | -0.008 |
| | | | | (0.008) |
| Supermarket | -0.025 | -0.026 | -0.024 | -0.025 |
| | (0.027) | (0.027) | (0.027) | (0.027) |
| Age | -0.038 | -0.038 | -0.035 | -0.036 |
| | (0.141) | (0.141) | (0.141) | (0.141) |
| Edu | -0.001 | -0.001 | -0.002 | -0.002 |
| | (0.008) | (0.008) | (0.008) | (0.008) |
| Physical activity | -0.000 | -0.000 | -0.000 | -0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| Ln(income) | -0.015 | -0.015 | -0.015 | -0.015 |
| | (0.010) | (0.010) | (0.010) | (0.010) |
| Edu_mother | -0.001 | -0.001 | -0.001 | -0.001 |
| | (0.003) | (0.003) | (0.003) | (0.003) |
| Edu_ father | 0.002 | 0.002 | 0.002 | 0.002 |
| | (0.002) | (0.002) | (0.002) | (0.002) |
| Dietary knowledge | 0.005* | 0.005* | 0.005* | 0.005* |
| | (0.003) | (0.003) | (0.003) | (0.003) |

| | | | | |
|---|---|---|---|---|
| Household size | 0.015 | 0.016 | 0.015 | 0.015 |
| | (0.012) | (0.012) | (0.012) | (0.012) |
| Refrigerator | -0.019 | -0.020 | -0.019 | -0.020 |
| | (0.024) | (0.024) | (0.024) | (0.024) |
| Car | -0.000 | -0.001 | 0.000 | -0.000 |
| | (0.031) | (0.031) | (0.031) | (0.031) |
| Motorcycle | -0.003 | -0.003 | -0.002 | -0.003 |
| | (0.018) | (0.018) | (0.018) | (0.018) |
| Production diversity | 0.002 | 0.001 | 0.001 | 0.001 |
| | (0.015) | (0.015) | (0.015) | (0.015) |
| Free market | 0.012 | 0.012 | 0.013 | 0.013 |
| | (0.034) | (0.034) | (0.033) | (0.033) |
| Chinese restaurant | 0.061 | 0.062 | 0.062 | 0.063 |
| | (0.043) | (0.043) | (0.042) | (0.043) |
| Fast food restaurant | 0.091*** | 0.091*** | 0.092*** | 0.092*** |
| | (0.030) | (0.030) | (0.030) | (0.030) |
| Bus stop | 0.037 | 0.037 | 0.039 | 0.038 |
| | (0.024) | (0.024) | (0.024) | (0.024) |
| Individual FE | Yes | Yes | Yes | Yes |
| Year-by-region FE | Yes | Yes | Yes | Yes |
| N | 6,596 | 6,596 | 6,596 | 6,595 |

Notes: *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively. Robust standard errors clustered at the community-sex level in parentheses.

### A.3 Nutrition transition among children in China

Table A3 shows an increasing trend of energy share from fat and protein and a decreasing trend of energy share from carbohydrates.

**Table A3: Structure of energy sources of Chinese children (derived from the CHNS data)**

| | | 2004 | 2006 | 2009 | 2011 |
|---|---|---|---|---|---|
| Carbohydrates | g/day | 254.28 | 238.54 | 219.02 | 190.90 |
| share of energy | % | 59.99% | 58.82% | 56.15% | 52.52% |
| Protein | g/day | 53.25 | 50.19 | 49.80 | 50.40 |
| share of energy | % | 12.42% | 12.33% | 12.75% | 13.95% |
| Fat | g/day | 54.47 | 53.27 | 55.92 | 55.04 |
| share of energy | % | 27.54% | 28.77% | 31.06% | 33.45% |

## A.4-A.5 Full regression results

**Table A4: Effects of supermarkets on child dietary diversity**

| | Chinese CDDS | | | | WHO CDDS | | | |
|---|---|---|---|---|---|---|---|---|
| Models | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Supermarket | 0.138** | 0.151** | 0.198*** | 0.162** | 0.200*** | 0.208*** | 0.243*** | 0.197*** |
| | (0.068) | (0.066) | (0.066) | (0.065) | (0.062) | (0.061) | (0.056) | (0.057) |
| Age | | -0.185 | -0.063 | -0.770 | | -0.199 | -0.288 | -0.580 |
| | | (0.251) | (0.345) | (0.517) | | (0.180) | (0.261) | (0.402) |
| Edu | | -0.012 | -0.010 | -0.010 | | -0.011 | -0.010 | -0.010 |
| | | (0.020) | (0.019) | (0.020) | | (0.015) | (0.015) | (0.015) |
| Physical activity | | 0.000 | -0.000 | 0.000 | | 0.000 | 0.000 | 0.000 |
| | | (0.000) | (0.000) | (0.000) | | (0.000) | (0.000) | (0.000) |
| Ln(income) | | 0.015 | 0.009 | 0.015 | | 0.019 | 0.015 | 0.020 |
| | | (0.023) | (0.021) | (0.023) | | (0.019) | (0.019) | (0.019) |
| Edu_mother | | 0.012 | 0.011 | 0.012 | | 0.003 | 0.001 | 0.002 |
| | | (0.008) | (0.008) | (0.008) | | (0.006) | (0.006) | (0.006) |
| Edu_ father | | 0.009 | 0.012* | 0.009 | | 0.012** | 0.014*** | 0.012** |
| | | (0.007) | (0.007) | (0.007) | | (0.005) | (0.005) | (0.005) |
| Dietary knowledge | | 0.003 | 0.009 | 0.004 | | 0.000 | 0.005 | 0.001 |
| | | (0.007) | (0.007) | (0.007) | | (0.005) | (0.006) | (0.006) |
| Household size | | -0.041* | -0.041 | -0.040* | | -0.020 | -0.020 | -0.019 |
| | | (0.025) | (0.026) | (0.024) | | (0.024) | (0.024) | (0.024) |
| Refrigerator | | 0.189*** | 0.126** | 0.169*** | | 0.182*** | 0.144*** | 0.167*** |
| | | (0.062) | (0.062) | (0.061) | | (0.050) | (0.048) | (0.049) |
| Car | | 0.141 | 0.142 | 0.133 | | 0.107 | 0.096 | 0.113 |
| | | (0.106) | (0.101) | (0.107) | | (0.074) | (0.076) | (0.073) |
| Motorcycle | | 0.133** | 0.065 | 0.135** | | 0.076* | 0.029 | 0.077* |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | (0.057) | (0.055) | (0.057) | | (0.045) | (0.044) | (0.045) |
| Production diversity | | 0.050 | 0.044 | 0.057$^{*}$ | | 0.014 | 0.008 | 0.017 |
| | | (0.031) | (0.032) | (0.031) | | (0.026) | (0.026) | (0.025) |
| Free market | | -0.122$^{*}$ | -0.148$^{**}$ | -0.122 | | -0.138$^{**}$ | -0.155$^{**}$ | -0.166$^{**}$ |
| | | (0.065) | (0.071) | (0.076) | | (0.063) | (0.066) | (0.068) |
| Chinese restaurant | | 0.076 | -0.071 | 0.144$^{*}$ | | 0.046 | -0.035 | 0.097 |
| | | (0.084) | (0.094) | (0.087) | | (0.070) | (0.077) | (0.070) |
| Fast food restaurant | | 0.035 | -0.021 | 0.018 | | 0.083 | 0.075 | 0.082 |
| | | (0.071) | (0.080) | (0.074) | | (0.055) | (0.058) | (0.058) |
| Bus stop | | -0.033 | -0.022 | -0.022 | | 0.030 | 0.050 | 0.022 |
| | | (0.061) | (0.055) | (0.061) | | (0.043) | (0.040) | (0.041) |
| Individual FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | No | No | Yes | Yes | No | No |
| Year-by-region FE | No | No | Yes | No | No | No | Yes | No |
| Year-by-month FE | No | No | No | Yes | No | No | No | Yes |
| N | 6,596 | 6,596 | 6,596 | 6,595 | 6,596 | 6,596 | 6,596 | 6,595 |

Notes: $^{*}$, $^{**}$, and $^{***}$ indicate significance at the 10%, 5%, and 1% level, respectively. Robust standard errors clustered at the community-sex level in parentheses.

**Table A5: Effects of supermarkets on child nutrition index**

| | Chinese NI | | | | FAO/WHO NI | | | |
|---|---|---|---|---|---|---|---|---|
| Models | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) |
| Supermarket | 0.251$^{***}$ | 0.231$^{***}$ | 0.287$^{***}$ | 0.241$^{***}$ | 0.167$^{**}$ | 0.142$^{**}$ | 0.194$^{***}$ | 0.157$^{**}$ |
| | (0.086) | (0.086) | (0.087) | (0.084) | (0.069) | (0.069) | (0.068) | (0.068) |
| Age | | 0.207 | 0.182 | -1.076$^{*}$ | | 0.215 | 0.157 | -0.782 |
| | | (0.360) | (0.443) | (0.646) | | (0.272) | (0.348) | (0.517) |
| Edu | | -0.050$^{*}$ | -0.043$^{*}$ | -0.048$^{*}$ | | -0.082$^{***}$ | -0.078$^{***}$ | -0.083$^{***}$ |
| | | (0.026) | (0.026) | (0.026) | | (0.021) | (0.021) | (0.021) |

| | | | | | | |
|---|---|---|---|---|---|---|
| Physical activity | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Ln(income) | 0.029 | 0.025 | 0.030 | 0.038 | 0.034 | 0.038 |
| | (0.030) | (0.030) | (0.030) | (0.023) | (0.023) | (0.023) |
| Edu_mother | -0.009 | -0.009 | -0.010 | -0.012 | -0.012 | -0.012 |
| | (0.010) | (0.010) | (0.010) | (0.008) | (0.008) | (0.008) |
| Edu_ father | -0.010 | -0.007 | -0.009 | -0.008 | -0.006 | -0.008 |
| | (0.008) | (0.008) | (0.008) | (0.006) | (0.006) | (0.006) |
| Dietary knowledge | 0.004 | 0.006 | 0.004 | 0.005 | 0.008 | 0.005 |
| | (0.010) | (0.010) | (0.010) | (0.008) | (0.008) | (0.008) |
| Household size | -0.108*** | -0.097*** | -0.104*** | -0.082*** | -0.075*** | -0.080*** |
| | (0.037) | (0.037) | (0.037) | (0.028) | (0.027) | (0.028) |
| Refrigerator | 0.126 | 0.093 | 0.111 | 0.090 | 0.062 | 0.080 |
| | (0.078) | (0.075) | (0.077) | (0.061) | (0.059) | (0.061) |
| Car | 0.199 | 0.163 | 0.210* | 0.159 | 0.129 | 0.166* |
| | (0.128) | (0.126) | (0.126) | (0.101) | (0.102) | (0.100) |
| Motorcycle | 0.116* | 0.066 | 0.097 | 0.094* | 0.052 | 0.087 |
| | (0.068) | (0.066) | (0.067) | (0.055) | (0.054) | (0.054) |
| Production diversity | 0.015 | 0.019 | 0.028 | 0.021 | 0.024 | 0.028 |
| | (0.039) | (0.041) | (0.039) | (0.031) | (0.033) | (0.031) |
| Free market | -0.077 | -0.048 | -0.072 | -0.025 | -0.007 | -0.029 |
| | (0.099) | (0.098) | (0.102) | (0.074) | (0.074) | (0.081) |
| Chinese restaurant | 0.136 | 0.005 | 0.225** | 0.174* | 0.068 | 0.232*** |
| | (0.109) | (0.116) | (0.111) | (0.088) | (0.092) | (0.089) |
| Fast food restaurant | 0.099 | 0.130 | 0.121 | 0.079 | 0.088 | 0.084 |
| | (0.081) | (0.088) | (0.081) | (0.063) | (0.065) | (0.061) |
| Bus stop | 0.110 | 0.168** | 0.119 | 0.060 | 0.106* | 0.074 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | (0.075) | (0.073) | (0.074) | | (0.057) | (0.056) | (0.057) |
| Individual FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | No | No | Yes | Yes | No | No |
| Year-by-region FE | No | No | Yes | No | No | No | Yes | No |
| Year-by-month FE | No | No | No | Yes | No | No | No | Yes |
| N | 6,596 | 6,596 | 6,596 | 6,595 | 6,596 | 6,596 | 6,596 | 6,595 |

Notes: $^{*}$, $^{**}$, and $^{***}$ indicate significance at the 10%, 5%, and 1% level, respectively. Robust standard errors clustered at the community-sex level in parentheses.

## A.6 Results with supermarket proximity as explanatory variable

**Table A6: Effects of the proximity to supermarkets on child DDS and NI**

| | Chinese CDDS | WHO CDDS | Chinese NI | FAO/WHO NI |
|---|---|---|---|---|
| Models | (1) | (2) | (3) | (4) |
| Supermarket proximity | 0.094*** | 0.100*** | 0.090** | 0.069** |
| | (0.037) | (0.029) | (0.046) | (0.032) |
| Controls | Yes | Yes | Yes | Yes |
| Individual FE | Yes | Yes | Yes | Yes |
| Year-by-region FE | Yes | Yes | Yes | Yes |
| N | 6,596 | 6,596 | 6,596 | 6,596 |

Notes: *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. Robust standard errors clustered at the community-sex level in parentheses.

## A.7-A.8 Regressions with various clustered standard errors

**Table A7: Estimates with robust standard errors clustered at the household level**

| | Chinese CDDS | WHO CDDS | Chinese NI | FAO/WHO NI |
|---|---|---|---|---|
| Models | (1) | (2) | (3) | (4) |
| Supermarket | 0.198*** | 0.243*** | 0.287*** | 0.194*** |
| | (0.060) | (0.055) | (0.080) | (0.064) |
| CVs | Yes | Yes | Yes | Yes |
| Individual FE | Yes | Yes | Yes | Yes |
| Year-by-region FE | Yes | Yes | Yes | Yes |
| N | 6,596 | 6,596 | 6,596 | 6,595 |

Notes: *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. Robust standard errors clustered at household level in parentheses.

**Table A8: Estimates with robust standard errors clustered at community level**

| | Chinese CDDS | WHO CDDS | Chinese NI | FAO/WHO NI |
|---|---|---|---|---|
| Models | (1) | (2) | (3) | (4) |
| Supermarket | 0.198*** | 0.243*** | 0.287*** | 0.194** |
| | (0.069) | (0.057) | (0.098) | (0.076) |
| CVs | Yes | Yes | Yes | Yes |
| Individual FE | Yes | Yes | Yes | Yes |
| Year-by-region FE | Yes | Yes | Yes | Yes |
| N | 6,596 | 6,596 | 6,596 | 6,595 |

Notes: *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. Robust standard errors clustered at community level in parentheses.

## A.9-A.10 Placebo test results

**Table A9: Effects of one wave before a supermarket was established**

| | Chinese CDDS | WHO CDDS | Chinese NI | FAO/WHO NI |
|---|---|---|---|---|
| Models | (1) | (2) | (3) | (4) |
| One wave before ($SM_{it-1}$) | -0.152<br>(0.115) | -0.143<br>(0.098) | -0.072<br>(0.149) | -0.042<br>(0.113) |
| Supermarket | 0.211*** | 0.256*** | 0.293*** | 0.198*** |
| | (0.068) | (0.057) | (0.091) | (0.070) |
| Controls | Yes | Yes | Yes | Yes |
| Individual FE | Yes | Yes | Yes | Yes |
| Year-by-region FE | Yes | Yes | Yes | Yes |
| N | 6,596 | 6,596 | 6,596 | 6,596 |

Note: Robust standard errors clustered at the community-sex level in parentheses.

**Table A10: Effects of supermarkets on nutrient intakes at home and away from home**

| | Calorie | Protein | Vitamin A | Vitamin C | Vitamin E | Calcium | Iron | Zinc |
|---|---|---|---|---|---|---|---|---|
| Models | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| ***Panel A: At home*** | | | | | | | | |
| Supermarket | 76.728** | 3.873*** | 45.577* | -4.191 | 0.386** | 40.086*** | 1.254** | 0.670*** |
| | (36.974) | (1.468) | (24.872) | (6.280) | (0.173) | (10.268) | (0.501) | (0.238) |
| N | 6,596 | 6,596 | 6,596 | 6,596 | 6,596 | 6,596 | 6,596 | 6,596 |
| ***Panel B: Away from home*** | | | | | | | | |
| Supermarket | -2.059 | 0.347 | 8.578 | -0.497 | 0.028 | -1.448 | 0.097 | 0.087 |
| | (22.477) | (0.956) | (6.393) | (0.836) | (0.063) | (4.692) | (0.251) | (0.126) |
| N | 6,596 | 6,596 | 6,596 | 6,596 | 6,596 | 6,596 | 6,596 | 6,596 |
| ***Panel C: Away from home*** *(excluding observations without food intake away from home)* | | | | | | | | |
| Supermarket | 15.233 | 0.844 | 45.751 | -0.993 | 0.236 | -5.353 | -0.176 | 0.464 |
| | (72.414) | (3.872) | (28.979) | (3.000) | (0.288) | (20.338) | (1.080) | (0.451) |
| N | 2,696 | 2,696 | 2,696 | 2,696 | 2,696 | 2,696 | 2,696 | 2,696 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Individual FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Year-by-region FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Notes: *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. Robust standard errors clustered at the community-sex level in parentheses.

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[i] This is mentioned in the "No.1 Central Document 2004" by the Chinese central government (http://www.gov.cn/test/2006-02/22/content_207415.htm).

[ii] Due to dissimilar developments across the provinces in China, time trends that are correlated with dietary intake may differ regionally. Even within the same province, prefecture-level cities usually have better socioeconomic conditions than counties. Thus, we define city region and county region for each province and interact region dummies with year dummies to generate year-by-region fixed effects that are used to control for region-specific time trends.

[iii] Seasonal factors like food production volatility may affect food consumption (Sibhatu and Qaim, 2017).

[iv] The CHNS collects the places of all food items consumed, including at home, at nursery school, school, or work, at restaurants or food stands, in the house of relatives or friends, at festival/celebrations, and others. We calculate the intake away from home as everything not eaten at home.

[v] The continuous proximity variable is generated as:

$$Proximity = \ln\left(\frac{1}{distance\ to\ the\ nearest\ supermarket} + 1\right)$$

where proximity=0 if the community has no access to a supermarket or no distance was recorded, suggesting the distance approaches infinity.

[vi] The WHO CDDS was originally developed to evaluate the minimum dietary diversity of children under 23 months, but recent studies suggest that it can also be a useful indicator for older children (Fongar et al., 2019).

[vii] While the body needs more nutrients, this set of macro- and micronutrients provides a comprehensive picture of a child's dietary and nutrition situation.