# Research on the Influence of Food Prices on Children's Malnutrition

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**Abstract.** Nutrition poses a critical concern in developing nations. Studying economic factors like food prices aids in understanding how food prices impact children's well-being, informing policy decisions. This study selected relevant datasets and involved regression and time series analysis to examine the connection between food prices and children's malnutrition in low-income food-deficit countries, considering their higher malnutrition prevalence and diverse influencing factors. The results highlight significant yet complex correlations between the Consumer Price Index (CPI) of food and stunted children, as well as the CPI of food and Minimum Dietary Energy Requirement (MDER). The time series analysis of CPI indicates fluctuating trends with periodic seasonal patterns, suggesting potential instability in food prices and children's malnutrition. However, economic policies, socio-economic factors, agricultural practices, and cognitive behaviors affect nutritional outcomes synthetically, thus calling for deliberate interventions to address malnutrition among children.

**Keywords:** CPI of Food; Children's Malnutrition; Analysis of influence factors.

## 1. Introduction

Nutrition remains a critical concern in developing countries. The deficiency of protein-energy and essential micronutrients like iron, iodine, vitamin A, and zinc affects both pregnant women and children [1]. This insufficiency significantly impacts childhood development, emphasized by Ijarotimi's 2013 study stressing the importance of early childhood nutrition for growth, cognitive development, and overall well-being [2]. However, challenges such as poverty, limited knowledge, and infections persist in many developing areas, contributing to increased rates of malnutrition, childhood illnesses, and mortality. Moreover, based on the findings of Olofin et al. in 2013, increased mortality rates among children under five and various forms of being underweight, stunting, and wasting are linked directly [3]. These researches underscore the urgent need for effective interventions to address these health concerns.

A large body of literature has focused on indices such as stunting rate, the prevalence or percentage of children under a certain age (usually under five years old) who fall below a specific height-for-age threshold, and wasting rate, the prevalence or percentage of children under a certain age (usually under five years old) who have a low weight-for-height ratio [4]. In overseeing the economic factors impacting these indices, food prices and food inflation serve as fundamental metrics. Typically, these metrics are employed to gauge the prevailing economic conditions concerning the cost and inflation of food items. One of the more commonly utilized approaches involves employing various regression analyses to comprehensively grasp the intricate relationship between these economic factors and the indices under consideration. This method allows for a deeper understanding of how fluctuations in food prices and inflationary trends affect well-being, enabling more informed predictions and policy decisions.

This study aims to explore the interconnection between food prices and child malnutrition while also predicting the trajectory of food prices in nations facing food shortages. Very few studies have attempted to combine predicting the future food prices and the severity, diversity, or prevalence of child malnutrition. This paper endeavors to shed light on potential future scenarios of child malnutrition based on current conditions. This approach allows policymakers to consider not only present economic and social factors but also anticipate future indicators. This foresight aids in formulating more dependable policies related to food price variations, as well as import and export regulations, creating a more robust and informed framework for decision-making.

## 2. Literature Review

Ample studies have reaped significant progress in measuring how food price changes affect health or welfare. Campenhout et al. extensively analyzed the impact of price changes on household welfare in Uganda using the compensating variation (CV) to calculate the Welfare Index [5]. They assessed the short-term effects of price fluctuations on households, then expanded to encompass long-term scenarios, aiming to explore the effects of external changes in international prices and internal economic shocks on domestic prices. Their findings revealed a significant rise in welfare levels among rural farming households, primarily due to increased returns from agricultural labor and land and improved market prices for their output sold.

Likewise, the study conducted by Lee, Lim, Lee, and Park in 2013 reveals that increasing food prices negatively impact health indicators in developing countries [6]. This effect is more pronounced in the least developed nations. However, countries with a higher agricultural contribution to their GDP experience a moderated impact from rising food prices on health indicators.

Subsequent research pays more attention to health topics and responds to children’s well-being through health. Variable indices and methods are considered to better approach the results. In the study by Arndt et al., weight-for-height and weight-for-age during various survey periods marked by distinct food price inflation rates are selected as research indicators [7]. Employing propensity score matching methods, they observed lower inflation rates for essential food items in the fourth quarter compared to the earlier quarters, which generally experienced high food price inflation. Their analysis suggests that food scarcity, influenced by both the food and fuel price crisis along with a shortened agricultural production year, notably contributes to increased malnutrition among children under five in Mozambique.

To gauge the effects of actual fluctuations in food prices on child malnutrition across 44 developing nations, Headey and Ruel connected a broad multi-country DHS dataset with national-level data on distinct consumer price indices in 2023 [8]. Three models are used in this study: a three-step weighting approach, non-parametric local polynomial regressions, and weighted multivariate linear probability models. These models discern trends in the data, graphically represent malnutrition rates concerning child age, gender, asset poverty, urban/rural settings, and agricultural ownership within rural areas, and are capable of uncovering actual shifts in food prices and occurrences of child malnutrition. They found out that a 5 percent increase in real food prices raises wasting risk by 9 percent and severe wasting by 14 percent. Food inflation during pregnancy and a child's first year increases stunting risk for 2-5-year-olds. The study highlights the urgency for interventions to prevent food inflation and mitigate its harm to vulnerable children and mothers.

There are also abundant documents that have studied how policies actively affect food prices to improve well-being. For instance, one research from Brander, Bernauer, and Huss in 2023 investigated trade policy and price volatility synthetically [9]. In their study, an original dataset analyzing trade policy changes during food price crises was used to highlight that announcing alterations in wheat and maize trade policies can significantly increase global price volatility. This indicates that policy creators ought to focus on elevating stock levels to alleviate the impact of trade policy alterations on price instability.

## 3. Method

### 3.1. Select Suitable Datasets

To measure the relationship between food prices and children’s malnutrition, the following data are selected in this study: the Consumer Price Index (CPI) of food, the number of children under 5 years of age who are stunted, and the Minimum Dietary Energy Requirement (MDER) [10, 11]. Based on the fact that the CPI for food includes a diverse basket of food items and is calculated using a weighted average, meaning that the items in the basket are given different weightings based on their relative importance in typical consumer spending, the CPI of food is a desirable index to represent food prices. Since the standard for measuring malnutrition varies between countries, the number of children stunting, the index depicting a more severe condition and is typically used as a chronic malnutrition indicator, would be suitable for this study. The MDER provides important insights into children's nutritional status and adequacy of food intake.

### 3.2. Measure the Relationships

To explore the correlation among CPI of food, children's stunting amount, and MDER, regression analysis is applied. This can help in revealing existing trends between variables of interest. However, forecasting future trends of CPI of food might uncover the tendency of the prevalence of children's stunting and MDER progression, thus time series analysis is also conducted in this research. Seasonal decomposition separates the time series into trend, seasonal, and residual. Those fundamental components support further analysis.

Several tests were conducted in this study. Autocorrelation function (ACF), the correlation between a time series and a lagged version of itself at different lags, and partial autocorrelation function (PACF), the correlation between the series at a particular lag (k) while controlling for the influence of intermediate lags, are vital in time series analysis, helping identify temporal patterns and dependencies within a dataset. They reveal how past observations influence future values, validate assumptions about stationarity, and guide the choice of forecasting models. The Augmented Dickey-Fuller (ADF) test determines the dataset's stationarity. This study opts for the Error-Trend-Seasonality (ETS) model and Prophet forecasting to predict future trends in food CPI. These methods better handle complex seasonal behaviors, like holidays, enhancing prediction accuracy.

### 3.3. Select the Proper Countries

In the context of children's malnutrition, the relevant data from food-deficit countries is more representative and researchable. The higher prevalence and diverse factors of malnutrition may offer opportunities for implementing and studying the effectiveness of interventions aimed at improving nutrition. Therefore, this study narrowed its focus to six food-deficit countries due to data availability and stationarity. The countries are Ethiopia, Kenya, Malawi, Mozambique, the Syrian Arab Republic, and Uzbekistan.

## 4. Results

### 4.1. Correlation between CPI of food, number of children stunted, and MCER

The statistical analysis reveals compelling insights into the relationship between the Consumer Price Index (CPI) of food and the number of stunted children. The derived linear regression equation:

$$Number\ of\ Children\ Stunted\ (million) = \beta_0 + \beta_1 \times CPI\ of\ food + \varepsilon \tag{1}$$

signifies a discernible association. The P-values for slope and intercept exhibit statistical significance within the linear regression analysis. The values for multiple $R^2$ demonstrate what percent of the variability in the number of stunted children in these countries is linked to changes in the CPI of food, and showcases the predictive capacity (Table 1).

**Table 1.** Results from Number of Children Under 5 Years of Age Stunted.

| | $\boldsymbol{\beta_0}$ | P-value (intercept, α=0.05) | $\boldsymbol{\beta_1}$ | P-value (slope, α=0.05) | Multiple $R^2$ |
|---|---|---|---|---|---|
| Ethiopia | 7.030248 | $< 2 \times 10^{-16}$ | $-0.003966$ | $8.23 \times 10^{-5}$ | 0.5299 |
| Kenya | 2.4557169 | $< 2 \times 10^{-16}$ | $-0.0070232$ | $2.48 \times 10^{-11}$ | 0.8851 |
| Malawi | 1.2722791 | $< 2 \times 10^{-16}$ | $-0.0010153$ | $1.87 \times 10^{-7}$ | 0.7332 |
| Mozambique | 1.5783940 | $< 2 \times 10^{-16}$ | 0.0022617 | $3.16 \times 10^{-8}$ | 0.7742 |

Continued Table 1.

| | | | | | |
|---|---|---|---|---|---|
| Syrian Arab Republic | $\mathbf{0.7377622}$ | $\mathbf{< 2 \times 10^{-16}}$ | $\mathbf{-0.0002809}$ | $\mathbf{0.00012}$ | $\mathbf{0.5133}$ |
| Uzbekistan | 0.6238832 | $1.09 \times 10^{-14}$ | $-0.0017423$ | $4.68 \times 10^{-6}$ | 0.6395 |

Similarly, the statistical examination uncovers compelling observations about how the Consumer Price Index (CPI) for food correlates with MDER. The derived linear regression equation:

$$MDER\ (kcal/cap/day) = \beta_0 + \beta_1 \times CPI\ of\ food + \varepsilon \quad (2)$$

showcases a robust relationship. The statistical significance of both the slope and intercept's P-values is evident in the linear regression analysis. Additionally, the multiple R-squared values indicate the proportion of variance in the number of stunted children in these nations associated with fluctuations in the CPI for food, revealing the model's predictive capability.

**Table 2.** Results from Minimum Dietary Energy Requirement.

| | $\boldsymbol{\beta_0}$ | P-value (intercept, α=0.05) | $\boldsymbol{\beta_1}$ | P-value (slope, α=0.05) | Multiple $R^2$ |
|---|---|---|---|---|---|
| Ethiopia | 1671 | $< 2 \times 10^{-16}$ | 0.3029 | $3.14 \times 10^{-7}$ | 0.7199 |
| Kenya | 1661 | $< 2 \times 10^{-16}$ | 0.6048 | $< 2 \times 10^{-16}$ | 0.9715 |
| Malawi | 1643 | $< 2 \times 10^{-16}$ | 0.2607 | $1.64 \times 10^{-14}$ | 0.9426 |
| Mozambique | 1664 | $< 2 \times 10^{-16}$ | 0.1377 | $3.23 \times 10^{-12}$ | 0.9053 |
| Syrian Arab Republic | 1762 | $< 2 \times 10^{-16}$ | 0.06925 | $1.01 \times 10^{-7}$ | 0.7483 |
| Uzbekistan | 1829 | $1.09 \times 10^{-14}$ | 0.01963 | 0.68 | 0.008282 |

These outcomes underscore the varying degrees of association between the CPI of food and critical indicators such as children's stunting rates and Minimum Dietary Energy Requirements in the selected nations, highlighting the need for a nuanced understanding of the impact of food price fluctuations on these crucial factors.

### 4.2. Analysis of the Correlations.

Based on the result of the correlations (Table 3), it can be observed that the CPI of food slightly reflects the transformation in the number of children under five years old who are stunted. Although most of the countries exhibit negative correlations, they are not convincing. Whether or not the continuously increasing CPI of food indicates children less stunted is undetermined, the relationship between rising food prices and child stunting is complex and multifaceted. Various socioeconomic factors, access to resources, dietary habits, and government interventions all play significant roles in determining how a rise in food prices may impact child nutrition and growth. One study by Headey and Hirvonen (2023) has found that rising food prices tend to reduce poverty, except in more urban or non-agrarian countries. This is likely because higher food prices prompt increased agricultural production and create more demand for unskilled labor, leading to higher wages. This is one of the hypotheses explaining the reason why increased CPI of food might decrease the number of stunted children. However, the exact relationship between poverty and child stunting is indecisive.

Compared with the stunted number, the CPI of food estimates MDER better (Table 2). Unlike developed and developing countries, while the higher food prices can impact food accessibility and affordability for families (particularly those with low incomes), the poverty rate declined as people in low-income food-deficit countries gained the opportunity to boost their wages. Under this circumstance, the negative effect brought by the CPI of food is somewhat offset. However, whether or not the climb in wages surpasses the CPI requires further study. Whereas MDER focuses on energy intake, stunting is influenced not only by energy intake but also by the quality and diversity of the diet. In lower-income populations or areas with limited access to diverse and nutritious foods, meeting MDER might still indicate inadequate nutrition overall due to deficiencies in other essential nutrients like proteins, vitamins, and minerals.

**Table 3.** Highly reliable correlations with orientations.

| | Stunted Number ~ CPI of Food | MDER ~ CPI of Food |
|---|---|---|
| Ethiopia | × | × |
| Kenya | Very slightly negative | Positive |
| Malawi | × | Positive |
| Mozambique | × | Slightly positive |
| Syrian Arab Republic | × | × |
| Uzbekistan | × | × |

### 4.3. Forecast Directions of the CPI of Food.

In general, the CPI for food demonstrates variations across time. There is a noticeable rise in variability over time, implying potential periods of instability or fluctuating inflationary pressures. These time series do not show a consistent trend upwards or downwards, suggesting that although there are intervals of increasing prices, they are subsequently succeeded by periods of price decreases (Fig. 1). A clear recurring seasonal trend is evident, indicating specific periods throughout the year consistently showcasing either higher or lower CPI values. This pattern could stem from seasonal economic activities, holidays, or other contributing factors. The residuals exhibit notable variability, particularly towards the latter part of the series, suggesting the possibility of external shocks or events that aren't accounted for by the established trend and seasonal patterns.

Based on the ACF and PACF analysis, it can be concluded that both the autocorrelation values and the partial autocorrelation values remain significant for multiple lags, indicating a potential autoregressive or moving average process in the data. While this could be useful for predictions, the substantial variability might pose challenges in making accurate forecasts.

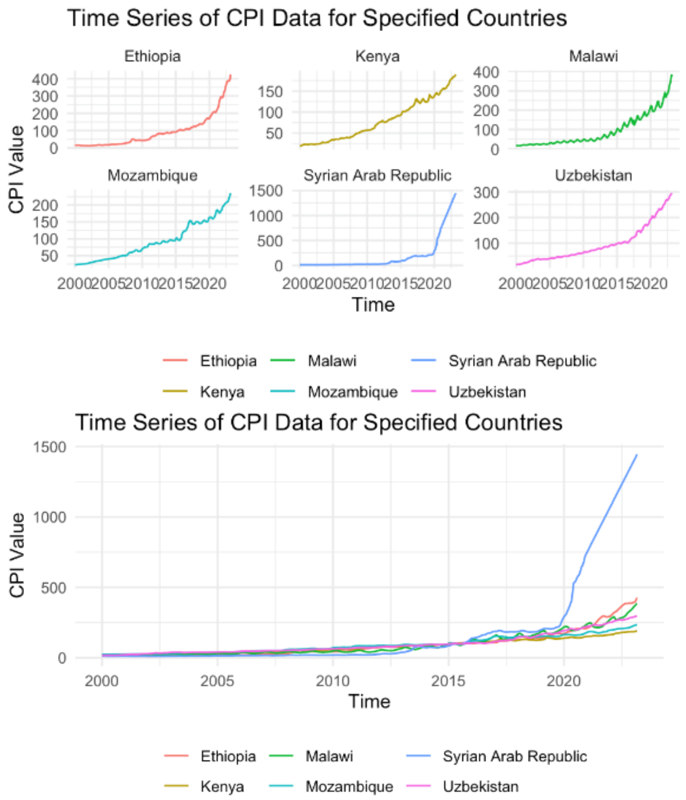


**Fig. 1** Time series plots of CPI of food for Ethiopia, Kenya, Malawi, Mozambique, Syria Arab Republic, and Uzbekistan (Photo/Picture credit: Original).

(a) (b)

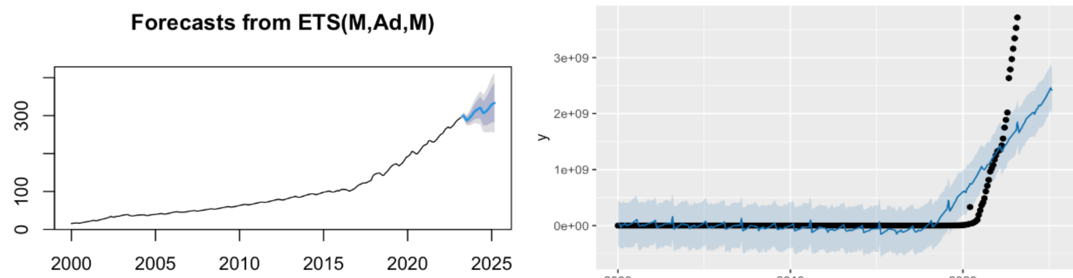


**Fig. 2** Time series forecasting of CPI of food. (a) Forecasting using the ETS model. (b) Forecasting using the Prophet method (Photo/Picture credit: Original).

The continuous upward trajectory of the Consumer Price Index (CPI) for food since 2023 indicates a consistent trend, aligning with historical patterns (Fig. 2). This suggests a likelihood of similar changes in children's stunting rates and minimum dietary calorie requirements. As the CPI for food demonstrates spikes, constituting a foreseeable ongoing trend, malnourished children in food-deficit nations might experience some relief, except for intermittent periods of price reductions.

However, the extent to which external shocks and the volatility in the CPI trend affect the current forecasting model remains uncertain. Furthermore, the implications for children's stunting or hunger necessitate thorough investigation. The severity of these external influences and fluctuations in the CPI trend necessitates a deeper exploration to better understand their impact on the prevailing forecasting models and the resulting circumstances for addressing children's stunting and hunger issues.

# 5. Discussions

## 5.1. Economic Policies

Government fiscal and monetary policies hold significant sway over society, notably affecting inflation rates and job prospects. These policies significantly affect individuals' purchasing power and their ability to access nutritious food. In the long run, real GDP and the previous year's world food price had a significant negative impact on food price inflation, refraining households' ability to afford and access adequate nutrition, especially for vulnerable populations like children in low-income food-deficit countries [12]. In the context of international trade, a prevalent apprehension is that these policies, although enacted to enhance domestic welfare and decrease children's malnutrition rate within the nation, could worsen fluctuations in global food prices, consequently impacting other nations negatively [9]. The interplay between these economic policies (both domestic and international) and food accessibility underscores the importance of considering their effects on nutritional well-being when crafting economic strategies.

## 5.2. Socio-economic Factors

The socio-economic landscape, characterized by income inequality, employment opportunities, and the presence of social safety nets, significantly influences people's nutritional status. Disparities in income distribution can lead to unequal access to nutritious food, exacerbating malnutrition among marginalized communities. Higher unemployment rates coupled with the absence of social safety nets intensify health vulnerabilities, especially in regions where individuals heavily rely on market prices for sustenance. Therefore, addressing socio-economic inequalities and fortifying safety nets becomes pivotal in ensuring equitable access to adequate nutrition for all.

## 5.3. Agricultural and Food Supply Chain.

The accessibility and nutritional quality of food hinge significantly on the efficiency of the agricultural sector and food distribution systems. Policies governing agricultural practices and food supply chains play a pivotal role in determining the availability and diversity of nutritious food options. Multiple studies have investigated regulations for the food supply chain and unveiled substantial flaws. For example, the impact of subsidy for maritime logistics appears to be focused primarily within the initial two years following its introduction [13]. Thus, optimizing agricultural policies and strengthening food supply chains are critical for fostering healthier diets and combatting malnutrition.

## 5.4. Cognitive and Behavioral Factors.

Beyond economic and infrastructural factors, cognitive and behavioral aspects significantly shape dietary preferences and nutritional outcomes. Dietary habits, influenced by cultural norms and traditions, greatly impact individuals' nutritional intake. Special periods such as the COVID-19 pandemic can affect food consumption behavior as well, heightened levels of staying at home led to increased consumption of non-perishable items, dairy, and eggs [14]. Understanding and addressing these cognitive and behavioral factors are crucial for designing effective interventions aimed at improving dietary diversity and reducing stunting rates among children in low-income food-deficit countries.

# 6. Conclusion

This study investigates the relationship between food prices and children's malnutrition using datasets involving the Consumer Price Index (CPI) of food, the number of stunted children under 5 years, and the Minimum Dietary Energy Requirement (MDER). Regression equations show robust yet complex relationships between rising food prices, child stunting, and MDER among different countries, which means food prices seem not capable of solely explaining the change in children's malnutrition status. The continuous upward trajectory of the CPI of food since 2023 suggests potential impacts on stunting rates and MDER, but external shocks and volatility in the CPI trend pose challenges for accurate forecasting and understanding their implications for child malnutrition. Even if price is a powerful tool for studying economic issues, it cannot be used to obtain accurate causal or relevant conclusions in this study. To address proper predictions of children's well-being, not only the food price but also economic policies, socio-economic factors, agricultural and food supply chains, as well as cognitive and behavioral aspects ought to be considered. How the access to resources, dietary habits, or government interventions altered across the years might be plausible when investigating children's malnutrition qualitatively.

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