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Invited paper presented at the 5th International Conference of the African Association of Agricultural Economists, September 23-26, 2016, Addis Ababa, Ethiopia

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Abstract
We analyze how the nutrition transition, which involves a westernization of diets and increased consumption of calorie-dense, processed foods, affects child malnutrition in developing countries. It is often assumed that the nutrition transition affects child weight but not child growth, which could be one reason why child underweight decreases faster than child stunting. But these effects have hardly been analyzed empirically. Our cross-country panel regressions show that the nutrition transition reduces child underweight, while no consistent effect on child overweight is found. Against common views, our results also suggest that the nutrition transition reduces child stunting. Further research is required to confirm these findings.

Keywords: Nutrition transition, malnutrition, stunting, underweight, obesity

Introduction

Nutrition and diets in many developing countries are changing rapidly. While undernutrition as a result of insufficient calorie intakes is still a widespread problem, other facets of malnutrition have gained in importance more recently, or they have simply become more evident (IFPRI, 2014). Once people can secure a sufficient amount of calories, income increases usually lead to dietary diversification and the consumption of more nutritious, higher-value foods. These shifts are associated with nutrition and health benefits. However, there are other important changes that now occur in parallel. In many developing countries, traditional diets rich in cereals and fiber are changing towards western diets rich in sugar, fat, and animal-source products, as well as higher shares of processed foods. At the same time, rising living standards and urbanization are contributing to more sedentary lifestyles. These changes in dietary habits and lifestyles are often referred to as the ‘nutrition transition’ (Popkin, 1993; Popkin & Ng, 2007; Pingali, 2007). Beside changing demand, it is likely that supply-side factors – such as globalizing food systems and the rapid spread of supermarkets in developing countries – contribute to this nutrition transition (Hawkes, 2008; (Hawkes et al. 2009). The nutrition transition is associated with increasing overweight and obesity (B. Popkin and Ng 2007; B. M. Popkin et al. 2012). In 2008, 34% of all adults worldwide were overweight or obese (Finucane et al. 2011). Especially in developing countries, overweight rates have increased very rapidly over the last 25 years. For children, this problem is still less widespread, but also increasing. In 2011, an estimated 6.6% of all children below five years of age were either overweight or obese, an increase from 4.5% in 1990 (United Nations Children's Fund et al. 2012).

As the rates of child overweight increase, the prevalence of underweight for children below five years of age has decreased by an annual rate of 2.2% since 1990. In 2011, rates of child underweight in developing countries were at 16% (United Nations Children's Fund et al. 2012). With this reduction, the world is almost on track to meet the Millennium Development Goal

(MDG) of halving the proportion of child undernutrition by 2015 (Haddad 2013). In comparison, progress in terms of reducing child stunting is much slower. In 2011, 26% of the children in developing countries were stunted (United Nations Children's Fund et al. 2012). Stunting is not used as an indicator to track progress towards the MDGs. Hence, the MDG reports may overestimate actual improvements in child nutrition. It is widely argued that stunting is a more reliable indicator than underweight for monitoring chronic undernutrition in children (de Onis et al., 2004; Klasen, 2008; Lutter, Chaparro, & Muñoz, 2011; de Haen, Klasen, & Qaim, 2011; Haddad, 2013; Black et al., 2013; UNICEF, 2013). Stunting is also a more severe problem in terms of the long-term consequences for child health (UNICEF 1998; Haddad 2013; Black et al. 2013).

Several authors pointed out that one reason why rates of child underweight have decreased faster than rates of child stunting over the last 25 years may be the nutrition transition (Misselhorn, 2010; de Haen, Klasen, & Qaim, 2011; Haddad, 2013). The observed shift towards processed foods rich in sugar and fat may imply higher calorie intakes, but not necessarily more healthy diets. Thus, the nutrition transition might contribute to increasing child weight, but possibly not to improved child growth. As is well known, child growth depends less on calories per se; beyond sanitation and health-related factors, dietary quality and micronutrient intakes were shown to be important determinants (Smith & Haddad, 2014; IFPRI, 2014).

However, the notion that the nutrition transition would reduce child underweight but not stunting is not based on empirical evidence. To our knowledge, this relationship has never been analyzed explicitly. In this article, we challenge this notion through cross-country regression analysis. In particular, building on various data sources we identify indicators for the nutrition transition, which we include in regression models to explain child malnutrition measured in different ways. For estimation, we use random and fixed effects panel data models.

Dietary Trends and Child Nutrition: Expected Relationships

In this section, we describe how the nutrition transition might influence child malnutrition based on a short review of the literature. As mentioned, the nutrition transition in developing countries implies dietary shifts away from traditional staple foods towards more processed, calorie-dense foods rich in sugar and fat (Popkin & Ng, 2007; Pingali, 2007). To some extent, these shifts are due to rising incomes, urbanization, and changes in people's preferences and lifestyles. However, global advertising of food companies and the rapid spread of supermarkets, fast food chains, and other modern retail outlets probably also contribute to the observed changes in shopping behavior and consumption patterns (Reardon et al., 2003; Hawkes, 2008; Asfaw, 2008; Timmer, 2009). Modern retail outlets tend to offer a greater variety of processed foods, sometimes at lower prices, at least when converted to the price per calorie consumed (Rischke et al. 2015; T. Reardon et al. 2003). Supermarkets and hypermarkets also pursue special marketing strategies to influence the purchase behavior of consumers (Hawkes, 2008; Swinburn et al., 2011).

The nutrition transition is associated with rising rates of overweight and obesity, thus contributing significantly to an upsurge in non-communicable diseases in developing countries

(Popkin, 2006; Popkin, Adair, & Ng, 2012). While overweight and obesity in developing countries are positively associated with income, poor population segments are also increasingly affected (Jones-Smith et al., 2012; Roemling and Qaim, 2012). These effects of the nutrition transition on body weight have primarily been observed in adult populations. For children, much less evidence is available, although the effects may possibly be similar. Increased consumption of calorie-dense foods will also lead to weight gains in children, which may reduce child underweight in poor households and increase child overweight in richer households. Beyond these direct effects for children, indirect effects through their parents' nutritional status can also play important roles. Several studies showed that growing up in obesogenic environments increases the risk of childhood overweight through imitating dietary patterns and lifestyles (Savage, Fisher, & Birch, 2007; Danesh et al., 2011; Black et al., 2013). Moreover, there is evidence that maternal overweight and obesity during pregnancy also increase the risk of childhood obesity (McGuire et al. 2010).

However, the effects of the nutrition transition on child nutritional status are far from settled. While weight gains are likely to a certain degree, children tend to be less prone to overweight than adults, because they are often physically more active. This is also reflected in much lower rates of childhood overweight and obesity around the world (UNICEF, WHO, & World Bank, 2012). In many developing countries, there is even a significant fraction of households with overweight mothers and underweight children, a phenomenon often referred to as dual-burden households (Doak et al., 2005).

There are also arguments why the nutrition transition may affect child growth in addition to weight. Especially in poor households with monotonous diets that are dominated by starchy staples, an increase in fat consumption may improve the supply of essential fatty acids and the absorption of fat-soluble vitamins (Prentice and Pau 2000; Brown et al. 1995; Biesalski 1997). Especially vitamin A is important for the child immune system; better supply reduces susceptibility to certain infectious diseases, which can contribute to more healthy body growth. A few studies have also shown that the spread of supermarkets may contribute to improved dietary quality and diversity in poor population segments (Rischke et al. 2015; Tessier et al. 2008). Even when the share of processed foods is increasing, a larger variety of foods may improve micronutrient supply, which is closely associated with child growth. A recent micro-level study in Kenya provided some preliminary evidence that purchasing in supermarkets increases height-for-age Z-scores among children and adolescents and reduces the probability of severe stunting (Kimenju et al. 2015).

We analyze the relationship between the nutrition transition and different indicators of child malnutrition using a cross-country approach, which has not been done previously.

Materials and Methods

To explore the relationship between the nutrition transition and child malnutrition we develop the following reduced-form panel data model that we estimate in a cross-country framework:

$$CM_{it} = \beta_0 + \beta_1 NT_{it} + \beta_2 \boldsymbol{X}_{it} + c_i + u_{it} \quad (1)$$

where CM_{it} is a measure of child malnutrition in country *i* and year *t*, NT_{it} is an indicator of the nutrition transition, and $\boldsymbol{X}_{it}$ is a vector of control variables that may also affect child malnutrition. Furthermore, c_i denotes unobserved effects, and u_{it} is the idiosyncratic error term.

We use child underweight, child overweight, and child stunting as different measures of child malnutrition for which we estimate separate models. In these models, we are particularly interested in the estimate for β_1, which tells us whether the nutrition transition has a positive, negative, or no effect on the particular measure of malnutrition. We use a panel data set with two or more observations per country, because we are interested to explain changes, not only levels of child malnutrition. Variable definitions and data sources are explained in the following.

(a) *Indicators of child malnutrition*

Commonly used indicators of child undernutrition are stunting, wasting, and underweight based on anthropometric measurements (Black et al. 2008). A stunted child has a low height-for-age, reflecting chronic hunger, while a wasted child has a low weight-for-height, reflecting acute weight loss. Underweight, which refers to a low weight-for-age, is used as a summary indicator, as it can result from a child being stunted or wasted. These indicators are determined with the help of Z-scores, measuring the distance (expressed in standard deviations) of an individual child from the median of a reference population (WHO 2006). With Z-scores of -2 or smaller, a child is classified as stunted, wasted, or underweight, depending on the particular indicator used (WHO, 2006). Here, we focus on stunting and underweight in children under five years of age, using data from Demographic and Health Surveys (DHS) that are available for many countries (ICF International 2012, 2013). DHS data are representative at the country level. As mentioned, underweight is the official MDG indicator for tracking progress to reduce child undernutrition.

In addition to undernutrition, overweight and obesity are other facets of child malnutrition that have been growing in importance (Black et al. 2013). A child is considered overweight if its weight-for-height is more than two standard deviations above the median of the reference population (WHO 2006; World Health Organization 2006). While rapid weight gain during the first 1000 days of life is considered beneficial for child health, there is evidence that excessive weight gain in children later on increases the risk of adult obesity and non-communicable diseases, especially for children who experienced undernutrition in early life (Victora et al. 2008). We focus on overweight in children below five years of age, using data from the World Development Indicators (WDI) (The World Bank 2014, December 23).

(b) *Indicators of the nutrition transition*

The nutrition transition is characterized by rapid changes in dietary habits towards more energy-dense, processed foods and a reduction in physical activity levels through more sedentary lifestyles (B. Popkin and Ng 2007). Unfortunately, data on these aspects are not readily available at the country level. In fact, it is not even clear what metrics could be used to measure stages of the nutrition transition. We use three different proxies that capture various aspects. None of these proxies may be a perfect indicator of the nutrition transition, but by using all three in separate models and comparing the estimation results we may get a better understanding of the true underlying relationships.

The first proxy that we use is average fat consumption per capita and day, for which we use data from the FAO food balance sheets (FAO, 2014). Fat contents from all foods available for human consumption were calculated and aggregated for the purpose of this analysis. An increase in fat consumption is a typical phenomenon of the nutrition transition. Research shows that – with westernizing diets – consumers get an increasing share of their calories from fats, while the relative importance of carbohydrates shrinks (B. Popkin and Ng 2007) This is mainly due to the rising consumption of animal-source foods, processed products, and convenience foods. Another possible dietary indicator of the nutrition transition could be the consumption of sugar, but unfortunately total sugar consumption in its various forms cannot be calculated from food balance sheets or other data sources at the country level.

The second proxy that we use for the nutrition transition is the share of modern retail in grocery sales. Modern retail covers supermarkets, but also other non-traditional retail outlets that are characteristic for globalizing food systems, such as hypermarkets and convenience stores (T. Reardon and Gulati 2008). In many developing countries, supermarkets and hypermarkets have spread so rapidly over the last 20 years that the term 'supermarket revolution' has been coined (T. Reardon et al. 2003). In large parts of Asia and Latin America, the share of modern retailers in grocery sales has increased from less than 10% in the early-1990s to over 50% today (Reardon & Gulati, 2008; Reardon, Timmer, & Minten, 2012; Planet Retail 2014). This trend is partly driven by foreign direct investments (FDI) of multinational retail chains, but in some developing countries domestic retailers are also growing. In Africa, the share of modern retail is still lower but also increasing rapidly.

The supermarket revolution is probably both a cause and a symptom of the nutrition transition in developing countries. In any case, the rise of supermarkets and other modern retail outlets is associated with changing lifestyles and higher consumption of processed foods (Popkin, 2006; Hawkes, 2008; Asfaw, 2008; Asfaw, 2011; Rischke et al. 2015)). Hence, the share of modern retail in grocery sales seem to be a suitable proxy for the nutrition transition. We use data from Planet Retail to construct this proxy (Planet Retail 2014). Planet Retail is a retail data services firm, tracking leading retailers at national level in more than 200 countries. While Planet Retail may not perfectly capture sales by small modern retailers, the overall trends seem to be represented quite well (T. Reardon et al. 2012). The share of modern retail in grocery sales refers to total grocery sales by modern retailers as a percentage of total market spending by consumers on grocery for a particular country and year (Planet Retail 2014). Total grocery sales comprise food, drinks, tobacco, household care, pet care, and health and beauty products. Data are available from 1994 onward.

The third proxy that we use for the nutrition transition is the prevalence of women overweight. As explained, the nutrition transition involves rising rates of overweight and obesity among adults, so that the prevalence among women can be considered a suitable outcome-based indicator. We focus on women for two reasons. First, women tend to be more affected by weight gain, so that rates of overweight and obesity are higher than for men (Jones-Smith et al., 2012; Roemling & Qaim, 2012). Second, the availability of anthropometric data is much better for women than for men. Many surveys include measurements for women of child-bearing age, but not for other adults in the household (Vollmer et al. 2014). We use data from DHS (ICF International 2013, 2012). Prevalence of women overweight refers to the proportion of women who are either overweight or obese, implying that they have a body mass index (BMI) greater than 25 kg/m^2 (World Health Organization 2000). DHS data are representative at the country level.

(c) *Control variables*

Child nutrition is also influenced by other variables, some of which may be correlated with the nutrition transition. Hence, we need to control for other relevant factors to avoid omitted variable bias when estimating the coefficients for the nutrition transition indicators. We use different sets of control variables in different specifications of equation (1), in order to see how robust the estimates for the nutrition transition indicators are.

A first control variable that we use is living standard, or economic growth. While empirical evidence of the role of economic growth for child nutrition is mixed (Smith & Haddad, 2002; (Smith and Haddad 2002; Heady 2013) (Vollmer et al. 2014), most cross-country studies suggest a negative relationship between growth and undernutrition. To control for possible effects of economic growth, we use per capita gross domestic product (GDP) expressed in 2005 international dollars (adjusted for purchasing power parity, PPP) from WDI (The World Bank 2014, December 23). A second control variable is female education. There is strong empirical evidence that the role of women in general, and maternal education in particular, are important factors in explaining child malnutrition (Desai and Alva 1998; Semba et al. 2008; Aslam and Kingdon 2012)Smith & Haddad, 2014). We use female literacy rates from DHS, referring to women of child-bearing age (ICF International 2013).

In addition to economic growth and female education, in some of the model specifications we also include other controls. We use the prevalence of undernourishment as a proxy for the overall situation of food availability and food security in the country. These data, which are included in WDI, are based on the FAO method of measuring hunger. This method does not refer to children in particular, but uses country level average numbers of calorie supply and minimum consumption requirements in the population (de Haen, Klasen, & Qaim, 2011). Calorie availability and access are important determinants of child nutritional status (Ali et al. 2013; Psaki et al. 2012). Furthermore, we control for sanitation conditions, which are also important for explaining child nutrition (Fink, Günther, & Hill, 2011; Smith & Haddad, 2014). The variable 'improved sanitation conditions' refers to the proportion of the population with access to flush toilets or protected pit latrines (World Bank, 2014).

For the models with child overweight as dependent variable, we additionally include urbanization as a control variable (World Bank, 2014). The literature shows that overweight and obesity are more prevalent in urban areas, where average levels of physical activity are lower and the food environment is different from rural areas (B. M. Popkin and Gordon-Larsen 2004). In some of the models with 'modern retail in grocery sales' used as an indicator of the nutrition transition, we further control for country openness, measured as the value of exports and imports relative to the country's GDP (World Bank, 2014). Country openness may have a direct effect on nutrition, as trade and trade policies can affect the prices and availability of food and other goods and services. In addition, country openness may encourage FDI by multinational food companies and retail chains (Hawkes, Chopra, & Friel, 2009). Hence not controlling for openness might lead to biased estimates for the nutrition transition effect on child malnutrition.

(d) *Sample size and missing data*

We combine country level data from DHS, WDI, FAO, and Planet Retail. The total sample size is limited mainly by the child undernutrition indicators. Though DHS were carried out in many countries, they are not available for all countries (ICF International, 2013; 2014). Moreover, as we need panel data to explain changes in child malnutrition, we could only use countries for which at least two rounds of DHS data were available. In some cases, data were not available from the official DHS website (ICF International, 2013), but could be obtained through WDI. Similarly, a few observations for women overweight and female literacy that were not available from the DHS website could be obtained from WDI, and in some cases from Index Mundi (2014).

The available data on rates of child malnutrition were merged with the data for the explanatory variables from different sources. Whenever data for individual variables were missing for a particular year, we tried to replace with data from the previous or next year, or at maximum with data from two years earlier or later. This was necessary, because WDI and Planet Retail also have frequent data gaps for relevant variables. In total, we managed to compile a sample with 109 observations from 41 developing countries, covering the time period 1996 to 2012. Even in this sample, some of the variables have missing data. Hence, most of the regression models use fewer than 109 observations. The actual number of observations used for each model is presented below together with the estimation results.

(e) *Panel estimators*

Common methods to estimate the panel model in equation (1) are either fixed or random effects estimators. The choice between these two estimators depends on how c_i is interpreted. The fixed effects estimator treats unobserved country-specific effects as parameters to be estimated. This means that unbiased estimation results can be obtained even if unobserved effects are correlated with the explanatory variables of interest. The random effects estimator is more efficient but assumes that unobserved effects are not correlated with explanatory variables. Hence, c_i is treated as a random error, giving rise to a composite error ($c_i + u_{it}$). Whether or not c_i is correlated with observed explanatory variables is the criterion for choosing between random and fixed effects estimators. This is analyzed with the Hausman test (Hausman 1978). Whenever the Hausman test fails to reject the null hypothesis of zero correlation, we use random effects, otherwise we use fixed effects estimators. For robustness checks however, we also report results of fixed effects estimator for all models.

Results

Distributions of the three indicators of child malnutrition in our sample are shown in Figures A1 to A3 in the Appendix. The sample mean rate for stunting is 34%, as compared to 16% for underweight, and 6.6% for overweight. These rates are reasonable for developing countries as a whole for the considered time period. As expected, child stunting and underweight have decreased over time, while child overweight has increased.

In the following, we present the results of the cross-country regression models with different specifications. The estimation results are presented in two subsections. First, we look at the effect of the nutrition transition on child weight, using the underweight and overweight indicators. As explained, the existing literature assumes that the nutrition transition reduces child underweight and increases overweight. Second, we analyze the effect on child growth. Several authors have argued that the nutrition transition does not contribute to growth in children, which could be one reason why child stunting is more persistent than underweight.

(a) *The nutrition transition and child weight*

We start by examining the association between our three nutrition transition indicators and child weight without controlling for any other factors. Table 1 shows these first sets of regression results for child overweight and underweight. Two of the nutrition transition indicators – fat consumption and women overweight – have a significantly positive association and with child overweight. Yet, the third nutrition transition indicator – share of modern retail in grocery sales – has a negative, but insignificant association. For underweight, we find significantly negative associations, regardless of which nutrition transition indicator is used.

Table 1. Association between nutrition transition indicators and child overweight and underweight

	Child overweight (%)			Underweight (%)		
	RE	RE	RE	RE	RE	RE
Fat consumption	0.093***			-0.324***		
(g/capita/day)	(0.03)			(0.05)		
Share of modern retail in		-0.238			-1.816***	
grocery sales (log)		(0.24)			(0.24)	
Women overweight (%)			0.102***			-0.477***
			(0.02)			(0.05)
Constant	1.805	7.351***	3.241***	33.608***	14.011***	30.637***
	(1.69)	(0.93)	(0.78)	(3.13)	(1.48)	(1.72)
Observations	101	69	82	109	76	88
Chi-squared	9.794***	1.018	17.810***	37.284***	56.965***	88.000***
Hausman test statistic	0.01	0.08	0.37	0.31	0.03	0.00

Notes: Coefficient estimates are shown with standard errors in parentheses. RE, random effects estimator.
*, **,***, statistically significant at the 10%, 5%, and 1%, level respectively.

Table 2 shows estimation results with only overweight used as dependent variable and different sets of control variables. When we use fat consumption as the nutrition transition indicator, the effect remains insignificant, regardless of the controls included. The results shown refer to models that do not include year dummies to save degrees of freedom. However, we also estimated the same models with year dummies; in the Table we indicate for each specification whether the nutrition transition effect is significant when year dummies are included. The effect on overweight remains insignificant with fat consumption used as the indicator. Somewhat surprisingly, we observe a significantly negative effect when we use 'share of modern retail in grocery sales' as the nutrition transition indicator and only control for GDP and female literacy. Yet, the effect turns insignificant with additional control variables added. Only for the women overweight indicator, we find significantly positive effects of the nutrition transition on child overweight. This effect also holds when we control for period effects (year dummies).

Table 2. Effect of the nutrition transition on child overweight

	RE	RE	RE	RE	RE	RE
Fat consumption	0.028	-0.023				
(g/capita/day)	(0.04)	(0.04)				
Share of modern retail in			-0.613**	-0.150		
grocery sales (log)			(0.25)	(0.28)		
Women overweight (%)					0.132***	0.142***
					(0.04)	(0.04)
GDP per capita, PPP (log)	1.560	4.302***	3.375***	4.981***	-0.817	1.183
	(1.18)	(1.41)	(1.21)	(1.58)	(0.91)	(1.63)
Female literacy (%)	0.012	-0.047	0.027	-0.051	-0.004	-0.025
	(0.03)	(0.03)	(0.05)	(0.05)	(0.02)	(0.03)
Undernourished (%)		0.024		0.015		0.037
		(0.05)		(0.07)		(0.05)
Urbanization (%)		-0.070		-0.156		-0.142
		(0.09)		(0.11)		(0.09)
Trade (% of GDP)				-0.011		
				(0.02)		
Constant	-7.842	-22.307**	-21.277**	-26.008**	8.909	-4.006
	(6.79)	(9.03)	(8.39)	(11.65)	(5.78)	(10.80)
NT effect significant with year dummies	No	No	Yes	No	Yes	Yes
Observations	95	77	69	60	78	64
Chi-squared	9.813***	15.337***	13.584***	13.599**	18.347***	19.985***
Hausman test statistic	1.05	6.21	6.05	8.94	3.49	3.54

Notes: The dependent variable in all models is child overweight expressed in percent. Coefficient estimates are shown with standard errors in parentheses. RE, random effects estimator. NT, nutrition transition.
*, **,***, statistically significant at the 10%, 5%, and 1%, level respectively.

For child underweight, we find more consistent effects (Table 3). Two of the nutrition transition indicators – fat consumption and share of modern retail in grocery sales – show negative and significant impacts on underweight. Mostly, these effects remain robust also when controlling for year dummies. The third nutrition transition indicator – women overweight – does not produce significant coefficients when not controlling for period effects. However, with year dummies added, these effects turn significant, with negative signs as expected. We interpret these findings as confirmation of the hypothesis that the nutrition transition reduced child underweight.

Table 3. Effect of the nutrition transition on child underweight

	RE	RE	RE	RE	FE	FE
Fat consumption (g/capita/day)	-0.168***	-0.156**				
	(0.06)	(0.07)				
Share of modern retail in grocery sales (log)			-1.396***	-1.380***		
			(0.25)	(0.26)		
Women overweight (%)					-0.139	-0.128
					(0.13)	(0.13)
GDP per capita, PPP (log)	-4.219**	-4.032*	-4.469***	-3.457	-6.551**	-6.071*
	(1.74)	(2.22)	(1.52)	(2.13)	(2.73)	(3.40)
Female literacy (%)	-0.186***	-0.165***	-0.043	-0.035	-0.257***	-0.253**
	(0.05)	(0.06)	(0.07)	(0.07)	(0.08)	(0.11)
Undernourished (%)		-0.002		-0.032		0.108
		(0.09)		(0.09)		(0.12)
Improved sanitation facilities (%)		-0.038		-0.069		0.054
		(0.07)		(0.07)		(0.20)
Trade (% of GDP)				-0.000		
				(0.02)		
Constant	71.078***	69.448***	52.634***	48.506***	88.246***	79.155***
	(10.28)	(14.70)	(10.55)	(14.79)	(16.79)	(22.52)
NT effect significant with year dummies	Yes	No	Yes	Yes	Yes	Yes
Observations	103	101	76	76	84	82
F statistic					22.099***	12.434***
Chi-squared	94.359***	88.838***	79.190***	77.757***		
Hausman test statistic	5.32	7.25	0.31	2.21	19.36***	26.85***

Notes: The dependent variable in all models is child underweight expressed in percent. Coefficient estimates are shown with standard errors in parentheses. RE, random effects estimator. FE, fixed effects estimator. NT, nutrition transition. *, **,***, statistically significant at the 10%, 5%, and 1%, level respectively.

(b) *The nutrition transition and child growth*

We now examine whether the nutrition transition has any effect on child stunting. Table 4 shows associations without any control variables included. All three indicators of the nutrition transition have a negative association with stunting. This might not surprise, because the nutrition transition indicators are correlated with economic growth, female education, and possibly other variables, so that the effects may be biased when not controlling for these other factors.

Table 4. Association between nutrition transition indicators and child stunting

	RE	RE	FE
Fat consumption (g/capita/day)	-0.412***		
	(0.06)		
Share of modern retail in grocery sales (log)		-1.671***	
		(0.43)	
Women overweight (%)			-0.876***
			(0.12)
Constant	55.599***	32.299***	59.465***
	(3.31)	(2.11)	(3.40)
Observations	109	76	88
F statistic			51.700***
Chi-squared	50.426***	14.761***	
Hausman test statistic	0.86	0.00	8.80***

Notes: The dependent variable in all models is child stunting expressed in percent. Coefficient estimates are shown with standard errors in parentheses. RE, random effects estimator. FE, fixed effects estimator.
*, **,***, statistically significant at the 10%, 5%, and 1%, level respectively.

However, the results in Table 5 suggest that the nutrition transition reduces child stunting even when controlling for economic growth, female literacy, and other variables. This holds true for all three nutrition transition indicators. Most coefficients remain significant even when including year dummies. Hence, the common hypothesis that the nutrition transition does not contribute to child growth may be wrong.

Table 5. Effect of the nutrition transition on child stunting

	RE	RE	RE	RE	FE	FE
Fat consumption	-0.242***	-0.244***				
(g/capita/day)	(0.07)	(0.08)				
Share of modern retail in			-0.847*	-0.985**		
grocery sales (log)			(0.45)	(0.48)		
Women overweight (%)					-0.654***	-0.638***
					(0.18)	(0.18)
GDP per capita, PPP	-5.290***	-4.809*	-8.997***	-5.988*	-1.174	-0.887
(log)	(2.03)	(2.54)	(2.21)	(3.13)	(3.81)	(4.72)
Female literacy (%)	-0.113*	-0.112*	-0.009	-0.016	-0.285**	-0.272*
	(0.06)	(0.06)	(0.10)	(0.10)	(0.11)	(0.15)
Undernourished (%)		0.090		0.220		0.150
		(0.10)		(0.15)		(0.17)
Improved sanitation		0.026		-0.039		0.088
facilities (%)		(0.07)		(0.09)		(0.28)
Trade (% of GDP)				0.016		
				(0.04)		
Constant	95.477***	88.764***	104.206***	77.525***	81.329***	70.653**
	(11.62)	(16.46)	(15.07)	(22.04)	(23.44)	(31.32)
NT effect significant with year dummies	Yes	Yes	No	No	Yes	Yes
Observations	103	101	76	76	84	82
F statistic					18.593***	10.388***
Chi-squared	90.795***	86.588***	39.852***	43.336***		
Hausman test statistic	3.07	3.02	1.56	2.58	16.71***	13.94**

Notes: The dependent variable in all models is child stunting expressed in percent. Coefficient estimates are shown with standard errors in parentheses. RE, random effects estimator. FE, fixed effects estimator. NT, nutrition transition. *, **,***, statistically significant at the 10%, 5%, and 1%, level respectively.

Discussion and Conclusion

We have analyzed how the nutrition transition, which involves a westernization of diets and increased consumption of calorie-dense, processed foods, affects child malnutrition in developing countries. In the existing literature, it is often assumed that the nutrition transition affects child weight but not child growth. Hence, the nutrition transition is mentioned as one possible reason why rates of child underweight have decreased more rapidly over the last 25 years than rates of child stunting (Misselhorn, 2010; de Haen, Klasen, & Qaim, 2011; Haddad, 2013). The nutrition transition might possibly also contribute to child overweight. Yet, such kinds of relationships have hardly been analyzed empirically.

We have compiled cross-country panel data from various sources to estimate regression models with different specifications and using different indicators for the nutrition transition. A first set of regressions looked at the effects on child overweight with mixed results. While in some specifications, the nutrition transition indicators had a positive and significant effect on child overweight, in other specifications the effects were insignificant or even negative. Previous research showed that the nutrition transition clearly contributes to overweight and obesity in adults (Popkin, 2006; Swinburn et al., 2011; Popkin, Adair, & Ng, 2012). We conclude that this relationship may be less pronounced in children, which may partly be explained by higher average levels of physical activity and an energy metabolism that differs between children and adults. This does not mean that changing diets and lifestyles would not contribute to overweight in children that are sufficiently supplied with calories. But in many developing countries, child undernutrition is still more widespread. With the aggregate data used here differences between population segments within countries cannot be analyzed.

In a second set of regressions, we examined the effects on child underweight. In most specifications, we found that the nutrition transition contributes to reducing underweight in children, as expected. A third set of regressions looked at the effect on child stunting. Contrary to expectations voiced in the literature, the nutrition transition seems to influence child growth positively, thus reducing the prevalence of stunting. This effect is observed across the different nutrition transition indicators. It also remains robust after controlling for other factors that are known to influence child stunting, such as average living standard, female education, sanitation conditions, and the overall situation of food security in the country.

These results are consistent with one micro-level study that was recently carried out in Kenya. In that study, (Kimenju et al. 2015) found that an increase in the consumption of processed foods purchased in supermarkets did not lead to higher rates of overweight among children and adolescents, but was associated with higher height-for-age Z-scores and reduced rates of severe stunting. The mechanisms for this negative relationship between the nutrition transition and child stunting are not entirely clear and deserve further research with micro-level data. It appears that the nutrition transition – with cheaper access to a variety of processed foods – may contribute to increased dietary diversity and improved micronutrient supply in poor households. In richer households, with more healthy and diverse diets as the starting basis, the same shift towards processed foods may decrease dietary quality. It may be argued that stunting in younger children would be less affected by the nutrition transition, because these children are either breastfed or provided with special child food. While this is true to some extent, household food and dietary conditions, and the nutritional status of mothers in particular, certainly play an important role for child nutrition.

For robustness check, we also report results of fixed effect estimations for all regressions (Tables A1 to A5 in the appendix). Despite a few differences here and there, the results of these estimations are largely similar.

Our study has a couple of limitations. First, the cross-country approach may be useful to study general relationships, but it is not very suitable to analyze the mechanisms underlying the observed effects. Second, the nutrition transition is difficult to measure, especially at the aggregate level. With our three indicators – fat consumption, share of modern retail in grocery sales, and women overweight rates – we have proxied for typical consumption shifts and symptoms of the nutrition transition, but the variables remain imperfect. Third, our panel data set is relatively small. Although we tried hard to get as many observations as possible, missing data for important variables mean that the model estimates build on limited samples. Against this background, the results obtained should not be interpreted as conclusive evidence. What we can conclude is that the nutrition transition in developing countries has diverse nutritional implications for children, not all of which seem to be negative. Further details will have to be analyzed in follow-up research.

Acknowledgement

This research was financially supported by the German Research Foundation (DFG).

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Appendix

Table A1. Association between nutrition transition indicators and child overweight and underweight, FE models

	Child overweight (%)			Underweight (%)		
	FE	FE	FE	FE	FE	FE
Fat supply quantity (g/capita/day)	0.097*			-0.353***		
	(0.05)			(0.07)		
Share of modern retail in grocery sales (log)		-0.205			-1.802***	
		(0.26)			(0.25)	
Women overweight %			0.057			-0.473***
			(0.08)			(0.10)
Constant	1.673	7.417***	4.590**	34.178***	13.711***	30.353***
	(2.48)	(0.26)	(2.06)	(3.82)	(0.26)	(2.89)
Observations	101	69	82	109	76	88
F statistic	3.994***	0.607	0.520	22.440***	51.231***	20.864***

Notes: Coefficient estimates are shown with standard errors in parentheses. FE, fixed effects estimator.
*, **,***, statistically significant at the 10%, 5%, and 1%, level respectively.

Table A2. Effect of the nutrition transition on child overweight, FE models

	FE	FE	FE	FE	FE	FE
Fat supply quantity (g/capita/day)	0.017	0.081				
	(0.08)	(0.07)				
Share of modern retail in grocery sales (log)			-0.772**	-0.205		
			(0.29)	(0.34)		
Women overweight %					-0.058	-0.052
					(0.12)	(0.14)
GDP per capita, PPP (log)	3.011	5.953**	6.980***	9.250***	1.587	2.718
	(1.99)	(2.33)	(2.07)	(2.52)	(2.39)	(3.54)
Female literacy %	-0.030	-0.150	0.003	-0.088	0.029	0.016
	(0.07)	(0.09)	(0.09)	(0.11)	(0.07)	(0.13)
Undernourished %		0.058		-0.029		0.027
		(0.10)		(0.12)		(0.10)
Population in urban agglomerations (% of total population)		-0.244		-0.425		-0.273
		(0.28)		(0.32)		(0.31)
Trade (% of GDP)				-0.028		
				(0.03)		
Constant	-15.392	-31.387*	-47.656***	-50.270**	-6.268	-10.655
	(12.31)	(16.24)	(14.83)	(19.09)	(14.53)	(22.46)
NT effect significant with year dummies	No	No	Yes	No	No	No
Observations	95	77	69	60	78	64
F statistic	1.342	2.780***	4.862***	3.321***	0.446	0.487

Notes: The dependent variable in all models is child overweight expressed in percent. Coefficient estimates are shown with standard errors in parentheses. FE, fixed effects estimator. NT, nutrition transition. *, **,***, statistically significant at the 10%, 5%, and 1%, level respectively.

Table A3. Effect of the nutrition transition on child underweight, FE models

Notes: The dependent variable in all models is child underweight expressed in percent. Coefficient estimates are

	FE	FE	FE	FE	FE	FE
Fat supply quantity (g/capita/day)	-0.178*	-0.168*				
	(0.09)	(0.10)				
Share of modern retail in grocery sales (log)			-1.430***	-1.481***		
			(0.28)	(0.30)		
Women overweight %					-0.139	-0.128
					(0.13)	(0.13)
GDP per capita, PPP (log)	-6.488***	-5.041	-3.995*	-6.097*	-6.551**	-6.071*
	(2.30)	(3.08)	(2.21)	(3.17)	(2.73)	(3.40)
Female literacy %	-0.215***	-0.162*	-0.072	-0.102	-0.257***	-0.253**
	(0.08)	(0.10)	(0.10)	(0.11)	(0.08)	(0.11)
Undernourished %		0.021		-0.061		0.108
		(0.12)		(0.12)		(0.12)
Improved sanitation facilities %		-0.125		0.105		0.054
		(0.17)		(0.16)		(0.20)
Trade (% of GDP)				0.009		
				(0.03)		
Constant	90.762***	81.038***	50.990***	64.842***	88.246***	79.155***
	(14.50)	(20.61)	(15.64)	(21.84)	(16.79)	(22.52)
NT effect significant with year dummies	No	No	Yes	Yes	Yes	Yes
Observations	103	101	76	76	84	82
F statistic	22.628***	13.017***	20.826***	10.081***	22.099***	12.434***

shown with standard errors in parentheses.

FE, fixed effects estimator. NT, nutrition transition. *, **,***, statistically significant at the 10%, 5%, and 1%, level respectively.

Table A4. Association between nutrition transition indicators and child stunting, FE models

	FE	FE	FE
Fat supply quantity (g/capita/day)	-0.327***		
	(0.11)		
Share of modern retail in grocery sales (log)		-1.673***	
		(0.47)	
Women overweight %			-0.876***
			(0.12)
Constant	50.727***	32.549***	59.465***
	(5.58)	(0.49)	(3.40)
Observations	109	76	88
F statistic	9.061***	12.850***	51.700***

Notes: The dependent variable in all models is child stunting expressed in percent.
Coefficient estimates are shown with standard errors in parentheses. FE, fixed effects estimator.
*, **,***, statistically significant at the 10%, 5%, and 1%, level respectively.

Table A5. Effect of the nutrition transition on child stunting, FE models

	FE	FE	FE	FE	FE	FE
Fat supply quantity (g/capita/day)	-0.149	-0.135				
Share of modern retail in grocery sales (log)			-1.189**	-1.221**		
			(0.54)	(0.58)		
Women overweight %					-0.654***	-0.638***
					(0.18)	(0.18)
	(0.14)	(0.15)				
GDP per capita, PPP (log)	-6.038*	-3.094	-5.588	-5.274	-1.174	-0.887
	(3.52)	(4.68)	(4.25)	(6.07)	(3.81)	(4.72)
Female literacy %	-0.282**	-0.185	-0.068	-0.092	-0.285**	-0.272*
	(0.12)	(0.15)	(0.19)	(0.21)	(0.11)	(0.15)
Undernourished %		0.100		0.041		0.150
		(0.18)		(0.22)		(0.17)
Improved sanitation facilities %		-0.195		-0.093		0.088
		(0.26)		(0.31)		(0.28)
Trade (% of GDP)				0.052		
				(0.06)		
Constant	108.345***	85.698***	82.166***	82.258*	81.329***	70.653**
	(22.18)	(31.30)	(30.03)	(41.88)	(23.44)	(31.32)
NT effect significant with year dummies	No	No	Yes	Yes	Yes	Yes
Observations	103	101	76	76	84	82
F statistic	10.474***	6.156***	5.339***	2.732***	18.593***	10.388***

Notes: The dependent variable in all models is child stunting expressed in percent. Coefficient estimates are shown with standard errors in parentheses.

FE, fixed effects estimator. NT, nutrition transition. *, **,***, statistically significant at the 10%, 5%, and 1%, level respectively.

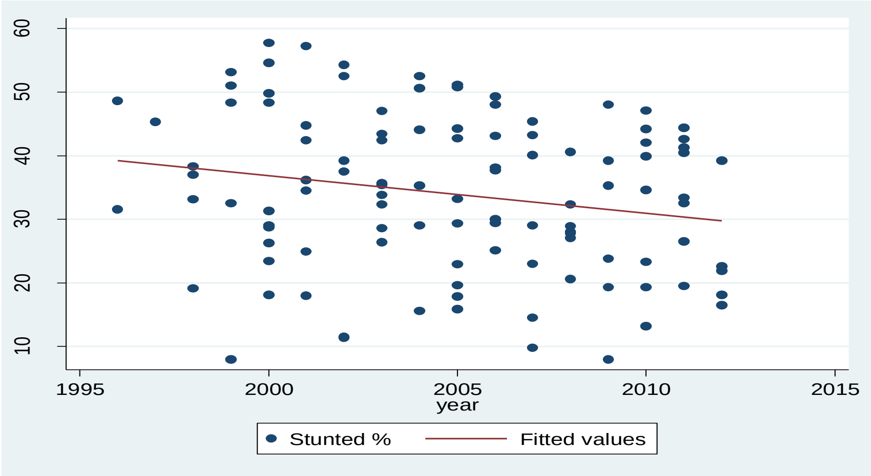

Fig A1. Prevalence of child stunting over time

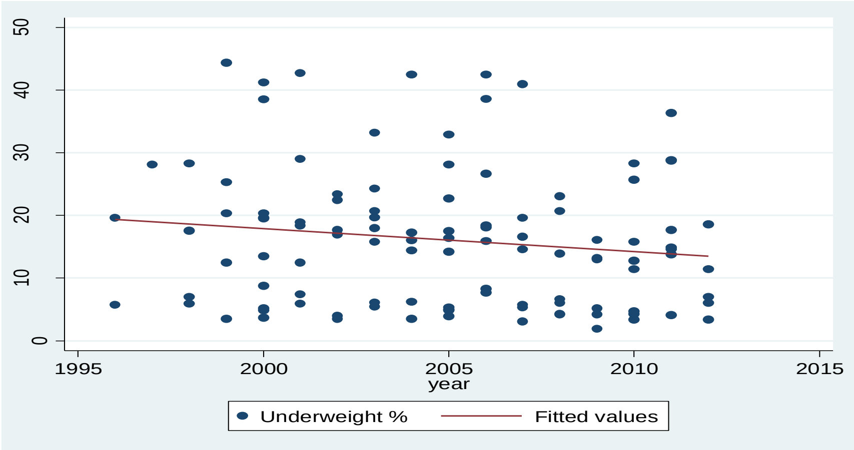

Figure A2. Prevalence of underweight over time

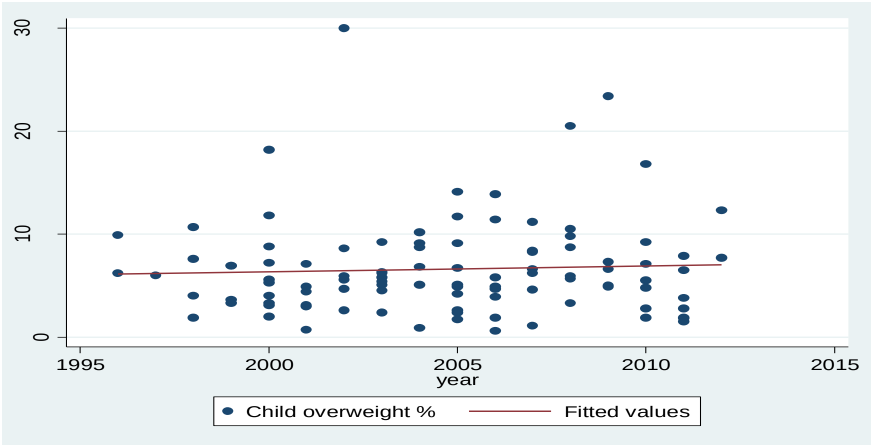

Fig A3. Prevalence of child overweight over time