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ABSTRACT

High food prices can be an immediate threat to household food security, undermining population health, retarding human development, and lowering labor productivity for the economy in the long term. We employ a panel dataset covering 63 developing countries from 2001 to 2010 to make a comprehensive assessment of the effects of food price inflation and volatility on population health measured by infant mortality rate, child mortality rate, and the prevalence of undernourishment. We find that rising food prices have a significant and adverse effect on all three health indicators in developing countries. Furthermore, the impact of food prices is severer in the least developing countries although the effect is moderated in countries with a greater share of agriculture in gross domestic product.

Keywords: food price, health, food security

JEL Classification: I15, I18, I19, Q18

I. INTRODUCTION

Global food prices have remained high and volatile since the peak of the global food crisis of 2008, exacerbating hunger and malnutrition around the world. Although vulnerabilities would differ even within societies and households, the impact will be the most severe among the poorest households of the poorest countries.

Children are particularly vulnerable to food insecurity resulting from high food prices. Inadequate food intake and unfavorable changes in dietary patterns may affect their physical and mental development. In the short term, the effects are likely to be the increased prevalence of stunting (low height for age), wasting (low weight for height), and other micronutrient deficiency disorders among children, as well as increased chances of developing chronic diseases. In turn, these lead to an increase in child morbidity and mortality. Malnutrition at a young age may also impair proper mental development and learning ability, leading to reduced work productivity in later years.

Brinkman et al. (2010) warn that high food prices risk undoing much of the progress made toward achieving the Millennium Development Goals (MDGs),¹ which call for the reduction in under-5 mortality by two-thirds (Goal 4) and the halving of the proportion of underweight children (Goal 1) between 1990 and 2015. On the other hand, Konandreas (2012) reveals that low-income countries, especially the poor net food-importing countries that depend on imports for a large share of their food consumption, have limited means to procure food and other necessities, and have been deeply affected by the food crisis in recent years.

High and increasing food prices can be an immediate threat to household food security, undermining population health, retarding human development, and lowering labor productivity for the economy in the long term. In addition, the high volatility of food prices and the associated uncertainty may impede sustainable and long-term consumption decisions of households, increasing the risk of chronic low food intake. Understanding the effect of the food crisis on nutrition, health, and poverty is therefore critical for the development of public policies and social programs to help vulnerable groups. An accurate assessment is needed to help target social assistance policies and programs, monitor their progress, and evaluate their effects.

Some studies have examined the impact of the recent global food crisis, in combination with the global financial crisis, on nutrition and health (Brinkman et al. 2010; Christian 2010; Webb 2010; Darnton-Hill and Cogill 2010; Bloem et al. 2010). Brinkman et al. (2010) assess the potential effects of the global financial crisis on food consumption, nutrition, and health by examining various transmission channels. Focusing on the effect of high food prices on food consumption, they show that a food consumption score—a measure of diet frequency and diversity—was negatively correlated with food prices in Haiti, Nepal, and Niger; and argue that a large number of vulnerable households in developing countries reduced the quality and quantity of their food consumption, and faced the risk of malnutrition as a result of the global financial crisis. Drawing from the experience of previous crises, Christian (2010) identifies and elaborates a number of nutritional pathways by which the economic crisis and increase in food prices may affect infant and child mortality. The food crisis and decreased food availability can lead to increases in childhood wasting and stunting, intrauterine growth restriction, and micronutrient deficiencies such as that of vitamin A, iron, and zinc. Webb (2010) argues that high food prices

¹ The Millennium Development Goals (MDGs) are eight international development goals with specific targets and means of measurements, officially established following the Millennium Summit of the United Nations (UN) in 2000 and the adoption of the UN Millennium Declaration.

are likely to persist, and urges increased agricultural investment and appropriate food policy to improve diet quality as well as food quantity. Darnton-Hill and Cogill (2010) review past food price shocks and their known impacts on nutrition, and emphasize that such shocks primarily compromise maternal and child nutrition, mainly through a reduction in dietary quality and an increase in micronutrient deficiencies, and concomitant increases in infectious disease morbidity and mortality. Bloem et al. (2010) summarize a series of papers exploring the impact of economic crises, climate change, and the increase in food prices on vulnerable populations, particularly through hidden hunger.

While the impact of the food crisis on nutrition and health draws much policy attention, empirical estimates of this impact remain scarce. Instead, many studies have relied on conceptual representations to explain how high food prices could affect nutrition and health conditions.

This paper aims to assess the effects of food prices on population health. While earlier studies have provided limited empirical evidence on the link between food prices and health, we undertake a comprehensive and systematic regression analysis by employing a panel dataset comprising population health variables, food price inflation and volatility, and other control variables for 63 developing countries during 2001–2010. Specifically, this paper attempts to show the impact of not only food price inflation but also food price volatility on population health. In doing so, we assess how the impact of food prices on population health can be affected by different country characteristics in terms of income/human development and the relative importance of agriculture in the gross domestic product (GDP).

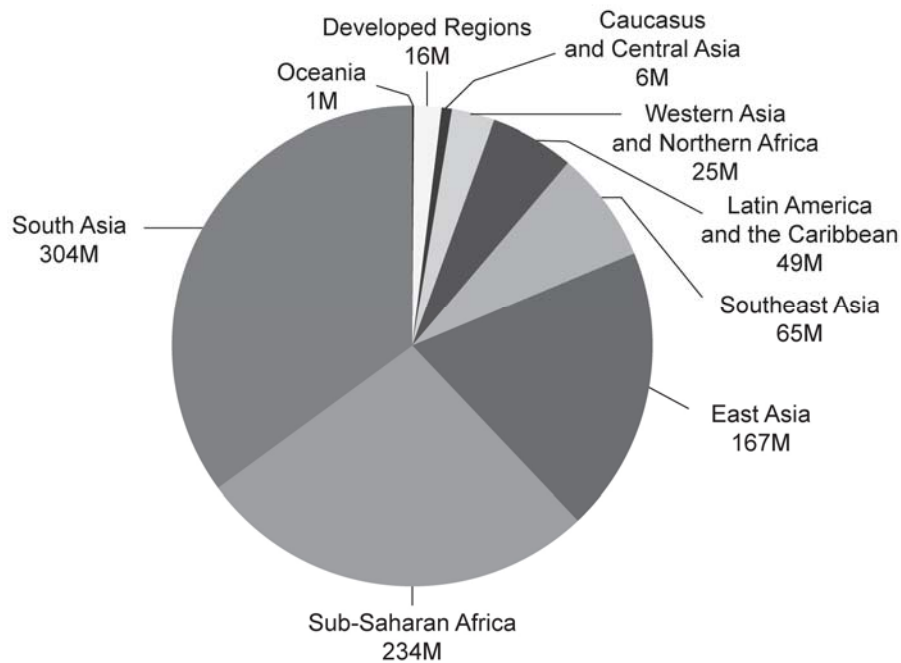
The remainder of this paper is organized as follows. Section II offers a brief overview of how food, nutrition, and health are essential for achieving overall development goals in poor countries. It also presents the progress of the MDGs that highlight good nutrition. In Section III, we employ a panel data analysis to assess the effects of food price inflation and volatility on health conditions, specifically infant mortality, child mortality, and the prevalence of undernourishment. Section IV concludes with a summary of empirical findings and a discussion on policy implications.

II. FOOD, NUTRITION, AND HEALTH IN DEVELOPING COUNTRIES

Food and nutrition are critical factors which influence health conditions especially among the poor and vulnerable. About 868 million people in the world are chronically undernourished and 84% of them live in developing countries (Figure 1). Scientific research shows that poor nutrition affects health through the immune system, increasing the incidence and severity of diseases (see e.g. Chandra 1991, 1997; Tomkins and Watson 1989). Malnutrition and undernutrition also adversely affect physical and cognitive development, especially among children, which may lead to chronic health problems later in life and impede individual work capacity and productivity. A study by the World Bank (2009) reports that a child undernourished during the first two years of his/her life is less likely to complete school, and as an adult is expected to earn 10%–17% less than someone who was well nourished.

Figure 1: Undernourishment in 2010–2012, by Region
(millions)

Total: 868 million



Source: Food and Agriculture Organization of the United Nations (FAO). [http:// www.fao.org/hunger/en/](http://www.fao.org/hunger/en/)

Food security—the ability to access food of sufficient quantity and quality to satisfy nutrition needs—is one of the most important items on the development agenda. Ensuring adequate nutrition is crucial not only for the health and survival of an individual, but also for the human capital and economic development of a society. Human capital and productivity are often positively related to an individual’s real income, which then allows people to obtain adequate food, build their human capital, educate their children, and so forth. The circular relationship among malnutrition, ill health, and poor economic outcomes is a serious development problem, as this often traps people in poverty. ADB (2012) argues that food security and poverty are highly interconnected, and estimate that food price increases in the late 2000s have trapped about 112 million people in poverty in Asia alone. On the other hand, improved nutrition contributes to poverty reduction and promotes economic growth that is inclusive.

Malnutrition is also a major hurdle to achieving the MDGs—particularly Goal 1, eradicating extreme poverty and hunger; Goal 4, reducing child mortality; Goal 5, improving maternal health; and Goal 6, fighting HIV/AIDS, malaria, and other diseases.

Specifically, MDG 1 calls for halving the proportion of people who suffer from hunger by 2015, as its third target. Table 1 shows the prevalence of undernourishment as an indicator for this target. In the least developed countries (LDCs),² one in three people still suffers from food intake that is continuously insufficient to meet dietary energy requirements.

² The LDCs have been identified by the UN using the following three criteria: income, human resource, and economic vulnerability.

Table 1: Percentage of Undernourished in Total Population (%)

	1990–1992	2000–2002	2010–2012
World	16	14	13
Developing Regions	20	17	15
Least Developed Countries (LDCs)	40	36	32
North Africa	< 5	< 5	< 5
Sub-Saharan Africa	31	29	27
Latin America and the Caribbean	12	10	8
East Asia	18	10	12
South Asia	22	21	18
Southeast Asia	24	17	11
West Asia	6	8	10
Oceania	12	13	12
Caucasus and Central Asia	16	17	7

Note: < 5 signifies data less than 5%.
Source: UN 2012.

MDG 4 aims at reducing child mortality rates by two-thirds between 1990 and 2015. Table 2 reports the mortality rates for children (under 5) and infants (under 1) in developing countries over time. Substantial progress has been made since 1990. In the developing regions, child mortality rate has dropped by more than 30%—from 97 deaths per 1,000 live births in 1990 to 63 in 2011. North Africa, Latin America and the Caribbean, Southeast Asia, and West Asia have reduced their under-5 mortality rate by more than 50%. Globally, however, the data suggests that 19,000 children under five died everyday in 2011 and more than a third of the under-five deaths were attributable to undernutrition (United Nations Children’s Fund [UNICEF] 2012).

Table 2: Infant and Child Mortality Rates Per 1,000 Live Births

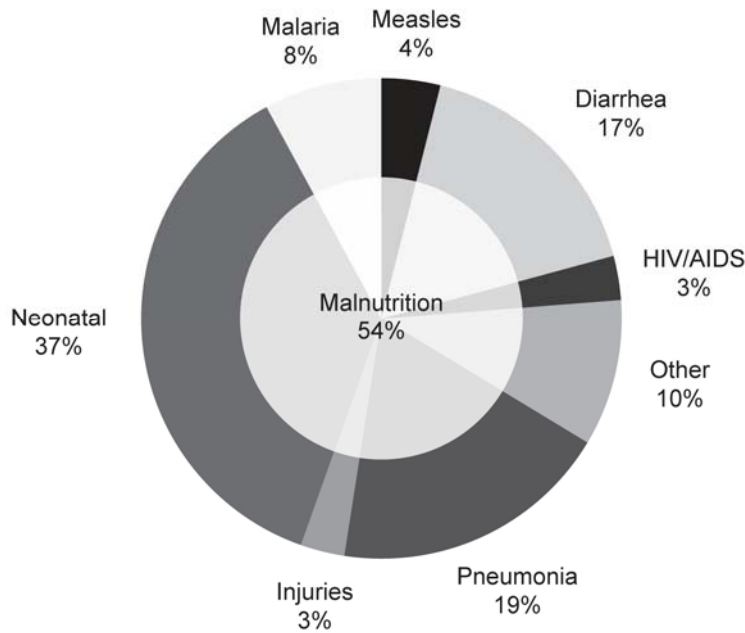
	Infant Mortality Rate			Child Mortality Rate		
	1990	2000	2010	1990	2000	2010
World	61	51	40	88	73	57
Developing Regions	67	56	44	97	80	63
Least Developed Countries (LDCs)	106	88	71	170	138	110
North Africa	62	38	23	82	47	27
Sub-Saharan Africa	105	94	76	174	154	121
Latin America and the Caribbean	43	29	18	54	35	23
East Asia	38	27	16	48	33	18
South Asia	84	65	51	117	87	66
Southeast Asia	49	36	25	71	48	32
West Asia	52	35	25	67	45	32
Oceania	55	48	41	75	63	52
Caucasus and Central Asia	63	52	39	77	62	45

Source: UN 2012.

MDG 5 targets at improving maternal health by reducing the maternal mortality ratio by 75% between 1990 and 2015, and achieving universal access to reproductive health by 2015. Maternal undernutrition, characterized by a short stature and a low body mass index, and anemia caused by iron deficiency, can lead to adverse pregnancy outcomes, contributing to at least 20% of maternal deaths (World Health Organization The Partnership for Maternal, Newborn, and Child Health 2010). Poor maternal health and nutrition also explain at least 20% of disease in children under age 5 (UNICEF 2013).

Good nutrition is key to achieving MDG 6, which targets to combat HIV/AIDS, malaria, and other diseases. Malnutrition and undernutrition remain major causes of death in developing countries, especially among children. Malnutrition is implicated in more than half of all deaths among children worldwide because it dramatically increases their vulnerability to infectious diseases (Figure 2).

Figure 2: Major Causes of Under-5 Deaths in Developing Countries and the Contribution of Malnutrition



The major causes of under-5 mortality include common preventable or treatable diseases such as measles, diarrhea, and pneumonia. Malnutrition increases children’s vulnerability to these conditions.

Note: Percentages do not total 100% due to rounding.

Source: United States Agency for International Development (USAID). Adapted from “WHO Estimates of the Causes of Death in Children.” 2005. *The Lancet* 365 (9465). pp. 1147–1152.

Good nutrition and health are essential for improving productivity and economic growth, and for reducing poverty. In particular, providing adequate nutrition to the young gives promise to the future, not only for individuals but also for societies and nations. Therefore, a society’s health and nutrition should be considered prerequisites for the long-term socioeconomic progress of a country as well as primary indicators of development.

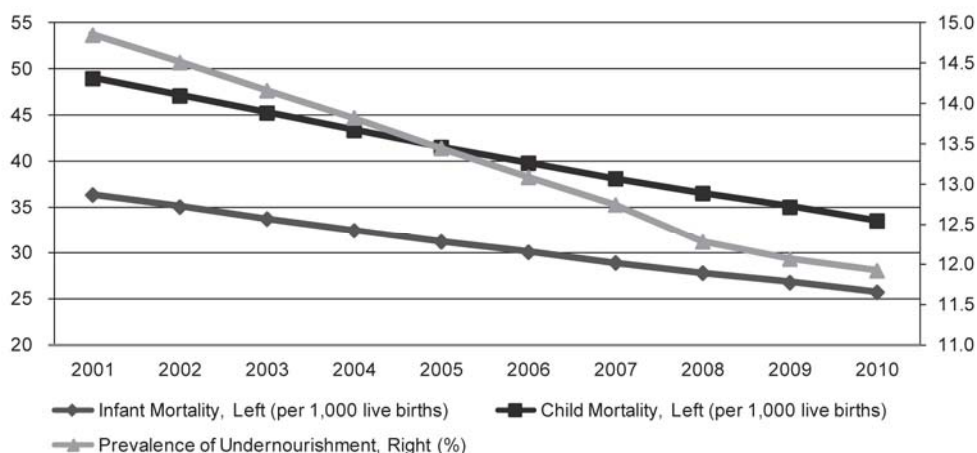
III. EMPIRICAL ANALYSIS

A. Model Specification

In order to empirically assess the effects of food prices on population health, we constructed a panel dataset covering 63 developing countries with observations from 2001 to 2010. In the analysis, population health indicators such as infant mortality rate, child mortality rate, and the prevalence of undernourishment are used as three different dependent variables. As discussed in the previous section, they are also indicators included in MDGs 1 and 4. All of these variables were taken from the UN MDG Indicators database.³

Figure 3 illustrates the trend of population health in terms of infant mortality, child mortality, and the prevalence of undernourishment in our dataset. All of these indicators show a very persistent decreasing trend throughout 2001–2010. In the figure, it is hard to notice any fluctuations except the slope of the prevalence of undernourishment, which has become more gradual since 2008. The prevalence of undernourishment appears to decline more rapidly than the other two indicators, but this is because it is expressed as a percentage (right scale in the figure), while the other two indicators are expressed as per 1,000 live births (left scale in the figure).

Figure 3: Trend of Population Health in Developing Countries, 2001–2010

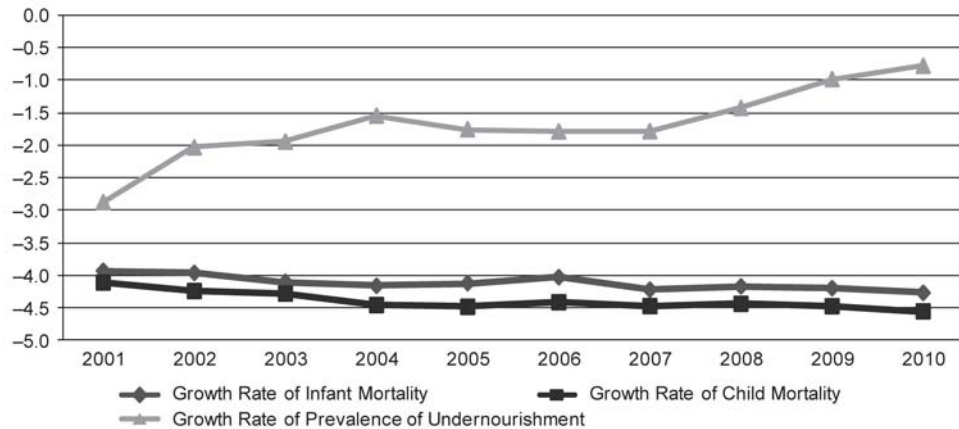


Source: Authors' calculations using the United Nations (UN) Millennium Development Goals (MDGs) Indicators database.

Figure 4 shows the comparative scale of the annual growth rates for the three indicators. Of the three, the prevalence of undernourishment has been decreasing on a scale smaller than the other two indicators. In particular, the annual change rate of undernourishment prevalence has become smaller in recent years.

³ UN MDG Indicators, <http://mdgs.un.org/unsd/mdg/Default.aspx>

Figure 4: Trend of the Growth Rates of Population Health, 2001–2010 (%)



Source: Authors' calculations using the UN MDGs Indicators database.

Because infant mortality, child mortality, and prevalence of undernourishment show a gradual downward trend, we must try to fully capture the precise impact of high and volatile food prices. While all three indicators exhibit a slowly decreasing trend, the slope differs across different countries. Thus, our panel regression model employs country-specific linear time trends to de-trend the deterministic trends in the health-related indicators. This captures the impact of slow-moving changes occurring in a specific country throughout the period of analysis (Yang 2003; Gerdtham and Ruhm 2006).

Thus, the equation to be estimated is

$$C_{it} = \beta_0 + \beta_1 FP_{it} + \beta_2' CV_{it} + \gamma_i' TREND_i \mu_j + \theta_t + \varepsilon_{it} \tag{1}$$

where C_{it} is the log of infant mortality rate, child mortality rate, or the prevalence of undernourishment in country i and year t . FP is annual food price inflation rate or food price volatility, and CV is a vector of control variables. Region fixed effects μ_j control for time-invariant differences among regions (j),⁴ while year fixed effects θ_t control for global changes in the same year. The vector of country-specific linear time trends, $TREND$, controls for factors that vary over time within nations. ε_{it} is a mean-zero error term.

B. Explanatory Variables

In this subsection, we explain our key independent variables—food price inflation and volatilities—and seven control variables included in equation (1).

Food price inflation and volatilities

Food price inflation and food price volatility are calculated based on the domestic food consumer price index (CPI) for each developing country, which is drawn from the Food and Agriculture Organization of the United Nations (FAO) statistical database or FAOSTAT. The food CPI measures the changes over time in the prices of food items that households acquire

⁴ The regions are East Asia and the Pacific, South Asia, Sub-Saharan Africa, the Middle East and North Africa, Latin America and the Caribbean, and Europe and Central Asia. Appendix A lists the countries within each region.

for consumption. However, it should be noted that the index does not consider the possibility of different food consumption baskets across countries. The baseline year of food CPI is the year 2000 for most of the countries, but some countries report different baseline years.⁵

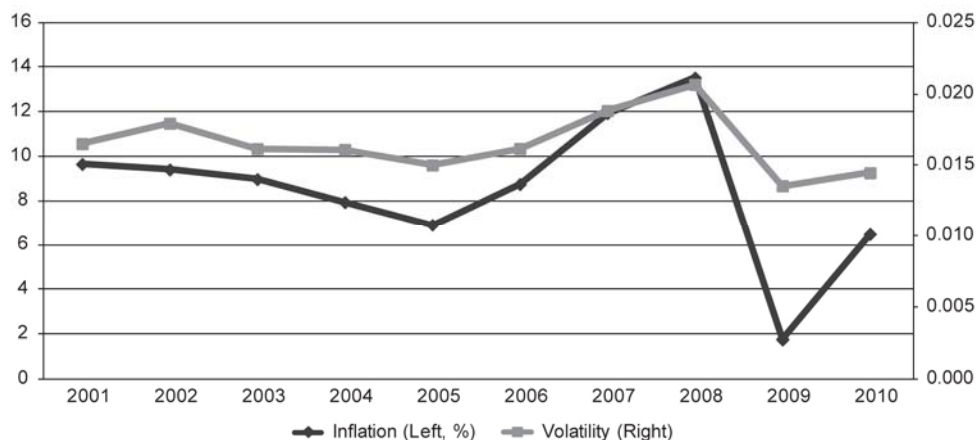
Food price inflation rate is calculated as the annual growth rate of food CPI based on observations made in December of every year. The volatility of food prices can be measured in different ways. Some papers use the GARCH or spline-GARCH model (e.g., Rapsomanikis and Mugera 2011). However, the long-term series of food price indexes are not readily available in many developing countries, disallowing the use of GARCH or spline-GARCH. Therefore, following an approach used by Balcombe (2011) and Lee and Park (forthcoming), we calculate food price volatility as the square root of the sum of the squared percentage changes in the monthly series:

$$V_{it} = \sqrt{\frac{\sum_{j=1}^{12} (\Delta \ln(p_{i,j,t}))^2}{11}} \quad (2)$$

where $P_{i,j,t}$ is the food price of the country i in the j th month in year t .

Figure 5 illustrates the trend of calculated annual price inflation and volatility in our sample. Inflation rate and volatility seem to be persistent or slightly decreasing until the mid-2000s. Then they show an increase in 2007–2008 and a decrease in 2009 before rising again in 2010.

Figure 5: Trend of Annual Food Price Inflation and Volatility in Developing Countries, 2001–2010



Source: Authors' calculations using the Food and Agriculture Organization of the United Nations Statistical Database (FAOSTAT).

⁵ Because food price inflation rates and volatilities are calculated using the growth rate of the indices, having different base years does not incur a problem. But there are some countries that report more than one baseline year during the sample period of this study, and these countries are excluded in the analysis.

Table 3 provides a summary of statistics for food price inflation and volatilities as well as the three health indicators for 11 LDCs and 52 other developing countries.⁶ On average, the LDCs reported higher infant and child mortalities as well as higher undernourishment prevalence than the non-LDCs between 2001 and 2010. Reflecting the substantial progress toward MDGs, all three health-related indicators dropped sharply in the LDCs even faster than in the non-LDCs, even with food price inflation being higher in the LDCs than in other developing countries. Specifically, during 2001–2010, the average food price inflation rate for the LDCs was 12.3% while that for other developing countries was 8.6%. Also, food price volatilities were higher in the LDCs than in other developing countries

Table 3: Summary Statistics

		LDCs	Non-LDCs	Total
Food Price Inflation	Average	12.3	8.6	9.3
Food Price Volatility	Average	0.0187	0.0163	0.0167
Infant Mortality	2001	58.8	32.8	37.3
	2010	39.2	23.1	25.9
	Change	19.5	9.7	11.4
Child Mortality	2001	82.1	44.1	50.7
	2010	52.2	30.3	34.1
	Change	29.9	13.8	16.6
Prevalence of Undernourishment	2001	25.6	13.5	15.6
	2010	21.9	11.0	12.9
	Change	3.7	2.5	2.8

LDC = least developed countries.

Notes:

1. LDCs were identified by the United Nations using the following three criteria: income, human resource, and economic vulnerability.

2. Average is the annual average rate during 2001–2010.

3. Change is the difference between the figures of 2010 and 2001.

Source: Authors' calculations using data from FAOSTAT and UN MDGs Indicators database.

The main objective of this paper is to capture the effects of food price inflation and volatility on population health in developing countries, but there is no doubt that various other factors also influence health conditions. Therefore, the regression analysis also includes some control variables which may affect infant mortality, child mortality, and the prevalence of undernourishment.

Listed below are the seven control variables included in the analysis:

1. Log of general government expenditure on health per capita in constant (2005) dollars: This variable captures the government's commitment to the maintenance and improvement of health and medicine. The role of public health in population health is examined in many studies (e.g., Preston 1975, 1980, and 1996; Cutler, Deaton, and Lleras-Muney 2006; Muldoon et al. 2011; Houweling et al. 2005; Evans 1995; Schell et al. 2007). Source: WHO database.⁷

⁶ The names of the 11 countries classified as LDCs are reported in Appendix A.

⁷ World Health Organization (WHO) Global Health Observatory Data Repository, <http://apps.who.int/gho/data/view.main>

2. Log of GDP per capita, purchasing power parity (PPP) in constant (2005) international dollars: This is to capture the country's level of economic development. Higher income should translate to higher expenditures on food and health for households, and higher standards of infrastructure for health and medicine for states (Pritchett and Summers 1996). However, the role of economic development in health improvement in developing countries has been controversial. Although income brings so many things—better nutrition, better housing, the ability to pay for health care, as well as the means for the public provision of clean water and sanitation—cross-country evidence does not suggest that economic development will improve health without deliberate public action (Dreze and Sen 2002; Cutler, Deaton, and Lleras-Muney 2006). Source: World Development Indicators (WDI), World Bank.⁸
3. Political score: This is an index of political regime (Polity IV) which measures the concomitant qualities of democratic and autocratic authority in governing institutions, on a 21-point scale ranging from -10 (hereditary monarchy) to +10 (consolidated democracy). We include the index as a control variable to see whether democracy level promotes population health conditions in developing countries (Wilson 2011; Houweling et al. 2005; Frey and Field 2000). Source: Center for Systemic Peace.⁹
4. Armed conflict dummy: This is a dummy variable for armed conflict, with “1” indicating if there is conflict and “0” if otherwise. It is included to capture conflict-related deaths (Mishra and Newhouse 2007). Source: International Institute for Strategic Studies.¹⁰
5. Log of youth population ages 0–14 (% of total): This is to assess how the population structure affects population health. Following Muldoon et al. (2011) and Mishra and Newhouse (2007), we also used fertility rate as an alternative indicator of population structure and found similar results. Source: WDI, World Bank.
6. Log of proportion of the population using an improved sanitation facility: The provision of sanitation is seen as an essential complement to the availability of food in preventing child malnutrition. Even if there is sufficient food for children, diarrhea hampers the intake of calories and micronutrients, and thereby prevents adequate nutritional outcomes and increases the likelihood of mortality (Charmarbagwala et al. 2004; Muldoon et al. 2011; Schell et al. 2007; Mishra and Newhouse 2007). Source: UN MDGs Indicators Database.¹¹
7. Log of agriculture, value-added as a percentage of GDP: This is to capture the level of self-sufficiency in developing countries. According to the FAO, WFP, and IFAD (2012), agricultural growth is found to be particularly effective in reducing hunger and malnutrition. Most of the extreme poor depend on agriculture and related activities for a significant part of their livelihoods. Agricultural growth involving smallholders, especially women, will be most effective in reducing

⁸ World Bank World Development Indicators (WDI), <http://data.worldbank.org/data-catalog/world-development-indicators>

⁹ Center for Systemic Peace, <http://www.systemicpeace.org/>

¹⁰ International Institute for Strategic Studies, <http://www.iiss.org/>

¹¹ UN MDG Statistics, <http://www.un.org/millenniumgoals/stats.shtml>

extreme poverty and hunger when it increases returns to labor and generates employment for the poor. Source: WDI, World Bank.

Variables on male–female education and economic inequality have also been suggested as determinants of population health in the literature (Schell et al. 2007; Charmarbagwala et al. 2004; Cutler, Deaton, and Lleras-Muney 2006; Shen and Williamson 2000). However, these variables are excluded in the regression because the annual data for developing countries are not available.

C. Results and Discussions

Table 4 reports the estimated results for contemporaneous and lagged effects of food price inflation on population health in terms of infant mortality, child mortality, and the prevalence of undernourishment. All specifications include year effects, region-fixed effects, and country-specific linear time trends. Results in columns (1), (3), and (5) show that contemporaneous price inflation rates are positively and significantly associated with all three measures of population health. A 1% increase in contemporaneous price inflation rate is associated with a 0.2% increase in infant and child mortality rate and a 0.4% increase in prevalence of undernourishment, all things being equal. Columns (2), (4), and (6) report the results when one- and two-period lagged food price inflation rates are included in the estimation to see how quickly the different health measures are affected by inflation. While undernourishment prevalence is more sensitive to contemporaneous food price inflation, infant and child mortality are more responsive to the food price inflation rates of the previous years.

Table 4: Contemporaneous and Lagged Effects of Food Price Inflation

	Infant Mortality		Child Mortality		Undernourishment	
	(1)	(2)	(3)	(4)	(5)	(6)
Food price inflation rates	0.002*** (0.001)	0.001 (0.001)	0.002*** (0.001)	0.001 (0.001)	0.004*** (0.001)	0.004*** (0.001)
Food price inflation rates (t-1)		0.001* (0.001)		0.001* (0.001)		0.002** (0.001)
Food price inflation rates (t-2)		0.001** (0.001)		0.001** (0.001)		0.0003 (0.001)
Log of government health expenditure per capita	-0.165*** (0.026)	-0.103*** (0.028)	-0.163*** (0.028)	-0.097*** (0.030)	-0.382*** (0.042)	-0.261*** (0.048)
Log of GDP per capita, PPP	0.078 (0.051)	0.014 (0.053)	0.076 (0.054)	0.025 (0.057)	0.034 (0.083)	0.004 (0.090)
Political score	-0.006** (0.002)	-0.004 (0.003)	-0.006** (0.003)	-0.004 (0.003)	0.010** (0.004)	0.011** (0.004)
Armed conflict dummy	-0.016 (0.029)	-0.021 (0.027)	-0.016 (0.031)	-0.023 (0.029)	0.038 (0.048)	0.034 (0.047)
Log of youth population share	1.002*** (0.090)	0.895*** (0.103)	1.126*** (0.097)	1.030*** (0.111)	0.506*** (0.148)	0.443** (0.176)
Log of improved sanitation facilities	-0.412*** (0.047)	-0.410*** (0.058)	-0.498*** (0.051)	-0.508*** (0.062)	-0.545*** (0.077)	-0.702*** (0.098)
Log of value-added agriculture (% of GDP)	-0.066** (0.028)	-0.022 (0.027)	-0.096*** (0.030)	-0.051* (0.029)	-0.161*** (0.046)	-0.111** (0.046)

continued on next page

Table 4 *continued*

	Infant Mortality		Child Mortality		Undernourishment	
	(1)	(2)	(3)	(4)	(1)	(2)
Constant	1.569*** (0.565)	2.186*** (0.621)	1.798*** (0.608)	2.316*** (0.670)	4.277*** (0.926)	4.848*** (1.061)
Number of observations	539	416	539	416	537	414
R2	0.963	0.981	0.966	0.982	0.927	0.960

() = standard errors, GDP = gross domestic product, PPP = purchasing power parity, R2 = R-squared.

Notes:

1. ***, ** and * denote significance at 1%, 5%, and 10%, respectively.
2. Dependent variables are log of infant mortality rate, log of child mortality rate, and log of prevalence of undernourishment.
3. All specifications control for year effects, region-fixed effects, and country-specific linear time trends.

Source: Authors' calculations.

For all specifications, the log of government health expenditures per capita is negatively associated with infant mortality, child mortality, and the prevalence of undernourishment, implying that governments' strong commitment to public health plays an important role in improving population health. While the log of youth population share has a positive association with population health in developing countries, the log of improved sanitation facilities and the log of value-added agriculture as a percentage of GDP have statistically significant negative relationships in all equations. Political score, or the level of democracy, does not have consistent results: while columns (1) and (3) seem to show that a high democracy level reduces infant and child mortality, it is a puzzle that in columns (5) and (6), political score shows a positive association with the prevalence of undernourishment. Meanwhile, the coefficients of the log of GDP per capita and the armed conflict dummy are not statistically significant for all specifications. The reason why GDP per capita is not significant is that the log of GDP per capita is highly correlated with other control variables.¹² The insignificance of conflict is consistent with the findings of Mishra and Newhouse (2007), but the reason for this finding deserves further investigation.

Table 5 reports the contemporaneous and lagged effects of food price volatility on population health. According to the findings, high food price volatility increases infant and child mortality, but does not seem to affect the prevalence of undernourishment. Infant and child mortalities are mostly affected by the past food price volatilities, implying that it takes some time for food price volatility to affect mortality rates. Although the coefficients of price volatility are larger than price inflation rates, we cannot say that price volatility has a bigger impact on population health outcomes, because different units are used to measure inflation and volatility. Other control variables reveal similar results for food price inflation rate, as in Table 3.

¹² In our sample, the simple correlation between the log of GDP per capita and the log of government health expenditure per capita is 0.888, while between the log of GDP per capita and the log of youth population share is -0.5862.

Table 5: Contemporaneous and Lagged Effects of Food Price Volatility

	Infant Mortality		Child Mortality		Undernourishment	
	(1)	(2)	(3)	(4)	(5)	(6)
Food price volatility	1.920** (0.797)	0.415 (0.786)	1.978** (0.855)	0.410 (0.848)	1.823 (1.339)	1.537 (1.368)
Food price volatility (t-1)		0.823 (0.732)		0.898 (0.789)		0.437 (1.272)
Food price volatility (t-2)		1.957*** (0.694)		2.139*** (0.748)		0.940 (1.205)
Log of government health expenditure per capita	-0.198*** (0.030)	-0.136*** (0.030)	-0.198*** (0.032)	-0.136*** (0.032)	-0.306*** (0.051)	-0.206*** (0.052)
Log of GDP per capita, PPP	0.087* (0.051)	0.034 (0.053)	0.084 (0.055)	0.049 (0.057)	-0.016 (0.086)	-0.043 (0.092)
Political score	-0.003 (0.003)	-0.002 (0.003)	-0.002 (0.003)	-0.001 (0.003)	0.002 (0.005)	0.003 (0.005)
Armed conflict dummy	-0.003 (0.029)	-0.021 (0.028)	-0.002 (0.031)	-0.024 (0.030)	0.016 (0.049)	-0.021 (0.049)
Log of youth population share	1.030*** (0.090)	0.935*** (0.104)	1.162*** (0.097)	1.073*** (0.112)	0.647*** (0.151)	0.588*** (0.180)
Log of improved sanitation facilities	-0.378*** (0.046)	-0.362*** (0.057)	-0.461*** (0.049)	-0.455*** (0.061)	-0.513*** (0.077)	-0.642*** (0.099)
Log of value-added agriculture (% of GDP)	-0.098*** (0.028)	-0.046* (0.028)	-0.132*** (0.031)	-0.078*** (0.030)	-0.155*** (0.048)	-0.107** (0.048)
Constant	1.437** (0.558)	1.826*** (0.611)	1.656*** (0.599)	1.906*** (0.659)	3.836*** (0.936)	4.363*** (1.061)
Number of observations	531	411	531	411	529	409
R2	0.963	0.980	0.966	0.982	0.924	0.957

() = standard errors, GDP = gross domestic product, PPP = purchasing power parity, R2 = R-squared.

Notes:

1. ***, ** and * denote significance at 1%, 5%, and 10%, respectively.
2. Dependent variables are log of infant mortality rate, log of child mortality rate, and log of prevalence of undernourishment.
3. All specifications control for year effects, region-fixed effects, and country-specific linear time trends.

Source: Authors' calculations.

Table 6 reports the different effects of food price and volatility on population health in the LDCs and other developing countries. In our sample, 11 countries are classified as LDCs.¹³ As one may expect, the results show that the LDCs are more vulnerable to high food price inflation and volatility than other developing countries. A 1% increase in food price inflation incurs an increase of 0.3% in both infant and child mortalities, and 0.5% in undernourishment prevalence. On the other hand, food price inflation does not have a significant impact on infant and child mortalities, and has a smaller influence on the prevalence of undernourishment in other

¹³ Although there are 49 countries categorized by the UN as LDCs, only 11 of them have been included in this study because of data limitations. Therefore, one should be cautious when generalizing the estimated results.

developing countries than in the LDCs. It also appears that food price volatility has a detrimental effect on population health only among the LDCs.

**Table 6: Effects of Food Price Inflation and Volatility:
Least Developed Countries vs. Other Developing Countries**

	Infant Mortality (1)	Child Mortality (2)	Under- nourishment (3)	Infant Mortality (4)	Child Mortality (5)	Under- nourishment (6)
Food price inflation *	0.003***	0.003***	0.005***			
LDCs	(0.001)	(0.001)	(0.001)			
Food price inflation *	0.001	0.001	0.003*			
non-LDCs	(0.001)	(0.001)	(0.001)			
Food price volatility *				3.199***	3.579***	4.546**
LDCs				(1.156)	(1.239)	(1.936)
Food price volatility *				1.023	0.856	-0.091
non-LDCs				(0.990)	(1.061)	(1.659)
Log of government health expenditure per capita	-0.167***	-0.165***	-0.385***	-0.204***	-0.204***	-0.318***
	(0.026)	(0.028)	(0.043)	(0.030)	(0.032)	(0.051)
Log of GDP per capita, PPP	0.086*	0.085	0.045	0.103**	0.103*	0.018
	(0.051)	(0.055)	(0.083)	(0.052)	(0.056)	(0.088)
Political score	-0.006**	-0.006**	0.011***	-0.002	-0.002	0.003
	(0.002)	(0.003)	(0.004)	(0.003)	(0.003)	(0.005)
Armed conflict dummy	-0.017	-0.018	0.035	-0.003	-0.002	0.016
	(0.029)	(0.031)	(0.048)	(0.029)	(0.031)	(0.049)
Log of youth population share	1.000***	1.124***	0.505***	1.024***	1.154***	0.635***
	(0.090)	(0.097)	(0.148)	(0.090)	(0.097)	(0.151)
Log of improved sanitation facilities	-0.409***	-0.495***	-0.541***	-0.370***	-0.451***	-0.496***
	(0.047)	(0.051)	(0.077)	(0.046)	(0.050)	(0.077)
Log of value-added agriculture (% of GDP)	-0.063**	-0.093***	-0.158***	-0.094***	-0.127***	-0.147***
	(0.028)	(0.030)	(0.046)	(0.029)	(0.031)	(0.048)
Constant	1.496***	1.716***	4.176***	1.306**	1.492**	3.558***
	(0.566)	(0.609)	(0.929)	(0.564)	(0.604)	(0.944)
Number of observations	539	539	537	531	531	529
R2	0.963	0.966	0.927	0.963	0.966	0.925

() = standard errors, GDP = gross domestic product, PPP = purchasing power parity, R2 = R-squared.

Notes:

1. ***, ** and * denote significance at 1%, 5%, and 10%, respectively.
2. Dependent variables are log of infant mortality rate, log of child mortality rate, and log of prevalence of undernourishment.
3. All specifications control for year effects, region-fixed effects, and country-specific linear time trends.

Source: Authors' calculations.

Lastly, Table 7 reports the results when food price inflation and volatility variables are interacted with the log of agriculture, value-added as a percentage of GDP. In most of the specifications, the coefficients of interaction terms are negative numbers, implying a smaller impact of food price inflation and volatility on population health in developing countries with a

greater share of agriculture in GDP. The results support the assessment made by Konandreas (2012) that better trade policy responses to food prices are necessary in poor net food-importing countries since they are more vulnerable to high and volatile food prices.

Table 7: Food Price Inflation and Volatility: Agriculture Interaction Effects

	Infant Mortality (1)	Child Mortality (2)	Under-nourishment (3)	Infant Mortality (1)	Child Mortality (2)	Under-nourishment (3)
Food price inflation	0.009*** (0.002)	0.009*** (0.003)	0.012*** (0.004)			
Food price inflation * Agriculture	-0.003*** (0.001)	-0.003*** (0.001)	-0.003* (0.002)			
Food price volatility				10.506*** (2.822)	10.696*** (3.030)	6.544 (4.780)
Food price volatility * Agriculture				-3.351*** (1.057)	-3.402*** (1.135)	-1.842 (1.791)
Log of government health expenditure per capita	-0.159*** (0.026)	-0.157*** (0.028)	-0.376*** (0.042)	-0.197*** (0.030)	-0.197*** (0.032)	-0.305*** (0.051)
Log of GDP per capita, PPP	0.061 (0.051)	0.058 (0.054)	0.016 (0.083)	0.092* (0.051)	0.088 (0.055)	-0.013 (0.086)
Political score	-0.006** (0.002)	-0.006** (0.003)	0.011*** (0.004)	-0.002 (0.003)	-0.002 (0.003)	0.003 (0.005)
Armed conflict dummy	-0.018 (0.029)	-0.018 (0.031)	0.035 (0.047)	-0.013 (0.029)	-0.012 (0.031)	0.011 (0.049)
Log of youth population share	0.989*** (0.090)	1.113*** (0.096)	0.493*** (0.148)	1.033*** (0.089)	1.165*** (0.096)	0.649*** (0.151)
Log of improved sanitation facilities	-0.417*** (0.047)	-0.503*** (0.050)	-0.550*** (0.077)	-0.383*** (0.046)	-0.466*** (0.049)	-0.516*** (0.077)
Log of value-added agriculture (% of GDP)	-0.049* (0.028)	-0.079*** (0.031)	-0.143*** (0.047)	-0.038 (0.034)	-0.071* (0.036)	-0.122** (0.057)
Constant	1.707*** (0.562)	1.942*** (0.605)	4.431*** (0.926)	1.255** (0.555)	1.472** (0.597)	3.737*** (0.941)
Number of observations	539	539	537	531	531	529
R2	0.964	0.966	0.928	0.964	0.967	0.924

() = standard errors, GDP = gross domestic product, PPP = purchasing power parity, R2 = R-squared.

Notes:

1. ***, ** and * denote significance at 1%, 5%, and 10%, respectively.
2. Dependent variables are log of infant mortality rate, log of child mortality rate, and log of prevalence of undernourishment.
3. All specifications control for year effects, region-fixed effects, and country-specific linear time trends.

Source: Authors' calculations.

IV. SUMMARY AND POLICY IMPLICATIONS

High food prices have a potentially detrimental impact on the nutrition and health of the population in developing countries where the majority of the household income is spent on basic foodstuff.

High and volatile food prices are of major concern because they erode the purchasing power of poor households, and could undermine nutrition and health especially among women and children. Using a panel dataset covering 63 developing countries for the period from 2001 to 2010, this paper makes a comprehensive assessment on the effects of food price inflation and volatility on population health, measured as infant mortality rate, child mortality rate, and the prevalence of undernourishment. We find that rising and fluctuating food prices have a significant and adverse effect on all three health indicators in developing countries. Furthermore, the impact of food prices is greater in the LDCs. Interestingly, however, the impact is smaller in countries with a higher share of agriculture in GDP.

Empirical findings support the international call for an increase in government investment in public health. In all specifications, government health expenditures per capita have a negative relationship with infant mortality, child mortality, and undernourishment prevalence. Governments can play an important role in improving population health in developing countries by taking the lead in developing effective national health systems and strengthening investment in public health.

Strong policy actions are needed to mitigate the effects of food price inflation and volatility on health and nutrition. In the short run, the focus may be on helping poor households and farmers cope with the risks of transitory food price hikes and volatility. Well-targeted safety nets such as cash or in-kind transfers, feeding programs, and emergency employment programs may offer effective short-term relief (ADB 2012). In the long run, investing in agriculture and human capital development is critical for ensuring food security and achieving overall development goals. Investing in human development and basic infrastructure services is fundamental to helping the poor break out of the poverty trap and achieve food security, while farm investments should target increased agricultural productivity and rural development to meet the growing demand for food in a sustainable manner over the long term.

APPENDIXES

Appendix A: Country List and Statistics on Food Price

Region	Country	Least Developed Countries	Food Price Inflation 2001–2010 Average (%)	Food Price Volatility 2001–2010 Average	
East Asia and the Pacific	1	Cambodia	LDC	1.7	0.0179
	2	People's Republic of China		5.8	0.0164
	3	Fiji		4.8	0.0156
	4	Indonesia		10.0	0.0175
	5	Lao People's Democratic Republic	LDC	9.0	0.0174
	6	Malaysia		7.8	0.0096
	7	Philippines		8.6	0.0197
	8	Solomon Islands	LDC	7.6	0.0077
	9	Thailand		0.1	0.0164
	10	Timor-Leste	LDC	6.1	0.0192
	11	Viet Nam		13.3	0.0191
South Asia	12	Bangladesh	LDC	7.4	0.0129
	13	Bhutan	LDC	5.5	...
	14	India		7.4	0.0123
	15	Nepal	LDC	5.7	0.0120
	16	Pakistan		5.6	0.0064
	17	Sri Lanka		7.3	0.0262
Sub-Saharan Africa	18	Angola	LDC	50.8	0.0329
	19	Botswana		9.7	0.0099
	20	Cameroon		3.9	0.0113
	21	Ethiopia	LDC	17.4	0.0265
	22	Kenya		15.5	0.0228
	23	Malawi	LDC	4.7	0.0054
	24	Mauritius		5.6	0.0101
	25	Nigeria		11.1	0.0177
	26	South Africa		11.9	0.0268
Middle East and North Africa	27	Algeria		4.6	0.0260
	28	Egypt		9.4	0.0158
	29	Jordan		6.1	0.0162
	30	Morocco		8.3	0.0182
	31	Syrian Arab Republic		4.7	0.0080
	32	Tunisia		4.0	0.0065
	33	Yemen	LDC	19.3	0.0356

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Table *continued*

Region	Country	Least Developed Countries	Food Price Inflation 2001–2010 Average (%)	Food Price Volatility 2001–2010 Average
Latin America and the Caribbean	34	Argentina	12.8	0.0132
	35	Bolivia	6.2	0.0105
	36	Brazil	8.0	0.0103
	37	Chile	4.6	0.0093
	38	Colombia	7.0	0.0091
	39	Costa Rica	12.6	0.0123
	40	Dominican Republic	13.1	0.0170
	41	El Salvador	4.2	0.0130
	42	Guatemala	8.8	0.0100
	43	Honduras	7.4	0.0101
	44	Jamaica	13.0	0.0141
	45	Mexico	2.8	0.0135
	46	Nicaragua	13.6	0.0188
	47	Panama	11.6	0.0244
	48	Paraguay	3.6	0.0062
49	Peru	5.2	0.0059	
50	Uruguay	10.5	0.0153	
51	Venezuela	28.4	0.0283	
Europe and Central Asia	52	Albania	3.0	0.0231
	53	Armenia	6.2	0.0279
	54	Azerbaijan	9.4	0.0166
	55	Belarus	28.3	0.0215
	56	Bulgaria	4.7	0.0193
	57	Georgia	2.3	0.0229
	58	Latvia	7.1	0.0132
	59	Lithuania	4.3	0.0093
	60	Republic of Moldova	7.4	...
	61	Former Yugoslav Republic of Macedonia	8.6	0.0446
	62	Turkey	17.9	0.0257
	63	Ukraine	9.9	0.0156

... = no data.

Source: Authors' calculations using FAOSTAT.

Appendix B: Country List and Statistics on Population Health

Region	Country	Least Developed Countries	Infant Mortality			Child Mortality			Undernourishment			
			2001	2010	Change	2001	2010	Change	2001	2010	Change	
East Asia and the Pacific	1	Cambodia	LDC	72.1	39.0	33.1	94.5	46.0	48.5	32.8	18.9	13.9
	2	People's Republic of China		27.1	13.7	13.4	32.7	15.9	16.8	14.3	11.5	2.8
	3	Fiji		18.6	14.7	3.9	21.8	17.1	4.7	< 5.0	< 5.0	0.0
	4	Indonesia		36.4	25.8	10.6	50.5	33.3	17.2	17.4	9.4	8.0
	5	Lao	LDC	57.0	35.2	21.8	76.4	43.9	32.5	38.4	28.0	10.4
		People's Democratic Republic										
	6	Malaysia		15.4	13.0	2.4	17.7	15.2	2.5	6.3	5.5	0.8
	7	Philippines		19.5	14.3	5.2	22.9	16.6	6.3	< 5.0	< 5.0	0.0
	8	Solomon Islands	LDC	53.0	35.5	17.5	76.3	52.6	23.7	< 5.0	< 5.0	0.0
	9	Thailand		13.7	9.2	4.5	15.6	10.2	5.4	< 5.0	< 5.0	0.0
	10	Timor-Leste	LDC	81.1	48.5	32.6	102.8	57.6	45.2	28.2	36.2	-8.0
11	Viet Nam		25.3	18.1	7.2	32.5	22.6	9.9	20.9	10.1	10.8	
South Asia	12	Bangladesh	LDC	59.2	38.6	20.6	80.0	48.7	31.3	17.0	17.1	0.1
	13	Bhutan	LDC	62.6	43.6	19.0	85.2	55.9	29.3	< 5.0	< 5.0	0.0
	14	India		62.4	48.6	13.8	85.0	63.4	21.6	21.6	18.3	3.3
	15	Nepal	LDC	32.7	22.7	10.0	40.4	27.0	13.4	31.3	21.5	9.8
	16	Pakistan		20.6	17.1	3.5	25.1	20.0	5.1	24.1	11.1	13.0
	17	Sri Lanka		18.7	13.7	5.0	22.0	15.9	6.1	< 5.0	< 5.0	0.0
Sub-Saharan Africa	18	Angola	LDC	116.6	98.2	18.4	195.4	161.0	34.4	45.6	28.0	17.6
	19	Botswana		48.8	21.3	27.5	80.8	27.5	53.3	34.2	29.0	5.2
	20	Cameroon		85.9	79.9	6.0	138.9	128.9	10.0	26.8	15.1	11.7
	21	Ethiopia	LDC	82.1	54.0	28.1	131.5	81.5	50.0	53.5	41.0	12.5
	22	Kenya		67.8	50.1	17.7	109.2	76.1	33.1	34.3	30.9	3.4
	23	Malawi	LDC	8.7	5.8	2.9	10.1	6.8	3.3	< 5.0	< 5.0	0.0
	24	Mauritius		22.8	14.1	8.7	27.5	16.6	10.9	< 5.0	< 5.0	0.0
	25	Nigeria		74.3	60.4	13.9	93.0	73.7	19.3	23.9	20.3	3.6
	26	South Africa		15.8	10.8	5.0	18.4	12.6	5.8	28.6	24.5	4.1
Middle East and North Africa	27	Algeria		37.1	26.9	10.2	43.6	31.3	12.3	5.5	< 5.0	0.0
	28	Egypt		33.5	19.1	14.4	41.5	22.5	19	< 5.0	< 5.0	0.0
	29	Jordan		23.3	18.4	4.9	27.2	21.1	6.1	5.0	5.0	0.0
	30	Morocco		59.3	40.6	18.7	78.9	50.3	28.6	24.0	18.4	5.6
	31	Syrian Arab Republic		15.4	11.0	4.4	17.9	12.8	5.1	< 5.0	< 5.0	0.0
	32	Tunisia		23.4	14.8	8.6	27.9	17.2	10.7	< 5.0	< 5.0	0.0
	33	Yemen	LDC	70.0	58.3	11.7	96.9	78.5	18.4	30.9	31.8	-0.9

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Table *continued*

Region	Country	Least Developed Countries	Infant Mortality			Child Mortality			Undernourishment		
			2001	2010	Change	2001	2010	Change	2001	2010	Change
	34	Argentina	17.6	13.0	4.6	19.7	14.5	5.2	< 5.0	< 5.0	0.0
	35	Bolivia	56.8	40.9	15.9	77.1	52.9	24.2	28.5	24.8	3.7
	36	Brazil	29.4	15.0	14.4	33.6	16.8	16.8	11.1	7.2	3.9
	37	Chile	8.7	7.7	1.0	10.4	8.8	1.6	< 5.0	< 5.0	0.0
	38	Colombia	20.5	15.8	4.7	24.3	18.3	6	13.1	12.4	0.7
	39	Costa Rica	10.5	8.7	1.8	12.3	10.1	2.2	< 5.0	5.8	-0.8
	40	Dominican Republic	30.3	21.7	8.6	37.0	25.7	11.3	21.9	15.4	6.5
Latin America and the Caribbean	41	El Salvador	26.2	14.0	12.2	31.6	16.3	15.3	8.8	11.9	-3.1
	42	Guatemala	35.8	25.2	10.6	46.2	31.6	14.6	25.7	29.7	-4.0
	43	Honduras	27.7	18.9	8.8	33.5	22.2	11.3	15.7	10.0	5.7
	44	Jamaica	21.0	16.3	4.7	24.8	19.0	5.8	6.7	8.7	-2.0
	45	Mexico	42.6	29.4	13.2	50.5	34.3	16.2	5.8	5.4	0.4
	46	Nicaragua	109.0	80.8	28.2	181.3	129.2	52.1	10.1	8.1	2.0
	47	Panama	27.9	19.9	8.0	33.8	23.4	10.4	12.1	22.1	-10.0
	48	Paraguay	27.9	15.1	12.8	36.3	19.4	16.9	22.8	12.6	10.2
	49	Peru	28.4	21.0	7.4	37.3	26.4	10.9	21.0	16.6	4.4
	50	Uruguay	14.4	9.1	5.3	16.6	10.8	5.8	< 5.0	< 5.0	0.0
	51	Venezuela	18.3	13.4	4.9	21.5	15.6	5.9	16.2	< 5.0	11.2
Europe and Central Asia	52	Albania	22.2	13.4	8.8	25.0	15.0	10.0	< 5.0	< 5.0	0.0
	53	Armenia	25.0	16.4	8.6	28.3	18.3	10.0	16.1	< 5.0	11.1
	54	Azerbaijan	55.0	39.8	15.2	66.4	46.4	20.0	10.4	< 5.0	5.4
	55	Belarus	10.1	4.3	5.8	12.8	6.1	6.7	< 5.0	< 5.0	0.0
	56	Bulgaria	17.0	11.0	6.0	19.9	12.7	7.2	5.0	5.0	0.0
	57	Georgia	27.5	19.2	8.3	31.3	21.5	9.8	22.8	28.2	-5.4
	58	Latvia	13.5	7.6	5.9	16.1	8.9	7.2	< 5.0	< 5.0	0.0
	59	Lithuania	9.0	5.1	3.9	11.2	6.2	5.0	< 5.0	< 5.0	0.0
	60	Republic of Moldova	24.7	18.9	5.8	29.6	22.2	7.4	14.0	12.5	1.5
	61	Former Yugoslav Republic of Macedonia	94.2	56.1	38.1	156.6	89.0	67.6	27.3	23.2	4.1
	62	Turkey	26.1	12.5	13.6	32.8	16.3	16.5	< 5.0	< 5.0	0.0
	63	Ukraine	15.1	9.2	5.9	17.6	10.7	6.9	< 5.0	< 5.0	0.0

Note: <5 are data less than 5%. They are regarded as 5 in the estimation.

Source: Authors' calculations using the UN MDGs Indicators database.

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**Food Prices and Population Health in Developing Countries:
An Investigation of the Effects of the Food Crisis Using a Panel Analysis**

The effects of high and unstable food prices can be felt anywhere in the world—but more so in developing countries, where the poor are most vulnerable. Prohibitive food prices threaten food security, hindering the poor from getting adequate nutrition. Using a dataset covering 63 developing countries from 2001 to 2010, this paper examines the effects of food price inflation and volatility on population health in developing countries, specifically in terms of infant mortality, child mortality, and undernourishment. The paper finds that rising food prices have a significant and adverse effect on health indicators in developing countries.

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