A Tax on Children? Food Price Inflation and Health

Andinet Woldemichael, Daniel Kidane and Abebe Shimeles

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Abstract

Using a high-frequency local market price data from Ethiopia, we estimate the effects of exposure to food price inflation during “early life”—inception to the first 24 months after birth—on children’s health. Our analysis focuses on three major staple cereals. The results show that exposure to food price inflation while in utero and during infancy has detrimental and long-term impacts on children’s heights and weights. For instance, exposure to 10 percent inflation in teff prices in the 5–6th month of infancy, during which transition to complementary feeding starts, results in a loss of up to 0.08 centimeters of height and 5 grams of weight. Due to the complicated biological mechanisms and other factors through which malnutrition affects growth during “early life,” the effects vary considerably, depending on the specific month of exposure. Furthermore, we detect some heterogeneity along observed factors.

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A Tax on Children? Food Price Inflation and Health ¹

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JEL Classification: D13, E31, I10, I15

Keywords: In utero; Height; Weight; Stunting; Wasting; Underweight; Macroeconomic instability.

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1 Introduction

The impacts of headline-grabbing nutritional shocks, such as famine and drought, on child health are well recognized, and policy responses are relatively speedy through emergency food aid and other interventions. What is less understood is the long-term consequences of frequent malnutrition and seasonal hunger that results from exposure to high food price inflation. Evidence from biomedical and pediatric literature shows that the right nutrition during pregnancy and in the first 1,000 days is critical for brain development, physical growth, and the development of a strong immune system.\(^1\) Furthermore, the effects of malnutrition experienced during “early life”—between inception and the first 1,000 days—during which growth is accelerated, are particularly the most difficult ones to reverse through remediation.

Evidence shows that intrauterine stimulus and insults, commonly referred to as fetal programming or fetal origin, and shocks experienced during early childhood have lasting consequences on many later-life outcomes such as health, education and skills formation, labor market outcomes, and social behavior (Godfrey and Barker, 2000; Behrman and Rosenzweig, 2004; Cunha and Heckman, 2007; Case and Paxson, 2008; Hoddinott et al., 2008; Currie, 2009; Case and Paxson, 2010; Currie and Almond, 2011; Hoddinott et al., 2013). The most important in utero shocks include fetal malnutrition and infection, economic shocks such as recession, exposure to pollution, conflict, and weather shocks, which result in fetal programming with lifelong consequences (Currie and Almond, 2011). Similarly, exposure to factors in the home environment, such as maternal mental health or substance abuse, maternal employment, child abuse/foster care, toxins and pollution, are important childhood shocks, which are found to have lasting impacts on human capital, skills formation, and social behavior (Nilsson, 2009; Currie and Almond, 2011).

In 2014, about 169 million children under 5 years of age were stunted, and 51 million were wasted worldwide (Haddad et al., 2015). The problem of childhood malnutrition is even bigger for African countries below the Sahara. Although the proportion is trending downwards, where the proportion of under-five stunting declined for sub-Saharan African countries from 49 percent in 1990 to 35 percent in 2015, the absolute number has risen from 45 million in 1990 to 60 million during the same period (UNICEF et al., 2016). Cognizant of the detrimental impacts of malnutrition and the failure of market to correct the problem, the international community put forth a concerted effort to eradicate extreme hunger and poverty under the now defunct Millennium Development Goal #1 (MDG1) and to end hunger and all forms of malnutrition by 2030 under the Sustainable Development Goals #2 (SGD2). In order to achieve these ambitious global goals, determining whether high levels of malnutrition can be attributed, in part, to unfavorable initial conditions, such as exposure to high food price inflation during “early life,”

\(^1\)http://thousanddays.org/the-issue/why-1000-days/
is paramount.

In this study, we investigate the effects of exposure to food price inflation during the critical periods of “early life” on children’s health outcomes in Ethiopia. We examine the effects on key indicators of child health and nutritional outcomes: weight-for-age (underweight), height-for-age (stunting), and weight-for-height (wasting), which are good predictors of morbidity and mortality for under-five children.\(^2\) The study exploits the exogenous nature of food price hikes to identify the causal effects. We construct a rich set of data using three rounds of the Ethiopian Demographic and Health Survey (DHS) and high-frequency (monthly) market-level retail price data collected over 15 years (1996–2012). Our data construct is rich, in the sense that it combines detailed area-level monthly food price inflation data matched with each month of “early life.” The DHS data covers about 23,000 under-five children, whereas the monthly retail market price survey covers 119 nationally representative markets and thousands of commodities throughout the country. We merged the two datasets using a GIS-based nearest neighbor matching algorithm, which is then triangulated to each child’s months of “early life” from inception to the 24th month after birth.

Our approach, which looks at exposure to high food price inflation at different months of “early life” is particularly relevant, because nutritional shocks at different stages of growth—trimesters of the fetus, infancy, and toddlerhood—can have varying degrees of impacts. This is owing to the complicated and heterogeneous biological mechanisms through which nutrition affects growth. For instance, pregnant women may naturally find themselves avoiding food (for example, due to nausea and vomiting) during the embryonic phase, or experiencing cravings in the third trimester when fetal growth is accelerated. Our study not only addresses such heterogeneity arising from complicated biological processes but also uncovers the most important periods of “early life,” during which exposure to food price inflation has the biggest impact.

Our focus on Ethiopia is motivated by two factors. First, although Ethiopia had had mild inflationary episodes in the past, the food price inflation experienced in the second half of the 2000s was unprecedented. The overall inflation sharply rose from 15.1 percent in June 2007 to a historic peak of 55.3 percent in June 2008 (Admassie, 2013). During the same period, food price inflation, which accounts for more than 50 percent of the Consumer Price Index (CPI) consumption basket, rose from 18.2 percent to 91.7 percent (CSA, 2009). The level of inflation during this period was even higher for major staple crops; teff, wheat and maize which account for more than 50 percent of the total daily calorie intake (Rashid, 2010). Between 2008 and 2009, the month-on-month inflation levels of these staple crops were well above 100% during this period.\(^2\) Stunting, or low height-for-age, is caused by long-term insufficient nutrition intake and frequent infections, occurring before age 2, and effects are largely irreversible. These include delayed motor development, impaired cognitive function and poor school performance. Wasting, or low weight-for-height, is a strong predictor of mortality among under-five children. It is usually the result of acute shortage of food and/or disease (UNICEF, 2007).
Second, despite some progress in reducing childhood malnutrition in Ethiopia, the level of malnutrition remains unacceptably high. For instance, in year 2010, every other child under the age of 5 is too short for her age (stunted); 1 in 3 is underweight; and 1 in 10 do not weight enough for her age (wasted) (CSA and IFC-Int, 2012). See Figure 2. Such high and persistent malnutrition rates could be attributed to frequent malnutrition experienced during the critical periods of child growth. This paper provides evidence on whether food price inflation has undermined some of the progress made thus far in reducing childhood malnutrition.

We find that food price inflation has detrimental and long-term consequences on children’s health, especially when the children are exposed while in utero and during infancy. Our analysis shows that children who were exposed to 10 percent inflation in these cereals when they were 5–6 months, during which transition to complementary feeding starts, lose up to 0.08 centimeters of height and up to 5 grams of weight. Similarly, we find that exposure to 10 percent inflation while in utero increases the likelihood of childhood stunting and underweight by up to 0.6 percent. Owing to the complicated mechanisms through which nutrition affects growth during “early life”, there is however significant level of heterogeneity in the effects depending on the specific month of exposure. Furthermore, the effects vary depending on the type of cereal, with the effects of teff price inflation are much pronounced than for wheat and maize. The effects also vary by gender, wealth, location of residence, and remedial interventions such as vitamin A supplementation.
The results highlight that the detrimental consequences of macroeconomic instability, such as inflation, are not only limited to the standard macroeconomic indicators that experts keep a tab on, but also on key individual-level outcomes, particularly, of the most vulnerable members of society: children’s health. What is alarming is that the effects are not just short-term or transitory, but potentially lifelong, determining their future health, educational achievement, job market, family formation, social behavior, and a host of other life-course outcomes. The results also shed light on the heterogeneous impacts of frequent malnutrition due to exposure to food price inflation, in that exposure while in utero and during infancy are more consequential.

Although our focus is on Ethiopia, the findings shed some light on how exposure to food price inflation during the critical periods of “early life” affects children’s growth in other developing countries. Given that the weight of food in the CPI consumption basket is higher than 50 percent in most low-income countries and households spend significant proportions of their incomes on food, the impacts of food price hikes are far reaching (Durevall et al., 2013). In fact, many countries across Africa and other low-income regions of the world experienced higher food price inflation, particularly in 2008 and 2009, which affected staple foods such as rice, maize, and wheat, and the crisis triggered several emergency food aid, in some, cases riots.

This study also contributes to the existing literature and provides policy-relevant evidence. In light of the resource constraints that low-income countries face, the findings also can help formulate well-targeted policies to alleviate malnutrition during the specific periods of “early life” and inflationary episodes. In times of high inflationary episodes, for instance, inflation-targeted nutrition programs could be put in place to help pregnant women, infants, and children. Such targeted interventions are common in developed countries. In the United States, for instance, programs such as the Special Nutrition Program for Women, Infants, and Children (WIC) provides supplemental foods, health care referrals, and nutrition education for low-income preg-
nant, breastfeeding, and non-breastfeeding women, and to infants and children up to age 5 who are at nutritional risk. Although in resource poor countries, neither implementing such wide-scale interventions nor waiting for the market to correct the problem of malnutrition are realistic, targeting malnutrition experienced in utero and during infancy could reduce the long-term consequences of malnutrition.

Furthermore, the study contributes to the policy discourse surrounding inclusive and sustainable growth in Africa, providing specific evidence on the detrimental consequences of food price inflation on children’s health, particularly in countries that grapple with growth-induced inflationary episodes. If low-income countries in Africa and elsewhere are to achieve the SDGs, nutritional goals, it is imperative to tackle the frequent incidence of “early life” malnutrition due to high food price inflation.

The rest of the paper is organized as follows. Section 2 reviews the relevant literature, Section 3 and Section 4 presents the data and empirical framework, respectively. Section 5 discusses the results, and Section 6 concludes the paper.

2 Literature Review

Recently, studies analyzed the impact of macroeconomic shocks on a wide range of children’s health outcomes in different low-income settings. Arndt et al. (2016) investigated the impact of the 2008–2009 food price inflation on child nutritional outcomes in Mozambique, where food price hikes have contributed to the prevalence of underweight children. Particularly, they find that the prevalence of underweight children falls by about 40 percent during the period when food price inflation was low, compared to the period when it was high.

Considering a variety of outcomes, Cogneau and Jedwab (2012) investigated the impact of the 1990 cocoa price shocks on children school enrollment, labor, height stature and sickness in Côte d’Ivoire and find that children in cocoa-producing households, experiencing an income shock in 1990 due to a drastic cut in cocoa prices, were substantially impacted by the shock on the four outcome variables. Looking at the long-term consequences of early childhood malnutrition using a panel dataset from Zimbabwe, Alderman et al. (2006) also find that exposure to the 1982–1984 drought as a preschooler resulted in a loss of 2.3 cm in stature, a delayed start in schooling by 3.7 months, and a 0.4 loss in completed grade. In another study, Akresh and Verwimp (2006) explain the impact of crop failure and civil war on child health using a 1992 panel data set in Rwanda. While they find no impact on the health status of boys, they find evidence that the exogenous shocks have a significant impact on girls, in that height-for-age z-scores of girls born in the region after experiencing a crisis are 0.72 standard deviations lower and the impact is worse among poor households.
In a similar study, Yamano et al. (2005) explored the impact of exposure to malnutrition on early child growth due to crop damage and the effectiveness of food aid in reversing the negative impacts in Ethiopia. They find that crop failure leads to impeded child growth, in which they find a loss of growth of about 0.9 cm over a 6-month period, compared to areas where crop loss was 50 percentage points less. They also pointed out that food aid plays a positive role in offsetting the detrimental consequences, even when aid has not been well targeted. More recently, building on Alderman et al. (2006), Dercon and Porter (2014) investigated the long—term impacts of the 1984 famine shock in Ethiopia 20 years later, on the height of young adults aged 17–25 who experienced this severe shock in utero and as infants during the crisis. They find that children that were 3 years old at the peak of the crisis were at least 3 cm shorter than older cohorts by the time they reached adulthood. Moreover, they were less likely to have completed primary school, and more likely to have experienced recent illnesses. Using data from the 2004 Ethiopian Child Survival Survey, De Waal et al. (2006) concluded that the impact of the 2002–2003 drought in Ethiopia has substantially increased child mortality rate in affected areas.

The literature examining the impacts of economic shocks on welfare is voluminous and by no means is the review here exhaustive. However, many of the prior studies focus on exploring the impacts of major shocks, such as drought and crop failure, on the well-being of children. As such, there is little understanding as to how frequent malnutrition due to exposure to high food price inflation has affected children’s health. This study fills that gap.

3 Data

This study uses the Ethiopian DHS data collected in three rounds over a span of 10 years period between 2000 and 2010. The DHS data collects detailed information on children’s characteristics, anthropometric and health outcome indicators, parents’ and household characteristics, etc. The three waves cover about 23,000 children under the age of 5, who were born between 1995 and 2010. Moreover, the survey covers all regions in the country, making it one of the few nationally representative and detailed household surveys on children’s health.

The key outcome variables of interest are children’s anthropometric measures—height (in centimeters) and weight (in kilograms)—at the time of survey. We use the World Health Organization (WHO) standard references to calculate standardized z-scores of height-for-age, weight-for-age, and weight-for-height scores from which we determine stunting, underweight, and wasting status. The calculation of these scores takes children’s age and sex into account. Detailed description of the methodology and the software (Stata) are available on WHO website(Organization et al., 2006).
Table 1 presents summary statistics of the outcome variables by survey year. Under-five children have gained centimeters of height and kilograms of weight over the years. The average height and weight of children aged 6–59 months and born between 1996 and 2010 was 83.87 cm and 10.92 kg, respectively. During this period, however, Ethiopian children gained an average of 2 cm and 0.5 kg of height and weight, respectively. See, also Figure 3, panel (a). For a country known for severe malnutrition of children, these are significant gains in children’s stature and weight. The gains in height and weight are consistently positive for each age level as well.

Figure 3: Growth of status of children born between 1996 and 2010

![Growth of status of children born between 1996 and 2010](image)

(a) Height and Weight by Year  
(b) Height and Weight by Sex  
(c) Z-scores by Age

Similarly, height and weight differ by gender, with boys taller and heavier than girls (see Figure 3, panel [b]). As expected, height and weight are geometric functions of age, which increase as age increases but at a decreasing rate. Furthermore, Ethiopian children start their lives largely with an equal nutritional status compared to the WHO median reference group (see Figure 3, panel [c]). However, they quickly start to lose scores on the standard distribution curve as they grow older. By the time they reached age 2 (24 months), they have already lost about 2.07, 1.57, and 0.72 points in their height-for-age, weight-for-age, and weight-for-height z-scores, respectively.

Although these gains in height and weight are substantial, Ethiopian children remained largely below the global standard in all measures of child malnutrition as implied by the negative z-scores (see Table 1 and Figure 4). Relative to the WHO international standard, the gains over time are also notable. For instance, the average height-for-age z-score increased from -2.3 (SD=1.90) in 2000 to -1.83 (SD =1.88) in 2010. Similarly, weight-for-age scores increased from -1.83 (SD = 1.32) in 2000 to -1.50 (SD = 1.29) in 2010. Hence, under-five children in Ethiopia have steadily gained few centimeters of height and grams of weight, approaching the levels of their peers elsewhere in the world. Similarly, we observe some progress in terms of standard child malnutrition incidence measures—stunting, underweight and wasting. In 2000, staggering 58, 42, and 14 percent of children under the age of five were stunted, underweight, and wasted, respectively. However, these numbers decreased to 46, 33 and 12 percent, respec-
Table 1: **Summary Statistics of Child Health Outcomes**

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<tr>
<td><strong>Height (cm)</strong></td>
<td>83.87 (11.7)</td>
<td>82.94 (11.34)</td>
<td>83.65 (12.77)</td>
<td>84.83 (11.47)</td>
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<td><strong>Weight (kg)</strong></td>
<td>10.92 (2.88)</td>
<td>10.62 (2.77)</td>
<td>11.09 (3.09)</td>
<td>11.12 (2.85)</td>
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<td><strong>Z-score</strong></td>
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<tr>
<td>Height-for-age</td>
<td>-2.08 (2.02)</td>
<td>-2.23 (1.90)</td>
<td>-2.16 (2.46)</td>
<td>-1.83 (1.88)</td>
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<tr>
<td>Weight-for-age</td>
<td>-1.63 (1.35)</td>
<td>-1.83 (1.32)</td>
<td>-1.52 (1.52)</td>
<td>-1.5 (1.29)</td>
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<tr>
<td>Weight-for-height</td>
<td>-0.06 (7.8)</td>
<td>-0.31 (6.76)</td>
<td>1.03 (12.16)</td>
<td>-0.3 (6.05)</td>
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<td><strong>Incidence</strong></td>
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<tr>
<td>Stunted</td>
<td>0.52 (0.5)</td>
<td>0.58 (0.49)</td>
<td>0.52 (0.5)</td>
<td>0.46 (0.50)</td>
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<td>Underweight</td>
<td>0.37 (0.48)</td>
<td>0.42 (0.49)</td>
<td>0.36 (0.48)</td>
<td>0.33 (0.47)</td>
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<tr>
<td>Wasted</td>
<td>0.13 (0.34)</td>
<td>0.14 (0.35)</td>
<td>0.13 (0.34)</td>
<td>0.12 (0.33)</td>
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<tr>
<td><strong>No. of Obs.</strong></td>
<td>20,770</td>
<td>8,160</td>
<td>3,806</td>
<td>8,804</td>
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Tively, in 2010. These are nontrivial changes that underscore the country’s progress in reducing childhood stunting, underweight, and wasting.

Figure 4: **Average Standard Z-Scores of Ethiopian Children Aged 6-59 Months Relative to WHO Reference Group**

![Average Standard Z-Scores](image)

(a) Height-for-age Z-score  
(b) Weight-for-age z score

Since the DHS survey does not have food price information, we use monthly food prices data collected by the Ethiopian Central Statistical Agency (CSA) from 119 markets between 1996 and 2012. The monthly price survey covers thousands of goods and services and is one of the most comprehensive surveys that CSA uses to analyze prices and construct monthly Consumer Price Index (CPI) at the national and regional levels. We spatially merged the DHS clusters with the high-frequency local market prices, using a GIS-based, Nearest Neighbor Match algorithm.
Then, using month of birth as an anchor, we matched each child’s month of “early life” with the corresponding monthly inflation rates, counting 9 months backwards to inception and 24 months after birth. Such an approach allows us to estimate the effects of exposure to food price inflation during each month since inception. It also allows us to identify the exact month of “early life” during which exposure to inflation has the most impact. Depending on their age, some children drop out of the analysis. For instance, children who were 60 months old during the 2000 survey (or born in 1995) drop out from the analysis that estimates the effect of exposure while *in utero* because we do not have price information for periods prior to 1996. Similarly, younger children (say, 11 months old at the time of survey) drop out from our analysis of exposure to food price inflation in the 12th, 13th, . . . , 24th months after birth, since they are not yet old enough to be exposed to the inflation during those months. As a result, the sample size of our analysis varies for each month of exposure.

Figure 5: **Spatial Nearest Neighbor Match between Local Market Hubs and the DHS Clusters**

We focus on the prices of the three major cereals (teff, wheat, and maize), which are staples in various regions of the country. Households in Ethiopia spend a significant proportion of their resources on food, where expenditure on food accounts for more than 83.1 percent and 71 percent of consumption expenditure in rural and urban areas, respectively. Cereals, specifically, account for about 42.4 percent and 22 percent of consumption expenditures in rural and urban areas, respectively. While the combined share of teff, wheat, and maize in total consumption accounts.

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3 In line with the literature, we assume normal gestation period of 40 weeks (9 months) (Almond and Mazumder, 2008)
Table 2: **Mineral Content of Teff, Wheat, and Maize mg/100g**

<table>
<thead>
<tr>
<th>Minerals</th>
<th>Teff</th>
<th>Wheat</th>
<th>Maize</th>
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</thead>
<tbody>
<tr>
<td>Iron</td>
<td>11.5 — &gt;150</td>
<td>3.7</td>
<td>3.6 — 4.8</td>
</tr>
<tr>
<td>Zinc</td>
<td>3.8 — 3.9</td>
<td>1.7</td>
<td>2.6 — 4.6</td>
</tr>
<tr>
<td>Calcium</td>
<td>78.8 — 147</td>
<td>15.2 — 39.5</td>
<td>16</td>
</tr>
<tr>
<td>Copper</td>
<td>1.6</td>
<td>0.23</td>
<td>1.3</td>
</tr>
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For one-fourth of total consumption expenditure in rural areas, the share is more than one-fifth in urban areas (see (Shimeles and Woldemichael, 2013)). Furthermore, teff, wheat, and maize provide important micro-nutrients and carbohydrates that are essential for the mother, the fetus, and the infant. For instance, teff, a gluten-free grain is a good source of essential minerals (iron, magnesium, and calcium), carbohydrates/fiber, vitamin B-12, protein (see Table 2).

We calculate month-on-month and month-to-month inflation rates for each cereal. For item $x$, the annual inflation rate between month $m$ in year $t-1$ and month $m$ in year $t$ are calculated as $\pi^x_{m,t} = \frac{P^x_{m,t} - P^x_{m,t-1}}{P^x_{m,t-1}} \times 100$, where $P^x_{m,t}$ is the price of item $x$ in month $m$ and year $t$. Similarly, the month-to-month inflation rate is calculated as $\pi^x_{m,t} = \frac{P^x_{m,t} - P^x_{m,t-1}}{P^x_{m,t-1}} \times 100$. In order to address issues of seasonality, we also calculate quarterly inflation using prices averaged over 3 months. The data show that prices started to pick up in late 2005 and remained at significantly higher levels in the years that followed. Inflation reached historically higher levels in 2008–2009 with month-on-month inflation of the three major crops exceeding 100 percent. Furthermore, inflation was widespread across the country, affecting all regions. Such a high level of inflation was unprecedented in the country, and its consequence on children’s health is yet to be documented, particularly of those who were born or were still *in utero* during these inflationary episodes.

In addition to exogeneity, a sufficient level of variation in inflation across time and space is needed to establish causality between inflation and child health within a reasonable confidence bound. As shown in Figure 6 which presents the kernel distribution of inflation levels, children were exposed to varying levels of teff, wheat, and maize inflation rates. Some children who were born prior to 2005 experienced deflation, whereas children born after 2005 were exposed to higher levels of food price inflation. Coupled with exogeneity in food price inflation, such temporal and spatial differences present sufficient variation to identify the impacts of exposure to food price inflation during “early life” on nutritional and health outcomes of children. The data also show that children exposed to higher teff price inflation have lower height and weight $z$-scores (see Figure 7).

In our econometric analysis, we control for several factors which potentially affect children’s health. Specifically, we control for child, parental, household, geographic, and temporal char-
characteristics. Child-level factors include age, age squared, gender, birth order, relation to the head of the household, vaccination status, and month of birth. Parental characteristics include
mother’s age, height, level of education, prenatal and postnatal visits, and receipt of vitamins during pregnancy. Household-level factors include age of household head, educational level of the husband, household size, number of under-five children in the household, and wealth index. Table 3 summarizes the set of control variables included in our formal regression analysis.

It is also important to note that in the context of rural Ethiopia, the impacts of food price inflation could vary by households’ status as net sellers or net buyers. Net selling households could benefit from food price hikes of the particular cereal they produce and sell at the market. On the contrary, for a constant level of income, net buyers of cereals under consideration could suffer from such price hikes in as they will be forced to reduce the quantity (calories) they purchase or increase their spending to maintain the same levels of quantities consumed. The effects of food price inflation on calorie intake could, therefore, vary by households’ net-seller and net buyer status. Since we do not have information on households’ net-buyer/net-seller status, we control for region, location of residency, and altitude, and run separate analysis for rural and urban areas to see how the effects vary by location. The next section outlines our empirical strategies.

4 Empirical Model

Our primary interest is to identify the causal effects of exposure to food price inflation during the critical periods of “early life” on health outcomes for children aged 6–59 months. Food price is expected to affect child health production through its effect on child health input (nutrition) prices. The empirical model is simple OLS, in that children’s health outcome is regressed on the month-on-month inflation rates experienced during different months of “early life.” Specifically, we write the regression as

$$y_i = \beta_0 + \beta_{m,k} \pi_{i,m,k} + \gamma X_i + \varepsilon_i, \forall m \in [-9, \ldots, \text{Birth}, \ldots, +24]$$

where $y_i$ is child $i$’s health outcome measure (height, weight, weight-for-age, height-for-age, weight-for-height z-scores), $\pi_{i,m,k}$ denotes the level of inflation during month $m$ of “early life”, $k = \{\text{teff, wheat, maize}\}$, $X_i$ is a vector of control variables including household, mother, child, and geographic characteristics, $\beta_{1,m,k}$ is our primary coefficient of interest that measures the impact of exposure to inflation of cereal $k$ during month $m$ of “early life,” $\beta_0$ is the intercept, $\gamma$ is a vector of coefficients to be estimated, and $\varepsilon_i$ is an iid error term assumed to be normally distributed.

Identification relies on the exogeneity of food price inflation. Our estimates can be considered as “Intent to Treat” (ITT) effects, because exposure to food price inflation does not necessarily imply a reduction in nutritional intake for some pregnant women and infants. In addition to
Table 3: Summary Statistics of Control Variables (Pooled Data: 2000–2010)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean</th>
<th>Variables</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Child Characteristics</strong></td>
<td></td>
<td><strong>Household Characteristics</strong></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>50.5%</td>
<td>Household size</td>
<td>6.2 (2.23)</td>
</tr>
<tr>
<td>Age (months)</td>
<td>32.26 (15.5)</td>
<td>Head’s sex: Male</td>
<td>0.8 (0.4)</td>
</tr>
<tr>
<td>Birth Order</td>
<td>4 (2.6)</td>
<td>Head’s age</td>
<td>38.4 (11.5)</td>
</tr>
<tr>
<td>Vaccine: BCG</td>
<td>57.3%</td>
<td>Number of Under-Five children</td>
<td>1.8 (0.8)</td>
</tr>
<tr>
<td>Vaccine: DPT1</td>
<td>53.7%</td>
<td>Wealth quintile: Q1</td>
<td>25.3%</td>
</tr>
<tr>
<td>Vaccine: DPT2</td>
<td>44.5%</td>
<td>Wealth quintile: Q2</td>
<td>18.7%</td>
</tr>
<tr>
<td>Vaccine: DPT3</td>
<td>32.8%</td>
<td>Wealth quintile: Q3</td>
<td>18.7%</td>
</tr>
<tr>
<td>Vaccine: Polio0</td>
<td>18.4%</td>
<td>Wealth quintile: Q4</td>
<td>18%</td>
</tr>
<tr>
<td>Vaccine: Polio1</td>
<td>78.2%</td>
<td>Religion: Orthodox Christian</td>
<td>38%</td>
</tr>
<tr>
<td>Vaccine: Polio2</td>
<td>62.8%</td>
<td>Religion: Catholic</td>
<td>0.8%</td>
</tr>
<tr>
<td>Vaccine: Polio3</td>
<td>48.8%</td>
<td>Religion: Protestant</td>
<td>16.9%</td>
</tr>
<tr>
<td>Vaccine: Measles</td>
<td>41.1%</td>
<td>Religion: Muslim</td>
<td>41.7%</td>
</tr>
<tr>
<td>Vaccine: Ever</td>
<td>57.3%</td>
<td>Religion: Traditional</td>
<td>1.9%</td>
</tr>
<tr>
<td>Received Vitamin A in the last 6 mths</td>
<td>55.2%</td>
<td>Religion: Other</td>
<td>0.8%</td>
</tr>
<tr>
<td>Breastfed: Never</td>
<td>1.3%</td>
<td><strong>Geographic Characteristics</strong></td>
<td></td>
</tr>
<tr>
<td>Breastfed: Missing</td>
<td>25.6%</td>
<td>Urban</td>
<td>15.3%</td>
</tr>
<tr>
<td>Breastfed: Less than 6 months</td>
<td>1.2%</td>
<td>Altitude</td>
<td>1,715 (669)</td>
</tr>
<tr>
<td>Breastfed: Longer than/equal to 6 months</td>
<td>71.8%</td>
<td>Tigray</td>
<td>11.1%</td>
</tr>
<tr>
<td><strong>Parental Characteristics</strong></td>
<td></td>
<td>Affar</td>
<td>7.23%</td>
</tr>
<tr>
<td>Mother: Married</td>
<td>90.2%</td>
<td>Amhara</td>
<td>13.2%</td>
</tr>
<tr>
<td>Mother’s age</td>
<td>29.6 (6.8)</td>
<td>Oromiya</td>
<td>18.1%</td>
</tr>
<tr>
<td>Mother’s years of education</td>
<td>1.2 (2.8)</td>
<td>Somali</td>
<td>7%</td>
</tr>
<tr>
<td>Mother’s height (cm)</td>
<td>157.33 (6.67)</td>
<td>Benishangul Gumuz</td>
<td>8%</td>
</tr>
<tr>
<td>Received prenatal care</td>
<td>32.8%</td>
<td>SNNP</td>
<td>14.9%</td>
</tr>
<tr>
<td>Pregnancy desired: Then</td>
<td>73.3%</td>
<td>Gambela</td>
<td>5.8%</td>
</tr>
<tr>
<td>Pregnancy desired: Later</td>
<td>15.3%</td>
<td>Harari</td>
<td>5.2%</td>
</tr>
<tr>
<td>Pregnancy desired: No more</td>
<td>11.3%</td>
<td>Addis Ababa</td>
<td>3.9%</td>
</tr>
<tr>
<td>Husband’s age</td>
<td>38.1 (10.4)</td>
<td>Dire Dawa</td>
<td>5.3%</td>
</tr>
<tr>
<td>Husband’s years of education</td>
<td>1.2 (2.6)</td>
<td><strong>No. of Observations</strong></td>
<td>20,778</td>
</tr>
</tbody>
</table>

No. of Observations 20,778
nutrition, several factors determine children’s health. We control for household-level factors, maternal characteristics, child characteristics, season of birth, geography, etc. Household-level factors include age of the household head, educational level, household size, wealth, etc. Maternal characteristics include age, education, number of children, prenatal and postnatal visits, receipt of vitamins during pregnancy, etc. Similarly, child-level factors include sex, birth order, relation to the household head, vaccination status, month of birth, etc. Finally, we include dummies for location of residence (urban/rural), regions, and altitude, and dummies for survey years to control for spatial and temporal variations.

5 Results and Discussions

In this section, we discuss results from the OLS regressions of Equation (1). We estimate the model for each of the 34 “early life” months, 9 before birth and 24 after birth months, explicitly accounting for heterogeneity arising from the complicated biological mechanisms through which nutrition affects growth. We run the regressions for eight different but related child health outcomes: height, weight, height-for-age z-score, weight-for-age z-score, weight-for-height z-score, stunting, underweight, and wasting. (As a result, we have a total of 816 regressions). Month-on-month inflation index is generally prone to seasonality. In addition to including month of birth in our regressions to ameliorate issues of seasonality, we also estimate the models using quarter-on-quarter inflation, which is less susceptible to seasonality. Regardless, as we discuss later, the results remain consistent across different models.

Reporting the full regression tables for all estimations is unmanageable and messy. Instead, we graphically present the coefficients of interest so that it is easier to read and compare. The accompanying tables are provided in the Supplemental Appendix. For brevity we also focus on discussing results of specifications that control for the full vector of covariates.

5.1 Effects of Food Price Inflation

Height and Weight

The results show that exposure to food price inflation has detrimental medium- and long-term impacts on the health of children aged 6–59 months. In addition, the effects depend on the specific month of exposure. Figure 8 graphically summarizes the effects of exposure to teff, wheat, and maize price inflation during different months of “early life” on height.\(^4\) The x-axis

\(^4\)For the sake of brevity, we did not plot the 95 percent confidence intervals for specifications that use month-on-month inflation levels (Panel [a]). The corresponding tables in the supplemental appendix show the t-values for each coefficient, as well as the sample sizes in each regression.
represents month (quarter) of exposure and the y-axis represents the estimated slope parameter \( \hat{\beta}_{m,k} \), where \( m \) denotes month of exposure and \( k \) denotes the cereal. Each panel presents the results without controls (except age and age squared, since child height and weight are known to be quadratic functions of age and age squared) and with controls. In regressions without controls, the effects of exposure to food price inflation, particularly of inflationary episodes experienced while in utero through the first two months after birth are positive, which seems counterintuitive. After controlling for the full list of confounding factors, the effects, however, become negative for exposure during most of the “early life” periods with effects approaching zero or positive for inflationary episodes experienced during toddlerhood (15–24 months). Although the effect of exposure to teff price inflation during the first trimester (3 months after inception) on height is positive, it becomes negative for exposures during the second and third trimesters of the fetus through infancy.

**Figure 8: OLS Results on the Effects of Food Price Inflation on Height (cm)**

Furthermore, compared to wheat and maize, the effects of teff price inflation are particularly pronounced, giving rise to a “u-shaped” pattern across the spectrum of children’s “early life” periods. The largest effect on height is observed when a child is exposed to inflationary episodes between birth and the first 12th months after birth with a deep around the 5–6th month. For instance, exposure to 10 percent inflation in teff prices during the 5–6th month after birth reduces children’s height by about 0.08 cm. Similarly, exposure to a 10 percent inflation in wheat and maize prices just after birth leads to a loss of 0.05 cm in children’s height. As stated above, Ethiopia experienced unprecedented food price inflation in 2008–2009, during which time, in-
flation of some cereals reached well above 100 percent. This implies that a typical child who was 5 to 6 months old during these periods has lost about 0.8 cm of height due to teff price inflation, all other factors remaining the same. One plausible explanation for why the impacts of exposure to food price inflation during the first 5–6 months after birth are much more pronounced than any other “early life” months is that this period represents the critical period of nutritional transition from exclusive breastfeeding to complementary feeding. According to the WHO and UNICEF Global Strategy for Infant and Young Child Feeding, complementary feeding should start at the 6th month when infants could be fed pureed, mashed, and semi-solid foods. Hence, during this transition period when feeding begins, infants are especially vulnerable to malnutrition and infection (WHO and UNICEF, 2003).

Figure 9 presents the effects of exposure to food price inflation on weight. As in the case of height, we include age and age squared in all specifications. Although most of the coefficients in the models without control are positive, once we control for confounders, they become negative for exposures periods between the third trimester and approximately the 15th month after birth. Similar to height, the effect of teff price inflation on child weight is more pronounced when experienced around the 5th month after birth. For instance, exposure to 10 percent inflation in teff prices around the 5th month after birth leads to about 0.019 kg (19 gram) loss in weight. Whereas, the effect of exposure to 10 percent inflation in wheat and maize prices during the same period leads to a loss of about 0.005 kg (5 gram) in a child’s weight. In general, although the effects of exposure to food price inflation are mainly in the negative domain, the magnitude, the statistical significance, and the direction of effects largely depend on the specific month of exposure. Furthermore, the effects vary by the type of cereal in question, perhaps owing to the nutritional contents and share in the daily calorie and energy intake.

**Height-for-age, weight-for-age and weight-for-height z-scores**

Figures 10 - 12 present the effects on height-for-age, weight-for-age, and weight-for-height standardized z-scores. What makes these scores different from the absolute height and weight measures is that they are standardized scores relative to the WHO reference group. The scores also account for children’s age and gender. As shown in Figure 10, the impacts of food price inflation on height-for-age score (stunting) are larger when children are exposed to such episodes while *in utero*. For instance, exposure to 10 percent teff price inflation in any given month while *in utero* leads to a 0.02 lower height-for-age z-score. These effects are statistically significant. Moreover, the effects, particularly of teff, remain negative and statistically significant for inflationary episodes experienced during the first 6 months after birth. The impacts of wheat and maize price inflation are, however, negative and significant if a child is exposed while *in utero*; exposure to inflation of these two cereals after birth have little or no effect on height-for-age z-score.

Similarly, the impacts of food price inflation on weight-for-age scores (underweight) are neg-
ative when a child is exposed while *in utero* and during the first 5–6 months of infancy. The effects of teff price inflation are much pronounced than the effects of wheat and maize price
Figure 11: OLS Results on the Effect of Food Price Inflation on Weight-for-Age z-score (underweight)

Exposure to 10 percent inflation in teff price during the 5th month, for instance, leads to a loss of 0.013 points in weight-for-age score. Whereas, the effects of wheat and maize price inflation are small and statistically insignificant irrespective of month of exposure. This implies that the effects of food price inflation vary considerably by the specific type of cereal.

Figure 12 graphically summarizes the effects on weight-for-height z-score which is a continuous measure of wasting status. The results show that, after controlling for other factors, the effects of food price inflation on children’s weight-for-height z-scores become negligible and statistically insignificant. This is true irrespective of month of exposure and the type of cereal.

Effects on the incidence of stunting, underweight, and wasting

We also estimate the effects of exposure to food price inflation on the incidence of stunting, wasting, and underweight using simple Linear Probability Model. As described above, a child is considered stunted, underweight, or wasted if her height-for-age, weight-for-age, or weight-for-height scores, respectively, are below –2.00. The regression results show that inflation experienced while in utero leads to an increase in the probability of stunting or underweight, irrespective of the specific trimester of exposure (see Figures 13 - 15). Specifically, exposure to 10 percent teff price inflation while in utero increases the probability of being stunted and underweight by up to 0.6 and 0.3 percent, respectively, which are statistically significant. Although the effects of exposure to wheat and maize price inflation after birth disappear, the effect
of exposure to teff price inflation during any month of the first year after birth leads to positive and statistically significant increase in the risk of stunting and underweight. The estimated co-efficients on the incidence of wasting are mostly close to zero and statistically insignificant for all cereals (see Figure 15). However, the coefficients on teff price inflation during the 1st and 6–8th months are positive and statistically significant, in that exposure to 10 percent inflation in teff prices during these periods increases the chance of wasting by 0.2 percent.

### 5.2 Heterogeneity

Averages hide the true extent of the effects. Owing to a multitude of complicated biological, cultural, socio-economic, environmental, etc. factors influencing the growth trajectory of a child, the effect on one child is expected to differ from the next. Some of these factors are observed, and others are unobserved by the researchers. Since our data is cross-sectional, which limits us from statistically accounting for unobserved heterogeneity using methods such as panel data econometrics, we assess whether the effects vary by some key observable variables.

As discussed above, the effects of food price inflation are heterogeneous depending on the specific month of exposure and the type of staple food under consideration. In general, food price inflation has the largest detrimental impact on children’s height and weight when it is experienced during the last trimester *in utero*, approximately, during the first 12 months after
birth. We also observed that the effects of exposure to *teff* price inflation are more pronounced than the effects of exposure to wheat and maize price inflation. Furthermore, the effects of *teff* price inflation on height and weight are severe when exposure occurs around the 5th month after birth.
Figure 15: **OLS Results on the Effect of Food Price Inflation on the Incidence of Underweight**

- Whereas wheat and maize price inflation has the largest impact on children’s health when exposed during the last trimester *in utero* and during the first few months after birth. These findings highlight the heterogeneous impacts of food price inflation on child health depending on the type of cereal and the specific month of exposure.

In order to further probe whether there is heterogeneity on some observed characteristics, we estimate separate regressions for height by Vitamin A supplement intake, wealth, gender, and residential location. The implicit assumption for wealth and residential location, albeit strong, is that these factors remain unchanged between the month of exposure and the month of interview during which children’s height and weight were measured. Figure 16 shows the results by Vitamin A supplement intake status. Vitamin A supplementation is an important remediation often given to children aged 6–59 months to support rapid growth and help combat infections. As a result, we expect some of the detrimental effects on children’s physical growth due to food price inflation could be minimized or reversed if children take the supplement at the right time. The results show that children who took Vitamin A in the past 6 months were, indeed, able to weather the detrimental impacts of exposure to food price inflation, particularly of teff price inflation. While children who took the supplement lost only 0.05 cm due to exposure to 10 percent teff price inflation during the 5th month after birth, those who did not take the supplement lost as much as 0.1 cm. However, we do not find much variation in the effects of wheat and maize price inflation by Vitamin A supplement intake.
Similarly, we run the regressions by wealth quintile (see Figure 17) to see how the effects vary depending on households’ economic status. We expect that wealthy households better cushion the impacts of higher food price inflation on their children’s nutritional status, as they have...
the resources to ensure that children get sufficient nutrition during periods of high food price inflation. Although the variation in the effects generally seem negligible, children in the 2nd wealth quintile do worse in enduring the detrimental impacts of, particularly, teff price inflation,
compared to those in the top wealth quintile. For instance, exposure to 10 percent teff price inflation during the 5th month after birth leads to a loss of 0.13 cm in height for children in the 2nd quintile, compared to those in the top wealth quintile, who lost only 0.04 cm. This implies that children in relatively poor households and who were 5 months old during the 2008–2009 inflationary episode, where inflation of these major staple foods surpassed 100 percent, have lost up to 1.3 cm in height.

Figures 18 and 19 present the effects by gender and net buyer or net seller status, respectively. Although they are relatively taller, boys appear to lose the most in height, compared to girls when they were exposed to teff price inflation during much of their “early life.” The estimated effects of wheat and maize price inflation, however, do not systematically vary by gender. One of the advantages of estimating the regressions for each month since inception is that we are likely to detect the impacts of some unobserved factors such as parental sex preferences. The logic is that as far as parents do not have information on the sex of the fetus, after controlling for other factors, we should not observe significant differences in the effects of food price inflation exposures while in utero between boys and girls. At birth, however, parents know the sex of the baby. Therefore, if there is any sex bias in parental preference in children’s health production function, we should expect the coefficients for boys and girls to differ. Although we did not conduct a formal hypothesis test, visual inspection of the figures does not show dramatic jumps in the effects of inflation for exposures around the birth month by which time parents have information on gender vis-a-vis exposures while in utero.

The effects of food price inflation could also vary by households’ net-buyer and net-seller status. In times of inflation, net-sellers are more likely to benefit, whereas net-buyers suffer as they have to spend more to buy the same quantity of food or reduce the quantity purchased. The net effects of food price inflation depend on a household’s net buyer or net seller status. Since we do not have a variable which indicates whether a household is net buyer or net seller of teff, wheat, or maize, we use residential location as a proxy. In the context of Ethiopia, urban residents are mainly net buyers of the cereals. So, it is plausible to argue that the majority of households in urban areas are net buyers of these staple foods. However, we do not claim that a rural household is a net seller, but depending on the region could be one. In the absence of a good proxy, though, we assess if there are noteworthy differences by urban and rural areas.

The results show that children in urban areas lose slightly more centimeters of height when they are exposed to teff price inflation in utero and during the first 4 months after birth than their peers in rural areas. However, for teff price inflation experienced during the 5th and 10th months, the pattern is reversed in that teff price inflation has no effect on heights of children in urban areas but a negative effect on children in rural areas. There is, therefore, slight variation in the effects of teff price inflation based on location of residence (a proxy for net buyer or net seller status), but these variations, in turn, depend on the specific month of exposure. We also
observe some variation in the effects of wheat and maize price inflation, but this variation is not as noticeable as the effects of teff price inflation.

6 Concluding Remarks

In low-income countries, high food prices erode the purchasing power of poor households and undermine dietary quality and total energy intake, compromising child growth and cognitive development. In this study, we investigate the nutritional and health consequences of exposure to food price inflation during “early life.” We use data from three rounds of the Ethiopian DHS collected over 10 years and high-frequency local market-level retail price data. We spatially combined the two datasets using a GIS-based Nearest Neighbor Matching algorithm and merged with each child’s “early life” months between inception and the 24th month after birth. Our focus is on children aged 6–59 months and three major staple foods in Ethiopia (teff, wheat, and maize).

We find that food price inflation has detrimental medium- and long-term consequences on the health of children. The effects vary considerably, depending on the specific month, with exposure to inflationary episodes while in utero and during infancy having the largest effects on children’s physical growth. The results vary by the type of cereal, with teff price inflation having the largest effect and by other observable factors such as gender, location of residency, and wealth.

The findings highlight that food price inflation has far-reaching consequences on children’s health, potentially lifelong that determine their future health, educational achievement, job market, family formation, social behavior, and many other life-course outcomes. The findings also can help formulate well-targeted policies to alleviate malnutrition during the specific periods of “early life” and inflationary episodes. Although in resource-poor countries, neither implementing such programs nor leaving the problem of malnutrition for the market is realistic, targeted nutritional support programs can be extended to pregnant women, breastfeeding mothers, and infants in times of high food price inflation. Furthermore, existing safety-net programs, such as productive safety-net, feeding, and emergency employment, maybe customized for families with pregnant women and infants to provide a cushion against “early life” malnutrition due to high food price inflation.
References


