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*Original Article*

# Understanding the Impact of Macroeconomic Factors on Undernourishment: A Study of BRICS Nations

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***Abstract*** *- The countries that make up the BRICS (Brazil, Russia, India, China, and South Africa) account for a substantial share of the global economy, with Emerging Market Economies (EMEs) that mirror India's economic landscape. However, these nations face challenges related to undernourishment, impacting health and economic growth. The prevalence of undernourishment is a critical concern, affecting various age groups and hindering optimal development. This panel data study aims to analyze the macroeconomic factors influencing undernourishment across the BRICS nations. The selected independent variables include economic growth, unemployment, health expenditure, and environmental health, with the prevalence of undernourishment as the dependent variable. Through a fixed regression analysis, the findings reveal that economic growth and health expenditure have a significant direct impact on undernourishment, with higher GDP growth rates and increased health expenditure correlating with a higher prevalence of undernourishment. In contrast, environmental health, as measured by Greenhouse Gas (GHG) emissions, exhibits an inverse impact on undernourishment, which means higher GHG emissions are associated with a lower prevalence of undernourishment. These findings have important implications for policymakers in BRICS countries. They underscore the need for a nuanced approach to addressing undernourishment that considers the interplay of economic and environmental factors. Policymakers can use these insights to develop targeted interventions aimed at reducing undernourishment rates. This may involve strategies to promote sustainable economic growth while also addressing environmental challenges.*

***Keywords*** *- BRICS, Economic Growth, Environmental Health, Health Expenditure, Undernourishment*.

## 1. Introduction

According to the National Institute of Health, undernutrition is defined as the condition where 'insufficient intake of energy and nutrients to meet an individual's needs to maintain good health'[1]. Global undernourishment remains a pressing issue, with severe impacts on health, development and economic stability. The latest reports confirm the seriousness of this problem. The World Health Organization's (WHO) 2022 data reveals that around 149 million children under the age of 5 globally experience stunting [2].

According to the State of Food Security and Nutrition's 2023 World(SOFI) report, the prevalence of undernourishment is approximately 16.6%. Moreover, over one-third of children under 5 suffer from stunting, highlighting a critical public health concern. India's ranking of 111th out of 121 countries in the global hunger index [3] further underscores the complexity of the challenge within the nation, even in states like Mizoram, Sikkim, and Manipur, which exhibit a comparatively low incidence rate, deal with malnutrition higher than those found in many developed countries. [4]

Existing studies have sought to identify factors contributing to undernourishment. For instance, a study conducted on Sumatra Island revealed that wealth distribution plays a significant role in determining malnutrition levels. [5] The wealthy exhibit lower rates of stunting, wasting, and underweight children compared to the general population, underscoring socioeconomic disparities in nutritional outcomes. Similarly, research in Lahore highlighted the impact of macroeconomic factors such as job opportunities and income levels on malnutrition prevalence. [6] These studies emphasize the complex interplay between economic conditions and nutritional health, demonstrating how household income and socioeconomic status influence dietary adequacy and health outcomes.

Educational attainment also emerges as a crucial factor affecting malnutrition, as shown by Zerihun Yohannes Amare's study (2016) in Ethiopia [7]. The study showed a clear correlation between education levels and malnutrition rates, emphasizing the role of government intervention in promoting educational opportunities to improve public health outcomes. Moreover, research underscores the economic

consequences of malnutrition, linking it to reduced productivity, higher healthcare costs, and diminished cognitive abilities, thereby hindering long-term economic growth.[8] Furthermore, Sub-Saharan Africa and South Asia highlighted how macroeconomic factors such as poverty and income inequality exacerbate malnutrition by limiting access to nutritious food, clean water, and healthcare services. [9] Economic development efforts have shown promise in alleviating malnutrition by raising living standards and enhancing healthcare access, yet disparities persist, particularly in low-to-middle-income countries.

While existing research has extensively explored micro-economic aspects of malnutrition, there remains a significant gap in understanding the underlying macroeconomic determinants contributing to widespread undernourishment. These macroeconomic factors play a crucial role in shaping nutritional outcomes on a large scale, yet comprehensive studies focusing on this aspect are scarce. Understanding the intricate relationship between economic variables and nutrition is crucial for developing targeted interventions and effective global policies to alleviate undernourishment.

This research explores the macroeconomic determinants of undernourishment in the BRICS countries during the 20 years from 2001 to 2021. The countries that I have selected are Brazil, Russia, India, China, and South Africa, which are also known as BRICS, which is crucial due to their global economic influence and diverse socioeconomic contexts. By encompassing a range of economic development stages, demographic profiles, and policy environments, the study aims to offer nuanced insights into how economic factors impact undernourishment levels. Utilizing recent data from sources like the World Bank Database and Statista, the study seeks to uncover novel findings amid conflicting literature on variables affecting undernourishment. Through employing panel study techniques across all BRICS nations, the research analyzes the impact of four key variables—health expenditure, economic growth, unemployment rate, and environmental health. The findings aim to provide new evidence for policy formulation aimed at enhancing global nutritional outcomes.

## 2. Methodology

This study aims to explore and understand the impact of macroeconomic determinants on the prevalence of undernourishment in the BRICS nations.

### *2.1. Sample and Research Design*

This study is based on a sample of BRICS countries (Brazil, Russia, India, China, and South Africa) from 2001 to 2021, i.e. 20 years. The countries of BRICS were chosen to check the effect of macroeconomic variables on the prevalence of undernourishment due to the fact that they represent the developing countries in the world. This is important because these countries have a significant global influence, and the fact that most countries in the world are developing, so research into these countries will help close the knowledge gap.

Regression analysis explains the cause-and-effect relationship between two or more variables. Two types of variables are used: one whose value is being predicted – the outcome variable or the dependent variable, and the other(s) which is (are) used to predict the value – the predictor variable or the independent variable. In this study, regression analysis is used to understand the impact of four macroeconomic variables on the prevalence of undernourishment. This study employs an analysis of panel data, integrating both cross-sections and time-series data, to distinguish between nations through the use of unique letters. Panel data emphasizes individual heterogeneity and offers a greater depth of information while also facilitating the detection and measurement of effects that may not be easily identified through time series or cross-sectional analysis alone. When working with panel data, it is essential to decide the type of regression model. The Hausman test shows that fixed effects regression is most appropriate for this study ($p<0.05$). The model may be expressed as follows:

$$y_{it} = \alpha + v_i + \beta' x_{it} + e_{it}$$

In this context $y_{it}$ represents the dependent variable, $\alpha$ is the intercept(constant) term, $\beta'$ is the vector of coefficients, and $x_{it}$ is the vector of explanatory variables for each country i (i=1,...,5) in each year t (t=1,...,20). In the fixed-effects approach, each country, each nation i, has a unique constant $v_i$. It is assumed that differences between units can be captured by this term, along with $e_{it}$, which stands for the term of error.

### *2.2. Variables and Hypotheses*

In order to understand the effect of macroeconomic indicators on undernourishment, the study considers the following variables for the analysis:

1. Prevalence of Undernourishment (P_UN): Prevalence of undernourishment (% of the population) serves as the dependent variable, representing a critical indicator of food security and nutritional adequacy within a population. The variable, sourced from the World Bank Database, quantifies the proportion of individuals whose food intake does not meet the minimum dietary energy requirements necessary for maintaining a healthy and active life.

The study considers four macroeconomic independent variables for the purpose of the analysis. These are:

1. Economic Growth (GDPGR**):** Economic growth, proxied by the annual GDP Growth Rate (%) reflecting the percentage increase in a country's GDP from one year to the next. The growth rate provides a snapshot of economic performance and is a critical indicator of

economic health and vitality. Data for the same has been sourced from the World Bank database. The hypothesis to be tested for this variable is:

$H_{01}$: There is no significant effect of economic growth on the prevalence of undernourishment in the context of BRICS nations.

$H_{a1}$: There is a significant effect of economic growth on the prevalence of undernourishment in the context of BRICS nations.

2. Unemployment Rate (UNEMP**):** The rate of unemployment, which also represents the proportion of the labour force that is looking for but is unable to obtain employment, functions as a key indicator of economic stability. Data on unemployment rates for the study period are collected from the World Bank database. The hypothesis to be tested is:

   $H_{02}$: There is no significant effect of unemployment on the prevalence of undernourishment in the context of BRICS nations.

   $H_{a2}$: There is a significant effect of unemployment on the prevalence of undernourishment in the context of BRICS nations.

3. Environmental Health (GHG**):** Greenhouse Gas (GHG) emissions per capita serve as a proxy for environmental health. It measures the average amount of greenhouse gas emissions, including methane (CH4), nitrous oxide (N2O), and carbon dioxide(CO2), emitted per person within a country measured in metric tons (t). The data for this variable has been sourced from the JRC/IEA 2023 Report on 'GHG Emissions of all World Countries'.[10] The hypothesis has been formulated as follows:

   $H_{03}$: There is no significant effect of Environmental Health on the prevalence of undernourishment in the context of BRICS nations.

   $H_{a3}$: There is a significant effect of Environmental Health on the prevalence of undernourishment in the context of BRICS nations.

4. Health Expenditure (HEALTH**):** Current health expenditure (% of GDP) captures the proportion of a country's GDP allocated to health expenditures in a given year, reflecting national priorities in healthcare funding and resource allocation. The data for this has also been sourced from the World Bank database. The hypothesis for the same is:

   $H_{04}$: There is no significant effect of health expenditure on the prevalence of undernourishment in the context of BRICS nations.

   $H_{a4}$: There is a significant effect of health expenditure on the prevalence of undernourishment in the context of BRICS nations.

### *2.3. Model Diagnostics*

In order to conduct a fixed effects regression, the model calls for the satisfaction of the following three assumptions: absence of multicollinearity, serial correlation and heteroskedasticity. Multicollinearity is a situation wherein there is high inter-correlation or inter-association between the independent variables. It has been considered as a sort of disturbance in the data. The results of the regression analysis lose their reliability if multicollinearity is present in the data. There are two commonly used methods of testing multicollinearity – manual assessment using a correlation matrix and variance inflation factor (VIF). First, the correlation between independent variables in this model has been calculated (See Table 1). Subsequently, VIF has been used as well. As can be observed, there is no problem with multicollinearity in the dataset, as all the correlation coefficients lie within the acceptable range of -0.8 to 0.8 and VIF < 10 (Mean VIF = 1.523), which represents the generally accepted threshold for multicollinearity.

**Table 1. Correlation matrix of independent variables**

| Variables | GDPGR | UNEMP | GHG | HEALTH |
|---|---|---|---|---|
| GDPGR | 1.000 | | | |
| UNEMP | -0.414 | 1.000 | | |
| GHG | -0.238 | 0.074 | 1.000 | |
| HEALTH | -0.579 | 0.581 | 0.179 | 1.000 |

*Source: STATA Output*

Furthermore, the presence of autocorrelation in a regression model suggests that the values pertaining to a time series are influenced by the lagged version of itself, which can create a large bias in the standard errors. The Wooldridge test for autocorrelation of the model data has a $p < 0.05$, which indicates that there is the presence of first-order autocorrelation.

Finally, the Modified Wald test for groupwise heteroskedasticity shows $chi^2(5)=215.46$ with a $p < 0.05$. This result confirms the presence of heteroskedasticity in the dataset. The 'vce(cluster id)' command available in Stata software has been applied to overcome this. Clustering corrects the standard errors and tests statistics to allow for autocorrelation and heteroscedasticity. [11]

## 3. Results and Discussion

This section interprets the results of the regression analysis, which examines the impact of macroeconomic variables on undernourishment in BRICS countries. To ensure accuracy, the three key assumptions for regression analysis were verified as mentioned above.

**Table 2. Descriptive statistics**

| Variable | Obs | Mean | SD | Min | Max |
|---|---|---|---|---|---|
| P_UN | 105 | 6.637 | 5.465 | 2.5 | 22 |
| GDPGR | 105 | 4.504 | 3.987 | -7.8 | 14.231 |
| UNEMP | 105 | 10.241 | 6.433 | 3.8 | 28.77 |
| GHG | 105 | 8.67 | 4.753 | 1.812 | 18.147 |
| HEALTH | 105 | 5.927 | 2.006 | 2.858 | 10.313 |

*Source: STATA Output*

Table 2 presents descriptive statistics for key socioeconomic and environmental variables across the BRICS nations from 2001 to 2021. The prevalence of undernourishment (P_UN) shows a mean of 6.637% with a high standard deviation of 5.465%, indicating moderate but variable undernourishment levels across these countries. High variability in undernourishment points to severe food security issues in some regions, contrasting with better conditions in others. GDP growth rate (GDPGR) averages 4.504% with a significant standard deviation of 3.987%, highlighting fluctuating economic performance, from a contraction of -7.8% to a robust growth of 14.231%. The unemployment rate (UNEMP) exhibits a mean of 10.241% and a large standard deviation of 6.433%, reflecting diverse labor market conditions ranging from 3.8% to 28.77%. Greenhouse gas emissions (GHG) average 8.67 metric tons per capita, with variability (SD of 4.753) indicating differing environmental impacts, from as low as 1.812 to as high as 18.147 metric tons. Health expenditure (HEALTH) averages 5.927% of GDP, with a standard deviation of 2.006%, showcasing varying investment levels in public health. These statistics underscore significant disparities among the BRICS countries.

The analysis in Table 3 provides the statistical test for overall model fit in terms of the F ratio. Since the significance (p-value = 0.000) for the F-test is less than 0.05, the overall regression model has the best fit. Furthermore, the $R^2$ value of 0.508 for this model suggests that the independent variables account for approximately 51 per cent of the variation in the dependent variable.

**Table 3. Results of panel data regression using fixed effects model**

| **DV: ROE** | **Coefficient** | **P-value** | |
|---|---|---|---|
| Constant | 12.692 | 0.026 | |
| GDPGR | 0.112 | 0.000*** | |
| UMEMP | -.1 | 0.407 | |
| GHG | -1.491 | 0.002*** | |
| HEALTH | 1.246 | 0.147 | |
| **R-Squared** | 0.508 | **No. of obs** | 105 |
| **F-Test** | 113.782 | **Prob > F** | 0.0000 |

**p<0.10, **p<0.05, ***p<0.01*
Source: STATA Output

The regression analysis reveals a significant positive impact of GDP growth on undernourishment in BRICS countries ($\beta$=0.112, t=17.01, p<0.01). This counterintuitive finding suggests that higher economic growth actually leads to an increase in undernourishment. This can be explained by the fact that economic growth often exacerbates income inequality. The benefits of growth are not evenly distributed, leaving large segments of the population, particularly the poor, undernourished [12], [13]. Fast-paced urbanization linked to economic development tends to prioritize cities over rural areas, neglecting the welfare of rural populations and increasing their vulnerability. [14] Additionally, the focus on industrial and service sectors at the expense of agriculture and food security results in insufficient investment in these critical areas, leading to a decreased food supply for marginalized groups [14]. Furthermore, economic growth often leads to environmental degradation, which negatively impacts agricultural productivity and food security through deforestation, water pollution, and soil degradation [12].

Contrary to these findings, some studies suggest that economic growth, particularly when combined with measures aimed at poverty reduction and agricultural improvement, can reduce undernourishment. Investments in social programs and rural development can help ensure a more equitable distribution of growth benefits [13]. Technological advancements in agriculture, supported by economic growth, can also enhance food security. However, in BRICS countries, investment has primarily focused on industrialization rather than agriculture, which explains why these positive effects have not been observed [14]

Furthermore, the analysis shows that the unemployment rate does not significantly impact undernourishment in BRICS countries ($\beta$=-0.1, t=-0.93, p>0.05). This indicates that changes in unemployment rates do not have a notable effect on undernourishment. Various studies suggest that while unemployment can influence food insecurity, it is not the sole cause. Factors such as economic growth, household size, conflict, and environmental conditions also play crucial roles in undernourishment. For instance, studies in Nigeria have demonstrated that food insecurity is affected by multiple factors, including household size, economic shocks, and demographic variables. Larger households, which often have more members competing for limited resources, may experience higher rates of undernutrition despite employment status. The need to distribute resources among more people can lead to insufficient nutrition, even if some household members are employed [15]. Contradictory findings in developed countries link higher unemployment to increased food insecurity due to the direct loss of income and inability to afford adequate food. [16] This discrepancy could be attributed to the significant informal sector employment in BRICS countries. Studies in regions with strong informal sectors have shown that the impact of unemployment on food security is less pronounced, supporting the findings in the BRICS context. [17]

The analysis reveals a significant negative impact of greenhouse gas emissions on the prevalence of undernourishment in BRICS countries ($\beta$=-1.491, t=-7.34, p<0.01). This suggests that higher greenhouse gas emissions are associated with lower levels of undernourishment. While this finding appears counterintuitive, several factors may explain this relationship. Firstly, investments in biotechnology and agricultural innovations have played a crucial role in enhancing food security. Advances in biotechnology have led to the development of crops that are resistant to pests, diseases, and adverse weather conditions. These improved crop

varieties ensure stable and increased agricultural production, even in the face of environmental challenges. By mitigating the impact of unfavorable conditions on crop yields, biotechnology contributes to food security in regions vulnerable to climate shocks.[18] Additionally, modern farming techniques, such as precision agriculture, have optimized resource use, maintained soil health, and improved crop resilience. These technologies enhance the efficiency and sustainability of agricultural practices, helping to secure food supplies despite high emissions levels.

However, it is essential to recognize the long-term negative impacts of greenhouse gas emissions. Environmental degradation resulting from high emissions—such as deforestation, soil erosion, and water pollution—can impair agricultural productivity and food security. While current technological advancements may offset some adverse effects, the long-term sustainability of this balance remains uncertain [19]. Furthermore, government policies in BRICS countries have played a significant role in mitigating the negative impacts of greenhouse gas emissions on food security. For instance, China's policies aimed at enhancing food security while managing natural resources have been effective in addressing these challenges.[20] These policies, combined with technological advancements, help ensure that efforts to improve food security are successful.

Finally, health expenditure does not have a statistically significant impact on the prevalence of undernourishment in BRICS countries ($\beta$=1.246, t=1.79, p>0.05). This indicates that increased health expenditure does not necessarily translate into reduced undernourishment. One reason for this could be the uneven distribution of health resources. Health expenditures tend to be concentrated in urban areas and among wealthier individuals, leaving rural and impoverished areas underserved. This unequal distribution of health spending exacerbates health disparities and limits the effectiveness of financial resources in addressing undernutrition. [21] [22] Additionally, health expenditure alone does not guarantee comprehensive health services. Effective prevention and treatment of malnutrition require a range of services, including sanitation, maternal and child health care, and nutrition education. Without these targeted services, increased health spending may not significantly impact undernutrition rates [23]

Contradictory evidence suggests that well-managed health expenditure can positively impact population health, including nutrition. Research indicates that improved health financing systems, which increase access to health services, can help prevent undernutrition and enhance overall health outcomes. Efforts to improve primary health care and public health initiatives have shown positive effects on the health and nutrition of disadvantaged groups in certain areas.[21] However, while increased health expenditure has the potential to improve nutrition and reduce undernourishment, its effectiveness depends on the equitable distribution of resources and the inclusion of comprehensive health services.

## 4. Conclusion

The objective of this paper was to analyze the influence of macroeconomic indicators on the undernutrition rate in BRICS countries from 2001 to 2021. The fixed-effects regression analysis revealed that economic growth and environmental health significantly impact undernourishment, while unemployment and health expenditure do not. The positive correlation between economic growth and undernourishment highlights the complexities of rapid economic development, including issues like income inequality and urban-rural disparities. Additionally, while increased greenhouse gas emissions were associated with lower undernourishment, this may reflect the short-term benefits of technological advancements in agriculture, overshadowed by long-term environmental degradation.

These findings have important implications for policymakers in BRICS countries. To effectively combat undernutrition, policies must address income inequality and ensure that economic growth benefits all population segments, especially the rural and underprivileged. Policymakers should prioritize investments in sustainable agricultural technologies that can enhance food security without exacerbating environmental degradation.

Moreover, comprehensive health services, including sanitation, maternal and child health care, and nutrition education, are crucial for improving nutritional outcomes. By focusing on equitable economic policies, ensuring that the benefits of economic growth reach all societal segments, particularly the marginalized and rural populations, implementing environmentally sensitive practices to mitigate the long-term adverse effects of industrialization on food security, and expanding health expenditures to include services that directly impact nutrition, such as maternal and child health programs and sanitation, BRICS countries can create a more inclusive and sustainable approach to reducing undernourishment.

This study, however, has limitations. Firstly, focusing on four broad macroeconomic factors—economic growth, unemployment, health expenditure, and environmental health—may overlook other influential factors such as political stability, cultural norms, or agricultural policies. Secondly, the study period (2001-2021) includes significant events like the global financial crisis and the COVID-19 pandemic, which may introduce additional variables affecting long-term trends.

Finally, the findings may not be generalizable to other developing or developed nations due to the unique socioeconomic contexts of BRICS countries. Further research

should incorporate more macroeconomic factors and consider micro-level data to provide a comprehensive understanding of the impact of various economic indicators on undernutrition. Expanding the scope of the study could yield more detailed insights and aid in developing targeted strategies to improve nutritional well-being globally.

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